COMMUNITY ASSISTANCE
PLANNING REPORT NO. 330

A RESTORATION PLAN FOR THE OAK CREEK WATERSHED

VOLUME 3: APPENDICES

SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

KENOSHA COUNTY
Aloysius Nelson
John O'Day
Robert W. Pitts

RACINE COUNTY
Jonathan Delagrave
James A. Ladwig
Peggy L. Shumway

MILWAUKEE COUNTY
Donna Brown-Martin
Theodore Lipscomb, Sr.
Adam M. Tindall-Schlicht

WALWORTH COUNTY
Charles L. Colman,
Chairman
Brian E. Holt
Mary Knipper

OZAUKEE COUNTY
Thomas H. Buestrin
Natalia Minkel-Dumit
Gustav W. Wirth, Jr.,
Secretary

WASHINGTON COUNTY
Jeffrey D. Schleif
Daniel S. Schmidt
David L. Stroik,
Treasurer

WAUKESHA COUNTY
Michael A. Crowley,
Vice-Chairman
James T. Dwyer
Dewayne J. Johnson

ADVISORY GROUP FOR THE OAK CREEK WATERSHED RESTORATION PLAN

Robert Anderson
Philip Beiermeister
Benjamin Benninghoff
Timothy Detzer
Greg Failey
Jacob Fincher
Dave Giordano
Craig Helker
Laura Herrick
Jeffrey Katz
Julie Kinzelman
Mary Jo Lange
Janette Marsh
Glen Morrow
Cheryl Nenn
Brian Russart
Tom Slawski
Timothy Thur
Kyle Vandercar
Jennifer Wright

Titles and affiliations of members can be found in Appendix B of this report

Special acknowledgement is due to Mr. Stevan Keith, former Principal Environmental Engineer and County Conservationist, Milwaukee County Environmental Services who served on the Advisory Group for much of the planning process.

SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION STAFF

Kevin J. Muhs, PE, AICP	Executive Director
Benjamin R. McKay, AICP	Deputy Director
Joel E. Dietl, AICP	Chief Land Use Planner
Laura K. Herrick, PE, CFM	Chief Environmental Engineer
Christopher T. Hiebert, PE	Chief Transportation Engineer
Elizabeth A. Larsen, SPHR, SHRM-SCP	Director of Administration
Eric D. Lynde	Chief Special Projects Planner
Rob W. Merry, PLS	Chief Surveyor
Nakeisha N. Payne	Public Involvement and Outreach Manager
Dr. Thomas M. Slawski	Chief Biologist

Special acknowledgement is due to Dr. Joseph E. Boxhorn, Principal Planner; Aaron W. Owens, Senior Planner; Megan A. Beauchaine, Planner; Laura K. Herrick, PE, CFM, Chief Environmental Engineer; Dr. Justin P. Poinsatte, Senior Specialist Biologist; Julia C. Orlowski, PE, CFM, Engineer; James M. Mahoney, PE, Engineer; Zijia Li, PE, Engineer; Patricia L. Bouchard, GIS Applications Specialist; Dale J. Buser, PE, PH, Principal Specialist; Dr. Dan Carter, Former Principal Specialist-Biologist; Anna Cisar, Former Research Analyst; Megan I. Deau, Senior Graphic Designer; Frank G. Fierek, Senior Specialist; Timothy R. Gorsegner, GIS Specialist; Karin M. Hollister, PE, Principal Engineer; Zachary P. Kron, Senior Specialist-Biologist; Ronald Scerbicke, Former Research Aide; Dr. Thomas Slawski, Chief Biologist; Kathryn E. Sobottke, Principal Specialist; Kimberly A. Walsh, Former Research Aide; and Emma Weiss-Burns, Former Research Analyst for their contributions to the conduct of this study and the preparation of this report.

COMMUNITY ASSISTANCE PLANNING REPORT
NUMBER 330

A RESTORATION PLAN FOR THE OAK CREEK WATERSHED
VOLUME 3: APPENDICES

Prepared by the
Southeastern Wisconsin Regional Planning Commission
W239 N1812 Rockwood Drive
P.O. Box 1607
Waukesha, Wisconsin 53187-1607
www.sewrpc.org

The preparation of this publication was financed in part through planning funds provided by Milwaukee County Parks, City of South Milwaukee, Milwaukee Metropolitan Sewerage District, and Fund for Lake Michigan.
The contents of this report do not necessarily reflect the official views or policy of these organizations.

December 2021

PLAN OUTLINE

VOLUME 1: CHAPTERS 1 – 5

Chapter 1 – Introduction
1.1 Purpose of Plan
1.2 Planning Process
1.3 Plan Format and Organization

Chapter 2 – Prior and Ongoing Studies, Plans, Projects, and Programs
2.1 Introduction
2.2 Regional Water Quality Management Plan Update (RWQMPU)
2.3 Flood Mitigation and Stormwater Plans
2.4 Other Plans, Projects, and Programs

Chapter 3 – Characterization of the Watershed
3.1 Introduction
3.2 Assessment Areas
3.3 Civil Divisions
3.4 Population and Households
3.5 Land Use
3.6 Climate and Climate Change
3.7 Topography and Geology
3.8 Soils
3.9 Natural Resource Elements
3.10 Water Resources

Chapter 4 – Inventory Findings
4.1 Introduction
4.2 Physical Characteristics of Streams Within the Oak Creek Watershed
4.3 Water Quantity Conditions
4.4 Surface Water Quality
4.5 Sources of Water Pollution
4.6 Current Management Practices
4.7 Recreational Access and Use
4.8 Archeological Inventory

Chapter 5 – Watershed Goals and Management Objectives
5.1 Introduction
5.2 Water Quality
5.3 Habitat
5.4 Water Quantity
5.5 Recreational Access and Use

VOLUME 2: CHAPTER 6

Chapter 6 – Plan Recommendations
6.1 Introduction
6.2 Recommended Actions to Improve Water Quality
6.3 Recommended Actions to Improve Habitat
6.4 Recommended Actions to Improve Recreational Opportunities
6.5 Recommended Actions to Address Targeted Flooding Problems
6.6 Alternatives and Recommended Actions for the Mill Pond and Mill Pond Dam
6.7 Recommended Actions for Public Awareness and Participation in Watershed Restoration Activities
6.8 Priority Projects for Implementation
6.9 Measuring Plan Progress and Success
6.10 Plan Implementation
6.11 Required Technical and Financial Assistance

VOLUME 3: APPENDICES

Appendix A – Acronyms and Abbreviations

Appendix B – Membership and Activities of the Oak Creek Watershed Plan Advisory Group and the Oak Creek Stakeholders' Group

Appendix C – Designated Natural Area Profiles for Natural Areas Partially or Wholly Within the Oak Creek Watershed

Appendix D – STEPL Load Reduction Results for Streambank Erosion Restoration Practices

Appendix E – Known Outfalls Within the Oak Creek Watershed

Appendix F – Physical Stream Conditions and Habitat Characteristics Collected During Instream Surveys of Oak Creek, North Branch Oak Creek, and Mitchell Field Drainage Ditch

Appendix G – Existing and Potential Riparian Buffer Areas

Appendix H – Stream Crossing Descriptions, Condition, and Fish Passage Assessment for the Oak Creek Watershed

Appendix I – Oak Creek Mill Pond Dam

Appendix J – Emerging Pollutants in Surface Water: 2002-2009

Appendix K – Pesticides in Surface Water: 2002-2016

Appendix L – Macroinvertebrate Survey Data

Appendix M – Water Quality Simulation Model and Pollutant Loads from the RWQMPU

Appendix N – Design, Operation, and Maintenance Recommendations for Iron–Enhanced BMPs To Treat Dissolved Phosphorus in Stormwater

Appendix O – Desktop Analysis Procedure Developed for Illicit Discharge Detection and Elimination Screening

Appendix P – Bibliography of References Related to Mycoremediation to Address Fecal indicator Bacteria and Pathogens

Appendix Q – Best Management Practices for Chloride Management

Appendix R – Milwaukee County Parks Quick Reference Guide: Phenology and Control of Common Invasive Plant Species in Southeastern Wisconsin

Appendix S – Considerations for Design and Placement of Stream Crossings

Appendix T – Detailed Cost Estimates for the Mill Pond and Dam Alternatives

Appendix U – Model Resolution for Adoption of the Oak Creek Watershed Restoration Plan

APPENDIX A
ACRONYMS AND ABBREVIATIONS.. 3

APPENDIX B
MEMBERSHIP AND ACTIVITIES OF THE OAK CREEK WATERSHED PLAN ADVISORY GROUP AND THE OAK CREEK STAKEHOLDERS' GROUP 9
THE OAK CREEK WATERSHED ADVISORY GROUP.. 9
PUBLIC EDUCATION EFFORTS CONDUCTED AS PART OF THE PLANNING PROCESS AND THE OAK CREEK WATERSHED STAKEHOLDERS' GROUP........................ 9

APPENDIX C
DESIGNATED NATURAL AREA PROFILES FOR NATURAL AREAS PARTIALLY OR WHOLLY WITHIN THE OAK CREEK WATERSHED 13

APPENDIX D
STEPL LOAD REDUCTION RESULTS FOR STREAMBANK EROSION RESTORATION PRACTICES 27

APPENDIX E
KNOWN OUTFALLS WITHIN THE OAK CREEK WATERSHED 39

APPENDIX F
PHYSICAL STREAM CONDITIONS AND HABITAT CHARACTERISTICS COLLECTED DURING INSTREAM SURVEYS OF OAK CREEK, NORTH BRANCH OAK CREEK, AND MITCHELL FIELD DRAINAGE DITCH 85
DESCRIPTION OF FIELD MEASUREMENTS AND OBSERVATIONS COLLECTED AT CROSS-SECTION SURVEYS..85
Stream Bank Characteristics 85
Instream Habitat Characteristics..85
DESCRIPTIONS OF ADDITIONAL LINE OR POINT FEATURES GEOLOCATED DURING INSTREAM SURVEYS..88

APPENDIX F-1
LOCATIONS OF INSTREAM TRANSECT SURVEYS AND OBSERVED DEEP POOLS AND RIFFLES BY ASSESSMENT AREA..93

APPENDIX F-2
LOCATIONS OF STREAM SURVEY INVENTORY DATA BY ASSESSMENT AREA 107

APPENDIX G
EXISTING AND POTENTIAL RIPARIAN BUFFER AREAS... 133
RIPARIAN BUFFER MANAGEMENT GUIDE NO. 1 – MANAGING THE WATER'S EDGE................ 159

APPENDIX H
STREAM CROSSING DESCRIPTIONS, CONDITION, AND FISH PASSAGE ASSESSMENT FOR THE OAK CREEK WATERSHED 183

APPENDIX I
OAK CREEK MILL POND DAM PLANS AND PERMIT DOCUMENTS..................... 209

APPENDIX J
EMERGING POLLUTANTS IN SURFACE WATER: 2002-2009 261

TABLE OF CONTENTS

APPENDIX K
PESTICIDES IN SURFACE WATER: 2002-2016 265

APPENDIX L
MACROINVERTEBRATE SURVEY DATA 273

APPENDIX M
WATER QUALITY SIMULATION MODEL AND
POLLUTANT LOADS FROM THE RWQMPU 285
RELATIONSHIP OF THE OAK CREEK WATERSHED RESTORATION PLAN
TO THE REGIONAL WATER QUALITY MANAGEMENT PLAN 285
WATER QUALITY MODELING 285
WATER QUALITY RESULTS OF THE RWQMPU MODELING ANALYSES 286
ADJUSTMENT OF MODELED LOADS TO DEVELOP
POLLUTANT LOAD REDUCTION TARGETS 287

APPENDIX N
DESIGN, OPERATION, AND MAINTENANCE
RECOMMENDATIONS FOR IRON-ENHANCED BMPS TO
TREAT DISSOLVED PHOSPHORUS IN STORMWATER 303
DESIGN CONSIDERATIONS FOR IRON-ENHANCED SAND FILTERS (IESF) 303
Design Considerations Specific to IESF Trenches Adjacent to Wet Ponds 304
Design Considerations Specific to IESF Ditch Check Dams 305
OPERATION AND MAINTENANCE 306

APPENDIX O
DESKTOP ANALYSIS PROCEDURE DEVELOPED FOR ILLICIT
DISCHARGE DETECTION AND ELIMINATION SCREENING 307

APPENDIX P
BIBLIOGRAPHY OF REFERENCES RELATED TO MYCOREMEDIATION
TO ADDRESS FECAL INDICATOR BACTERIA AND PATHOGENS 311

APPENDIX Q
BEST MANAGEMENT PRACTICES FOR CHLORIDE MANAGEMENT 315
BEST MANAGEMENT PRACTICES FOR SALT AND
DEICER STORAGE AND ONSITE MANAGEMENT 315
BEST MANAGEMENT PRACTICES FOR APPLICATION OF DEICERS TO ROADS 317
BEST MANAGEMENT PRACTICES FOR SNOW AND
ICE CONTROL ON PARKING LOTS AND SIDEWALKS 318
BEST MANAGEMENT PRACTICES FOR WATER SOFTENING 319

APPENDIX R
MILWAUKEE COUNTY PARKS QUICK REFERENCE GUIDE:
PHENOLOGY AND CONTROL OF COMMON INVASIVE PLANT SPECIES
IN SOUTHEASTERN WISCONSIN 321

APPENDIX S
CONSIDERATIONS FOR DESIGN AND
PLACEMENT OF STREAM CROSSINGS 351
TYPES OF CROSSINGS 351
BIOLOGICAL CONSIDERATIONS 351

PHYSICAL CONSIDERATIONS 352
Provide Adequate Depth 252
Provide Adequate Width and Openness 253
Provide Adequate Resting Areas 253
Inlet and Outlet Protection 253

APPENDIX T
DETAILED COST ESTIMATES FOR THE
MILL POND AND DAM ALTERNATIVES 355

APPENDIX U
MODEL RESOLUTION FOR ADOPTION OF THE
OAK CREEK WATERSHED RESTORATION PLAN 369

LIST OF FIGURES

Appendix E
Figure E.1 Known Outfalls Within the Oak Creek Watershed 61

Appendix F
Figure F.1 Example of Bank Height and Undercut Depth Measured at an Actively Eroding Site 86
Figure F.2 Example of Length of Erosion and Bank Slope Measured at an Actively Eroding Site 86
Figure F.3 Typical Deep Water Pool Habitats in the Oak Creek Watershed 88
Figure F.4 Typical Shallow Water Riffle Habitats in the Oak Creek Watershed 88

Appendix G
Figure G.1 Examples of Areas that Should be Identified in Maps G.1 Through G.22 to Implement Recommendations 135

Appendix H
Figure H.1 Stream Crossings Along Surveyed Reaches of Oak Creek, North Branch Oak Creek, and Mitchell Field Drainage Ditch: 2016 196

Appendix I
Figure I.1 1932 Construction Plans for the Oak Creek Mill Pond Dam 211
Figure I.2 1938 Construction Plans for the Sluice Gate for the Oak Creek Mill Dam 212
Figure I.3 1989 Design Plan for the Sluice Gate Intake Grate 213
Figure I.4 Wisconsin Department of Natural Resources Correspondence 214
Figure I.5 Masonry Inspection Report for the Oak Creek Mill Pond Dam 237
Figure I.6 Repair Plans for the Oak Creek Mill Pond Dam Slide Gate 253

Appendix S
Figure S.1 Considerations for Culvert Design and Placement 352
Figure S.2 Key Features that Promote Fish and Wildlife Passage 354

LIST OF MAPS

Appendix E
Map E.1 Locations of Known Outfalls Within the Oak Creek Watershed 41

Appendix F
Map F.1 Locations of Instream Transect Surveys and Observed Deep Pools and Riffles Within the Grant Park Ravine Assessment Area 95

Map F.2 Locations of Instream Habitat Transect Surveys and Observed Deep Pools and Riffles Within the Lower Oak Creek – Mill Pond Assessment Area 96
Map F.3 Locations of Instream Habitat Transect Surveys and Observed Deep Pools and Riffles Within the Lower Oak Creek Assessment Area 97
Map F.4 Locations of Instream Habitat Transect Surveys and Observed Deep Pools and Riffles Within the Middle Oak Creek Assessment Area 98
Map F.5 Location of Instream Habitat Transect Surveys and Observed Deep Pools and Riffles Within the Upper Oak Creek Assessment Area (Reach 1) 99
Map F.6 Location of Instream Habitat Transect Surveys and Observed Deep Pools and Riffles Within the Upper Oak Creek Assessment Area (Reach 2) 100
Map F.7 Location of Instream Habitat Transect Surveys and Observed Deep Pools and Riffles Within the Upper Oak Creek Assessment Area (Reach 3) 101
Map F.8 Location of Instream Habitat Transect Surveys and Observed Deep Pools and Riffles Within the Oak Creek Headwaters Assessment Area 102
Map F.9 Location of Instream Habitat Transect Surveys and Observed Deep Pools and Riffles Within the Lower North Branch Oak Creek Assessment Area (Reach 1) 103
Map F.10 Location of Instream Habitat Transect Surveys and Observed Deep Pools and Riffles Within the Lower North Branch Oak Creek Assessment Area (Reach 2) 104
Map F.11 Location of Instream Habitat Transect Surveys and Observed Deep Pools and Riffles Within the Upper North Branch Oak Creek Assessment Area 105
Map F.12 Location of Instream Habitat Transect Surveys and Observed Deep Pools and Riffles Within the Lower Mitchell Field Drainage Ditch Assessment Area 106
Map F.13 Stream Survey Inventory Within the Grant Park Ravine Assessment Area 109
Map F.14 Stream Survey Inventory for the Lower Oak Creek – Mill Pond Assessment Area (Reach 1) 110
Map F.15 Stream Survey Inventory for the Lower Oak Creek – Mill Pond Assessment Area (Reach 2) 111
Map F.16 Stream Survey Inventory for the Lower Oak Creek Assessment Area (Reach 1) 112
Map F.17 Stream Survey Inventory for the Lower Oak Creek Assessment Area (Reach 2) 113
Map F.18 Stream Survey Inventory for the Lower Oak Creek Assessment Area (Reach 3) 114
Map F.19 Stream Survey Inventory for the Middle Oak Creek Assessment Area (Reach 1) 115
Map F.20 Stream Survey Inventory for the Middle Oak Creek Assessment Area (Reach 2) 116
Map F.21 Stream Survey Inventory for the Middle Oak Creek Assessment Area (Reach 3) 117
Map F.22 Stream Survey Inventory for the Middle Oak Creek Assessment Area (Reach 4) 118
Map F.23 Stream Survey Inventory for Upper Oak Creek Assessment Area (Reach 1) 119
Map F.24 Stream Survey Inventory for Upper Oak Creek Assessment Area (Reach 2) 120
Map F.25 Stream Survey Inventory for Upper Oak Creek Assessment Area (Reach 3) 121
Map F.26 Stream Survey Inventory for the Oak Creek Headwaters Assessment Area (Reach 1) 122
Map F.27 Stream Survey Inventory for the Oak Creek Headwaters Assessment Area (Reach 2) 123
Map F.28 Stream Survey Inventory for the Lower North Branch Oak Creek Assessment Area (Reach 1) 124
Map F.29 Stream Survey Inventory for the Lower North Branch Oak Creek Assessment Area (Reach 2) 125
Map F.30 Stream Survey Inventory for the Lower North Branch Oak Creek Assessment Area (Reach 3) 126
Map F.31 Stream Survey Inventory for the Upper North Branch Oak Creek Assessment Area (Reach 1) 127
Map F.32 Stream Survey Inventory for the Upper North Branch Oak Creek Assessment Area (Reach 2) 128
Map F.33 Stream Survey Inventory for the Upper North Branch Oak Creek Assessment Area (Reach 3) 129
Map F.34 Stream Survey Inventory for the Lower Mitchell Field Drainage Ditch Assessment Area (Reach 1) 130
Map F.35 Stream Survey Inventory for the Lower Mitchell Field Drainage Ditch Assessment Area (Reach 2) 131

Appendix G

Map G.1 Existing and Potential Riparian Buffer Areas Within the Grant Park Ravine Assessment Area: 2015 136
Map G.2 Existing and Potential Riparian Buffer Areas Within the Lower Oak Creek – Mill Pond Assessment Area (Inset 1): 2015 137
Map G.3 Existing and Potential Riparian Buffer Areas Within the Lower Oak Creek – Mill Pond Assessment Area (Inset 2): 2015 138
Map G.4 Existing and Potential Riparian Buffer Areas Within the Lower Oak Creek Assessment Area (Inset 1): 2015 139
Map G.5 Existing and Potential Riparian Buffer Areas Within the Lower Oak Creek Assessment Area (Inset 2): 2015 140
Map G.6 Existing and Potential Riparian Buffer Areas Within the Lower Oak Creek Assessment Area (Inset 3): 2015 141
Map G.7 Existing and Potential Riparian Buffer Areas Within the Middle Oak Creek Assessment Area (Inset 1): 2015 142
Map G.8 Existing and Potential Riparian Buffer Areas Within the Middle Oak Creek Assessment Area (Inset 2): 2015 143
Map G.9 Existing and Potential Riparian Buffer Areas Within the Upper Oak Creek Assessment Area (Inset 1): 2015 144
Map G.10 Existing and Potential Riparian Buffer Areas Within the Upper Oak Creek Assessment Area (Inset 2): 2015 145
Map G.11 Existing and Potential Riparian Buffer Areas Within the Oak Creek Headwaters Assessment Area: 2015 146
Map G.12 Existing and Potential Riparian Buffer Areas Within the Middle Oak Creek – Drainage Ditches Assessment Area: 2015 147
Map G.13 Existing and Potential Riparian Buffer Areas Within the Lower North Branch Oak Creek Assessment Area (Inset 1): 2015 148
Map G.14 Existing and Potential Riparian Buffer Areas Within the Lower North Branch Oak Creek Assessment Area (Inset 2): 2015 149
Map G.15 Existing and Potential Riparian Buffer Areas Within the Upper North Branch Oak Creek Assessment Area (Inset 1): 2015 150
Map G.16 Existing and Potential Riparian Buffer Areas Within the Upper North Branch Oak Creek Assessment Area (Inset 2): 2015 151
Map G.17 Existing and Potential Riparian Buffer Areas Within the Southland Creek Assessment Area: 2015 152
Map G.18 Existing and Potential Riparian Buffer Areas Within the Drexel Avenue Tributary Assessment Area: 2015 153
Map G.19 Existing and Potential Riparian Buffer Areas Within the Rawson Avenue Tributary Assessment Area: 2015 154
Map G.20 Existing and Potential Riparian Buffer Areas Within the College Avenue Tributary Assessment Area: 2015 155
Map G.21 Existing and Potential Riparian Buffer Areas Within the Lower Mitchell Field Drainage Ditch Assessment Area: 2015 156
Map G.22 Existing and Potential Riparian Buffer Areas Within the Mitchell Field Drainage Ditch – Airport Assessment Area: 2015 157

Appendix M

Map M.1 Estimated Average Annual Nonpoint Source Pollution Loads of Total Phosphorus in the Oak Creek Watershed 293
Map M.2 Estimated Average Annual per Acre Nonpoint Source Pollution Loads of Total Phosphorus in the Oak Creek Watershed 294
Map M.3 Estimated Average Annual Nonpoint Source Pollution Loads of Total Suspended Solids in the Oak Creek Watershed 295
Map M.4 Estimated Average Annual per Acre Nonpoint Source Pollution Loads of Total Suspended Solids in the Oak Creek Watershed 296
Map M.5 Estimated Average Annual Nonpoint Source Pollution Loads of Fecal Coliform Bacteria in the Oak Creek Watershed 297

Map M.6 Estimated Average Annual Per Acre Nonpoint Source Pollution Loads of Fecal Coliform Bacteria in the Oak Creek Watershed 298
Map M.7 Estimated Average Annual Nonpoint Source Pollution Loads of Total Nitrogen in the Oak Creek Watershed 299
Map M.8 Estimated Average Annual Per Acre Nonpoint Source Pollution Loads of Total Nitrogen in the Oak Creek Watershed 300

LIST OF TABLES

Appendix B
Table B.1 Membership of the Oak Creek Watershed Plan Advisory Group 10
Table B.2 Meetings of the Oak Creek Watershed Restoration Plan Advisory Group 10
Table B.3 Stakeholder Meetings for the Oak Creek Watershed Restoration Plan 11

Appendix D
Table D.1 STEPL Model Load Reduction Results for Streambank Erosion Sites in Grant Park Ravine 29
Table D.2 STEPL Model Load Reduction Results for Streambank Erosion Sites in Lower Oak Creek – Mill Pond 30
Table D.3 STEPL Model Load Reduction Results for Streambank Erosion Sites in Lower Oak Creek 31
Table D.4 STEPL Model Load Reduction Results for Streambank Erosion Sites in Middle Oak Creek 32
Table D.5 STEPL Model Load Reduction Results for Streambank Erosion Sites in Upper Oak Creek 34
Table D.6 STEPL Model Load Reduction Results for Streambank Erosion Sites in Upper Oak Creek – Headwaters 35
Table D.7 STEPL Model Load Reduction Results for Streambank Erosion Sites in Lower North Branch Oak Creek 36
Table D.8 STEPL Model Load Reduction Results for Streambank Erosion Sites in Upper North Branch Oak Creek 37
Table D.9 STEPL Model Load Reduction Results for Streambank Erosion Sites in Lower Mitchell Field Drainage Ditch 38

Appendix E
Table E.1 Known Outfalls Within the Oak Creek Watershed 45

Appendix F
Table F.1 Transect and Point Feature Data Dictionary for Data Collected as Part of the Oak Creek Instream Survey Conducted by Commission Staff: 2016-2017 (See Maps F.1 through F.35) 90

Appendix H
Table H.1 Structure Description, Location, Condition, and Fish Passage Rating Assessment for Oak Creek and its Principal Tributaries: 2016-2017 185

Appendix J
Table J.1 Surface Water Quality Monitoring Results for Emerging Pollutants in the Mainstem of Oak Creek at 15th Avenue: 2002-2009 263

Appendix K
Table K.1 Surface Water Quality Monitoring Results for Pesticides in the Mainstem of Oak Creek at 15th Avenue: 2002-2016 267

Appendix L
Table L.1 Summary of Macroinvertebrate Data by Site in the Oak Creek Watershed: 1979-2015 275

Table L.2 Macroinvertebrate Survey Data by Taxa in the Oak Creek Watershed; 1979-2015 277

Appendix M

Table M.1 Water Quality Indicators Used to Compare Alternative Plans in the RWQMPU 287

Table M.2 Average Annual Total Phosphorus Loads for the Oak Creek Watershed Taken from the RWQMPU 289

Table M.3 Average Annual Total Suspended Solids Loads for the Oak Creek Watershed Taken from the RWQMPU 290

Table M.4 Average Annual Fecal Coliform Bacteria Loads for the Oak Creek Watershed Taken from the RWQMPU 291

Table M.5 Average Annual Total Nitrogen Loads for the Oak Creek Watershed Taken from the RWQMPU 292

Appendix O

Table O.1 Matrix for Prioritizing Drainage Areas for Outfall Screening Using Screening Factors for Illicit Discharge Potential of Human Waste 308

APPENDICES

APPENDIX A

ACRONYMS AND ABBREVIATIONS

°C	Degrees Celsius
°F	Degrees Fahrenheit
7Q10	Seven-day, 10-percent probability low flow

A

ACEP	Agricultural Conservation Easement Program
ADID	Advanced delineation and identification
AFFF	Aqueous film-forming foam
AIS	Aquatic invasive species
ANOVA	Analysis of variance
ASI	Archeological sites inventory
ATV	All-terrain vehicle

B

BBN	Bring Back the Natives program
BCPL	Wisconsin Board of Commissioners of Public Lands
BMP	Best management practice
BOD	Biochemical oxygen demand
BOD_5	Five-day biochemical oxygen demand
BRIC	Building Resilient Infrastructure and Communities program

C

CAFO	Concentrated animal feeding operation
cells per 100 ml	Cells per 100 milliliters
cfs	Cubic feet per second
cfu	Colony forming units
cfu per 100 ml	Colony forming units per 100 milliliters
CIG	Conservation Innovative Grant Program
CMOM	Capacity, management, operation, and maintenance
CPF	Captain Planet Foundation
CRP	Conservation Reserve Program
CSHS	Critical species habitat site
CSP	Conservation Stewardship Program
CTH	County trunk highway
CWA	Federal Clean Water Act
CWFP	Clean Water Fund Program
CWH	Course woody habitat
CY	Cubic yards

D

DATCP	Wisconsin Department of Agriculture, Trade and Consumer Protection
DPRC	Milwaukee County Department of Parks, Recreation, and Culture

E

E. coli	*Escherichia coli*
ECP	Emergency Conservation Program
EE	Environmental Education Grants Program
EHSFP	Ecosystem health and sustainable fish populations
EPT	Percent Ephemeroptera, Plecoptera, and Trichoptera
EQIP	Environmental Quality Incentives Program
EWP	Emergency Watershed Protection Program

F

FAL	Warmwater fish and aquatic life
FCRC	Fresh Coast Resource Center
FEMA	Federal Emergency Management Agency
FMA	Flood Mitigation Assistance program
fps	Feet per second
FSA	Farm Service Agency
ft	Feet

G

GCI	Grassland Conservation Initiative
GIS	Geographical information system
GLFT	Great Lakes Fishery Trust
GLRI	Great Lakes Restoration Initiative
GLSNRP	Great Lakes Sediment, and Nutrient Reduction Program
GPS	Global positioning system

H

HEC-RAS	Hydrological Engineering Center-River Analysis System
HBI	Hilsenhoff biotic index
HIDP	Human illicit discharge potential
HMGP	Hazard Mitigation Grant Program
HSPF	Hydrological Simulation Program – Fortran
HUC	Hydrological unit code

I

IBI	Index of biotic integrity
IDDE	Illicit discharge detection and elimination
IESF	Iron-enhanced sand filter
IGLD85	International Great Lakes Datum of 1985
IH	Interstate highway
INRA	Isolated natural resource area
ISS	Inline storage system (aka the Deep Tunnel)

L

LCWF	Federal Land and Water Conservation Fund
LOD	Limit of detection
LOP	Level of protection
LSPC	Loading Simulation Program in C++
LWRM	Land and water resource management
LWRMP	Land and water resource management plan

M

MEC	Midpoint effect concentration
mg/kg	Milligrams per kilogram
mg/l	Milligrams per liter
mgd	Million gallons per day
MMIA	Milwaukee Mitchell International Airport
MMSD	Milwaukee Metropolitan Sewerage District
MMSD 2020 FP	Milwaukee Metropolitan Sewerage District 2020 Facilities Plan
MS4	Municipal separate storm sewer system

N

NA	Natural area
NFIP	National Flood Insurance Program
NFWF	National Fish and Wildlife Foundation
NGVD29	National Geodetic Vertical Datum of 1929
NOAA	National Oceanic and Atmospheric Administration
NWIS	National Water Information System
ng/l	Nanograms per liter
NGVD29	National Geodetic Vertical Datum of 1929
NRCS	U.S. Natural Resources Conservation Service
NTP	National Toxicology Program
ntu	Nephelometric turbidity unit
NMFE	Nutrient Management Farmer Education program

P

PAH	Polycyclic aromatic hydrocarbon
PCB	Polychlorinated biphenyl
PEC	Primary environmental corridor
PEC	Probable effect quotient
PEC-Q	Mean probable effect quotient
PFAS	Perfluoroalkyl and polyfluoroalkyl substances
PFBS	Perfluorobutane sulfonic acid
PFHpA	Perfluoroheptanoic acid
PFHxS	Perfluorohexane sulfonic acid
PFNA	Perfluorononanoic acid
PFOA	Perflurooctanoic acid
PFOS	Perfluorooctane sulfonic acid
PFW	Partners for Fish and Wildlife program
POWTS	Private onsite wastewater treatment system
PR No. 50	SEWRPC Planning Report No. 50

R

RCPP	Regional Conservation Partnership Program
RHD	City of Racine Public Health Department
RM	River mile
Root-Pike WIN	Root-Pike Watershed Initiative Network
ROW	Right-of-way
RSC	Regenerative stormwater conveyance
RWQMP	Regional water quality management plan
RWQMPU	Regional water quality management plan update

S

SWDA	Federal Safe Drinking Water Act
SEC	Secondary environmental corridor
SEWISC	Southeastern Wisconsin Invasive Species Consortium
SEWRPC	Southeastern Wisconsin Regional Planning Commission
SHPO	Wisconsin State Historic Preservation Officer
SLAMM	Source Loading and Management Model
SSC	Suspended sediment concentration
STEM	Science, Technology, Engineering, and Mathematics
STEPL	Spreadsheet Tool of Estimating Pollutant Loads
STH	State trunk highway
stu	Standard units
STV	Statistical test value

S (continued)

SOGL	Sustain Our Great Lakes
Sweet Water	Southeastern Wisconsin Watersheds Trust, Inc.
SWIMS	Surface Water Information System
SWRM	Soil and Water Resource Management program

T

T	Maximum average tolerable soil loss rate
TEC	Threshold effect concentration
TMDL	Total maximum daily load
TRM	Targeted Runoff Management Grant Program
TSS	Total suspended solids

U

USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USFS	U.S. Forest Service
USFSA	U.S. Farm Services Agency
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UWEX	University of Wisconsin-Madison Division of Extension (formerly University of Wisconsin-Extension)

V

VHS	Viral hemorrhagic septicemia

W

WBI	Wisconsin Buffer Initiative
WCEF	Wisconsin Conservation & Education Foundation
WCMP	Wisconsin Coastal Management Program
WDHS	Wisconsin Department of Health Services
WDNR	Wisconsin Department of Natural Resources
WEM	Wisconsin Division of Emergency Management
WFLGP	Wisconsin Forest Landowner Grant Program
WHPD	Wisconsin Historic Preservation Database
WIANG	Wisconsin Air National Guard
WICCI	Wisconsin Initiative on Climate Change Impacts
WinSLAMM	Source Loading and Management Model for Windows
WisDOT	Wisconsin Department of Transportation
WPA	Works Progress Administration
WPDES	Wisconsin Pollutant Discharge Elimination System
WQMA	Water Quality Management Area
WRWG	Water Resources Working Group
WWCT	Wisconsin Wetland Conservation Trust
WWTP	Wastewater Treatment Plan

µ

μg/kg	Micrograms per kilogram
μg/l	Micrograms per liter
μS/cm	MicroSiemens per centimeter

APPENDIX B

MEMBERSHIP AND ACTIVITIES OF THE OAK CREEK WATERSHED PLAN ADVISORY GROUP AND THE OAK CREEK STAKEHOLDERS' GROUP

THE OAK CREEK WATERSHED ADVISORY GROUP

The Oak Creek watershed restoration plan was developed under the guidance of the Oak Creek Watershed Advisory Group. The purpose of this group was to actively involve units of government, technical agencies, and private interests in the development of the plan. A major role of the Advisory Group was to review and provide comments to Commission staff on drafts of plan sections. The Advisory Group also performs important educational functions by familiarizing local leadership in the watershed with the findings and recommendations of the plan and in encouraging plan implementation.

The Advisory Group included representatives from several organizations, including Commission staff, Milwaukee County, all the municipalities that are wholly or partially located within the Oak Creek watershed, the Milwaukee Metropolitan Sewerage District, the Wisconsin Department of Natural Resources, the U.S. Environmental Protection Agency, local environmental groups, and local colleges and universities. The members of the Advisory Group are listed in Table B.1.

The Advisory Group met eight times during the development of the plan. The dates and major topics of the Group's meetings are shown in Table B.2.

PUBLIC EDUCATION EFFORTS CONDUCTED AS PART OF THE PLANNING PROCESS AND THE OAK CREEK WATERSHED STAKEHOLDERS' GROUP

Several public education and outreach efforts were conducted as part of the planning process for this watershed restoration plan. A project webpage was established on the Southeastern Wisconsin Regional Planning Commission's website. This page presented a description of the planning project. Materials related to plan development were posted on this page in forms that could be downloaded. These materials included copies of draft chapters of the plan report, announcements of upcoming Advisory Group and stakeholder meetings, agendas and minutes from Advisory group meetings, and presentations from stakeholder meetings. The page also contained a comments screen through which members of the public could submit questions about and comments on the draft plan.

The planning effort also included periodic watershed stakeholder meetings to update members of the public about progress on the plan

Table B.1
Membership of the Oak Creek Watershed Plan Advisory Group

Name	Title and Affiliation
Robert Anderson	Professor of Biological Sciences, Wisconsin Lutheran College
Philip Beiermeister	Environmental Engineer, City of Oak Creek
Benjamin Benninghoff	Natural Resources Basin Supervisor, Wisconsin Department of Natural Resources
Timothy Detzer	Senior Environmental Engineer and County Conservationist, Milwaukee County Environmental Services
Greg Failey	Environmental Manager, Milwaukee Mitchell International Airport, Milwaukee County
Jacob Fincher	Executive Director, Southeastern Wisconsin Watersheds Trust, Inc.
Dave Giordano	Executive Director, Root-Pike Watershed Initiative Network
Craig Helker	Water Resources Management Specialist, Wisconsin Department of Natural Resources
Laura K. Herrick	Chief Environmental Engineer, Southeastern Wisconsin Regional Planning Commission
Jeffrey Katz	City Engineer, City of Greenfield
Julie Kinzelman	Associate Lecturer, University of Wisconsin-Parkside
Mary Jo Lange	Directory of Public Works/City Engineer, City of Cudahy
Janette Marsh	Nonpoint Source Technical Program Manager, U.S. Environmental Protection Agency, Region 5
Glen Morrow	City Engineer/Director of Public Works, City of Franklin
Cheryl Nenn	River Keeper, Milwaukee Riverkeeper
Brian Russart	Natural Areas Coordinator, Milwaukee County/Department of Parks, Recreation, and Culture
Thomas M. Slawski	Chief Biologist, Southeastern Wisconsin Regional Planning Commission
Timothy Thur	Infrastructure Administration Manager, City of Milwaukee Department of Public Works
Kyle Vandercar	City Engineer, City of South Milwaukee
Jennifer Wright	Watercourse Section Manager, Engineering Department, Milwaukee Metropolitan Sewerage District

Special acknowledgement is due to Mr. Stevan Keith, former Principal Environmental Engineer and County Conservationist, Milwaukee County Environmental Services who served on the Advisory Group for much of the planning process.

Source: SEWRPC

Table B.2
Meetings of the Oak Creek Watershed Restoration Plan Advisory Group

Date	Location	Major Topics Addressed
February 7, 2018	Oak Creek Civic Center	Review of Advisory Group's role, report outline and schedule
November 14, 2018	South Milwaukee City Administration Building	Review of Draft Chapters 1-3
October 30, 2019	Oak Creek Civic Center	Review of a portion of Draft Chapter 4
June 23, 2020	Online via GoToMeeting	Review of a portion of Draft Chapter 4
November 17, 2020	Online via GoToMeeting	Review of Draft Chapter 5
May 18, 2021	Online via GoToMeeting	Review a portion of Draft Chapter 6
July 29, 2021	Online via GoToMeeting	Review a portion of Draft Chapter 6
August 25, 2021	Online via GoToMeeting	Review a portion of Draft Chapter 6

Source: SEWRPC

and to present summaries of ongoing planning activities. Most of those meetings were held at locations within the watershed and were open to the public at large. Organizations and individual citizens with an interest in the watershed were notified using interested party lists developed by the Root-Pike WIN and others. Attendance at those meetings by members of the Advisory Group was encouraged.

A total of 10 stakeholder meetings were held. Table B.3 lists the dates and major topics of stakeholder meetings. Additional explanation is required for several of the meetings shown.

- Commission staff sought information from the public regarding problems and potential projects in the watershed at the August 30, 2016, stakeholder meeting. As part of this session, members of the public were able to point out specific locations of problems or potential projects on large-scale maps developed for that purpose. The information was recorded on the maps and used to inform the analyses presented in Chapters 3 and 4 and develop projects presented in Chapter 6.

Table B.3
Stakeholder Meetings for the Oak Creek Watershed Restoration Plan

Date	Location	Major Topics Addressed
April 12, 2016	South Milwaukee City Administration Building	Scope of plan, plan focus issues
August 30, 2016	Oak Creek Civic Center	Mapping exercise to receive public input on problem areas and potential projects
April 26, 2017	South Milwaukee City Administrative Building	Summary of public comments related to focus areas, report on field work progress
March 8, 2018	Oak Creek Civic Center	Summary of results of online survey, report on fieldwork progress
December 13, 2018	South Milwaukee City Administrative Building	Review of draft report Chapters 1-3, presentation on instream conditions by WDNR staff
December 12, 2019	Oak Creek Civic Center	Review of a portion of draft report Chapter 4
May 2020	Presentation posted on SEWRPC website	Review of a portion of draft report Chapter 4
December 9, 2020	Online via GoToMeeting	Review of draft report Chapter 5
June 18, 2021	Online via GoToMeeting	Review a portion of draft report Chapter 6
September 29, 2021	Online via GoToMeeting	Review a portion of draft report Chapter 6

Source: SEWRPC

- Because of public health concerns related to the COVID-19 pandemic, no stakeholder meeting was held following the presentation of the second portion of Chapter 4 to the Advisory Group in June 2020. Instead, a summary presentation of the material was developed and posted to the project webpage. An email was sent out to stakeholders alerting them of this presentation's availability.

- Beginning with the December 9, 2020, meeting, stakeholder meetings were conducted online using the GoToMeeting platform. This was done because of public health concerns related to the COVID-19 pandemic.

Two surveys were also conducted of stakeholders to determine their opinions regarding the Oak Creek watershed. One was completed by 34 attendees at the April 12, 2016, stakeholder meeting. A second survey was completed online in late 2017. Fully or partially completed surveys were submitted by 108 persons.

APPENDIX C

DESIGNATED NATURAL AREA PROFILES FOR NATURAL AREAS PARTIALLY OR WHOLLY WITHIN THE OAK CREEK WATERSHED

Barloga Woods: Natural Area of Local Significance (NA-3)
Level of Protection: High (Conservation Ownership with Site Management Plan)
Level of Threat: Medium (Invasive Species)

Size	64 Acres
Ownership	Milwaukee County
Site Management Plan	Yes
Number of Native Plant Species	134
Endangered, Threatened, or Special Concern Species	Yes, Plant and Animal

Formerly known as Esch-Honadel Woods, this remnant of the pre-European Beech-Maple hardwood forest and hardwood swamp was renamed in honor of the late local botanist and conservationist, Richard Barloga, whose efforts led to the recognition and preservation of many irreplaceable remnant communities in the Milwaukee area. Barloga Woods boasts a rich display of spring ephemeral wildflowers, with toothwort (*Cardamine concatenata*) and spring beauty (*Claytonia virginica*) in particularly high abundance. Several rare plants and animals are known to occur here, and many bird species have been observed, particularly during migration.

While most of the woods is protected, a small portion adjacent to Interstate High 94 was lost in the early 2010s with the redevelopment of a Drexel Avenue on-ramp. However, invasive species present an ongoing threat, and surrounding residential properties are potential sources of introduction. The 2016 SEWRPC survey discovered such a case; extremely invasive lesser celandine (*Ficaria verna*) was spreading from residential properties into a portion of the woods near a tributary to Oak Creek. Since that time, Milwaukee County has been working to address that particular threat.

A large opportunity to reconstruct forest habitat exists on County-owned agricultural land immediately to the north of the portion of the woods east of S. 20th Street. This would buffer the remnant community, increase interior habitat, and reduce the erosion of sediments into a tributary of Oak Creek that flows along the northern boundary of County property. Restoration of or the maintenance of a 250 meter buffer of open lands to the south of the woods would also help to ensure maintenance of critical wildlife habitat.


Left: Toothwort puts on an impressive display in early spring. **Right**: Dutchman's breeches (*Dicentra cucullaria*), one of several uncommon plant species afforded refuge at Barloga Woods.

Credit: SEWRPC Staff – Dan Carter

Cudahy Nature Preserve: Natural Area of County-Wide or Regional Significance (NA-2)
Level of Protection: High (Conservation Ownership with Site Management Plan)
Level of Threat: Medium (Invasive Species)

Size	47 Acres
Ownership	Milwaukee County
Site Management Plan	Yes
Number of Native Plant Species	178
Endangered, Threatened, or Special Concern Species	Yes, Plant and Animal

Cudahy Nature Preserve, also a State Natural Area known as Cudahy Woods, consists of a relatively large remnant tract of white oak-red oak dry-mesic forest, beech-maple northern hardwood forest, and hardwood swamp with skunk cabbage seeps. It harbors a rich ground flora that includes trout lilies (*Erythronium albidum* and *E. americanum*), Spring cress (*Cardamine bulbosa* and C. *douglassii*), toothwort (*Cardamine concatenata*), and many other species that have been extirpated from most of the surrounding area. American cancer root (*Conopholis americana*) and Beech drops (*Epifagus virginiana)*, both fully parasitic plants that lack chlorophyll, are two of the more unique members of the Cudahy Woods plant community. They respectively depend on the presence of oaks (*Quercus* sp.) and American beech (*Fagus americana*) as hosts. The woods also supports many bird species during migration and the breeding season.

Invasive species are the primary threats to the long-term preservation of biodiversity at Cudahy Nature Preserve. There are ongoing efforts to control garlic mustard (*Alliaria petiolata*), but perhaps the greatest threats the woods' diverse and irreplaceable spring ephemeral community are exotic "bulb" species, which are actively displacing spring ephemerals in parts of the woods. Siberian squill (*Scilla siberica*) and Bossier's glory-of-the-snow (S. *luciliae*) are the most problematic, but snowdrops (*Galanthus nivale*) also poses a threat. Other invasive species present in or at the margins of the woods and warranting consideration for eradication include bush honeysuckle (*Lonicera x bella*) and common buckthorn (*Rhamnus cathartica*).

Acquisition and afforestation of adjacent properties to the west and south of the woods, which already contain some mature oaks and wetland areas, would buffer the core remnant community from surrounding development and further enhance wildlife values.

Left: White trout lily, a spring ephemeral wildflower, carpets portions of Cudahy Nature Preserve in early spring. **Right**: Invasive Bossier's glory-of-the-snow expanding in a portion of the woods.

Credit: SEWRPC Staff – Dan Carter

Falk Park Woods: Natural Area of County-Wide or Regional Significance (NA-2)
Level of Protection: High (Conservation Ownership with Site Management Plan)
Level of Threat: Medium (Development)

Size	78 Acres
Ownership	Milwaukee County
Site Management Plan	Yes
Number of Native Plant Species	168
Endangered, Threatened, or Special Concern Species	Yes, Plant and Animal

Falk Park Woods consists predominantly of white oak-red oak dry-mesic forest, but mesic hardwood forest and bottomland forest, skunk cabbage seeps, and ephemeral ponds are also present. The woods provide critical habitat for several herptile species and many bird species both during migration and the breeding season. In early spring, the most impressive display of spring beauty (*Claytonia virginica*) in the Region adorns much of forest floor, and bright yellow marsh marigold (*Caltha palustris*) occurs in many of the wetter areas. Canada plum (*Prunus nigra*), an uncommon understory tree with showy flowers, was discovered here during the 2016 SEWRPC survey, illustrating how even well-known sites often contain undescribed biodiversity elements.

While invasive species like garlic mustard (*Alliaria petiolata*), common buckthorn (*Rhamnus cathartica*), and bush honeysuckle (*Lonicera* x *bella*) are present in some portions of Falk Park Woods, development is the primary threat. A road has recently been constructed through a portion of the woods to connect new retail development to South 27th Street, effectively splitting the woods into separate fragments. Wildlife underpassage would help diminish the road's impacts. Eco-passages to allow wildlife to move under the road between the two forested areas and wildlife barriers (like those already constructed nearby) to prevent reptile and amphibian mortality would lessen negative impacts of this development.

Acquisition and afforestation of agricultural lands to the west woods and the maintenance of 250-meter open space buffers of open lands, where still possible, would help protect the core remnant natural community, mitigate some of the recent development impacts, and guard against future impacts.

Left: An Eastern whip-poor-will, a rare and declining species, rests at Falk Park Woods during spring migration. **Center**: A large swamp white oak in one of several ephemeral ponds at Falk Park Woods. **Right**: Canada plum in flower.

Credit: SEWRPC Staff – Dan Carter

Fitzsimmons Road Woods: Natural Area of Local Significance (NA-3)
Level of Protection: Medium (Conservation Ownership without Site Management Plan)
Level of Threat: Medium (Invasive Species)

Size	39 Acres
Ownership	Milwaukee County Land Conservancy; Milwaukee County
Site Management Plan	No
Number of Native Plant Species	148
Endangered, Threatened, or Special Concern Species	Yes, Plant and Animal

Fitzsimmons Road Woods consists of dry-mesic hardwood forest and hardwood swamp with several ephemeral ponds. American beech (*Fagus grandifolia*) is present here at approximately the western boundary of its pre-European range, and there are several impressive swamp white oaks (*Quercus bicolor*) associated with the ephemeral ponds. This site has a particularly diverse sedge flora, which includes two State endangered, and one State threatened species. Brome hummock sedge, a regionally uncommon species, was discovered during the 2016 SEWRPC visit. Leatherwood (*Dirca palustris*), an uncommon shrub of hardwood forests, and spring ephemeral wildflowers are also present. In a 2004 article written about efforts to preserve Fitzsimmons Road Woods, the late Richard Barloga describes a native vine honeysuckle (*Lonicera prolifera*) inching towards the light in the opening created by a fallen tree: "This is a living thing. That's what drive's me."[1] Visitors will still find vine honeysuckle growing there.

Some of the northern portion of the woods was impacted by residential development, but opportunities exist to buffer the remaining natural community through afforestation of the parts of the periphery of County golf course property just to the north of the woods and to the southwest of the woods. Garlic mustard (*Alliaria petiolata*) is an ongoing invasive species concern. A site management plan should be developed to address this and other site management issues and long-term natural community health.

Left: Marsh marigold (*Caltha palustris*) brightens a wet draw in the western portion of the woods. **Right**: American beech growing in the northeast portion of the woods with an ephemeral pond and large swamp white oak in the background.

Credit: SEWRPC Staff – Dan Carter

[1] *Johnson, A. (2004, 12/5). Environmentalists, developer poised to preserve woods.* Milwaukee Journal Sentinel. *Retrieved from www.jsonline.com.*

Franklin (Puetz Road) Woods: Natural Area of Local Significance (NA-3)
Level of Protection: Medium (Conservation Ownership)
Level of Threat: Medium (Invasive Species)

Size	34 Acres
Ownership	City of Franklin / Private
Site Management Plan	No
Number of Native Plant Species	127
Endangered, Threatened, or Special Concern Species	Yes, Plant and Animal

Red Oak-red maple dry-mesic forest and hardwood swamp are both present within Franklin Woods. The woods support impressive mature red oaks, spring ephemeral wildflowers, and rare plants and animals. Spring beauty (*Claytonia virginica*), false mermaid (*Floerkea proserpinacoides*), prairie trillium (*Trillium recurvatum*), and blue wood violet (*Viola sororia*) are particularly abundant among the spring flora.

Swamp portions of Franklin Woods have been hit particularly hard by ash die-off caused by the emerald ash borer (*Agrilus planipennis*), areas of the canopy have been opened substantially. In addition, lesser celandine (*Ficaria verna*), a particularly aggressive invasive species, was detected by SEWRPC staff along Puetz road immediately adjacent to the woods, and other potential invasive species (e.g. wintercreeper, *Euonymus fortunei*) are being introduced through the dumping of yard waste from adjacent properties along the southern boundary of the woods.

Replacement of dead ash in the existing woods with other swamp hardwoods like swamp white oak (*Quercus bicolor*) and silver maple (*Acer saccharinum*) would mitigate some of the impacts of emerald ash borer. Acquisition and afforestation of agricultural lands to the west of woods would help to buffer the core remnant natural community. Also, much of the residential area immediately to the south and northwest of Franklin Woods was built in what was historically a larger forested tract. Thus, the effective size of the woods for wildlife would be enhanced by the maintenance of existing mature trees and utilization of native plants for landscaping on those residential properties.

Left: Spring beauty can be found at Franklin woods. **Right**: Wintercreeper (larger leaves with pale veins), a potentially invasive species that has become established from the dumping of yard waste and false mermaid, an uncommon annual usually found in moist, remnant forest.

Credit: SEWRPC Staff – Dan Carter

Grant Park Woods: Natural Area of Local Significance (NA-3)
Level of Protection: High (Conservation Ownership with Site Management Plan)
Level of Threat: Medium (Invasive Species)

Size	75 Acres
Ownership	Milwaukee County
Site Management Plan	Yes
Number of Native Plant Species	276
Endangered, Threatened, or Special Concern Species	Yes, Plant and Animal

Grant Park Woods is comprised of old growth and disturbed remnant mesic forest, but adjacent areas of the lake bluff with American arborvitae (*Thuja occidentalis*) and fens are included. The woods provide critical migratory and breeding season habitat for birds and support a critical spring ephemeral wildflower resource within a United States Fish and Wildlife Service-mapped high potential zone for the federally endangered rusty patched bumble bee (*Bombus affinis*). Among the spring ephemeral species present is crinkleroot (*Cardamine diphylla*, see below); this population is the southernmost in Wisconsin and is the only natural population known from the Region. The Milwaukee Public Museum Bioblitz in 2016 also found the brown scoopwing (*Calledapteryx dryopterata*), an aptly named moth that utilizes *Viburnum* species as hosts and has very seldom been observed in Wisconsin.

Many invasive species have been documented at this natural area. Several of these invasive species are new to the Region. Among them are Japanese tree lilac (*Syringa reticulata*), a common ornamental plant that has invaded a portion of the lake bluff; false spiraea (*Sorbaria sorbifolia*), a common ornamental that is has formed dense thickets where the lake bluff meets the beach; coltsfoot (*Tussilago farfara*), which has been observed at the base of the lake bluff; porcelainberry (*Ampelopsis brevipedunculata),* a very aggressive vine; and spreading cotoneaster (*Cotoneaster divaricatus*), an ornamental that is invading open areas of the lake bluff. Monitoring and control of these and other invasive species will be an important component of stewardship at this site for the foreseeable future.

This natural area is being enhanced and buffered by ongoing afforestation efforts in adjacent open areas. The natural area provides indispensable habitat for several critical plant and animal species.

Left: Crinkleroot (*Caltha palustris*) at Grant Park Woods **Right**: Yellow trout lily (Erythronium americanum) is abundant.

Credit: SEWRPC Staff – Dan Carter

Oak Creek Low Woods: Natural Area of Local Significance (NA-3)
Level of Protection: Medium (Partial Conservation Ownership with Site Management Plan)
Level of Threat: Medium (Invasive Species)

Size	68 Acres
Ownership	Milwaukee County, Private
Site Management Plan	Yes
Number of Native Plant Species	152
Endangered, Threatened, or Special Concern Species	Yes, Plant and Animal

Oak Creek Low Woods consists of two separate tracts, each a mosaic of lowland hardwoods and upland southern dry-mesic forest. Oaks are well-represented in both communities, with abundant red oak (*Quercus rubra*) and white oak (*Quercus alba*) in drier areas, and abundant swamp white oak (*Quercus bicolor*) and bur oak (*Quercus macrocarpa)* in wetter areas. Pileated, downy, red-bellied, and hairy woodpeckers have been observed here during the winter months. Spring ephemeral wildflowers are present in upland areas.

Common buckthorn (*Rhamnus cathartica*), and bush honeysuckle (*Lonicera* x *bella*) are moderately abundant and the edges, and some of the open portions of wetlands are dominated by reed canary grass (*Phalaris aurundinacea*), though native sedges typical of swamps and ephemeral ponds such as lake sedge (*Carex lacustris*), brome-like sedge (*Carex bromoides*) and hop sedge (*Carex lupulina*) are present. Recently, emerald ash borer has caused the mortality of numerous ash (*Fraxinus* spp.) trees, especially in the wetter areas. In some cases, the impacts are likely to be lessened by the presence of oaks, but the opening of the canopy also has the potential to exacerbate the spread of buckthorn and reed canary grass.

Acquisition and afforestation of adjacent lands, particularly lands presently separating the two tracts could create a sizeable block of forest interior habitat. Oak-dominated portions of the uplands are in the process of transitioning to shadier, maple-dominated forest. A potential alternative, particularly in the eastern tract, would be to manage that area as an oak forest or woodland with scattered thickets of native *Viburnum* species and chokecherry (*Prunus virginiana*).

Left: Southern dry-mesic forest with mature white oak and an understory of sugar maple (*Acer saccharum*) in the eastern tract. **Right**: Tussocks of brome-like sedge rise above a layer of swamp white oak leaf litter in an area of southern hardwood swamp.

Credit: SEWRPC Staff – Dan Carter

Oak Creek Parkway Woods: Natural Area of Local Significance (NA-3)
Level of Protection: High (Conservation Ownership with Site Management Plan)
Level of Threat: Medium (Invasive Species)

Size	24 Acres
Ownership	Milwaukee County
Site Management Plan	Yes
Number of Native Plant Species	123
Endangered, Threatened, or Special Concern Species	Yes, Plant and Animal

This woods consists of Beech-Maple northern hardwood forest on slopes and floodplain forest with ephemeral ponds adjacent to Oak Creek. It supports a critical spring ephemeral wildflower resource within a United States Fish and Wildlife Service-mapped high potential zone for the federally endangered rusty patched bumble bee (*Bombus affinis*). It also supports numerous bird species during breeding and migratory seasons and several reptiles and amphibians. This is one of a few known sites in Milwaukee County with Long-stalked sedge (*Carex pedunculata*), a unique sedge that entices ants to disperse its seeds with nutritious structures called elaiosomes. The seeds are often deposited in rotting logs where the ants have colonies, which are ideal sites for long-stalked sedge seedlings to grow.

While the woods continue to support exceptional native biodiversity, many invasive species are present. These include garlic mustard (*Alliaria petiolata*), black alder (*Alnus glutinosa*), Japanese knotweed (*Reynoutria japonica*), privet (*Ligustrum vulgare*), bush honeysuckle (*Lonicera* x *bella*), and common buckthorn (*Rhamnus cathartica*). Monitoring and control of these and other invasive species will be an important component of stewardship at this site for the foreseeable future.

Further buffering of the woods is largely constrained by roads, an existing golf course, and other past development, though afforestation of the mowed area immediately southeast of the natural area would increase available interior habitat.

Left: Long-stalked sedge flowering in early spring. **Right**: Invasive black alder along the lower reaches of Oak Creek.

Credit: SEWRPC Staff – Dan Carter

Rawson Park Woods: Natural Area of County-Wide or Regional Significance (NA-2)
Level of Protection: High (Conservation Ownership with Site Management Plan)
Level of Threat: Medium (Invasive Species)

Size	23 Acres
Ownership	Milwaukee County
Site Management Plan	Yes
Number of Native Plant Species	99
Endangered, Threatened, or Special Concern Species	Yes, Plant and Animal

Despite heavy human use, Rawson Park Woods is probably the highest quality remaining fragment of beech-maple climax forest in Milwaukee County. The woods support many bird species and a rich ground flora, including spring ephemeral wildflowers and a State-endangered plant species. The United States Fish and Wildlife Service includes part of the woods within a high potential zone for rusty patched bumble bee (*Bombus affinis*), which is listed as endangered under the Endangered Species Act (ESA). The spring ephemeral wildflowers present provide important floral resources for this and other native bees.

Invasive species are the primary threats to the long-term preservation of biodiversity at Rawson Park Woods. Lily-of-the-Valley (*Convallaria majalis*) has become the most serious invasive species problem and is widespread within the park. It is displacing a State-endangered plant species, spring ephemeral wildflowers, and other native plant species, which are important food sources for native pollinators (including rusty patched bumble bee) and other wildlife. Other invasive species present in or at the margins of the woods and warranting consideration for eradication include garlic mustard (*Alliaria petiolata*), Japanese barberry (*Berberis thunbergii*), bush honeysuckle (*Lonicera x bella*), Japanese knotweed (*Reynoutria japonica*), and common buckthorn (*Rhamnus cathartica*).

An opportunity to restore forest habitat exists at the southern portion of Rawson Park Woods, where a large area is presently mowed, but mature trees and some spring ephemeral wildflowers are still present. Here, reduction of the mowed area would likely allow for recovery under the existing canopy.

Left: American beech co-dominates the forest canopy at Rawson Park Woods. **Right**: Invasive lily-of-the-valley dominates the forest floor in several areas; garlic mustard is also visible.

Credit: SEWRPC Staff – Dan Carter

Ryan Road Woods: Natural Area of Local Significance (NA-3)
Level of Protection: High (Conservation Ownership with Site Management Plan)
Level of Threat: Medium (Surrounding Land Use, Invasive Species)

Size	42 Acres
Ownership	Milwaukee County
Site Management Plan	Yes
Number of Native Plant Species	90
Endangered, Threatened, or Special Concern Species	Yes, Plant and Animal

Nearly all remnant sugar maple-red oak dry-mesic forest and hardwood swamp at Ryan Road Woods has been acquired and protected by Milwaukee County. The site contains ephemeral ponds, which support rare plant and animal species, as well as mature swamp white oaks (*Quercus bicolor*). Spring ephemeral wildflowers are present, but not abundant. Milwaukee County Parks staff have observed many bird species at Ryan Road Woods during the winter and migratory seasons; this includes a noteworthy siting of summer tanager with SEWRPC staff in 2018 (see below). Open lands along the upper reaches of a tributary to the Root River are located immediately west of the railroad right of way that runs along the western edge of the property, so this site is part of an important link between the Oak Creek and Root River systems.

Off-road driving has caused damage to portion of the woods in the past, and siltation and sedimentation from adjacent agricultural and industrial properties is an ongoing issue. Loss of ash, particularly green ash (*Fraxinus pennsylvanica*) in wet areas, is creating opportunities for invasive species. Reed canary grass (*Phalaris aurundinacea*) and garlic mustard (*Alliaria petiolata*) are both present. However, there are excellent opportunities to buffer and improve forest connectivity. Afforestation of County-owned agricultural land between the natural area and a smaller fragment of woods known as Ryan Roads-East, a SEWRPC-designated critical species habitat, could unite the two forested areas into one continuous tract. Another opportunity for afforestation exists southeast, but options there are somewhat constrained because that area sits atop a deep layer of fill material. Lastly, the far southern portion of the natural area, which consists of wetlands and an ephemeral pond, extends onto private property. Maintenance of open space buffers (250 meters) between any future development and the natural area is important for the maintenance of critical wildlife habitat, and acquisition and afforestation of adjacent lands would be ideal.

Left: Summer tanager (*Piranga rubra*) stands out among the early spring forest's grays and browns. **Right**: Swamp white oak and dying green in an ephemeral pond along the western edge of the woods. The turbidity originates from sediments carried off of a nearby agricultural field.

Credit: Left – Milwaukee County Parks Staff (copyrighted image); Right – SEWRPC Staff – Dan Carter

Wedge Woods: Natural Area of Local Significance (NA-3)
Level of Protection: Low/None
Level of Threat: High

Size	17 Acres
Ownership	City of Franklin / Private
Site Management Plan	No
Number of Native Plant Species	78
Endangered, Threatened, or Special Concern Species	Yes, Plant

Wedge Woods is privately owned remnant southern dry-mesic forest dominated by red oak (*Quercus rubra*), basswood (*Tilia americana*), and sugar maple (*Acer saccharum*). There is also an area of southern hardwood swamp with a small ephemeral pond in the northeast corner. Wedge Woods was last inventoried by SEWRPC staff in 1991, though the below photograph was taken from the property line in December 2019. At the time of the inventory, this tract supported a large population of State-endangered Bluestem goldenrod (*Solidago caesia*) as well as many characteristic forest species. The present condition of the woods is unknown. It appears to be largely intact, based on the below photographs and aerial photography. However, a small portion of the woods was recently cleared to make way for a new structure. Residential development is generally encroaching, and a residential street terminates at the woods' edge, therefore this site is perceived to be at high risk of future development.

SEWRPC's recommendation is that Wedge Woods be acquired for protection. Opportunities for protection beyond the core property are limited, but adjacent property owners could be engaged to encourage the use of native plants in home landscapes and discourage the dumping of yard waste. The woods may also serve as an important genetic resource for nearby restoration efforts.

Left: Wedge Woods as viewed from the end of South Regency Drive. **Right**: Bluestem goldenrod in seed at a site elsewhere in Milwaukee County.

Credit: SEWRPC Staff – Dan Carter

Wood Creek Woods: Natural Area of Local Significance (NA-3)
Level of Protection: Medium (Partial Conservation Ownership with Site Management Plan)
Level of Threat: Medium (Surrounding Land Use, Invasive Species)

Size	49 Acres
Ownership	Milwaukee County, Private
Site Management Plan	Yes
Number of Native Plant Species	121
Endangered, Threatened, or Special Concern Species	Yes, Plant and Animal

Wood Creek Woods' natural area designation was previously removed after a portion of the woods was lost to residential development. However, a significant tract of remnant mesic to dry-mesic hardwood forest and hardwood swamp remains in an increasingly developed area. The woods continue to support a high level of native biodiversity, which is comparable to other nearby natural areas. For these reasons, the site's natural area designation has been restored.

Notably, Woods Creek Wood's supports a large population of purple spring cress (*Cardamine douglassii*), along with spring beauty (*Claytonia virginica*), and both white and yellow trout lilies (*Erythronium albidum* and *E. americanum*), which make for an impressive spring ephemeral wildflower display in parts of the woods. Pretty sedge (*Carex woodii*), was documented for the first time at the site during the 2016 SEWRPC survey; it is co-dominant in parts of the woods. The woods also contain two spring ephemeral ponds, which support a State-endangered plant species, and many bird species have been observed in the vicinity during both the winter and migratory seasons.

Garlic mustard (*Alliaria petiolata*) is present and threatens native biodiversity in the woods, particularly at the south end along a small tributary to Oak Creek. The loss of many black and green ash (*Fraxinus nigra* and *F. pennsylvanica*) to the emerald ash borer may also create opportunities for invasive species in wetter portions of the woods.

Acquisition and afforestation of land immediately to the west and northeast of the woods would increase forest interior habitat. Other opportunities exist to reconstruct forest and wetland habitat on lands adjacent to Oak Creek immediately to the south of Woods Creek Woods.

Left: Pink spring cress growing amongst brome hummock sedge (*Carex bromoides*) adjacent to an ephemeral pond. **Right**: Pretty sedge in an upland portion of the woods.

Credit: SEWRPC Staff – Dan Carter

APPENDIX D

STEPL LOAD REDUCTION RESULTS FOR STREAMBANK EROSION RESTORATION PRACTICES

Table D.1
STEPL Model Load Reduction Results for Streambank Erosion Sites in Grant Park Ravine

Impaired Streambank Dimensions and Recession Rates									
Erosion ID	Erosion Length (feet)	Erosion Height (feet)	Lateral Recession	Recession Rate Range (feet/year)	Applied Recession Rate (feet/year)	BMP Efficiency Applied (0-1)	Soil Textural Class	Soil Dry Weight (ton/feet^3)	Nutrient Correction Factor
1	75	4	Slight	0.01 - 0.05	0.03	0.75	Silty clay loam, silty clay	0.04	1
2	234	6	Severe	0.3 - 0.5	0.4	0.75	Sands, Loamy sands	0.055	0.85
3	154	6	Moderate	0.06 - 0.2	0.13	0.75	Loams, sandy clay loams	0.045	0.85
4	170	30	Very Severe	0.5+	0.5	0.75	Sandy clay	0.045	0.85
5	34	15	Severe	0.3 - 0.5	0.4	0.75	Sandy clay	0.045	0.85
6	275	8	Moderate	0.06 - 0.2	0.13	0.75	Sandy loam	0.0525	0.85
7	51	9	Severe	0.3 - 0.5	0.4	0.75	Sandy loam	0.0525	0.85
8	317	6	Moderate	0.06 - 0.2	0.13	0.75	Silty clay loam, silty clay	0.04	1
9	93	5	Moderate	0.06 - 0.2	0.13	0.75	Silty clay loam, silty clay	0.04	1

Pollutant Loads and Load Reductions												
	Pollutant Loads with no BMP				Pollutant Reduction				Pollutant Loads with BMP			
Erosion ID	N Load[a]	P Load[a]	BOD Load[a]	Sediment Load[b]	N Reduction[a,c]	P Reduction[a,c]	BOD Reduction[a,c]	Sediment Reduction[b,c]	N Load[a]	P Load[a]	BOD[a]	Sediment Load[b]
1	0.6	0.2	1.2	0.4	0.4	0.2	0.9	0.3	0.2	0.0	0.3	0.1
2	42.0	16.2	84.0	30.9	31.5	12.1	63.0	23.2	10.5	4.1	21.0	7.7
3	7.4	2.8	14.7	5.4	5.5	2.1	11.0	4.1	1.9	0.7	3.7	1.3
4	156.1	60.1	312.1	114.8	117.0	45.1	234.1	86.1	39.1	15.0	78.0	28.7
5	12.5	4.8	25.0	9.2	9.4	3.6	18.7	6.9	3.1	1.2	6.3	2.3
6	20.4	7.9	40.8	15.0	15.3	5.9	30.6	11.3	5.1	2.0	10.2	3.7
7	13.1	5.0	26.2	9.6	9.8	3.8	19.7	7.2	3.3	1.2	6.5	2.4
8	15.8	6.1	31.6	9.9	11.9	4.6	23.7	7.4	3.9	1.5	7.9	2.5
9	3.9	1.5	7.7	2.4	2.9	1.1	5.8	1.8	1.0	0.4	1.9	0.6
Total	271.8	104.6	543.3	197.6	203.7	78.5	407.5	148.3	68.1	26.1	135.8	49.3

Note: Erosion ID matched streambank erosion sites shown on Maps F.13 through F.35 in Appendix F.

[a] *Measured in pounds per year.*

[b] *Measured in tons per year.*

[c] *Assuming 75 percent BMP efficiency.*

Source: U.S. Environmental Protection Agency and SEWRPC

Table D.2
STEPL Model Load Reduction Results for Streambank Erosion Sites in Lower Oak Creek – Mill Pond

Impaired Streambank Dimensions and Recession Rates									
Erosion ID	Erosion Length (feet)	Erosion Height (feet)	Lateral Recession	Recession Rate Range (feet/year)	Applied Recession Rate (feet/year)	BMP Efficiency Applied (0-1)	Soil Textural Class	Soil Dry Weight (ton/feet^3)	Nutrient Correction Factor
10	66	6	Moderate	0.06 - 0.2	0.13	0.75	Silty clay loam, silty clay	0.04	1
11	26	3	Moderate	0.06 - 0.2	0.13	0.75	Silty clay loam, silty clay	0.04	1
12	107	4	Severe	0.3 - 0.5	0.4	0.75	Silty clay loam, silty clay	0.04	1
13	74	7	Severe	0.3 - 0.5	0.4	0.75	Silty clay loam, silty clay	0.04	1
14	105	7	Moderate	0.06 - 0.2	0.13	0.75	Silty clay loam, silty clay	0.04	1
15	53	5	Slight	0.01 - 0.05	0.03	0.75	Sandy loam	0.0525	0.85
16	221	6	Moderate	0.06 - 0.2	0.13	0.75	Silty clay loam, silty clay	0.04	1
17	70	5.5	Moderate	0.06 - 0.2	0.13	0.75	Silty clay loam, silty clay	0.04	1
18	80	3.8	Slight	0.01 - 0.05	0.03	0.75	Silty clay loam, silty clay	0.04	1
19	90	5	Slight	0.01 - 0.05	0.03	0.75	Silty clay loam, silty clay	0.04	1
20	177	3.5	Slight	0.01 - 0.05	0.03	0.75	Silty clay loam, silty clay	0.04	1
21	59	4.5	Slight	0.01 - 0.05	0.03	0.75	Silty clay loam, silty clay	0.04	1
22	22	4.5	Slight	0.01 - 0.05	0.03	0.75	Silty clay loam, silty clay	0.04	1
23	130	4	Slight	0.01 - 0.05	0.03	0.75	Silty clay loam, silty clay	0.04	1
24	61	4.3	Moderate	0.06 - 0.2	0.13	0.75	Silty clay loam, silty clay	0.04	1

Pollutant Loads and Load Reductions												
	Pollutant Loads with no BMP				Pollutant Reduction				Pollutant Loads with BMP			
Erosion ID	N Load[a]	P Load[a]	BOD Load[a]	Sediment Load[b]	N Reduction[a,c]	P Reduction[a,c]	BOD Reduction[a,c]	Sediment Reduction[b,c]	N Load[a]	P Load[a]	BOD[a]	Sediment Load[b]
10	3.3	1.3	6.6	2.1	2.5	1.0	4.9	1.5	0.8	0.3	1.7	0.6
11	0.6	0.2	1.3	0.4	0.5	0.2	1.0	0.3	0.1	0.0	0.3	0.1
12	11.0	4.2	21.9	6.8	8.2	3.2	16.4	5.1	2.8	1.0	5.5	1.7
13	13.3	5.1	26.5	8.3	9.9	3.8	19.9	6.2	3.4	1.3	6.6	2.1
14	6.1	2.4	12.2	3.8	4.6	1.8	9.2	2.9	1.5	0.6	3.0	0.9
15	0.6	0.2	1.1	0.4	0.4	0.2	0.9	0.3	0.2	0.0	0.2	0.1
16	11.0	4.2	22.1	6.9	8.3	3.2	16.5	5.2	2.7	1.0	5.6	1.7
17	3.2	1.2	6.4	2.0	2.4	0.9	4.8	1.5	0.8	0.3	1.6	0.5
18	0.6	0.2	1.2	0.4	0.4	0.2	0.9	0.3	0.2	0.0	0.3	0.1
19	0.9	0.3	1.7	0.5	0.6	0.2	1.3	0.4	0.3	0.1	0.4	0.1
20	1.2	0.5	2.4	0.7	0.9	0.3	1.8	0.6	0.3	0.2	0.6	0.1
21	0.5	0.2	1.0	0.3	0.4	0.1	0.8	0.2	0.1	0.1	0.2	0.1
22	0.2	0.1	0.4	0.1	0.1	0.1	0.3	0.1	0.1	0.0	0.1	0.0
23	1.0	0.4	2.0	0.6	0.7	0.3	1.5	0.5	0.3	0.1	0.5	0.1
24	2.2	0.8	4.4	1.4	1.6	0.6	3.3	1.0	0.6	0.2	1.1	0.4
Total	55.7	21.3	111.2	34.7	41.5	16.1	83.4	26.1	14.2	5.2	27.7	8.6

Note: Erosion ID matched streambank erosion sites shown on Maps F.13 through F.35 in Appendix F.

[a] *Measured in pounds per year.*

[b] *Measured in tons per year.*

[c] *Assuming 75 percent BMP efficiency.*

Source: U.S. Environmental Protection Agency and SEWRPC

Table D.3
STEPL Model Load Reduction Results for Streambank Erosion Sites in Lower Oak Creek

Impaired Streambank Dimensions and Recession Rates									
Erosion ID	Erosion Length (feet)	Erosion Height (feet)	Lateral Recession	Recession Rate Range (feet/year)	Applied Recession Rate (feet/year)	BMP Efficiency Applied (0-1)	Soil Textural Class	Soil Dry Weight (ton/feet^3)	Nutrient Correction Factor
25	78	4.6	Severe	0.3 - 0.5	0.4	0.75	Silty clay loam, silty clay	0.04	1
26	46	4	Moderate	0.06 - 0.2	0.13	0.75	Silty clay loam, silty clay	0.04	1
27	54	4	Slight	0.01 - 0.05	0.03	0.75	Silty clay loam, silty clay	0.04	1
28	75	5	Moderate	0.06 - 0.2	0.13	0.75	Silty clay loam, silty clay	0.04	1
28a	75	5	Moderate	0.06 - 0.2	0.13	0.75	Silty clay loam, silty clay	0.04	1
29	242	3.5	Moderate	0.06 - 0.2	0.13	0.75	Silty clay loam, silty clay	0.04	1
30	32	5	Moderate	0.06 - 0.2	0.13	0.75	Organic	0.011	1.5
31	67	7	Slight	0.01 - 0.05	0.03	0.75	Organic	0.011	1.5
32	90	3	Slight	0.01 - 0.05	0.03	0.75	Organic	0.011	1.5
33	34	8	Moderate	0.06 - 0.2	0.13	0.75	Silty clay loam, silty clay	0.04	1
34	32	6	Severe	0.3 - 0.5	0.4	0.75	Silty clay loam, silty clay	0.04	1
35	14	15	Moderate	0.06 - 0.2	0.13	0.75	Silty clay loam, silty clay	0.04	1
36	68	5	Moderate	0.06 - 0.2	0.13	0.75	Silty clay loam, silty clay	0.04	1
37	42	4	Moderate	0.06 - 0.2	0.13	0.75	Organic	0.011	1.5
38	327	5.5	Moderate	0.06 - 0.2	0.13	0.75	Organic	0.011	1.5
39	156	7	Severe	0.3 - 0.5	0.4	0.75	Organic	0.011	1.5
40	214	9	Severe	0.3 - 0.5	0.4	0.75	Organic	0.011	1.5

Pollutant Loads and Load Reductions												
	Pollutant Loads with no BMP				Pollutant Reduction				Pollutant Loads with BMP			
Erosion ID	N Load[a]	P Load[a]	BOD Load[a]	Sediment Load[b]	N Reduction[a,c]	P Reduction[a,c]	BOD Reduction[a,c]	Sediment Reduction[b,c]	N Load[a]	P Load[a]	BOD[a]	Sediment Load[b]
25	9.2	3.5	18.4	5.7	6.9	2.7	13.8	4.3	2.3	0.8	4.6	1.4
26	1.5	0.6	3.1	1.0	1.1	0.4	2.3	0.7	0.4	0.2	0.8	0.3
27	0.4	0.2	0.8	0.3	0.3	0.1	0.6	0.2	0.1	0.1	0.2	0.1
28	3.1	1.2	6.2	2.0	2.3	0.9	4.7	1.5	0.8	0.3	1.5	0.5
28a	3.1	1.2	6.2	2.0	2.3	0.9	4.7	1.5	0.8	0.3	1.6	0.5
29	7.0	2.7	14.1	4.4	5.3	2.0	10.6	3.3	1.7	0.7	3.5	1.1
30	0.5	0.2	1.1	0.2	0.4	0.2	0.8	0.2	0.1	0.0	0.3	0.0
31	0.4	0.1	0.7	0.2	0.3	0.1	0.6	0.1	0.1	0.0	0.1	0.1
32	0.2	0.1	0.4	0.1	0.2	0.1	0.3	0.1	0.0	0.0	0.1	0.0
33	2.3	0.9	4.5	1.4	1.7	0.7	3.4	1.1	0.6	0.2	1.1	0.3
34	4.9	1.9	9.8	3.1	3.7	1.4	7.4	2.3	1.2	0.5	2.4	0.8
35	1.7	0.7	3.5	1.1	1.3	0.5	2.6	0.8	0.4	0.2	0.9	0.3
36	2.8	1.1	5.7	1.8	2.1	0.8	4.2	1.3	0.7	0.3	1.5	0.5
37	0.6	0.2	1.2	0.2	0.4	0.2	0.9	0.2	0.2	0.0	0.3	0.0
38	6.2	2.4	12.3	2.6	4.6	1.8	9.3	1.9	1.6	0.6	3.0	0.7
39	11.5	4.4	23.1	4.8	8.6	3.3	17.3	3.6	2.9	1.1	5.8	1.2
40	20.3	7.8	40.7	8.5	15.3	5.9	30.5	6.4	5.0	1.9	10.2	2.1
Total	75.7	29.2	151.8	39.2	56.8	22.0	114.0	29.5	18.9	7.2	37.8	9.9

Note: Erosion ID matched streambank erosion sites shown on Maps F.13 through F.35 in Appendix F.

[a] *Measured in pounds per year.*

[b] *Measured in tons per year.*

[c] *Assuming 75 percent BMP efficiency.*

Source: U.S. Environmental Protection Agency and SEWRPC

Table D.4
STEPL Model Load Reduction Results for Streambank Erosion Sites in Middle Oak Creek

Impaired Streambank Dimensions and Recession Rates									
Erosion ID	Erosion Length (feet)	Erosion Height (feet)	Lateral Recession	Recession Rate Range (feet/year)	Applied Recession Rate (feet/year)	BMP Efficiency Applied (0-1)	Soil Textural Class	Soil Dry Weight (ton/feet^3)	Nutrient Correction Factor
41	49	10	Severe	0.3 - 0.5	0.4	0.75	Organic	0.011	1.5
42	75	6.5	Moderate	0.06 - 0.2	0.13	0.75	Organic	0.011	1.5
43	83	8	Slight	0.01 - 0.05	0.03	0.75	Organic	0.011	1.5
44	17	5	Moderate	0.06 - 0.2	0.13	0.75	Silty clay loam, silty clay	0.04	1
45	51	6	Slight	0.01 - 0.05	0.03	0.75	Silty clay loam, silty clay	0.04	1
46	44	3	Slight	0.01 - 0.05	0.03	0.75	Silty clay loam, silty clay	0.04	1
47	54	3.5	Slight	0.01 - 0.05	0.03	0.75	Silty clay loam, silty clay	0.04	1
48	109	3.8	Slight	0.01 - 0.05	0.03	0.75	Silty clay loam, silty clay	0.04	1
49	7	4.8	Slight	0.01 - 0.05	0.03	0.75	Silty clay loam, silty clay	0.04	1
50	151	4.5	Slight	0.01 - 0.05	0.03	0.75	Silty clay loam, silty clay	0.04	1
51	192	5.8	Moderate	0.06 - 0.2	0.13	0.75	Silty clay loam, silty clay	0.04	1
52	48	5.5	Moderate	0.06 - 0.2	0.13	0.75	Silty clay loam, silty clay	0.04	1
53	67	4.5	Slight	0.01 - 0.05	0.03	0.75	Silty clay loam, silty clay	0.04	1
54	186	6	Moderate	0.06 - 0.2	0.13	0.75	Silty clay loam, silty clay	0.04	1
55	59	6	Moderate	0.06 - 0.2	0.13	0.75	Silty clay loam, silty clay	0.04	1
56	47	5.8	Slight	0.01 - 0.05	0.03	0.75	Silty clay loam, silty clay	0.04	1
57	40	4	Moderate	0.06 - 0.2	0.13	0.75	Organic	0.011	1.5
58	5	5.5	Moderate	0.06 - 0.2	0.13	0.75	Silty clay loam, silty clay	0.04	1
59	79	3.5	Slight	0.01 - 0.05	0.03	0.75	Clay	0.035	1.15
60	108	6	Moderate	0.06 - 0.2	0.13	0.75	Silty clay loam, silty clay	0.04	1
61	132	6	Moderate	0.06 - 0.2	0.13	0.75	Silty clay loam, silty clay	0.04	1
62	59	6.5	Moderate	0.06 - 0.2	0.13	0.75	Silty clay loam, silty clay	0.04	1
63	93	5.8	Moderate	0.06 - 0.2	0.13	0.75	Silty clay loam, silty clay	0.04	1
64	39	9	Severe	0.3 - 0.5	0.4	0.75	Silty clay loam, silty clay	0.04	1
65	33	5.8	Severe	0.3 - 0.5	0.4	0.75	Silty clay loam, silty clay	0.04	1
66	86	10	Severe	0.3 - 0.5	0.4	0.75	Silty clay loam, silty clay	0.04	1
67	34	6.5	Moderate	0.06 - 0.2	0.13	0.75	Silty clay loam, silty clay	0.04	1
68	67	8	Moderate	0.06 - 0.2	0.13	0.75	Silty clay loam, silty clay	0.04	1
69	91	7	Moderate	0.06 - 0.2	0.13	0.75	Silty clay loam, silty clay	0.04	1
70	107	8	Severe	0.3 - 0.5	0.4	0.75	Silty clay loam, silty clay	0.04	1
71	166	6	Severe	0.3 - 0.5	0.4	0.75	Silty clay loam, silty clay	0.04	1
72	139	5.7	Moderate	0.06 - 0.2	0.13	0.75	Silty clay loam, silty clay	0.04	1
73	100	7.2	Moderate	0.06 - 0.2	0.13	0.75	Clay	0.035	1.15
74	15	3	Slight	0.01 - 0.05	0.03	0.75	Silty clay loam, silty clay	0.04	1
75	40	3	Slight	0.01 - 0.05	0.03	0.75	Clay	0.035	1.15
76	62	3.5	Slight	0.01 - 0.05	0.03	0.75	Silty clay loam, silty clay	0.04	1
77	114	9.5	Severe	0.3 - 0.5	0.4	0.75	Silty clay loam, silty clay	0.04	1
78	21	4	Moderate	0.06 - 0.2	0.13	0.75	Silty clay loam, silty clay	0.04	1
79	145	9.5	Moderate	0.06 - 0.2	0.13	0.75	Silty clay loam, silty clay	0.04	1

Table continued on next page.

Table D.4 (Continued)

	Pollutant Loads and Load Reductions											
	Pollutant Loads with no BMP				Pollutant Reduction				Pollutant Loads with BMP			
Erosion ID	N Load[a]	P Load[a]	BOD Load[a]	Sediment Load[b]	N Reduction[a,c]	P Reduction[a,c]	BOD Reduction[a,c]	Sediment Reduction[b,c]	N Load[a]	P Load[a]	BOD[a]	Sediment Load[b]
41	5.2	2.0	10.3	2.2	3.9	1.5	7.8	1.6	1.3	0.5	2.5	0.6
42	1.7	0.6	3.3	0.7	1.3	0.5	2.5	0.5	0.4	0.1	0.8	0.2
43	0.5	0.2	1.1	0.2	0.4	0.2	0.8	0.2	0.1	0.0	0.3	0.0
44	0.7	0.3	1.4	0.4	0.5	0.2	1.1	0.3	0.2	0.1	0.3	0.1
45	0.6	0.2	1.2	0.4	0.4	0.2	0.9	0.3	0.2	0.0	0.3	0.1
46	0.3	0.1	0.5	0.2	0.2	0.1	0.4	0.1	0.1	0.0	0.1	0.1
47	0.4	0.1	0.7	0.2	0.3	0.1	0.5	0.2	0.1	0.0	0.2	0.0
48	0.8	0.3	1.6	0.5	0.6	0.2	1.2	0.4	0.2	0.1	0.4	0.1
49	0.1	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.0
50	1.3	0.5	2.6	0.8	1.0	0.4	2.0	0.6	0.3	0.1	0.6	0.2
51	9.3	3.6	18.5	5.8	6.9	2.7	13.9	4.3	2.4	0.9	4.6	1.5
52	2.2	0.8	4.4	1.4	1.6	0.6	3.3	1.0	0.6	0.2	1.1	0.4
53	0.6	0.2	1.2	0.4	0.4	0.2	0.9	0.3	0.2	0.0	0.3	0.1
54	9.3	3.6	18.6	5.8	7.0	2.7	13.9	4.4	2.3	0.9	4.7	1.4
55	2.9	1.1	5.9	1.8	2.2	0.9	4.4	1.4	0.7	0.2	1.5	0.4
56	0.5	0.2	1.0	0.3	0.4	0.2	0.8	0.2	0.1	0.0	0.2	0.1
57	0.5	0.2	1.1	0.2	0.4	0.2	0.8	0.2	0.1	0.0	0.3	0.0
58	0.2	0.1	0.5	0.1	0.2	0.1	0.3	0.1	0.0	0.0	0.2	0.0
59	0.5	0.2	1.1	0.3	0.4	0.2	0.8	0.2	0.1	0.0	0.3	0.1
60	5.4	2.1	10.8	3.4	4.0	1.6	8.1	2.5	1.4	0.5	2.7	0.9
61	6.6	2.5	13.2	4.1	4.9	1.9	9.9	3.1	1.7	0.6	3.3	1.0
62	3.2	1.2	6.4	2.0	2.4	0.9	4.8	1.5	0.8	0.3	1.6	0.5
63	4.5	1.7	9.0	2.8	3.4	1.3	6.7	2.1	1.1	0.4	2.2	0.7
64	9.0	3.5	18.0	5.6	6.7	2.6	13.5	4.2	2.2	0.9	4.5	1.4
65	4.9	1.9	9.8	3.1	3.7	1.4	7.3	2.3	1.2	0.5	2.4	0.8
66	22.0	8.5	44.0	13.8	16.5	6.4	33.0	10.3	5.5	2.1	11.0	3.5
67	1.8	0.7	3.7	1.1	1.4	0.5	2.8	0.9	0.4	0.2	0.9	0.2
68	4.5	1.7	8.9	2.8	3.3	1.3	6.7	2.1	1.2	0.4	2.2	0.7
69	5.3	2.0	10.6	3.3	4.0	1.5	7.9	2.5	1.3	0.5	2.7	0.8
70	21.9	8.4	43.8	13.7	16.4	6.3	32.9	10.3	5.5	2.1	10.9	3.4
71	25.5	9.8	51.0	15.9	19.1	7.4	38.2	12.0	6.4	2.4	12.8	3.9
72	6.6	2.5	13.2	4.1	4.9	1.9	9.9	3.1	1.7	0.6	3.3	1.0
73	6.0	2.3	12.1	3.3	4.5	1.7	9.0	2.5	1.5	0.6	3.1	0.8
74	0.1	0.0	0.2	0.1	0.1	0.0	0.1	0.0	0.0	0.0	0.1	0.1
75	0.2	0.1	0.5	0.1	0.2	0.1	0.3	0.1	0.0	0.0	0.2	0.0
76	0.4	0.2	0.8	0.3	0.3	0.1	0.6	0.2	0.1	0.1	0.2	0.1
77	27.7	10.7	55.4	17.3	20.8	8.0	41.6	13.0	6.9	2.7	13.8	4.3
78	0.7	0.3	1.4	0.4	0.5	0.2	1.0	0.3	0.2	0.1	0.4	0.1
79	11.5	4.4	22.9	7.2	8.6	3.3	17.2	5.4	2.9	1.1	5.7	1.8
Total	205.4	78.8	410.8	126.1	153.8	59.6	307.9	94.7	51.6	19.2	102.9	31.4

Note: Erosion ID matched streambank erosion sites shown on Maps F.13 through F.35 in Appendix F.

[a] *Measured in pounds per year.*

[b] *Measured in tons per year.*

[c] *Assuming 75 percent BMP efficiency.*

Source: U.S. Environmental Protection Agency and SEWRPC

Table D.5
STEPL Model Load Reduction Results for Streambank Erosion Sites in Upper Oak Creek

Impaired Streambank Dimensions and Recession Rates									
Erosion ID	Erosion Length (feet)	Erosion Height (feet)	Lateral Recession	Recession Rate Range (feet/year)	Applied Recession Rate (feet/year)	BMP Efficiency Applied (0-1)	Soil Textural Class	Soil Dry Weight (ton/feet³)	Nutrient Correction Factor
80	39	5	Moderate	0.06 - 0.2	0.13	0.75	Silty clay loam, silty clay	0.04	1
81	56	6	Moderate	0.06 - 0.2	0.13	0.75	Silty clay loam, silty clay	0.04	1
82	78	6	Moderate	0.06 - 0.2	0.13	0.75	Silty clay loam, silty clay	0.04	1
83	33	5.5	Moderate	0.06 - 0.2	0.13	0.75	Silty clay loam, silty clay	0.04	1
84	47	3	Slight	0.01 - 0.05	0.03	0.75	Silty clay loam, silty clay	0.04	1
85	62	5	Moderate	0.06 - 0.2	0.13	0.75	Silty clay loam, silty clay	0.04	1
86	66	4.5	Moderate	0.06 - 0.2	0.13	0.75	Silty clay loam, silty clay	0.04	1
87	90	5.5	Moderate	0.06 - 0.2	0.13	0.75	Silty clay loam, silty clay	0.04	1
88	40	5	Moderate	0.06 - 0.2	0.13	0.75	Silty clay loam, silty clay	0.04	1
89	86	5.5	Moderate	0.06 - 0.2	0.13	0.75	Silty clay loam, silty clay	0.04	1
90	42	4.4	Moderate	0.06 - 0.2	0.13	0.75	Silty clay loam, silty clay	0.04	1
91	23	4.5	Moderate	0.06 - 0.2	0.13	0.75	Silty clay loam, silty clay	0.04	1
92	154	5.1	Severe	0.3 - 0.5	0.4	0.75	Silty clay loam, silty clay	0.04	1
93	42	4.9	Moderate	0.06 - 0.2	0.13	0.75	Organic	0.011	1.5
94	38	5.5	Moderate	0.06 - 0.2	0.13	0.75	Silty clay loam, silty clay	0.04	1
95	10	10	Severe	0.3 - 0.5	0.4	0.75	Silty clay loam, silty clay	0.04	1
96	11	4.5	Severe	0.3 - 0.5	0.4	0.75	Silty clay loam, silty clay	0.04	1
97	16	4.8	Moderate	0.06 - 0.2	0.13	0.75	Silty clay loam, silty clay	0.04	1
98	66	3	Moderate	0.06 - 0.2	0.13	0.75	Silty clay loam, silty clay	0.04	1

Pollutant Loads and Load Reductions												
	Pollutant Loads with no BMP				Pollutant Reduction				Pollutant Loads with BMP			
Erosion ID	N Load[a]	P Load[a]	BOD Load[a]	Sediment Load[b]	N Reduction[a,c]	P Reduction[a,c]	BOD Reduction[a,c]	Sediment Reduction[b,c]	N Load[a]	P Load[a]	BOD[a]	Sediment Load[b]
80	1.6	0.6	3.2	1.0	1.2	0.5	2.4	0.8	0.4	0.1	0.8	0.2
81	2.8	1.1	5.6	1.7	2.1	0.8	4.2	1.3	0.7	0.3	1.4	0.4
82	3.9	1.5	7.8	2.4	2.9	1.1	5.8	1.8	1.0	0.4	2.0	0.6
83	1.5	0.6	3.0	0.9	1.1	0.4	2.3	0.7	0.4	0.2	0.7	0.2
84	0.3	0.1	0.5	0.2	0.2	0.1	0.4	0.1	0.1	0.0	0.1	0.1
85	2.6	1.0	5.2	1.6	1.9	0.7	3.9	1.2	0.7	0.3	1.3	0.4
86	2.5	1.0	4.9	1.5	1.9	0.7	3.7	1.2	0.6	0.3	1.2	0.3
87	4.1	1.6	8.2	2.6	3.1	1.2	6.2	1.9	1.0	0.4	2.0	0.7
88	1.7	0.6	3.3	1.0	1.2	0.5	2.5	0.8	0.5	0.1	0.8	0.2
89	3.9	1.5	7.9	2.5	3.0	1.1	5.9	1.8	0.9	0.4	2.0	0.7
90	1.5	0.6	3.1	1.0	1.2	0.4	2.3	0.7	0.3	0.2	0.8	0.3
91	0.9	0.3	1.7	0.5	0.6	0.2	1.3	0.4	0.3	0.1	0.4	0.1
92	20.1	7.7	40.2	12.6	15.1	5.8	30.2	9.4	5.0	1.9	10.1	3.2
93	0.7	0.3	1.4	0.3	0.5	0.2	1.1	0.2	0.2	0.1	0.3	0.1
94	1.7	0.7	3.5	1.1	1.3	0.5	2.6	0.8	0.4	0.2	0.9	0.3
95	2.6	1.0	5.1	1.6	1.9	0.7	3.8	1.2	0.7	0.3	1.3	0.4
96	1.3	0.5	2.5	0.8	1.0	0.4	1.9	0.6	0.3	0.1	0.6	0.2
97	0.6	0.2	1.3	0.4	0.5	0.2	1.0	0.3	0.1	0.0	0.3	0.1
98	1.6	0.6	3.3	1.0	1.2	0.5	2.5	0.8	0.4	0.1	0.8	0.2
Total	55.9	21.5	111.7	34.7	41.9	16.0	84.0	26.0	14.0	5.5	27.7	8.7

Note: Erosion ID matched streambank erosion sites shown on Maps F.13 through F.35 in Appendix F.

[a] *Measured in pounds per year.*

[b] *Measured in tons per year.*

[c] *Assuming 75 percent BMP efficiency.*

Source: U.S. Environmental Protection Agency and SEWRPC

Table D.6
STEPL Model Load Reduction Results for Streambank Erosion Sites in Upper Oak Creek – Headwaters

Impaired Streambank Dimensions and Recession Rates									
Erosion ID	**Erosion Length (feet)**	**Erosion Height (feet)**	**Lateral Recession**	**Recession Rate Range (feet/year)**	**Applied Recession Rate (feet/year)**	**BMP Efficiency Applied (0-1)**	**Soil Textural Class**	**Soil Dry Weight (ton/feet^3)**	**Nutrient Correction Factor**
99	22	5	Moderate	0.01 - 0.05	0.03	0.75	Silty clay loam, silty clay	0.04	1
100	298	8	Severe	0.01 - 0.05	0.03	0.75	Silty clay loam, silty clay	0.04	1
101	428	8.5	Severe	0.01 - 0.05	0.03	0.75	Silty clay loam, silty clay	0.04	1

Pollutant Loads and Load Reductions												
	Pollutant Loads with no BMP				**Pollutant Reduction**				**Pollutant Loads with BMP**			
Erosion ID	N Load[a]	P Load[a]	BOD Load[a]	Sediment Load[b]	N Reduction[a,c]	P Reduction[a,c]	BOD Reduction[a,c]	Sediment Reduction[b,c]	N Load[a]	P Load[a]	BOD[a]	Sediment Load[b]
99	0.9	0.4	1.8	0.6	0.7	0.3	1.4	0.4	0.2	0.1	0.4	0.2
100	61.0	23.5	122.1	38.1	45.8	17.6	91.5	28.6	15.2	5.9	30.6	9.5
101	93.1	35.9	186.3	58.2	69.8	26.9	139.7	43.7	23.3	9.0	46.6	14.5
Total	155.0	59.8	310.2	96.9	116.3	44.8	232.6	72.7	38.7	15.0	77.6	24.2

Note: Erosion ID matched streambank erosion sites shown on Maps F.13 through F.35 in Appendix F.

[a] *Measured in pounds per year.*

[b] *Measured in tons per year.*

[c] *Assuming 75 percent BMP efficiency.*

Source: U.S. Environmental Protection Agency and SEWRPC

Table D.7
STEPL Model Load Reduction Results for Streambank Erosion Sites in Lower North Branch Oak Creek

Impaired Streambank Dimensions and Recession Rates									
Erosion ID	Erosion Length (feet)	Erosion Height (feet)	Lateral Recession	Recession Rate Range (feet/year)	Applied Recession Rate (feet/year)	BMP Efficiency Applied (0-1)	Soil Textural Class	Soil Dry Weight (ton/feet^3)	Nutrient Correction Factor
102	68	7.5	Severe	0.3 - 0.5	0.4	0.75	Silty clay loam, silty clay	0.04	1
103	279	7	Moderate	0.06 - 0.2	0.13	0.75	Silty clay loam, silty clay	0.04	1
104	113	6.5	Severe	0.3 - 0.5	0.4	0.75	Silty clay loam, silty clay	0.04	1
104a	113	6	Severe	0.3 - 0.5	0.4	0.75	Silty clay loam, silty clay	0.04	1
105	132	7	Severe	0.3 - 0.5	0.4	0.75	Silty clay loam, silty clay	0.04	1
106	116	3.2	Moderate	0.06 - 0.2	0.13	0.75	Silty clay loam, silty clay	0.04	1
107	26	3.2	Slight	0.01 - 0.05	0.03	0.75	Silty clay loam, silty clay	0.04	1
108	29	4	Moderate	0.06 - 0.2	0.13	0.75	Silty clay loam, silty clay	0.04	1
109	43	2.8	Slight	0.01 - 0.05	0.03	0.75	Silty clay loam, silty clay	0.04	1
110	50	5	Moderate	0.06 - 0.2	0.13	0.75	Silty clay loam, silty clay	0.04	1
111	58	4	Moderate	0.06 - 0.2	0.13	0.75	Silty clay loam, silty clay	0.04	1
112	130	6	Moderate	0.06 - 0.2	0.13	0.75	Silty clay loam, silty clay	0.04	1
113	43	4.8	Moderate	0.06 - 0.2	0.13	0.75	Silty clay loam, silty clay	0.04	1
114	67	3.2	Slight	0.01 - 0.05	0.03	0.75	Silty clay loam, silty clay	0.04	1
115	131	3.5	Moderate	0.06 - 0.2	0.13	0.75	Silty clay loam, silty clay	0.04	1
116	89	2.2	Slight	0.01 - 0.05	0.03	0.75	Silty clay loam, silty clay	0.04	1
117	71	3.3	Slight	0.01 - 0.05	0.03	0.75	Silty clay loam, silty clay	0.04	1

Pollutant Loads and Load Reductions												
	Pollutant Loads with no BMP				Pollutant Reduction				Pollutant Loads with BMP			
Erosion ID	N Load[a]	P Load[a]	BOD Load[a]	Sediment Load[b]	N Reduction[a,c]	P Reduction[a,c]	BOD Reduction[a,c]	Sediment Reduction[b,c]	N Load[a]	P Load[a]	BOD[a]	Sediment Load[b]
102	13.1	5.0	26.1	8.2	9.8	3.8	19.6	6.1	3.3	1.2	6.5	2.1
103	16.2	6.3	32.5	10.2	12.2	4.7	24.4	7.6	4.0	1.6	8.1	2.6
104	18.8	7.2	37.6	11.8	14.1	5.4	28.2	8.8	4.7	1.8	9.4	3.0
104a	17.4	6.7	34.7	10.8	13.0	5.0	26.0	8.1	4.4	1.7	8.7	2.7
105	23.7	9.1	47.3	14.8	17.7	6.8	35.5	11.1	6.0	2.3	11.8	3.7
106	3.1	1.2	6.2	1.9	2.3	0.9	4.6	1.4	0.8	0.3	1.6	0.5
107	0.2	0.1	0.3	0.1	0.1	0.0	0.2	0.1	0.1	0.1	0.1	0.0
108	1.0	0.4	1.9	0.6	0.7	0.3	1.4	0.5	0.3	0.1	0.5	0.1
109	0.2	0.1	0.5	0.1	0.2	0.1	0.3	0.1	0.0	0.0	0.2	0.0
110	2.1	0.8	4.2	1.3	1.6	0.6	3.1	1.0	0.5	0.2	1.1	0.3
111	1.9	0.7	3.9	1.2	1.4	0.6	2.9	0.9	0.5	0.1	1.0	0.3
112	6.5	2.5	13.0	4.1	4.9	1.9	9.7	3.0	1.6	0.6	3.3	1.1
113	1.7	0.7	3.4	1.1	1.3	0.5	2.6	0.8	0.4	0.2	0.8	0.3
114	0.4	0.2	0.8	0.3	0.3	0.1	0.6	0.2	0.1	0.1	0.2	0.1
115	3.8	1.5	7.6	2.4	2.9	1.1	5.7	1.8	0.9	0.4	1.9	0.6
116	0.4	0.1	0.8	0.2	0.3	0.1	0.6	0.2	0.1	0.0	0.2	0.0
117	0.4	0.2	0.9	0.3	0.3	0.1	0.7	0.2	0.1	0.1	0.2	0.1
Total	110.9	42.8	221.7	69.4	83.1	32.0	166.1	51.9	27.8	10.8	55.6	17.5

Note: Erosion ID matched streambank erosion sites shown on Maps F.13 through F.35 in Appendix F.

[a] *Measured in pounds per year.*

[b] *Measured in tons per year.*

[c] *Assuming 75 percent BMP efficiency.*

Source: U.S. Environmental Protection Agency and SEWRPC

Table D.8
STEPL Model Load Reduction Results for Streambank Erosion Sites in Upper North Branch Oak Creek

Impaired Streambank Dimensions and Recession Rates									
Erosion ID	**Erosion Length (feet)**	**Erosion Height (feet)**	**Lateral Recession**	**Recession Rate Range (feet/year)**	**Applied Recession Rate (feet/year)**	**BMP Efficiency Applied (0-1)**	**Soil Textural Class**	**Soil Dry Weight (ton/feet^3)**	**Nutrient Correction Factor**
118	62	3.8	Moderate	0.06 - 0.2	0.13	0.75	Silty clay loam, silty clay	0.04	1
119	88	4	Moderate	0.06 - 0.2	0.13	0.75	Silty clay loam, silty clay	0.04	1
135	10	5	Moderate	0.06 - 0.2	0.13	0.75	Silty clay loam, silty clay	0.04	1
136	25	8	Severe	0.3 - 0.5	0.4	0.75	Silty clay loam, silty clay	0.04	1
137	51	6	Moderate	0.06 - 0.2	0.13	0.75	Silty clay loam, silty clay	0.04	1
138	41	6	Moderate	0.06 - 0.2	0.13	0.75	Silty clay loam, silty clay	0.04	1
139	41	8	Moderate	0.06 - 0.2	0.13	0.75	Silty clay loam, silty clay	0.04	1
140	36	6.5	Moderate	0.06 - 0.2	0.13	0.75	Silty clay loam, silty clay	0.04	1
141	141	6	Moderate	0.06 - 0.2	0.13	0.75	Silty clay loam, silty clay	0.04	1
142	138	6	Moderate	0.06 - 0.2	0.13	0.75	Silty clay loam, silty clay	0.04	1
143	196	9	Moderate	0.06 - 0.2	0.13	0.75	Silty clay loam, silty clay	0.04	1
144	145	9	Severe	0.3 - 0.5	0.4	0.75	Silty clay loam, silty clay	0.04	1
145	45	8	Severe	0.3 - 0.5	0.4	0.75	Silty clay loam, silty clay	0.04	1

Pollutant Loads and Load Reductions												
	Pollutant Loads with no BMP				**Pollutant Reduction**				**Pollutant Loads with BMP**			
Erosion ID	N Load[a]	P Load[a]	BOD Load[a]	Sediment Load[b]	N Reduction[a,c]	P Reduction[a,c]	BOD Reduction[a,c]	Sediment Reduction[b,c]	N Load[a]	P Load[a]	BOD[a]	Sediment Load[b]
118	2.0	0.8	3.9	1.2	1.5	0.6	2.9	0.9	0.5	0.2	1.0	0.3
119	2.9	1.1	5.9	1.8	2.2	0.8	4.4	1.4	0.7	0.3	1.5	0.4
135	0.4	0.2	0.8	0.3	0.3	0.1	0.6	0.2	0.1	0.1	0.2	0.1
136	5.1	2.0	10.2	3.2	3.8	1.5	7.7	2.4	1.3	0.5	2.5	0.8
137	2.5	1.0	5.1	1.6	1.9	0.7	3.8	1.2	0.6	0.3	1.3	0.4
138	2.0	0.8	4.1	1.3	1.5	0.6	3.1	1.0	0.5	0.2	1.0	0.3
139	2.7	1.1	5.5	1.7	2.0	0.8	4.1	1.3	0.7	0.3	1.4	0.4
140	1.9	0.7	3.9	1.2	1.5	0.6	2.9	0.9	0.4	0.1	1.0	0.3
141	7.0	2.7	14.1	4.4	5.3	2.0	10.6	3.3	1.7	0.7	3.5	1.1
142	6.9	2.7	13.8	4.3	5.2	2.0	10.3	3.2	1.7	0.7	3.5	1.1
143	14.7	5.7	29.4	9.2	11.0	4.2	22.0	6.9	3.7	1.4	7.3	2.3
144	33.4	12.9	66.8	20.9	25.1	9.6	50.1	15.7	8.3	3.3	16.7	5.2
145	9.2	3.5	18.4	5.8	6.9	2.7	13.8	4.3	2.3	0.8	4.6	1.5
Total	90.7	35.2	181.9	56.9	68.2	26.2	136.3	42.7	22.5	9.0	45.6	14.2

Note: Erosion ID matched streambank erosion sites shown on Maps F.13 through F.35 in Appendix F.

[a] *Measured in pounds per year.*

[b] *Measured in tons per year.*

[c] *Assuming 75 percent BMP efficiency.*

Source: U.S. Environmental Protection Agency and SEWRPC

Table D.9
STEPL Model Load Reduction Results for Streambank Erosion Sites in Lower Mitchell Field Drainage Ditch

Impaired Streambank Dimensions and Recession Rates									
Erosion ID	Erosion Length (feet)	Erosion Height (feet)	Lateral Recession	Recession Rate Range (feet/year)	Applied Recession Rate (feet/year)	BMP Efficiency Applied (0-1)	Soil Textural Class	Soil Dry Weight (ton/feet^3)	Nutrient Correction Factor
120	43	12	Severe	0.3 - 0.5	0.4	0.75	Silty clay loam, silty clay	0.04	1
121	41	15	Severe	0.3 - 0.5	0.4	0.75	Silty clay loam, silty clay	0.04	1
122	68	7	Moderate	0.06 - 0.2	0.13	0.75	Silty clay loam, silty clay	0.04	1
123	38	4	Moderate	0.06 - 0.2	0.13	0.75	Silty clay loam, silty clay	0.04	1
124	37	5	Slight	0.01 - 0.05	0.03	0.75	Silty clay loam, silty clay	0.04	1
125	28	5	Moderate	0.06 - 0.2	0.13	0.75	Silty clay loam, silty clay	0.04	1
126	29	4	Moderate	0.06 - 0.2	0.13	0.75	Silty clay loam, silty clay	0.04	1
127	278	4	Slight	0.01 - 0.05	0.03	0.75	Organic	0.011	1.5
128	97	4.5	Slight	0.01 - 0.05	0.03	0.75	Silty clay loam, silty clay	0.04	1
129	143	6	Moderate	0.06 - 0.2	0.13	0.75	Silty clay loam, silty clay	0.04	1
130	50	5	Moderate	0.06 - 0.2	0.13	0.75	Silty clay loam, silty clay	0.04	1
131	52	6	Severe	0.3 - 0.5	0.4	0.75	Silty clay loam, silty clay	0.04	1
132	140	5	Moderate	0.06 - 0.2	0.13	0.75	Silty clay loam, silty clay	0.04	1
133	94	7	Moderate	0.06 - 0.2	0.13	0.75	Silty clay loam, silty clay	0.04	1
134	45	6	Moderate	0.06 - 0.2	0.13	0.75	Silty clay loam, silty clay	0.04	1

Pollutant Loads and Load Reductions												
	Pollutant Loads with no BMP				Pollutant Reduction				Pollutant Loads with BMP			
Erosion ID	N Load[a]	P Load[a]	BOD Load[a]	Sediment Load[b]	N Reduction[a,c]	P Reduction[a,c]	BOD Reduction[a,c]	Sediment Reduction[b,c]	N Load[a]	P Load[a]	BOD[a]	Sediment Load[b]
120	13.2	5.1	26.4	8.3	9.9	3.8	19.8	6.2	3.3	1.3	6.6	2.1
121	15.7	6.1	31.5	9.8	11.8	4.5	23.6	7.4	3.9	1.6	7.9	2.4
122	4.0	1.5	7.9	2.5	3.0	1.1	5.9	1.9	1.0	0.4	2.0	0.6
123	1.3	0.5	2.5	0.8	0.9	0.4	1.9	0.6	0.4	0.1	0.6	0.2
124	0.4	0.1	0.7	0.2	0.3	0.1	0.5	0.2	0.1	0.0	0.2	0.0
125	1.2	0.4	2.3	0.7	0.9	0.3	1.7	0.5	0.3	0.1	0.6	0.2
126	1.0	0.4	1.9	0.6	0.7	0.3	1.4	0.5	0.3	0.1	0.5	0.1
127	0.9	0.3	1.8	0.4	0.7	0.3	1.3	0.3	0.2	0.0	0.5	0.1
128	0.8	0.3	1.7	0.5	0.6	0.2	1.3	0.4	0.2	0.1	0.4	0.1
129	7.1	2.7	14.3	4.5	5.4	2.1	10.7	3.3	1.7	0.6	3.6	1.2
130	2.1	0.8	4.2	1.3	1.6	0.6	3.1	1.0	0.5	0.2	1.1	0.3
131	8.0	3.1	16.0	5.0	6.0	2.3	12.0	3.7	2.0	0.8	4.0	1.3
132	5.8	2.2	11.6	3.6	4.4	1.7	8.7	2.7	1.4	0.5	2.9	0.9
133	5.5	2.1	10.9	3.4	4.1	1.6	8.2	2.6	1.4	0.5	2.7	0.8
134	2.2	0.9	4.5	1.4	1.7	0.6	3.4	1.1	0.5	0.3	1.1	0.3
Total	69.2	26.5	138.2	43.0	52.0	19.9	103.5	32.4	17.2	6.6	34.7	10.6

Note: Erosion ID matched streambank erosion sites shown on Maps F.13 through F.35 in Appendix F.

[a] *Measured in pounds per year.*

[b] *Measured in tons per year.*

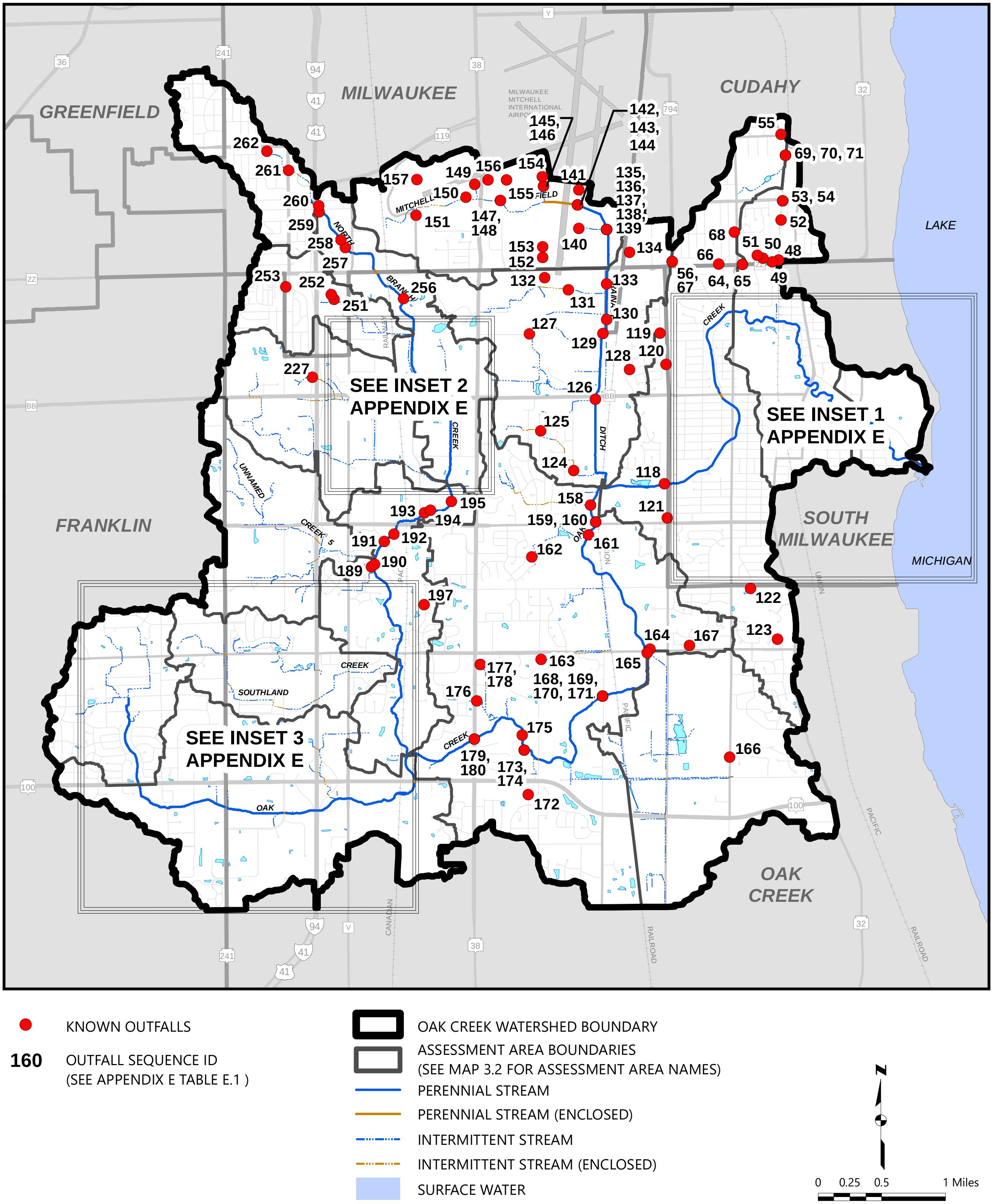
[c] *Assuming 75 percent BMP efficiency.*

Source: U.S. Environmental Protection Agency and SEWRPC

KNOWN OUTFALLS WITHIN THE OAK CREEK WATERSHED

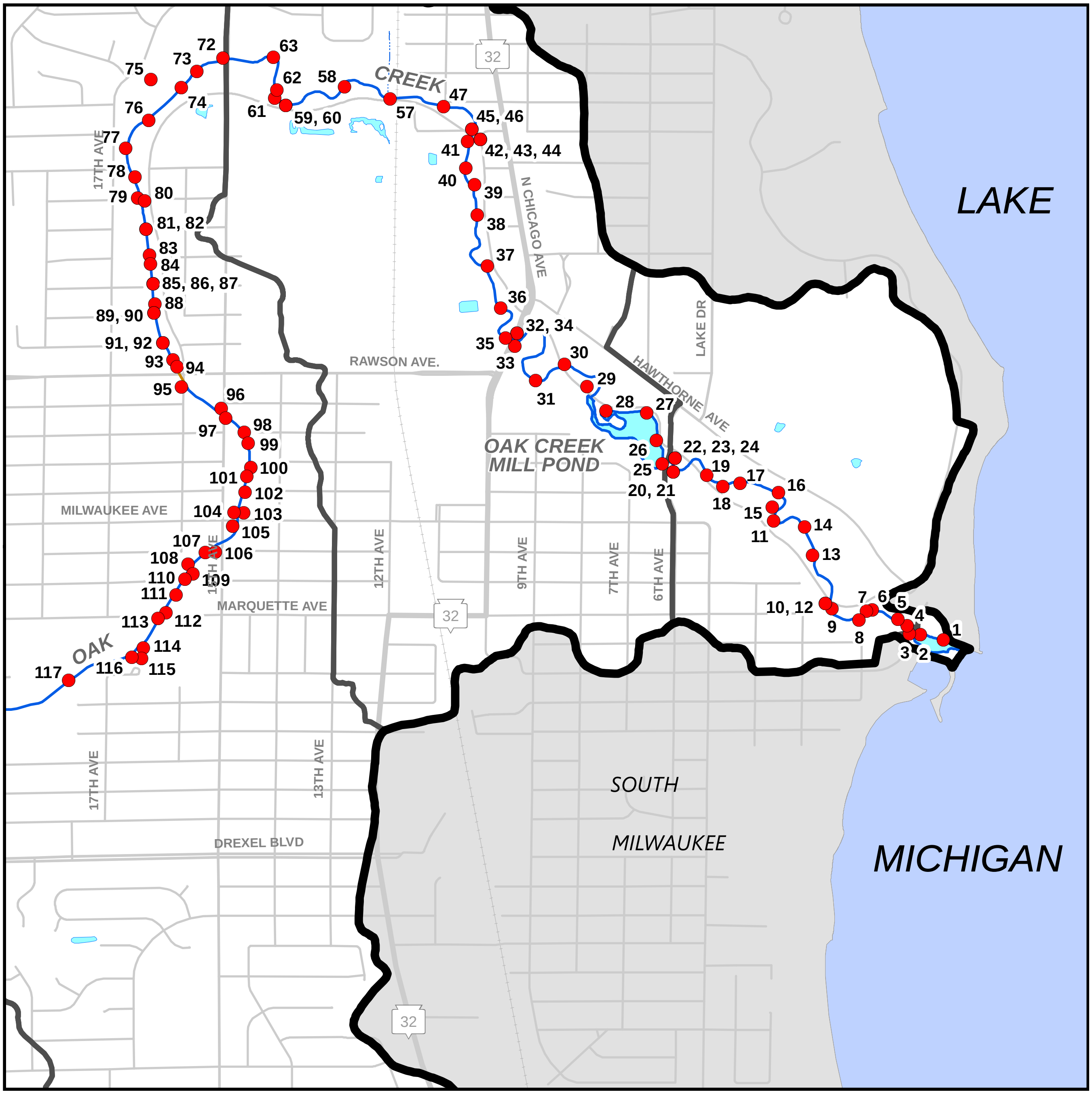
APPENDIX E

Map E.1
Locations of Known Outfalls Within the Oak Creek Watershed



Source: City of Cudahy, City of Franklin, City of Greenfield, City of Milwaukee, City of Oak Creek, City of South Milwaukee, Milwaukee County, City of Racine Public Health Department, and SEWRPC

Map E.1 (Inset 1)



KNOWN OUTFALLS

4 OUTFALL SEQUENCE ID (SEE APPENDIX E TABLE E.1)

OAK CREEK WATERSHED BOUNDARY

ASSESSMENT AREA BOUNDARIES (SEE MAP 3.2 FOR ASSESSMENT AREA NAMES)

PERENNIAL STREAM

PERENNIAL STREAM (ENCLOSED)

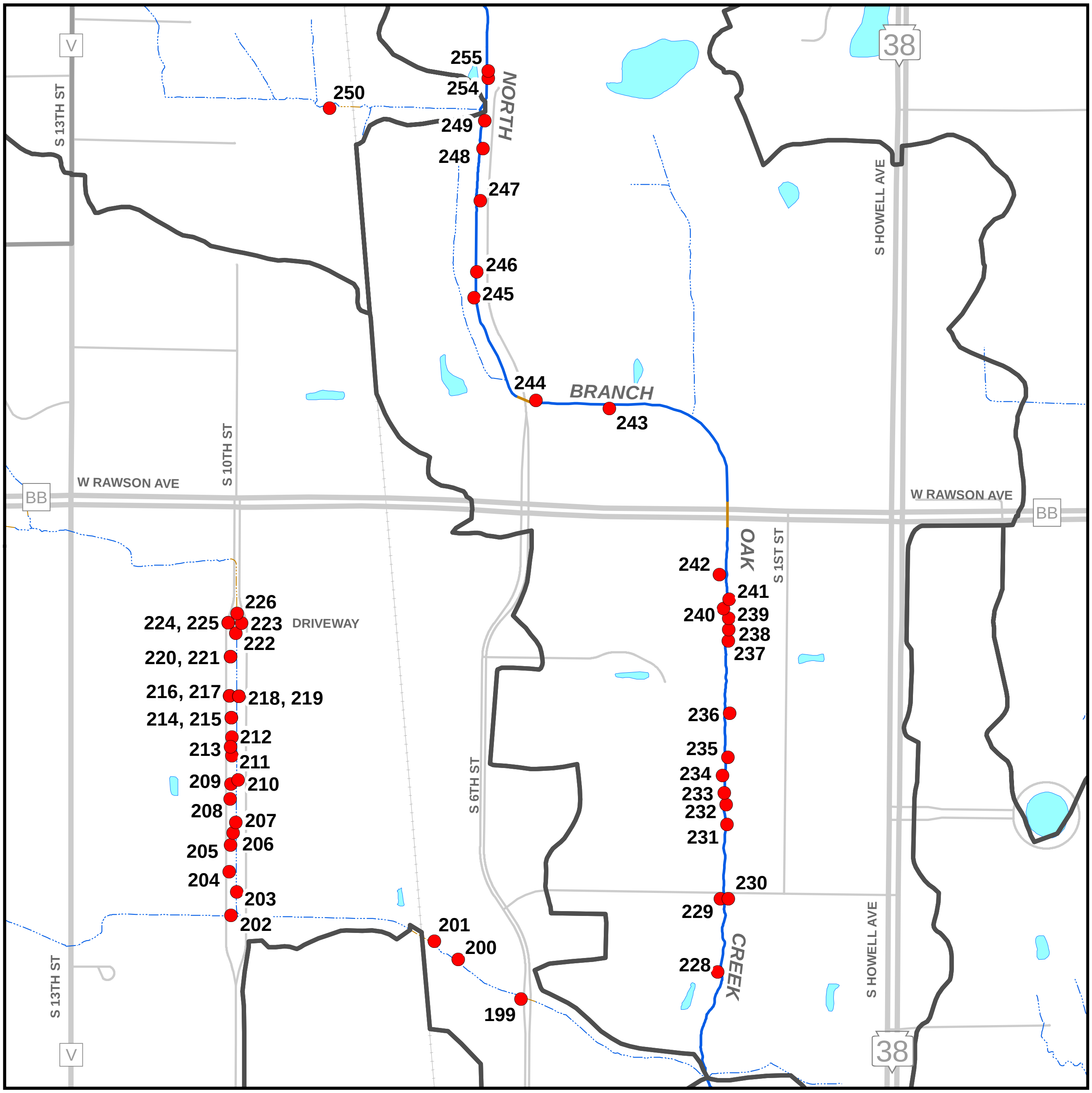
INTERMITTENT STREAM

INTERMITTENT STREAM (ENCLOSED)

SURFACE WATER

Source: City of Cudahy, City of Franklin, City of Greenfield, City of Milwaukee, City of Oak Creek, City of South Milwaukee, Milwaukee County, City of Racine Public Health Department, and SEWRPC

Map E.1 (Inset 2)



KNOWN OUTFALLS

213 OUTFALL SEQUENCE ID (SEE APPENDIX E TABLE E.1)

OAK CREEK WATERSHED BOUNDARY

ASSESSMENT AREA BOUNDARIES (SEE MAP 3.2 FOR ASSESSMENT AREA NAMES)

PERENNIAL STREAM

PERENNIAL STREAM (ENCLOSED)

INTERMITTENT STREAM

INTERMITTENT STREAM (ENCLOSED)

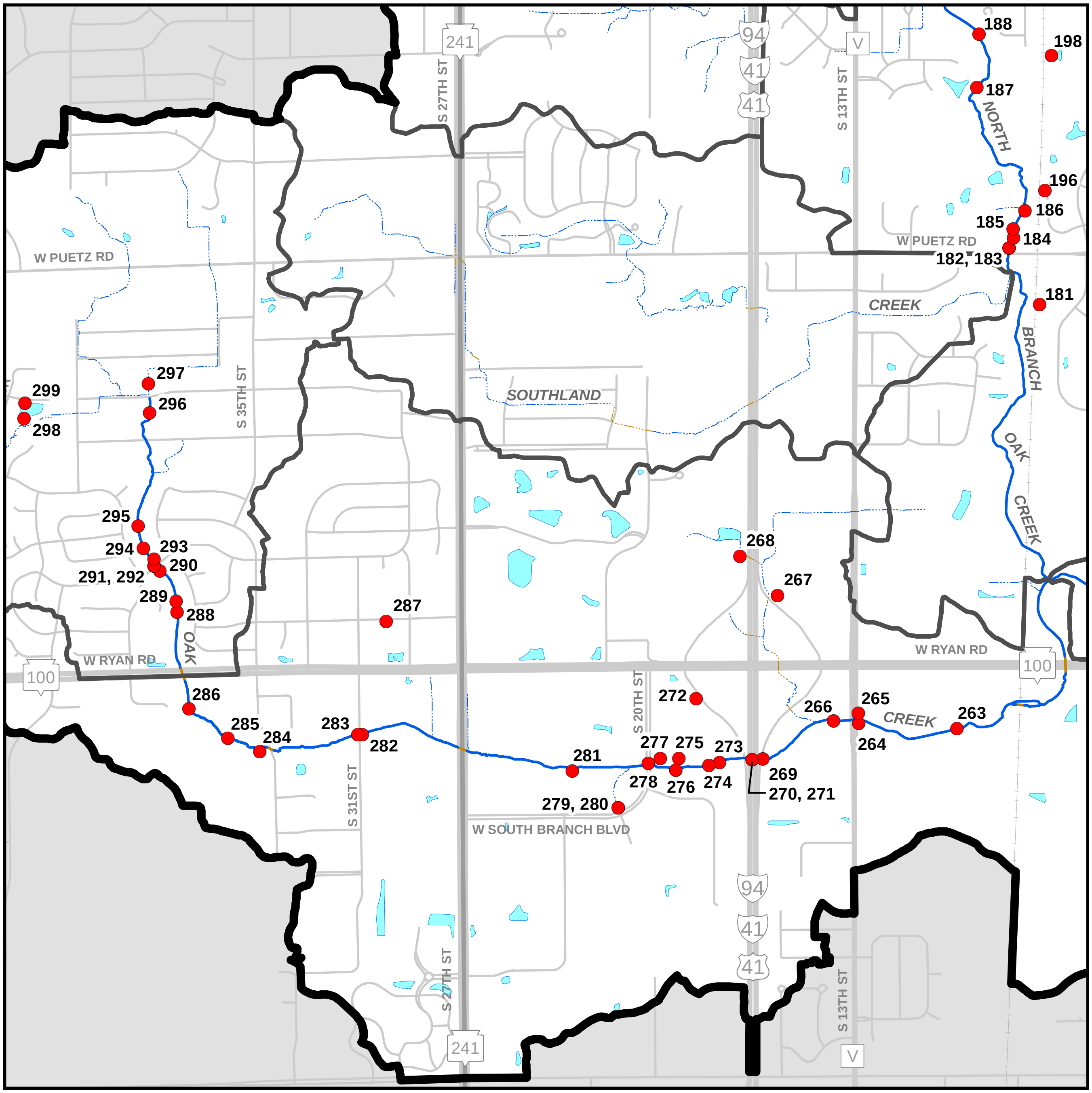
SURFACE WATER

N

0 250 500 1,000 Feet

Source: City of Cudahy, City of Franklin, City of Greenfield, City of Milwaukee, City of Oak Creek, City of South Milwaukee, Milwaukee County, City of Racine Public Health Department, and SEWRPC

Map E.1 (Inset 3)



KNOWN OUTFALLS

287 OUTFALL SEQUENCE ID (SEE APPENDIX E TABLE E.1)

OAK CREEK WATERSHED BOUNDARY

ASSESSMENT AREA BOUNDARIES (SEE MAP 3.2 FOR ASSESSMENT AREA NAMES)

PERENNIAL STREAM

PERENNIAL STREAM (ENCLOSED)

INTERMITTENT STREAM

INTERMITTENT STREAM (ENCLOSED)

SURFACE WATER

N

0 500 1,000 Feet

Source: City of Cudahy, City of Franklin, City of Greenfield, City of Milwaukee, City of Oak Creek, City of South Milwaukee, Milwaukee County, City of Racine Public Health Department, and SEWRPC

Table E.1
Known Outfalls Within the Oak Creek Watershed

Sequence Number[a]	Outfall Identifications[b]	Ownership	Water Body	Assessment Area	Latitude	Longitude	Condition	Dimensions (inches)	Notes
1	RHDOF37	Unknown	Oak Creek Mainstem	Grant Park Ravine	42.90676	-87.84205	--	--	Corrugated metal pipe
2	MC27; RDFOF38	Milwaukee County	Oak Creek Mainstem	Grant Park Ravine	42.90693	-87.84300	--	12	North side of Creek; near manhole L6
3	RHDOF39	Unknown	Oak Creek Mainstem	Grant Park Ravine	42.90697	-87.84346	--	--	Corrugated metal pipe
4	MC26; RHDOF40	Milwaukee County	Oak Creek Mainstem	Grant Park Ravine	42.90721	-87.84353	--	12	Oak Creek Parkway, north side of Creek; near manhole L4B
5	RHDOF41	Unknown	Oak Creek Mainstem	Grant Park Ravine	42.90742	-87.84390	--	--	Outfall submerged; Concrete end section
6	RHDOF42	Unknown	Oak Creek Mainstem	Grant Park Ravine	42.90771	-87.84495	--	--	--
7	RHDOF43	Unknown	Oak Creek Mainstem	Grant Park Ravine	42.90767	-87.84518	--	--	--
8	SM46	City of South Milwaukee	Oak Creek Mainstem	Grant Park Ravine	42.90741	-87.84550	--	10	Near manhole J13E
9	OSWO1; MC25	Milwaukee County	Oak Creek Mainstem	Grant Park Ravine	42.90779	-87.84659	Good	12	Right bank; Concrete pipe with riprap protection; near manhole J22A
10	OSWO2; SM45; RHDOF44	City of South Milwaukee	Oak Creek Mainstem	Grant Park Ravine	42.90788	-87.84675	Poor	18	Left bank; Concrete pipe built into WPA wall; near manhole J19
11	MC22; RHDHAW	Milwaukee County	Oak Creek Mainstem	Grant Park Ravine	42.91047	-87.84890	--	36	Near manhole M1A
12	OSWO3; MC24	Milwaukee County	Oak Creek Mainstem	Grant Park Ravine	42.90790	-87.84675	Good	12	Left bank; Concrete pipe built into WPA wall; Emergency sewage overflow pipe from wastewater pumping station up bank; near manhole J20A
13	MC23	Milwaukee County	Oak Creek Mainstem	Grant Park Ravine	42.90940	-87.84734	--	18	Near manhole M1A
14	OSWO4	Unknown	Oak Creek Mainstem	Grant Park Ravine	42.91027	-87.84763	Failed	24	Right bank; Sections of pipe have disconnected due to eroding bank
15	OSWO5; MC21; RHDOF45	Milwaukee County	Oak Creek Mainstem	Grant Park Ravine	42.91088	-87.84894	Good	12/18	Left bank; One foot diameter PVC pipe set back from creek about 50 feet; 18 inch pipe closer to road; near manhole M2B
16	OSWO6; SM44; RHDOF48	City of South Milwaukee	Oak Creek Mainstem	Grant Park Ravine	42.91132	-87.84866	Fair	24	Right bank; Concrete pipe with riprap protection; near manhole P23
17	OSWO7; SM43	City of South Milwaukee	Oak Creek Mainstem	Grant Park Ravine	42.91163	-87.85024	Good	12	Left bank; Concrete pipe; near manhole M4A
18	OSWO8	Unknown	Oak Creek Mainstem	Grant Park Ravine	42.91155	-87.85094	Good	--	Left bank; Concrete pipe was within wall that has since been rebuilt
19	OSWO9	Unknown	Oak Creek Mainstem	Grant Park Ravine	42.91190	-87.85159	Good	12	Right bank; Was on top of wall that has since been rebuilt
20	SM41	City of South Milwaukee	Oak Creek Mainstem	Grant Park Ravine	42.91219	-87.85299	--	24	Near manhole KK244
21	OSWO10; SM42; RHDOF49	City of South Milwaukee	Oak Creek Mainstem	Grant Park Ravine	42.91210	-87.85287	Fair	120	Left bank; near manhole KK37; large concrete arch culvert, may have other outfalls draining inside of culvert
22	OSWO11; SM40: RHDOF50	City of South Milwaukee	Oak Creek Mainstem	Grant Park Ravine	42.91235	-87.85302	Fair	15	Right bank; concrete pipe built in WPA wall; near manhole P1
23	OSWO12	Unknown	Oak Creek Mainstem	Grant Park Ravine	42.91226	-87.85309	Good	6	Left bank; Green PVC pipe
24	OSWO13	Unknown	Oak Creek Mainstem	Grant Park Ravine	42.91235	-87.85306	Good	12	Right bank; corrugated metal pipe resting on top of wall
25	OSWO14	Unknown	Oak Creek Mainstem	Grant Park Ravine	42.91229	-87.85329	Fair	36/12	Left bank; two outfalls
26	MC20; RHDOF51	Milwaukee County	Oak Creek Millpond	Lower Oak Creek – Mill Pond	42.91299	-87.85362	--	12	PVC pipe; flows into south side of Mill Pond; near manhole P2B
27	MC19; RHDOF52	Milwaukee County	Oak Creek Millpond	Lower Oak Creek – Mill Pond	42.91382	-87.85398	--	12	Corrugated metal pipe; flows into south side of Mill Pond; near manhole P10B

Table continued on next page.

Table E.1 (Continued)

Sequence Number[a]	Outfall Identifications[b]	Ownership	Water Body	Assessment Area	Latitude	Longitude	Condition	Dimensions (inches)	Notes
28	MC18	Milwaukee County	Oak Creek Millpond	Lower Oak Creek – Mill Pond	42.91392	-87.85565	--	12	Flows into south side of Mill Pond; near manhole P10C
29	OSWO15; MC17; RHDOF104	Milwaukee County	Oak Creek Mainstem	Lower Oak Creek – Mill Pond	42.91467	-87.85641	Good	24	Left bank; concrete pipe with flared end section and riprap protection; Oak Creek Parkway
30	OSWO16; MC16; RHDOF103	Milwaukee County	Oak Creek Mainstem	Lower Oak Creek – Mill Pond	42.91535	-87.85731	Good	12	Right bank; PVC pipe with riprap protection; near manhole O3; Oak Creek Parkway
31	OSWO17; SM39	City of South Milwaukee	Oak Creek Mainstem	Lower Oak Creek – Mill Pond	42.91489	-87.85850	Good	18	Left bank; corrugated metal pipe built into rock gabion wall; near manhole O3; 10th Avenue on west side of Creek
32	SM37; RHDOF99	City of South Milwaukee	Oak Creek Mainstem	Lower Oak Creek – Mill Pond	42.91624	-87.85933	--	24	Under N. Chicago Avenue bridge; north side of Creek; near manhole T1
33	SM38; RHDOF100	City of South Milwaukee	Oak Creek Mainstem	Lower Oak Creek – Mill Pond	42.91605	-87.85947	--	18	Under N. Chicago Avenue bridge; south side of Creek; near manhole Z12
34	RHDOF101	Unknown	Oak Creek Mainstem	Lower Oak Creek – Mill Pond	42.91621	-87.85941	--	--	Under N. Chicago Avenue bridge
35	SM36; RHDOF102	Unknown	Oak Creek Mainstem	Lower Oak Creek – Mill Pond	42.91619	-87.85969	--	24	South side of Creek near Rawson Avenue
36	CAT1; RHDOF98	Unknown	Oak Creek Mainstem	Lower Oak Creek – Mill Pond	42.91709	-87.85986	--	--	--
37	OSWO18; MC15; RHDOF97	Milwaukee County	Oak Creek Mainstem	Lower Oak Creek – Mill Pond	42.91837	-87.86036	Failed	18	Right bank; near manhole U2F; bank erosion causing at least six sections of concrete pipe to split
38	OSWO19; MC14; RHDOF96	Milwaukee County	Oak Creek Mainstem	Lower Oak Creek – Mill Pond	42.91991	-87.86072	Failed	18	Right bank; four foot concrete end section has separated from pipe
39	OSWO20; MC13	Milwaukee County	Oak Creek Mainstem	Lower Oak Creek – Mill Pond	42.92083	-87.86079	Poor	18	Right bank; Concrete pipe with end section separated from pipe; near manhole U8B; bank erosion occurring around outfall
40	OSWO21; SM35; RHDOF95	City of South Milwaukee	Oak Creek Mainstem	Lower Oak Creek – Mill Pond	42.92133	-87.86116	Failed	27	Right bank; concrete pipe; end section with wingwalls and a pipe section has separated; bank eroding at pipe; near manhole U26A and Aspen Street
41	OSWO22	Unknown	Oak Creek Mainstem	Lower Oak Creek – Mill Pond	42.92220	-87.86098	Fair	12	Left bank; concrete pipe
42	OSWO24; RHDOF91	Unknown	Oak Creek Mainstem	Lower Oak Creek – Mill Pond	42.92237	-87.86076	Fair	12	Right bank; concrete pipe
43	OSWO23; RHDOF91B	Unknown	Oak Creek Mainstem	Lower Oak Creek – Mill Pond	42.92237	-87.86075	Poor	12	Right bank; corrugated metal pipe rusted through; bank has eroded around pipe
44	OSWO25; SM34; RHDOF92	City of South Milwaukee	Oak Creek Mainstem	Lower Oak Creek – Mill Pond	42.92240	-87.86077	Poor	27	Right bank; concrete pipe with two sections separated; near manhole CC41
45	OSWO26; RHDOF93	Unknown	Oak Creek Mainstem	Lower Oak Creek – Mill Pond	42.92249	-87.86070	Poor	18	Left bank; concrete sections of pipe are separated within wall
46	OSWO27; RHDOF94	Unknown	Oak Creek Mainstem	Lower Oak Creek – Mill Pond	42.92251	-87.86070	Poor	12	Right bank; clay pipe is 50 percent plugged with debris
47	OSWO28;SM33; RHDOF89; RHDOF90	City of South Milwaukee	Oak Creek Mainstem	Lower Oak Creek – Mill Pond	42.92320	-87.86199	Fair	21	Right bank; near manhole J2E; corrugated metal pipe is rusted through, bent, and protruding about 5.5 feet from bank; MC12 is directly above outfall
48	CUD33	City of Cudahy	Offline	Lower Oak Creek – Mill Pond	42.93043	-87.86358	--	30	Likely connects to South Milwaukee's storm sewer system and eventually flows to Oak Creek's mainstem via outfall SM32

Table continued on next page.

Table E.1 (Continued)

Sequence Number[a]	Outfall Identifications[b]	Ownership	Water Body	Assessment Area	Latitude	Longitude	Condition	Dimensions (inches)	Notes
49	CUD32	City of Cudahy	Offline	Lower Oak Creek – Mill Pond	42.93022	-87.86460	--	24	Likely connects to South Milwaukee's storm sewer system and eventually flows to Oak Creek's mainstem via outfall SM32
50	CUD20	City of Cudahy	Offline	Lower Oak Creek – Mill Pond	42.93069	-87.86601	--	48	Likely connects to South Milwaukee's storm sewer system and eventually flows to Oak Creek's mainstem via outfall SM32
51	CUD21	City of Cudahy	Offline	Lower Oak Creek – Mill Pond	42.93103	-87.86655	--	--	Likely connects to South Milwaukee's storm sewer system and eventually flows to Oak Creek's mainstem via outfall SM32
52	CUD18	City of Cudahy	Offline	Lower Oak Creek – Mill Pond	42.93497	-87.86305	--	--	Likely connects to South Milwaukee's storm sewer system and eventually flows to Oak Creek's mainstem via outfall SM32
53	CUD25	City of Cudahy	Offline	Lower Oak Creek – Mill Pond	42.93716	-87.86292	--	--	Likely connects to South Milwaukee's storm sewer system and eventually flows to Oak Creek's mainstem via outfall SM32
54	CUD24	City of Cudahy	Offline	Lower Oak Creek – Mill Pond	42.93717	-87.86272	--	--	Likely connects to South Milwaukee's storm sewer system and eventually flows to Oak Creek's mainstem via outfall SM32
55	CUD27	City of Cudahy	Offline	Lower Oak Creek – Mill Pond	42.94470	-87.86271	--	--	Likely connects to South Milwaukee's storm sewer system and eventually flows to Oak Creek's mainstem via outfall SM32
56	CUD52	City of Cudahy	Offline	Lower Oak Creek – Mill Pond	42.93059	-87.88007	--	--	Likely connects to South Milwaukee's storm sewer system and eventually flows to Oak Creek's mainstem via outfall SM32
57	OTRIB1; SM32	City of South Milwaukee	Tributary to Oak Creek Mainstem	Lower Oak Creek – Mill Pond	42.92349	-87.86417	--	102	Major outfall; Likely drains Cudahy storm sewers in addition to South Milwaukee; Near Southtowne Apartments; Underground sewer daylights for about 700 feet and flows into Oak Creek's mainstem from the north
58	OSWO29; MC11; RHDOF88	Milwaukee County	Oak Creek Mainstem	Lower Oak Creek – Mill Pond	42.92388	-87.86603	Poor	12	Left bank; Near manhole J14D; Corrugated metal pipe is rusted through
59	OSWO30; SD1; RHDOF87	City of South Milwaukee	Oak Creek Mainstem	Lower Oak Creek – Mill Pond	42.92336	-87.86843	Failed	12	Left bank; Near manhole J15B; Corrugated metal pipe is rusted through; Located just downstream of larger outfall
60	OSWO31; RHDOF86	Unknown	Oak Creek Mainstem	Lower Oak Creek – Mill Pond	42.92337	-87.86847	Poor	27	Left bank; Corrugated metal pipe is rusted through and protruding from the bank about 12 feet due to erosion
61	OSWO31a; MC10	Milwaukee County	Oak Creek Mainstem	Lower Oak Creek – Mill Pond	42.92369	-87.86884	Failed	12	Left bank; Near manhole J15D; Corrugated metal pipe is rusted though
62	OSWO32	Unknown	Oak Creek Mainstem	Lower Oak Creek – Mill Pond	42.92384	-87.86881	Poor	24	Right bank; Corrugated metal pipe is protruding about 12 feet from bank; End section is nearly detached and is becoming embedded into bottom of stream channel
63	SM31; RHDOF85	City of South Milwaukee	Oak Creek Mainstem	Lower Oak Creek – Mill Pond	42.92482	-87.86892	--	21	Right bank; Near manhole K3D
64	CUD36	City of Cudahy	Offline	Lower Oak Creek	42.92983	-87.86914	--	12	Likely connects to South Milwaukee's storm sewer system and eventually flows to Oak Creek's mainstem via outfall SM30

Table continued on next page.

Table E.1 (Continued)

Sequence Number[a]	Outfall Identifications[b]	Ownership	Water Body	Assessment Area	Latitude	Longitude	Condition	Dimensions (inches)	Notes
65	CUD34	City of Cudahy	Offline	Lower Oak Creek	42.93019	-87.86937	--	8	Likely connects to South Milwaukee's storm sewer system and eventually flows to Oak Creek's mainstem via outfall SM30
66	CUD35	City of Cudahy	Offline	Lower Oak Creek	42.93015	-87.87285	--	48	Likely connects to South Milwaukee's storm sewer system and eventually flows to Oak Creek's mainstem via outfall SM30
67	CUD52	City of Cudahy	Offline	Lower Oak Creek	42.93059	-87.88007	--	15	Likely connects to South Milwaukee's storm sewer system and eventually flows to Oak Creek's mainstem via outfall SM30
68	CUD19	City of Cudahy	Offline	Lower Oak Creek	42.93374	-87.87034	--	24	Likely connects to South Milwaukee's storm sewer system and eventually flows to Oak Creek's mainstem via outfall SM30
69	CUD28	City of Cudahy	Offline	Lower Oak Creek	42.94223	-87.86217	--	36	Likely connects to South Milwaukee's storm sewer system and eventually flows to Oak Creek's mainstem via outfall SM30
70	CUD10	City of Cudahy	Offline	Lower Oak Creek	42.94229	-87.86202	--	--	Likely connects to South Milwaukee's storm sewer system and eventually flows to Oak Creek's mainstem via outfall SM30
71	CUD11	City of Cudahy	Offline	Lower Oak Creek	42.94232	-87.86213	--	27	Likely connects to South Milwaukee's storm sewer system and eventually flows to Oak Creek's mainstem via outfall SM30
72	OSWO33; SM30; RHDOF69	City of South Milwaukee	Oak Creek Mainstem	Lower Oak Creek	42.92484	-87.87098	Good	54	Major outfall; right bank; concrete outfall; likely drains Cudahy storm sewers in addition to South Milwaukee near manhole LL17
73	OSWO34; MC9	Milwaukee County	Oak Creek Mainstem	Lower Oak Creek	42.92446	-87.87208	Fair	30	Left bank; near manhole J15J; corrugated metal pipe
74	OSWO35; SM29; RHDOF68	City of South Milwaukee	Oak Creek Mainstem	Lower Oak Creek	42.92398	-87.87273	Good	36	Right bank; concrete outfall; near manhole NN50E
75	SM28; RHDOF67	City of South Milwaukee	Oak Creek Mainstem	Lower Oak Creek	42.92424	-87.87397	--	30	Right bank, setback 300 feet off Creek channel
76	OSWO 36; MC8; RHDOF66	Milwaukee County	Oak Creek Mainstem	Lower Oak Creek	42.92302	-87.87411	Failed	12	Left bank; corrugated metal pipe is rusted through; near outfall OO6B
77	OSWO 37; SM27; RHDOF65	City of South Milwaukee	Oak Creek Mainstem	Lower Oak Creek	42.92219	-87.87508	Good	30	Right bank; concrete pipe; near manhole OO3
78	OSWO 38; MC7	Milwaukee County	Oak Creek Mainstem	Lower Oak Creek	42.92132	-87.87473	Fair	12	Left bank; corrugated metal pipe; near manhole OO1I; Beech Street
79	RHDOF64	Unknown	Oak Creek Mainstem	Lower Oak Creek	42.92070	-87.87464	--	--	Cement outfall is blocked
80	OSWO 39; SM26; RHDOF63	City of South Milwaukee	Oak Creek Mainstem	Lower Oak Creek	42.92062	-87.87445	Good	12	Left bank; corrugated metal pipe is protruding from bank into channel and end section is bent; near manhole UU2; Walnut Street
81	OSWO 40; MC6; RHDOF61	Milwaukee County	Oak Creek Mainstem	Lower Oak Creek	42.91974	-87.87432	Good	42	Right bank; concrete pipe; near manhole TT1C; Cherry Street
82	OSWO41;SM25; RHDOF62	City of South Milwaukee	Oak Creek Mainstem	Lower Oak Creek	42.91970	-87.87428	Good	15	Left bank; corrugated metal pipe; near manhole TT1C; Cherry Street
83	OSWO42; SM24; RHDOF60	City of South Milwaukee	Oak Creek Mainstem	Lower Oak Creek	42.91897	-87.87422	Fair	48	Major outfall; right bank; concrete pipe with flared end section; some undercutting occurring; flow has about two foot drop to channel; near manhole TT6; Pine Street

Table continued on next page.

Table E.1 (Continued)

Sequence Number[a]	Outfall Identifications[b]	Ownership	Water Body	Assessment Area	Latitude	Longitude	Condition	Dimensions (inches)	Notes
84	MC5	Milwaukee County	Oak Creek Mainstem	Lower Oak Creek	42.91870	-87.87417	--	12	Left bank; near manhole Q3D; Pine Street
85	OSWO43; MC4; RHDOF59	Milwaukee County	Oak Creek Mainstem	Lower Oak Creek	42.91809	-87.87410	Failed	12	Left bank; corrugated metal pipe is plugged with sediment and debris; near manhole Q1C; Chestnut Street
86	OSWO44; SM23; RHDOF58	City of South Milwaukee	Oak Creek Mainstem	Lower Oak Creek	42.91800	-87.87409	Good	18	Left bank; corrugated metal pipe; near manhole Q1A; Chestnut Street
87	SM22; RHDOF57	City of South Milwaukee	Oak Creek Mainstem	Lower Oak Creek	42.91794	-87.87418	--	12	Right bank; corrugated metal pipe; near manhole SS9E; Chestnut Street
88	OSWO45; MC3	Milwaukee County	Oak Creek Mainstem	Lower Oak Creek	42.91748	-87.87404	Fair	12	Left bank; corrugated metal pipe; near manhole Q1E; Cedar Street
89	OSWO46; SM21; RHDOF56	City of South Milwaukee	Oak Creek Mainstem	Lower Oak Creek	42.91721	-87.87409	Poor	18	Right bank; concrete pipe has been undercut by erosion forming a 2.5 foot drop to channel bottom; near manhole SS6D; Cedar Street
90	OSWO47; SM20	City of South Milwaukee	Oak Creek Mainstem	Lower Oak Creek	42.91714	-87.87403	Poor	12	Right bank; corrugated metal pipe has rusted through and is protruding about 3.5 feet from bank; near manhole SS6C; Cedar Street
91	OSWO48; SM19; RHDOF55	City of South Milwaukee	Oak Creek Mainstem	Lower Oak Creek	42.91630	-87.87375	Failed	12	Right bank; corrugated metal pipe has rusted through and is protruding from bank by about 4.5 feet; end section is bent almost shut; near manhole R2D; Maple Street
92	OSWO49; MC2; RHDOF54	Milwaukee County	Oak Creek Mainstem	Lower Oak Creek	42.91623	-87.87365	Failed	15	Left bank; corrugated metal pipe is badly crushed and bent and is protruding from the bank by about eight feet; near manhole NN1-1; Maple Street
93	SM18; RHDOF53	City of South Milwaukee	Oak Creek Mainstem	Lower Oak Creek	42.91579	-87.87336	--	12	Left bank; clay pipe with concrete apron; near manhole PP14E; Rawson Avenue
94	MC1	Milwaukee County	Oak Creek Mainstem	Lower Oak Creek	42.91557	-87.87321	--	--	Right bank; Rawson Avenue
95	SM17	City of South Milwaukee	Oak Creek Mainstem	Lower Oak Creek	42.91496	-87.87304	--	27	Right bank; Rawson Avenue
96	OSWO50; SM16; RHDOF70	City of South Milwaukee	Oak Creek Mainstem	Lower Oak Creek	42.91413	-87.87135	Good	15	Left bank; concrete pipe built into 15th Avenue bridge structure; about five feet above channel; near manhole JJ1
97	OSWO51	Unknown	Oak Creek Mainstem	Lower Oak Creek	42.91398	-87.87127	Fair	12	Right bank; built into 15th Avenue bridge structure; pipe may be separated inside wall
98	OSWO52; SM15; RHDOF71	City of South Milwaukee	Oak Creek Mainstem	Lower Oak Creek	42.91354	-87.87051	Good	12	Left bank; corrugated metal pipe with a concrete block apron that carries flow down bank to channel; erosion is undercutting concrete apron; near manhole UU5-2; Manitoba Avenue
99	OSWO53	Unknown	Oak Creek Mainstem	Lower Oak Creek	42.91323	-87.87036	Failed	6	Left bank; metal pipe angle down from bank and is submerged into water; pipe has disconnected up-bank and percolates through bank
100	OSWO54; SM14; RHDOF72	City of South Milwaukee	Oak Creek Mainstem	Lower Oak Creek	42.91249	-87.87027	Fair	12	Left bank; corrugated metal pipe; metered with a concrete block apron carries flow down bank to channel; near manhole RR1; Minnesota Avenue
101	OSWO55; SM13; RHDOF73	City of South Milwaukee	Oak Creek Mainstem	Lower Oak Creek	42.91223	-87.87045	Good	18	Right bank; corrugated metal pipe with a concrete block apron that carries flow down bank to channel; near manhole SS3; Monroe Avenue

Table continued on next page.

Table E.1 (Continued)

Sequence Number[a]	Outfall Identifications[b]	Ownership	Water Body	Assessment Area	Latitude	Longitude	Condition	Dimensions (inches)	Notes
102	OSWO56; SM12; RHDOF75	City of South Milwaukee	Oak Creek Mainstem	Lower Oak Creek	42.91175	-87.87055	Fair	12	Left bank; corrugated metal pipe metered with a concrete block apron that carries flow down bank to channel; bank is eroding underneath apron; near manhole QQ1; Monroe Avenue
103	SM11; RHDOF77	City of South Milwaukee	Oak Creek Mainstem	Lower Oak Creek	42.91112	-87.87073	--	12	Left bank; near manhole KK227; Milwaukee Avenue
104	SM10; RHDOF76	City of South Milwaukee	Oak Creek Mainstem	Lower Oak Creek	42.91115	-87.87102	--	15	Right bank; corrugated metal pipe built into concrete side slope; near manhole SS2-1F
105	OSWO57	Unknown	Oak Creek Mainstem	Lower Oak Creek	42.91073	-87.87109	Fair	18	Right bank; corrugated metered metal pipe build into concrete side slope; bottom of pipe is rusted through slightly and collecting some sediment
106	OSWO58; SM9; RHDOF78	City of South Milwaukee	Oak Creek Mainstem	Lower Oak Creek	42.90998	-87.87193	Good	21	Left bank; corrugated metered metal pipe build into concrete side slope near upstream terminus of concrete side slope; concrete side slope is experiencing undercutting at terminus; near manhole FF1-1; Michigan Avenue
107	OSWO59; SM8	City of South Milwaukee	Oak Creek Mainstem	Lower Oak Creek	42.90996	-87.87223	Poor	18	Right bank; corrugated metal pipe metered with a concrete block apron that carries flow down bank to channel; pipe end is rusted through completely; some erosion undercutting end of apron; near manhole G4; Madison Avenue
108	OSWO60; SM7; OF79	City of South Milwaukee	Oak Creek Mainstem	Lower Oak Creek	42.90955	-87.87289	Poor	18	Right bank; corrugated metal pipe metered with a concrete block apron that carries flow down bank to channel; pipe end is beginning to rust through; Concrete apron is cracked in middle and bank is eroding under upstream side; near manhole EE8; Michigan Avenue
109	OSWO61	Unknown	Oak Creek Mainstem	Lower Oak Creek	42.90935	-87.87291	Fair	12	Left bank; corrugated metal pipe metered with a concrete block apron that carries flow down bank to channel; set back about 20 feet from channel
110	OSWO62; SM6; RHDOF80	City of South Milwaukee	Oak Creek Mainstem	Lower Oak Creek	42.90917	-87.87303	Fair	15	Left bank; corrugated metal pipe metered with a concrete block apron that carries flow down bank to channel; set back about 20 feet from channel; near manhole FF3-1H; Michigan Avenue
111	OSWO63	Unknown	Oak Creek Mainstem	Lower Oak Creek	42.90871	-87.87348	Fair	--	Left bank; outfall has a rubber flap that is closed on the end section; pump house directly up-bank from outfall; possibly an emergency sanitary sewer outfall
112	OSWO64; SM5; RHDOF82	City of South Milwaukee	Oak Creek Mainstem	Lower Oak Creek	42.90818	-87.87390	Good	24	Left bank; corrugated metal pipe with a one foot diameter PVC pipe inside main pipe; protected by boulder riprap; near manhole CC35; Marquette Avenue
113	OSWO65; SM4; RHDOF81	City of South Milwaukee	Oak Creek Mainstem	Lower Oak Creek	42.90801	-87.87424	Good	24	Right bank; corrugated metal pipe metered with a concrete block apron that carries flow down bank to channel; near manhole BB2; Marquette Avenue
114	OSWO66	Unknown	Oak Creek Mainstem	Lower Oak Creek	42.90714	-87.87487	Poor	12	Left bank; corrugated metal pipe with flared end section; pipe is protruding from bank about seven feet; roughly two foot drop from pipe end section to channel

Table continued on next page.

Table E.1 (Continued)

Sequence Number[a]	Outfall Identifications[b]	Ownership	Water Body	Assessment Area	Latitude	Longitude	Condition	Dimensions (inches)	Notes
115	OSWO67; SM3; RHDOF83	City of South Milwaukee	Oak Creek Mainstem	Lower Oak Creek	42.90682	-87.87496	Good	108	Major outfall; left bank; concrete culvert with 75 foot long concrete channel leading to Oak Creek; near manhole WW158; City Hall
116	OSWO68; SM2	City of South Milwaukee	Oak Creek Mainstem	Lower Oak Creek	42.90685	-87.87535	Good	18	Left bank; corrugated metal pipe with concrete block apron; near manhole WW270; Marshall Court
117	OSWO69; SM1; RHDOF84	City of South Milwaukee	Oak Creek Mainstem	Lower Oak Creek	42.90621	-87.87797	Good	18	Right bank; corrugated metal metered pipe with concrete block apron that carries flow to channel; near manhole W2; Marshall Avenue
118	OSWO70; 10-1-1	City of Oak Creek	Oak Creek Mainstem	Lower Oak Creek	42.90531	-87.88210	Fair	48	Major outfall; right bank; concrete pipe with poured cement apron; channel has a four-foot scour pool at outfall; drains subbasins O23-1 through O23-5, an area of about 95 acres; 7651 S. Pennsylvania Avenue
119	3-1-1	City of Oak Creek	Offline	Lower Oak Creek	42.92248	-87.88225	--	27	2307 E. Oak Street; drains subbasin L1-1, a total of about 25 acres
120	3-3-1	City of Oak Creek	Offline	Lower Oak Creek	42.91893	-87.88106	--	42	S. Pennsylvania Avenue and E. Chestnut Drive; drains subbasins L1-1, L1-2, L2-1, L2-2, and L2-3, a total area of about 81 acres
121	15-4-1	City of Oak Creek	Offline	Lower Oak Creek	42.90140	-87.88181	--	29 x 45	7887 S. Pennsylvania Avenue, drains subbasin OC499B, an area of about 17 acres
122	14-1-1	City of Oak Creek	Offline	Lower Oak Creek	42.89340	-87.86926	--	48	3331 E. Forest Hill Avenue, drains subbasins L3-1 through L3-12, an area of about 323 acres
123	14-5-1	City of Oak Creek	Offline	Lower Oak Creek	42.88728	-87.86528	--	58 x 91	3480 E. Puetz Road; drains subbasin L3-1, an area of about 129 acres
124	9-2-1	City of Oak Creek	Unnamed Tributary to Mitchell Field Drainage Ditch	Lower Mitchell Field Drainage Ditch	42.90707	-87.89613	--	54	S. Clement Avenue and E. Montana Avenue; drains subbasins M5-1 through M5-6, an area of about 134 acres
125	9-1-1	City of Oak Creek	Unnamed Tributary to Mitchell Field Drainage Ditch	Lower Mitchell Field Drainage Ditch	42.91169	-87.90108	--	42	S. Shepard Avenue and E. Monroe Avenue; drains subbasins M5-1 and M5-2, an area of about 55 acres
126	MFSWO1	Unknown	Mitchell Field Drainage Ditch	Lower Mitchell Field Drainage Ditch	42.91509	-87.89247	--	--	Outfall is mostly submerged under water with sediment accumulation
127	M4-1-1	City of Oak Creek	Unnamed Tributary to Mitchell Field Drainage Ditch	Lower Mitchell Field Drainage Ditch	42.92276	-87.90247	--	30	709 E. Oak Street; drains part of subbasin M4-1, an area of about 12 acres
128	3-2-1	City of Oak Creek	Offline	Lower Mitchell Field Drainage Ditch	42.91842	-87.88712	--	36	6915 S. Juniper Drive (rear); drains subbasin MF-15, an area of about 41 acres
129	MFDD1	Unknown	Mitchell Field Drainage Ditch	Lower Mitchell Field Drainage Ditch	42.92260	-87.89105	Fair	24	Left bank; corrugated metal pipe protrudes about five feet from the bank; erosion around pipe; sediment accumulation in pipe; likely drains Milwaukee County garden rental plots
130	MFSWO2	Unknown	Mitchell Field Drainage Ditch	Lower Mitchell Field Drainage Ditch	42.92419	-87.89047	Good	38	Right bank; corrugated metal pipe with flared end section terminates about 15 feet away from channel; potentially drainage associated with adjacent City of Milwaukee dump used for construction fill
131	--	Milwaukee County	Unnamed Tributary to Mitchell Field Drainage Ditch	Lower Mitchell Field Drainage Ditch	42.92767	-87.89621	--	--	No additional information available

Table continued on next page.

Table E.1 (Continued)

Sequence Number[a]	Outfall Identifications[b]	Ownership	Water Body	Assessment Area	Latitude	Longitude	Condition	Dimensions (inches)	Notes
132	--	Milwaukee County	Offline	Lower Mitchell Field Drainage Ditch	42.92911	-87.89988	--	--	No additional information available
133	MFSWO3	Unknown	Mitchell Field Drainage Ditch	Lower Mitchell Field Drainage Ditch	42.92822	-87.89028	Fair	36	Right bank; corrugated metal pipe outfalls about 15 feet away from channel
134	CUD16	City of Cudahy	Offline	Lower Mitchell Field Drainage Ditch	42.93173	-87.88662	--	--	No additional information available
135	--	Milwaukee County	Mitchell Field Drainage Ditch	Mitchell Field Drainage Ditch – Airport	42.93429	-87.88992	--	--	Milwaukee Mitchell International Airport
136	--	Milwaukee County	Mitchell Field Drainage Ditch	Mitchell Field Drainage Ditch – Airport	42.93430	-87.88991	--	--	Milwaukee Mitchell International Airport
137	--	Milwaukee County	Mitchell Field Drainage Ditch	Mitchell Field Drainage Ditch – Airport	42.93433	-87.88990	--	--	Milwaukee Mitchell International Airport
138	--	Milwaukee County	Unnamed Tributary to Mitchell Field Drainage Ditch	Mitchell Field Drainage Ditch – Airport	42.93442	-87.89007	--	--	Milwaukee Mitchell International Airport
139	--	Milwaukee County	Unnamed Tributary to Mitchell Field Drainage Ditch	Mitchell Field Drainage Ditch – Airport	42.93443	-87.89008	--	--	Milwaukee Mitchell International Airport
140	--	Milwaukee County	Unnamed Tributary to Mitchell Field Drainage Ditch	Mitchell Field Drainage Ditch – Airport	42.93458	-87.89441	--	--	Milwaukee Mitchell International Airport
141	--	Milwaukee County	Unnamed Tributary to Mitchell Field Drainage Ditch	Mitchell Field Drainage Ditch – Airport	42.93897	-87.89423	--	--	Milwaukee Mitchell International Airport
142	--	Milwaukee County	Mitchell Field Drainage Ditch	Mitchell Field Drainage Ditch – Airport	42.93718	-87.89452	--	--	Milwaukee Mitchell International Airport
143	--	Milwaukee County	Mitchell Field Drainage Ditch	Mitchell Field Drainage Ditch – Airport	42.93724	-87.89451	--	--	Milwaukee Mitchell International Airport
144	--	Milwaukee County	Mitchell Field Drainage Ditch	Mitchell Field Drainage Ditch – Airport	42.93730	-87.89448	--	--	Milwaukee Mitchell International Airport
145	--	Milwaukee County	Unnamed Tributary to Mitchell Field Drainage Ditch	Mitchell Field Drainage Ditch – Airport	42.93950	-87.89969	--	--	Milwaukee Mitchell International Airport
146	--	Milwaukee County	Unnamed Tributary to Mitchell Field Drainage Ditch	Mitchell Field Drainage Ditch – Airport	42.93951	-87.89967	--	--	Milwaukee Mitchell International Airport
147	--	Milwaukee County	Mitchell Field Drainage Ditch	Mitchell Field Drainage Ditch – Airport	42.93794	-87.90618	--	--	Milwaukee Mitchell International Airport
148	--	Milwaukee County	Mitchell Field Drainage Ditch	Mitchell Field Drainage Ditch – Airport	42.93800	-87.90638	--	--	Milwaukee Mitchell International Airport
149	--	Milwaukee County	Unnamed Tributary to Mitchell Field Drainage Ditch	Mitchell Field Drainage Ditch – Airport	42.93991	-87.91035	--	--	Milwaukee Mitchell International Airport
150	--	Milwaukee County	Mitchell Field Drainage Ditch	Mitchell Field Drainage Ditch – Airport	42.93849	-87.91176	--	--	Milwaukee Mitchell International Airport
151	RHDOF36	City of Milwaukee	Unnamed Tributary to Mitchell Field Drainage Ditch	Mitchell Field Drainage Ditch – Airport	42.93658	-87.91950	--	54	Concrete pipe with flared end section

Table continued on next page.

Table E.1 (Continued)

Sequence Number[a]	Outfall Identifications[b]	Ownership	Water Body	Assessment Area	Latitude	Longitude	Condition	Dimensions (inches)	Notes
152	--	Milwaukee County	Offline	Mitchell Field Drainage Ditch – Airport	42.93141	-87.90012	--	--	No additional information available
153	--	Milwaukee County	Offline	Mitchell Field Drainage Ditch – Airport	42.93262	-87.90008	--	--	No additional information available
154	--	Milwaukee County	Offline	Mitchell Field Drainage Ditch – Airport	42.94058	-87.89987	--	--	No additional information available
155	--	Milwaukee County	Offline	Mitchell Field Drainage Ditch – Airport	42.94033	-87.90538	--	--	No additional information available
156	--	Milwaukee County	Offline	Mitchell Field Drainage Ditch – Airport	42.94038	-87.90823	--	--	No additional information available
157	--	Milwaukee County	Offline	Mitchell Field Drainage Ditch – Airport	42.94063	-87.91929	--	--	No additional information available
158	OTRIB4; 9-3-1	City of Oak Creek	Unnamed Tributary to Oak Creek	Middle Oak Creek	42.90311	-87.89364	--	42	S. Clement Avenue and E. Manitowoc Avenue; outfall is about 750 feet west of Oak Creek's mainstem and flows to Creek as a tributary; drains subbasin O21-1, an area of about 63 acres
159	OSWO71	Unknown	Oak Creek Mainstem	Middle Oak Creek	42.90117	-87.89290	Fair	24	Left bank; concrete pipe with flared end section
160	OSWO72; OC498B-1	City of Oak Creek	Oak Creek Mainstem	Middle Oak Creek	42.90109	-87.89325	Fair	36	1442 E. Drexel; right bank; concrete pipe with flared end section slightly splitting at seam; drains subbasin OC498B, an area of about 18 acres
161	16-1-1	City of Oak Creek	Unnamed Tributary to Oak Creek	Middle Oak Creek	42.89973	-87.89411	--	96	1321 E. Drexel Avenue; flows to SEWRPC's OTRIB3; drains subbasins O20-1 through O20-10, an area of about 342 acres
162	16-2-1	City of Oak Creek	Unnamed Tributary to Oak Creek	Middle Oak Creek	42.89736	-87.90292	--	34 x 54	640 E. Lakeview Drive; drains subbasin O20-11, an area of about 62 acres
163	21-4-1	City of Oak Creek	Unnamed Tributary to Oak Creek	Middle Oak Creek	42.88568	-87.90191	--	54	8734 S. Shepard Avenue; drains subbasins O19-1 through O19-10, O19-10A, and O19-11, an area of about 180 acres
164	15-5-1	City of Oak Creek	Oak Creek Mainstem	Middle Oak Creek	42.88656	-87.88503	--	60	E. Puetz Road and Oak Creek; located off channel; drains subbasins 18-1 through O18-5, an area of about 114 acres
165	OTRIB8	--	Oak Creek Drainage Ditches	Middle Oak Creek	42.88613	-87.88550	--	--	Confluence of Oak Creek Drainage Ditches with Oak Creek's Mainstem; just upstream of E. Puetz Road
166	23-5-1	City of Oak Creek	Unnamed Drainage Ditch	Middle Oak Creek Drainage Ditches	42.87403	-87.87314	--	29 x 45	S. 15th Avenue and E. Woodview Avenue; drains subbasin O17-3, an area of about 30 acres
167	15-6-1	City of Oak Creek	Offline	Middle Oak Creek	42.88685	-87.87894	--	48	2630 E Sharon Drive; drains subbasin O18-3, an area of about 50 acres
168	OSWO73	Unknown	Oak Creek Mainstem	Middle Oak Creek	42.88149	-87.89227	Good	12	Right bank; downstream side of Nicholson Road crossing; corrugated plastic pipe with metal flared end section; about 15 feet up embankment
169	OSWO74	Unknown	Oak Creek Mainstem	Middle Oak Creek	42.88140	-87.89227	Good	12	Left bank; downstream side of Nicholson Road crossing; corrugated plastic pipe with metal flared end section; about 15 feet up embankment
170	OSWO75	Unknown	Oak Creek Mainstem	Middle Oak Creek	42.88147	-87.89250	Good	12	Right bank; upstream side of Nicholson Road crossing; corrugated plastic pipe with metal flared end section; about 15 feet up embankment

Table continued on next page.

Table E.1 (Continued)

Sequence Number[a]	Outfall Identifications[b]	Ownership	Water Body	Assessment Area	Latitude	Longitude	Condition	Dimensions (inches)	Notes
171	OSWO76	Unknown	Oak Creek Mainstem	Middle Oak Creek	42.88135	-87.89252	Good	12	Left bank; upstream side of Nicholson Road crossing; corrugated plastic pipe with metal flared end section; about 15 feet up embankment
172	28-1-1	City of Oak Creek	Offline	Middle Oak Creek	42.87038	-87.90441	--	36	S. Veronica Street extended; drains subbasins O10-1, O10-2, and O10-3, an area of about 42 acres
173	OSWO77	Milwaukee County	Oak Creek Mainstem	Middle Oak Creek	42.87536	-87.90483	Fair	36	Left bank; corrugated metal pipe protruding about eight feet from the bank
174	OSWO78; 21-9-1	City of Oak Creek	Oak Creek Mainstem	Middle Oak Creek	42.87538	-87.90484	Good	36 x 48	9220 S. Howell Avenue (County Park); left bank; concrete culvert with flared end section and riprap channel running about 17 feet to Creek; drains subbasin OC-472, an area of about 26 acres
175	OSWO79	Unknown	Oak Creek Mainstem	Middle Oak Creek	42.87715	-87.90512	Good	12	Left bank; white PVC pipe located about eight feet off channel; erosion occurring around pipe
176	21-5-1	City of Oak Creek	Unnamed Tributary to Oak Creek	Middle Oak Creek	42.88115	-87.91199	--	42	9000 S. Howell Avenue; drains subbasins O8-11 and O8-12, an area of about 55 acres
177	21-1-1	City of Oak Creek	Unnamed Tributary to Oak Creek	Middle Oak Creek	42.88522	-87.91132	--	48 x 96	8770 S. Howell Avenue; drains subbasins O8-1 through O8-8, O8-9A, and O8-9B, an area of about 178 acres
178	21-2-1	City of Oak Creek	Unnamed Tributary to Oak Creek	Middle Oak Creek	42.88527	-87.91130	--	42	8770 S. Howell Avenue; drains subbasin O8-10, an area of about 30 acres
179	OSWO81	Unknown	Oak Creek Mainstem	Middle Oak Creek	42.87681	-87.91252	Fair	--	Right bank; underneath Howell Avenue bridge, between northbound and southbound lanes
180	OSWO80	Unknown	Oak Creek Mainstem	Middle Oak Creek	42.87668	-87.91252	Fair	72	Left bank; concrete pipe with trash rack; underneath Howell Avenue bridge
181	NBTRIB3; 20-1-1	City of Oak Creek	North Branch Oak Creek	Lower North Branch Oak Creek	42.88502	-87.92291	--	42	Right bank; drains subbasin NB-58, an area of about 19 acres; outfall is about 175 feet off of North Branch Oak Creek; Flows into tributary channel to the North Branch
182	NBSWO1	Unknown	North Branch Oak Creek	Lower North Branch Oak Creek	42.88705	-87.92429	Good	12	Left Bank; corrugated plastic pipe; About 5.5 feet up bank; on City of Oak Creek Streets Division property
183	NBSWO2	Unknown	North Branch Oak Creek	Lower North Branch Oak Creek	42.88714	-87.92430	Good	30	Left bank: concrete pipe; about 18 feet up bank; on City of Oak Creek Streets Division property
184	NBSWO3	Unknown	North Branch Oak Creek	Lower North Branch Oak Creek	42.88741	-87.92409	Good	30	Right bank; concrete pipe with flared end section about 10 feet up bank; on City of Oak Creek Streets Division property
185	NBSWO4	Unknown	North Branch Oak Creek	Lower North Branch Oak Creek	42.88773	-87.92409	Failed	15	Left bank; concrete pipe protruding about 7 feet from bank due to bank erosion
186	NBSWO5	Unknown	North Branch Oak Creek	Lower North Branch Oak Creek	42.88836	-87.92349	Good	18	Right bank; concrete pipe with flared end section; setback about five feet from bank; about 1.5 foot drop from outfall to channel
187	NBSWO6	Unknown	North Branch Oak Creek	Lower North Branch Oak Creek	42.89278	-87.92567	Good	24	Left bank; outlet for stormwater pond about 100 feet up bank; outfall is about 26 feet off channel; riprap protection
188	NBSWO7	Unknown	North Branch Oak Creek	Lower North Branch Oak Creek	42.89468	-87.92549	Poor	24	Right bank; corrugated plastic pipe protruding from bank
189	NBSWO8	Unknown	North Branch Oak Creek	Lower North Branch Oak Creek	42.89667	-87.92781	Fair	24	Left bank; concrete pipe about 21 feet removed from channel

Table continued on next page.

Table E.1 (Continued)

Sequence Number[a]	Outfall Identifications[b]	Ownership	Water Body	Assessment Area	Latitude	Longitude	Condition	Dimensions (inches)	Notes
190	NBSWO9	Unknown	North Branch Oak Creek	Lower North Branch Oak Creek	42.89700	-87.92730	Good	24	Right bank; concrete pipe with flared end section; located about 56 feet up bank from channel; riprap protection and cattail channel down to North Branch Oak Creek
191	17-1-1	City of Oak Creek	North Branch Oak Creek	Lower North Branch Oak Creek	42.89951	-87.92567	--	42	7975 S. Wildwood Drive; drains subbasin NB-43, an area of about 60 acres
192	NBSWO10, 17-2-0	City of Oak Creek	North Branch Oak Creek	Lower North Branch Oak Creek	42.90035	-87.92417	Poor	36	Right bank; 8020 S. Wildwood Drive; concrete pipe; end section is splitting at seams; There is a blowout up bank from end section that has created a four foot deep hole that is covered by grass and hard to see; drains subbasins N6-1 and N6-2, an area of about 49 acres
193	NBSWO11, 18-10-1	City of Oak Creek	North Branch Oak Creek	Lower North Branch Oak Creek	42.90271	-87.91936	Poor	21	7815 S. 6th Street; drains subbasin NB-38, an area of about nine acres; left bank; Corrugated metal pipe that is rusted through and protruding from bank
194	8-11-1	City of Oak Creek	North Branch Oak Creek	Lower North Branch Oak Creek	42.90298	-87.91840	--	21	7800 S. 6th Street; drains subbasin NB-36, an area of about four acres
195	8-12-1	City of Oak Creek	North Branch Oak Creek	Lower North Branch Oak Creek	42.90390	-87.91514	--	24	7625 S. Howell Avenue; drains subbasin NB-35, an area of about three acres
196	17-10-1	City of Oak Creek	Offline	Lower North Branch Oak Creek	42.88906	-87.92251	--	36	406 W. Peutz Road; drains part of N9-3
197	N9-4-1	City of Oak Creek	Offline	Lower North Branch Oak Creek	42.89226	-87.91981	--	30	Drains part of subbasin N9-3
198	17-8-1	City of Oak Creek	Offline	Lower North Branch Oak Creek	42.89384	-87.92201	--	42	535 W. Forest Hill Avenue (rear); drains subbasin N9-1, an area of about 20 acres
199	N5-14-1	City of Oak Creek	Rawson Avenue Tributary	Rawson Avenue Tributary	42.90722	-87.92014	--	24	Drains subbasin N5-14, an area of about four acres
200	RHDOF28	Unknown	Rawson Avenue Tributary	Rawson Avenue Tributary	42.90795	-87.92163	--	--	Concrete pipe with poured concrete apron side slope
201	8-5-1	City of Oak Creek	Rawson Avenue Tributary	Rawson Avenue Tributary	42.90828	-87.92219	--	66	Drains subbasins N5-10 and N5-12, an area of about 80 acres
202	8-6-1; RHDOF1	City of Oak Creek	Rawson Avenue Tributary	Rawson Avenue Tributary	42.90883	-87.92708	--	36	7481 S. 10th Street; concrete box culvert exiting concrete wall; drains subbasin N5-8, an area of about 24 acres
203	RHDOF3	Unknown	Tributary to Rawson Avenue Tributary	Rawson Avenue Tributary	42.90924	-87.92693	--	--	concrete pipe exiting at concrete lined channel side slopes
204	RHDOF4	Unknown	Tributary to Rawson Avenue Tributary	Rawson Avenue Tributary	42.90961	-87.92710	--	--	Concrete pipe with poured concrete apron
205	RHDOF14	Unknown	Tributary to Rawson Avenue Tributary	Rawson Avenue Tributary	42.91007	-87.92704	--	--	Concrete pipe with poured concrete apron
206	RHDOF7	Unknown	Tributary to Rawson Avenue Tributary	Rawson Avenue Tributary	42.91033	-87.92696	--	--	Concrete pipe with poured concrete apron
207	RHDOF8	Unknown	Tributary to Rawson Avenue Tributary	Rawson Avenue Tributary	42.91041	-87.92694	--	--	Concrete pipe with poured concrete apron
208	RHDOF10	Unknown	Tributary to Rawson Avenue Tributary	Rawson Avenue Tributary	42.91089	-87.92703	--	--	Concrete pipe with poured concrete apron
209	RHDOF12	Unknown	Tributary to Rawson Avenue Tributary	Rawson Avenue Tributary	42.91115	-87.92700	--	--	Concrete pipe with poured concrete apron

Table continued on next page.

Table E.1 (Continued)

Sequence Number[a]	Outfall Identifications[b]	Ownership	Water Body	Assessment Area	Latitude	Longitude	Condition	Dimensions (inches)	Notes
210	RHDOF13	Unknown	Tributary to Rawson Avenue Tributary	Rawson Avenue Tributary	42.91122	-87.92682	--	--	Concrete pipe with poured concrete apron
211	RHDOF15	Unknown	Tributary to Rawson Avenue Tributary	Rawson Avenue Tributary	42.91166	-87.92696	--	12	Concrete pipe with poured concrete apron
212	RHDOF16B	Unknown	Tributary to Rawson Avenue Tributary	Rawson Avenue Tributary	42.91199	-87.92695	--	--	Concrete pipe with poured concrete apron
213	RHDOF16	Unknown	Tributary to Rawson Avenue Tributary	Rawson Avenue Tributary	42.91182	-87.92699	--	--	Concrete pipe with poured concrete apron
214	RHDOF18	Unknown	Tributary to Rawson Avenue Tributary	Rawson Avenue Tributary	42.91230	-87.92694	--	--	Concrete pipe with poured concrete apron
215	RHDOF17	Unknown	Tributary to Rawson Avenue Tributary	Rawson Avenue Tributary	42.91233	-87.92695	--	--	Concrete pipe with poured concrete apron
216	RHDOF19	Unknown	Tributary to Rawson Avenue Tributary	Rawson Avenue Tributary	42.91270	-87.92692	--	--	Concrete ellipse pipe with poured concrete apron
217	RHDOF20	Unknown	Tributary to Rawson Avenue Tributary	Rawson Avenue Tributary	42.91274	-87.92693	--	--	Concrete pipe with poured concrete apron
218	8-13-1; RHDOF21	City of Oak Creek	Tributary to Rawson Avenue Tributary	Rawson Avenue Tributary	42.91270	-87.92688	--	36	Concrete pipe exiting at concrete lined channel side slopes; entered as same ID as below with 2 different dimensions
219	8-13-1; RHDOF24	City of Oak Creek	Tributary to Rawson Avenue Tributary	Rawson Avenue Tributary	42.91275	-87.92685	--	48	Concrete pipe with flared end section and poured concrete apron; entered as same ID as above with 2 different dimensions
220	N4-21-1; RHDOF22	City of Oak Creek	Tributary to Rawson Avenue Tributary	Rawson Avenue Tributary	42.91342	-87.92694	--	24	Concrete pipe with poured concrete apron; Drains part of subbasin N4-21
221	RHDOF23	Unknown	Tributary to Rawson Avenue Tributary	Rawson Avenue Tributary	42.91342	-87.92694	--	--	Concrete pipe with poured concrete apron
222	RHDOF24B	Unknown	Tributary to Rawson Avenue Tributary	Rawson Avenue Tributary	42.91382	-87.92680	--	--	Silt and scum present at time of City of Racine Public Health Department visits
223	RHDOF27	Unknown	Tributary to Rawson Avenue Tributary	Rawson Avenue Tributary	42.91403	-87.92677	--	--	Metered concrete pipe exiting from concrete side slope
224	RHDOF25	Unknown	Tributary to Rawson Avenue Tributary	Rawson Avenue Tributary	42.91407	-87.92689	--	--	Concrete pipe exiting from concrete side slope
225	RHDOF26	Unknown	Tributary to Rawson Avenue Tributary	Rawson Avenue Tributary	42.91408	-87.92689	--	--	Concrete pipe exiting from concrete side slope; End of pipe is chipped exposing metal rebar
226	8-1-1	City of Oak Creek	Tributary to Rawson Avenue Tributary	Rawson Avenue Tributary	42.91410	-87.92676	--	144 x 60	Culvert carrying Tributary to Rawson Avenue Tributary in under S. 10th Street; drains subbasins N4-1 through N4-20, an area of about 338 acres
227	6-4-1	City of Oak Creek	Tributary to Rawson Avenue Tributary	Rawson Avenue Tributary	42.91844	-87.93617	--	54	Near southbound off-ramp I-94 and Rawson; drains subbasins N4-1 through N4-4
228	NBSWO12	Unknown	North Branch Oak Creek	Upper North Branch Oak Creek	42.90761	-87.91537	Poor	18	Left bank; corrugated metal pipe about 17 feet removed from channel; outlet crushed
229	NBSWO13; 8-7-1	City of Oak Creek	North Branch Oak Creek	Upper North Branch Oak Creek	42.90890	-87.91521	Good	36	Left bank; newly replaced concrete pipe with flared end section; 303 W. Marquette Avenue; drains subbasin NB-31 (west), an area of about eight acres; municipality reports pipe as 24 inches but may be dimensions before replacement; riprap protection

Table continued on next page.

Table E.1 (Continued)

Sequence Number[a]	Outfall Identifications[b]	Ownership	Water Body	Assessment Area	Latitude	Longitude	Condition	Dimensions (inches)	Notes
230	NBSWO14; 8-8-1	City of Oak Creek	North Branch Oak Creek	Upper North Branch Oak Creek	42.90890	-87.91512	Good	36	Right bank; newly replaced concrete pipe with flared end section; 181 W. Marquette Avenue; drains subbasin NB-31 (east), an area of about 13 acres; municipality reports pipe as 30 inches but may be dimensions before replacement; riprap protection
231	NBSWO15	Unknown	North Branch Oak Creek	Upper North Branch Oak Creek	42.91022	-87.91507	Fair	15	Right bank; concrete metered pipe; about seven feet up bank from channel
232	NBSWO16	Unknown	North Branch Oak Creek	Upper North Branch Oak Creek	42.91057	-87.91507	Poor	12	Right bank; corrugated metal pipe with some sediment inside
233	NBSWO17	Unknown	North Branch Oak Creek	Upper North Branch Oak Creek	42.91078	-87.91511	Failed	--	Left bank; corrugated metal pipe that is crushed; pipe is about eight feet up bank; possibly abandoned
234	NBSWO18	Unknown	North Branch Oak Creek	Upper North Branch Oak Creek	42.91109	-87.91514	Failed	--	Left bank; corrugated metal pipe is buried in soil and grass
235	NBSWD4	Unknown	North Branch Oak Creek	Upper North Branch Oak Creek	42.91141	-87.91501	Failed	--	Plastic pipe
236	NBSWO19	Unknown	North Branch Oak Creek	Upper North Branch Oak Creek	42.91219	-87.91493	--	12	Right bank; corrugated plastic pipe about 34 feet up bank
237	NBSWD5; 8-4-1	City of Oak Creek	North Branch Oak Creek	Upper North Branch Oak Creek	42.91347	-87.91492	Fair	30 x 42	Right bank; 7195 S. 1st Street (rear); corrugated metal pipe; drains subbasin NB-29, an area of about 23 acres
238	NBSWD6	Unknown	North Branch Oak Creek	Upper North Branch Oak Creek	42.91367	-87.91490	Failed	--	Right bank; corrugated plastic pipe; top has been mowed over and destroyed
239	NBSWD7	Unknown	North Branch Oak Creek	Upper North Branch Oak Creek	42.91388	-87.91489	Failed	--	Right bank, plastic pipe; top has been mowed over and damaged
240	NBSWO20	Unknown	North Branch Oak Creek	Upper North Branch Oak Creek	42.91405	-87.91502	Fair	24 x 30; 27	Left bank; two outfalls; outfall closest to channel is a corrugated metal pipe with blacktop on top; second outfall is a PVC pipe with a concrete apron
241	NBSWD8	Unknown	North Branch Oak Creek	Upper North Branch Oak Creek	42.91422	-87.91488	Failed	--	Right bank, plastic pipe; top has been mowed over and damaged
242	NBSWO21	Unknown	North Branch Oak Creek	Upper North Branch Oak Creek	42.91465	-87.91510	Failed	--	Left bank; pipe is covered by dirt and grass located about 12 feet up bank; water present doesn't seem to have path to Creek
243	NBSWO22	Unknown	North Branch Oak Creek	Upper North Branch Oak Creek	42.91764	-87.91765	Poor	--	Left bank; corrugated metal pipe is rusted through; located about 15 feet up bank; flow causing rill erosion to stream
244	NBSWO23; 5-6-1	City of Oak Creek	North Branch Oak Creek	Upper North Branch Oak Creek	42.91782	-87.91941	Good	21	Right bank; 7001 S. 6th Street; concrete pipe with flared end section flows onto concrete lined bank; drains subbasin NB-25, an area of about five acres
245	NBSWD11	Unknown	North Branch Oak Creek	Upper North Branch Oak Creek	42.91967	-87.92084	Good	30	Left bank; corrugated metal pipe
246	NB-21-1	City of Oak Creek	North Branch Oak Creek	Upper North Branch Oak Creek	42.92013	-87.92077	--	30	6845 S. 6th Street; drains subbasin NB-21, an area of about nine acres
247	NBSWO24, NB-20-1; RHDOF106	City of Oak Creek	North Branch Oak Creek	Upper North Branch Oak Creek	42.92139	-87.92064	Fair	30	Right bank; 8745 S. 6th Street; concrete pipe with flared end section; drains subbasin NB-20, an area of about nine acres

Table continued on next page.

Table E.1 (Continued)

Sequence Number[a]	Outfall Identifications[b]	Ownership	Water Body	Assessment Area	Latitude	Longitude	Condition	Dimensions (inches)	Notes
248	NBSWD12	Unknown	North Branch Oak Creek	Upper North Branch Oak Creek	42.92230	-87.92055	Poor	12	Left bank; corrugated metal pipe
249	NBSWO25; NB-19-1; RHDOF107	City of Oak Creek	North Branch Oak Creek	Upper North Branch Oak Creek	42.92280	-87.92049	Fair	24	Right bank; 8701 S. 6th Street; concrete pipe with flared end section; riprap piled at outlet; drains subbasin NB-19, an area of about five acres;
250	N2-7-1	City of Oak Creek	College Avenue Tributary	College Avenue Tributary	42.92310	-87.92421	--	36	1010 W. Anderson Court (rear); drains subbasin N2-7, an area of about 33 acres
251	RHDOF29	Unknown	College Avenue Tributary	College Avenue Tributary	42.92725	-87.93256	--	--	Small outfall; overgrown with weeds; sign reading "Storm Outlet 3"
252	RHDOF30	Unknown	College Avenue Tributary	College Avenue Tributary	42.92778	-87.93294	--	--	Sign reading "Storm Outlet 4"
253	6-1-3	City of Oak Creek	Offline	Upper North Branch Oak Creek	42.92881	-87.93993	--	48	8425 S. 20th Street; drains subbasins N2-2, N2-3, and N2-4, an area of about 86 acres
254	NBSWO26	Unknown	North Branch Oak Creek	Upper North Branch Oak Creek	42.92355	-87.92037	Fair	18	Right bank; corrugated metal pipe with flared end section; about 15 feet off channel; Located on MATC campus property near salt storage facility
255	NBSWO27	Unknown	North Branch Oak Creek	Upper North Branch Oak Creek	42.92369	-87.92036	Good	24	Right bank; corrugated plastic pipe with flared end section; located on MATC campus property near salt storage facility
256	NBSWO28	Unknown	North Branch Oak Creek	Upper North Branch Oak Creek	42.92711	-87.92180	Protruding	12	Right bank; corrugated metal pipe; protruding from bank about five feet and overhanging channel about four feet
257	RHDOF32	City of Milwaukee	North Branch Oak Creek	Upper North Branch Oak Creek	42.93309	-87.93062	--	15	PVC pipe
258	RHDOF31	City of Milwaukee	North Branch Oak Creek	Upper North Branch Oak Creek	42.93400	-87.93129	--	21	Corrugated metal pipe
259	I94 SW Outfall; RHDOF34	Unknown	North Branch Oak Creek	Upper North Branch Oak Creek	42.93722	-87.93454	--	24	Concrete pipe with flared end section
260	RHDOF33	Unknown	North Branch Oak Creek	Upper North Branch Oak Creek	42.93795	-87.93456	--	--	Concrete pipe with flared end section
261	RHDOF35	City of Milwaukee	North Branch Oak Creek	Upper North Branch Oak Creek	42.94205	-87.93906	--	--	Concrete pipe; submerged; black color appears to converge under bridge and discharge from outfall
262	US-most Outfall	City of Milwaukee	North Branch Oak Creek	Upper North Branch Oak Creek	42.94426	-87.94238	Poor	120 x 72	This is the point at which North Branch Oak Creek daylights; upstream of this outfall the Creek is underground; large concrete box culvert with wing walls and trash rack; large crack in apron of end section
263	OSWD3	Unknown	Oak Creek Mainstem	Upper Oak Creek	42.87007	-87.92740	--	--	Riprap lined stormwater pond outlet; Outlet channel runs about 500 feet from stormwater pond located on south side of Ryan Road to Oak Creek's main channel
264	OSWO82	Milwaukee County	Oak Creek Mainstem	Upper Oak Creek	42.87040	-87.93212	Good	48	Left bank; concrete pipe with flared end section; located up embankment
265	OSWO83	Milwaukee County	Oak Creek Mainstem	Upper Oak Creek	42.87051	-87.93215	Good	48	Right bank; concrete pipe with flared end section; about 1.5 foot drop from apron to channel
266	OSWO84	Unknown	Oak Creek Mainstem	Upper Oak Creek	42.87046	-87.93334	--	24	Concrete pipe with flared end section and trash rack

Table continued on next page.

Table E.1 (Continued)

Sequence Number[a]	Outfall Identifications[b]	Ownership	Water Body	Assessment Area	Latitude	Longitude	Condition	Dimensions (inches)	Notes
267	19-3-3	City of Oak Creek	Unnamed Tributary to Oak Creek Mainstem-Ryan Road Interchange	Upper Oak Creek	42.87494	-87.93589	--	42	9401 S. 13th Street (rear); drains subbasin O5-8, and area of about 24 acres
268	19-2-1	City of Oak Creek	Unnamed Tributary to Oak Creek Mainstem-Ryan Road Interchange	Upper Oak Creek	42.87637	-87.93766	--	36	9206 S. 22nd Street; drains subbasins O5-1, O5-2, and part of O3-1
269	OSWO85	Unknown	Oak Creek Mainstem	Upper Oak Creek	42.86916	-87.93678	--	--	Left bank; partially buried; located under Ryan Road off ramp from IH 94
270	OSWO87	Unknown	Oak Creek Mainstem	Upper Oak Creek	42.86924	-87.93725	Fair	24	Right bank; under IH 94; concrete pipe with flared end section; plugged with about two feet of sediment
271	OSWO86	Unknown	Oak Creek Mainstem	Upper Oak Creek	42.86910	-87.93727	Failed	24	Left bank; under IH 94; concrete pipe with flared end section; end section has detached from pipe
272	30-2-1	City of Oak Creek	Unnamed Tributary to Oak Creek Mainstem-Ryan Road Interchange	Upper Oak Creek	42.87135	-87.93993	--	48	Located near southbound on-ramp to IH 94 at Ryan Road; drains subbasins O3-2; O3-3; O3-1
273	OSWO88	Unknown	Oak Creek Mainstem	Upper Oak Creek	42.86909	-87.93888	Fair	18	Left bank; concrete pipe
274	OSWO89	Unknown	Oak Creek Mainstem	Upper Oak Creek	42.86897	-87.93938	Fair	12	Left bank; concrete pipe; buried at stream grade
275	OSWD4	Unknown	Oak Creek Mainstem	Upper Oak Creek	42.86926	-87.94082	Poor	18	Right bank; corrugated plastic pipe; drains truck stop parking lot up-bank
276	OSWO90; 30-9-1	City of Oak Creek	Oak Creek Mainstem	Upper Oak Creek	42.86884	-87.94100	Good	42	Left bank; corrugated metal pipe with cement apron and trash rack; 75 percent submerged; drains subbasin O4-2, an area of about 30 acres
277	OSWD5	Unknown	Oak Creek Mainstem	Upper Oak Creek	42.86928	-87.94173	Poor	18 (x2)	Right bank; two pipes, one corrugated metal and one corrugated plastic; drains truck stop up-bank
278	30-4-1	City of Oak Creek	Oak Creek Mainstem	Upper Oak Creek	42.86911	-87.94230	--	30	9680 S. 20th Street; drains subbasin OC-451, and area of about 16 acres
279	30-7-1	City of Oak Creek	Unnamed Tributary to Oak Creek Mainstem-U/S of S. 20th Street	Upper Oak Creek	42.86755	-87.94383	--	36	9775 S. 20th Street; drains part of O2-2, an area of about 10 acres
280	30-8-1	City of Oak Creek	Unnamed Tributary to Oak Creek Mainstem-U/S of S. 20th Street	Upper Oak Creek	42.86755	-87.94382	--	48 x 76	9775 S. 20th Street; drains O2-1 and part of O2-2, and area of about 89 acres
281	OSWO91; 30-6-1	City of Oak Creek	Oak Creek Mainstem	Upper Oak Creek	42.86889	-87.94599	Good	72	Major outfall; left bank; 2300 W. Southbranch Boulevard; concrete pipe with flared end section and trash rack; outlet has about two feet of sediment accumulation; drains subbasins OC-447, OC-448, and an additional 91 acres from Franklin for a total of about 165 acres
282	OSWO92	Unknown	Oak Creek Mainstem	Upper Oak Creek	42.87038	-87.95605	Fair	30	Left bank; corrugated metal pipe at S. 31st Street
283	OSWO93	Unknown	Oak Creek Mainstem	Upper Oak Creek	42.87039	-87.95627	Fair	24	Both banks; corrugated metal pipes on both embankments; drains neighborhood road ditch
284	OSWO94	Unknown	Oak Creek Mainstem	Upper Oak Creek	42.86986	-87.96102	Good	18	Left bank; concrete pipe set back about 30 feet from channel in residential backyard

Table continued on next page.

Table E.1 (Continued)

Sequence Number[a]	Outfall Identifications[b]	Ownership	Water Body	Assessment Area	Latitude	Longitude	Condition	Dimensions (inches)	Notes
285	OSWO95	Unknown	Oak Creek Mainstem	Upper Oak Creek	42.87036	-87.96254	Failed	24	Left bank; corrugated metal pipe; submerged and buried in sediment
286	OSWO96	City of Franklin	Oak Creek Mainstem	Upper Oak Creek	42.87144	-87.96437	Good	29 x45	Left bank; concrete pipe with flared end section; gravel, sand and cobble inside pipe; located about seven feet off channel with erosion
287	24-03	City of Franklin	Offline	Upper Oak Creek	42.87437	-87.95476	--	48	Offline; located on W. Central Avenue near S. 29th Street
288	Oswo97	City of Franklin	Oak Creek Mainstem	Upper Oak Creek Headwaters	42.87488	-87.96484	Good	27	Left bank; concrete metered pipe with flared end section; while pipe is 27 inches, apron measures 42x48; Outfall is located 35 feet from Creek; flow has formed channel to Creek
289	Oswo98	Unknown	Oak Creek Mainstem	Upper Oak Creek Headwaters	42.87526	-87.96487	Good	30	Right bank; concrete metered pipe with flared end section and trash rack
290	24-04	City of Franklin	Oak Creek Mainstem	Upper Oak Creek Headwaters	42.87635	-87.96564	--	42	--
291	RHD Southwood OF West	Unknown	Oak Creek Mainstem	Upper Oak Creek Headwaters	42.87653	-87.96590	--	--	--
292	RHD Southwood OF East	Unknown	Oak Creek Mainstem	Upper Oak Creek Headwaters	42.87653	-87.96590	--	--	--
293	24-01	City of Franklin	Oak Creek Mainstem	Upper Oak Creek Headwaters	42.87676	-87.96590	--	36	--
294	Oswo99	Unknown	Oak Creek Mainstem	Upper Oak Creek Headwaters	42.87717	-87.96639	Fair	24	Left bank; concrete pipe located about 10 feet up bank; pipe is covered with yard waste
295	Oswo100; RHDOF105	City of Franklin	Oak Creek Mainstem	Upper Oak Creek Headwaters	42.87795	-87.96661	Fair	48	Left bank; concrete metered pipe with flared end section
296	Oswo101	Unknown	Oak Creek Mainstem	Upper Oak Creek Headwaters	42.88196	-87.96593	Fair	--	Right bank; no outfall but large manhole at edge of channel
297	Oswo102	Unknown	Oak Creek Mainstem	Upper Oak Creek Headwaters	42.88299	-87.96596	Fair	--	Right bank; no outfall but manhole at edge of channel
298	23-02	City of Franklin	Stormwater Pond Draining To Tributary to Oak Creek Headwaters	Upper Oak Creek Headwaters	42.88188	-87.97200	--	36	Drains stormwater pond
299	23-01	City of Franklin	Stormwater Pond Draining To Tributary to Oak Creek Headwaters	Upper Oak Creek Headwaters	42.88241	-87.97192	--	30	Drains stormwater pond

Note: Right and left bank are determined while oriented upstream.

Outfall condition was only assessed at outfall sites surveyed by Commission staff. Conditions of these outfalls were based on best professional judgement and were assigned condition assessments of Good, Fair, Poor, and Failed. "Good" condition outfalls were relatively new structures that displayed no damage and were assumed to function as designed. "Fair" condition outfalls may have some slight cosmetic damage, but were still assumed to function at, or very near, designed functionality. "Poor" condition outfalls had moderate to severe structural damage or were experiencing bank erosion near the outfall that may affect the designed functionality of the outfall. "Failed" outfalls had severe structural damage to the structure itself, or to supporting bank and/or channel structure, which does not allow the outfall to function as designed.

[a] *Refers to a sequential number assigned in a downstream to upstream fashion in sequential order of input into the mainstem of Oak Creek.*

[b] *Outfall identifications originate from SEWRPC's instream surveys conducted from June 2016 through November 2016 and June 2017 through September 2017; Community reporting for MS4 stormwater permits; and the City of Racine Public Health Department's assessment of the impacts of storm water outfalls in the Oak Creek watershed in 2016.*

Source: Milwaukee County, City of Cudahy, City of Franklin, City of Greenfield, City of Milwaukee, City of Oak Creek, City of South Milwaukee, the City of Racine Public Health Department, and SEWRPC

Figure E.1
Known Outfalls Within the Oak Creek Watershed

Figure E.1 (Continued)

Figure E.1 (Continued)

Figure E.1 (Continued)

Figure E.1 (Continued)

Figure E.1 (Continued)

Figure E.1 (Continued)

Figure E.1 (Continued)

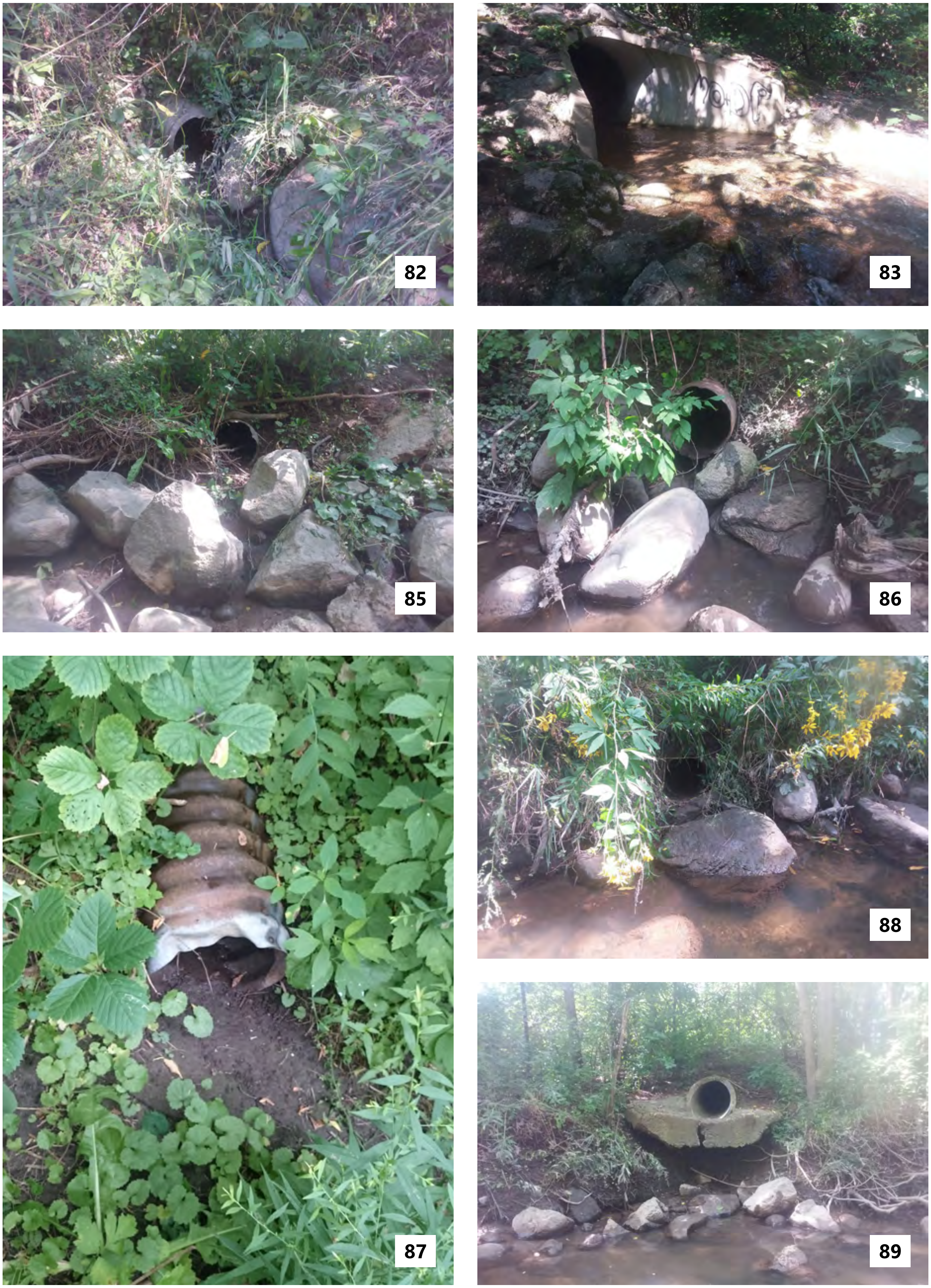


Figure E.1 (Continued)

Figure E.1 (Continued)


99


100


101


102


104


105


106

Figure E.1 (Continued)

Figure E.1 (Continued)

Figure E.1 (Continued)

Figure E.1 (Continued)

Figure E.1 (Continued)

Figure E.1 (Continued)


200


202


203


204


205


206


207

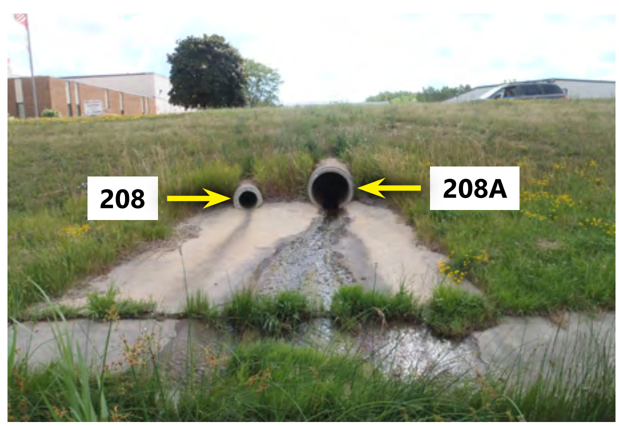


Figure E.1 (Continued)

Figure E.1 (Continued)


217


218


219


220


221


223


224


225

Figure E.1 (Continued)

Figure E.1 (Continued)

Figure E.1 (Continued)

Figure E.1 (Continued)

Figure E.1 (Continued)

Figure E.1 (Continued)

Note: Identification numbers appearing on photos correspond to sequence numbers in Table E.1 and Map E.1. Photos are not available for all outfalls.

Source: City of Racine Public Health Department and SEWRPC

APPENDIX F

PHYSICAL STREAM CONDITIONS AND HABITAT CHARACTERISTICS COLLECTED DURING INSTREAM SURVEYS OF OAK CREEK, NORTH BRANCH OAK CREEK, AND MITCHELL FIELD DRAINAGE DITCH

DESCRIPTION OF FIELD MEASUREMENTS AND OBSERVATIONS COLLECTED AT CROSS-SECTION SURVEYS

Stream Bank Characteristics

Bankfull Width: The stream channel that is formed by the dominant discharge, also referred to as the active channel, which meanders across the floodplain as it forms pools and riffles. Defined by the discharge that occurs when water just begins to leave the channel and spread onto the floodplain. It should be noted that in highly modified streams such as those in the Oak Creek watershed, the bankfull width is more confined than it would be in undisturbed conditions.

Bankfull Height: The height of a stream at various points across the channel at which the flow of water leaves the banks of the channel. Channelized and entrenched streams have banks that are much higher than would occur in undisturbed conditions. Therefore, other indicators often need to be used to estimate bankfull conditions including breaks in slope, vegetation lines, transition in soils, point bars and undercut banks, stain lines on boulders, the lowest line of moss or lichen, and other adjacent indicators upstream or downstream.

Bank Height: The height of the bank from the streambed to the top edge of the lateral scour line as shown in Figure F.1.

Incised Bank Height: For incised or entrenched streams, the height measured from the thalweg of the stream vertically to the point at which the stream would leave the channel at lower banks of the two banks.

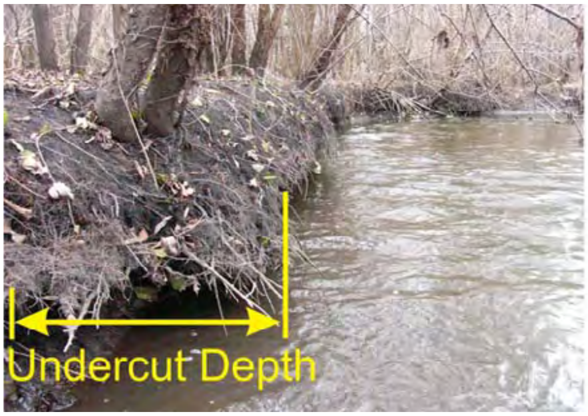
Undercut Depth: The distance over which the bank overhangs the streambed due to water action removing a portion of the bank toe of slope as shown in Figure F.1.

Bank Slope: The ratio of horizontal distance divided by the vertical height of the streambank as shown in Figure F.2.

Instream Habitat Characteristics

Water Width: The width of the existing water surface measured at a right angle to the direction of flow from shore to shore.

Figure F.1
Example of Bank Height and Undercut Depth Measured at an Actively Eroding Site



Note: These photos were not taken within the Oak Creek watershed and are for illustrative purposes only.

Source: SEWRPC

Figure F.2
Example of Length of Erosion and Bank Slope Measured at an Actively Eroding Site

Note: These photos were not taken within the Oak Creek watershed and are for illustrative purposes only.

Source: SEWRPC

Water Depth: The vertical height of the water column from the existing water surface level to the lowest point of the streambed above the surface of any substrate or sediment. Water depths were usually taken at three to ten points across the channel cross-section

Habitat Type: An aquatic unit, consisting of an aggregation of habitats having equivalent structure, function, and responses to disturbance. Pool, riffle, and run habitat types were observed in the Oak Creek watershed.

A pool is an area of the stream that has slow water velocity and is usually deeper than a riffle or run (Figure F.3). Pools usually form around bends or around large-scale obstructions that laterally constrict the channel or cause a sharp drop in the water surface profile. A single maximum depth was recorded for each pool habitat.

A riffle is an area of the stream where water velocity is fast, stream depths are relatively shallow, and the water surface gradient is relatively steep (Figure F.4). A single maximum depth was recorded for each riffle habitat.

A run is an area of the stream that does not form distinguishable pools or riffles but has a rapid nonturbulent flow. A run is usually too deep to be a riffle and has flow velocities too fast to be a pool.

Substrates: These are materials that make up the streambed. Substrate composition in the streams of the Oak Creek watershed was determined visually by recording the dominant substrate types at three to ten points along the stream transect. A percentage of the substrate present at each transect was also recorded. The following categories of substrate type were used.

Boulder: Rocks with diameters of 10 to 20 inches.

Cobble: Rocks with diameters of 2.5 to 10 inches.

Gravel: Rocks with diameters of 0.07 to 2.5 inches.

Sand: Inorganic particles smaller than gravel, but coarser than silt with diameters of 0.002 to 0.07 inch.

Silt: Fine inorganic particles, typically dark brown in color. Silt feels greasy and muddy in hands. The material is loose and does not retain shape when compacted into a ball and will not support a person's weight when it makes up the stream bottom. Silt particles have diameters of less than 0.0001 inch.

Clay: Very fine, inorganic, dark brown or gray particles. Individual particles are barely visible or not visible to the unaided eye. The particles feel gummy and sticky and slippery underfoot. Clay particles retain shape when compacted and partially or completely support a person's weight when they comprise the stream bottom. Clay particles have diameters of less than 0.0001 inch.

Detritus: Loose organic material typically produced by decomposing plant matter.

Muck: An accumulation of soft and slimy-like silt material.

Sediment Depth: The depth of fine sediments (usually sand or silt) that overlay or comprise the streambed. Sediment depth is an indicator of sediment deposition. This measurement was taken at each point that a water depth was measured.

Cover: This can consist of one or any combination of characteristics that include undercut banks, overhanging vegetation, logs or woody debris, deep pools, boulders and other substrates, aquatic macrophytes, and algae that provide 1) protection from predators, 2) feeding areas, 3) spawning habitat, or 4) some other benefit such as shading.

Velocity: A general observation of the speed of the stream flow (i.e., slow, moderate, or fast) taken at the time of the field survey.

Figure F.3
Typical Deep Water Pool Habitats in the Oak Creek Watershed

Source: SEWRPC

Figure F.4
Typical Shallow Water Riffle Habitats in the Oak Creek Watershed

Source: SEWRPC

DESCRIPTIONS OF ADDITIONAL LINE OR POINT FEATURES GEOLOCATED DURING INSTREAM SURVEYS

Beaver Dam: A structure created by beavers made of wood, mud, stone, and debris that can impound water and impact stream flow and channel characteristics.

Drain Tile: A subsurface drainage system made of plastic, clay, or metal corrugated pipe that allows excess water from current or former agricultural lands to discharge into a drainage ditch, stream, or wetland.

Fish Bed: An underwater solid surface on which fish spawn to reproduce. Fish beds are also referred to as spawning beds.

Groundwater Discharge: Movement of groundwater from the subsurface to the surface at springs or along streams, stream beds, lakes, and wetlands.

Erosion: The gradual wearing away of land surface material by water or wind.

Gully Erosion: The formation of a small valley or ravine through the action of running water. Gullies can act as drainage ways.

Rill Erosion: A type of erosion in which water forms small channels in the soil. Rills are smaller and shallower than gullies.

Streambank Erosion: Removal of bank materials and vegetation from the streambank by water. Erosion occurs in many natural streams that have vegetated banks.

Mussels: Freshwater bivalves that live in many types of habitats, ranging from small ditches and ponds, to lakes, canals, rivers, streams, and swamps. Mussels have two thick symmetrical shells that grow as the mussel ages, with rings similar to trees. Mussels can reach ages past 60 years old and spend their adult lives within the same one hundred yards of a river, stream, or lake.

Stormwater Outfall: The outlet of any drainage pipe system that allows for excess storm water to discharge into a certain location.

Stream Crossing: A structure such as a bridge, culvert, dam, drop structure, or ford that crosses over or is lying within the stream channel.

Trash: Discarded matter or refuse left in the stream or riparian area.

Tributary: Any stream or river that flows into a larger stream or mainstem. Any tributary inlet identified along a surveyed stream was recorded during the field surveys.

Weir: A low dam, or dam-like feature built across a river or stream to raise the level of water upstream or regulate its flow.

Wetland Drainage: A distinct channel feature indicating concentrated flow coming from a perennial or ephemeral wetland.

Woody Debris Jam: A collection of logs, branches, sticks, and other wood that has fallen into a stream. Identified and described the extent of the woody debris obstruction in the channel.

Table F.1 describes the attribute data collected at each transect and additional inventory features.

The location of cross-section surveys conducted on streams within the Oak Creek watershed are shown on Maps F.1 through F.12.

The location of additional line and point features collected during instream surveys to characterize the streams within the Oak Creek watershed area shown on Maps F.13 through F.35.

Note that shapefiles associated with the data described above are available to download from the Oak Creek Watershed Restoration Plan page on the SEWRPC website.

Table F.1
Transect and Point Feature Data Dictionary for Data Collected as Part of the Oak Creek Instream Survey Conducted by Commission Staff: 2016-2017 (See Maps F.1 through F.35)

Data Assortment	Description
AssessmentArea	The watershed's assessment area (defined in Chapter 3 of the Report) in which the stream or tributary is located was identified and noted during the stream survey.
ClassOrder	Each point surveyed was assorted into a class, or category of survey point. A *Class Order*, or a sequence number starting from downstream to upstream was assigned for each individual class category.
GIS_ID	Each point surveyed was given a unique GIS_ID during the instream survey using a GPS application device. Each identifier was given a prefix representing the class of data and a number indicating the order the point was observed.
Stream	Stream inventory data within the Oak Watershed was conducted along Oak Creek Mainstem, North Branch Oak Creek, and Mitchell Field Drainage Ditch. The "Stream" designation indicates which stream the data belongs to.

Parameters	Transect/Cross-Section Features
Habitat	Type of stream habitat at surveyed stream cross-sections (i.e., pool, riffle, or run).
Velocity	A general observation at stream cross-sections of how fast the water was flowing in the stream (i.e., slow, moderate, or fast).
Shading	Portion of the stream at a surveyed stream cross-section that is shaded by overhanging trees, shrubs, or grasses (i.e., unshaded, partially, halfway, or mostly shaded).
AmountCov	*Amount of instream fish cover*. The general percentage of stream containing fish cover at a surveyed cross-section ("low" indicating 15 percent or less, "high" indicating 15 percent or greater of fish cover, and NONE indicating no fish cover).
PrimaryCover	*The primary, or the most dominant form of instream fish cover* was recorded at each cross-section. If more than one type of instream cover was present it was also noted in parameters Cover2, Cover3, Cover4, Cover5, and Cover6. Instream fish cover typically consisted of undercut banks, roots, macrophytes, woody debris, or overhanging vegetation.
LB_Shape	*Left bank shape* at each cross-section was recorded as being either undercut, 45-90 degrees, or 90 degrees.
RB_Shape	*Right Bank shape* at each cross-section was recorded as being either undercut, 45-90 degrees, or 90 degrees.
LB_UndercutAvg	*Average Left Bank Undercut (ft.)* Undercut banks occur when the toe of the bank is eroded away, leaving just the top of the bank overhanging the stream. This measurement is the average depth of the undercutting on the left bank.
RB_UndercutAvg	*Same as above but for the right bank*
BF_Width	*Bankfull Width (ft.)*. The measurement of the channel width that occurs when water just begins to leave the channel and spread onto the floodplain. For heavily modified streams this is the width of the stream where indicators show the stream would overtop banks in unmodified conditions.
LB_Length	*Left Bank Length (ft)*. Horizontal measurement collected from top of bankfull (left bank) directly out to where it would meet the toe of bank. This was collected at each surveyed cross-section.
LB_Height	*Left Bank Height (ft)*. Vertical measurement from toe of bank directly straight up to top of bankfull. This was collected at each surveyed cross-section.
A_BF	*Bankfull Depth (ft)*. The maximum depth measured at the bankfull discharge, or where water would flow out from the banks in unmodified conditions. Bankfull depths were measured at three to eight points evenly spaced across a surveyed cross-section (e.g., A_BF, B_BF, C_BF, D_BF, E_BF, F_BF, G_BF, and H_BF).
A_Water	*Water Depth (ft.)* The first water depth measured at a stream cross-section. Each cross-section measured three to eight water depths that were evenly spaced across the stream (e.g., A_Water, B_Water, C_Water, D_Water, E_Water, F_Water, G_Water, and H_Water).
A_WaterSed	*Sediment plus Water Depth (ft.)* Sediment depth plus the water depth measured at stream cross-sections. Sediment and water depths were measured at three to eight points evenly spaced across a surveyed cross-section (e.g., A_WaterSed, B_WaterSed, C_WaterSed, D_WaterSed, E_WaterSed, F_WaterSed, G_WaterSed, and H_WaterSed).
A_Substrates	*Substrates*. The first substrates recorded at a stream cross-section. Each cross-section observed substrates at three to eight points evenly spaced across the stream (i.e., A_Substrates, B_Substrates, C_Substrates, D_Substrates, E_Substrates, F_Substrates, G_Substrates, and H_Substrates). Substrates included boulder, clay, cobble, detritus, gravel, muck, sand, and silt.
RB_Length	*Right Bank Length (ft.)*. Horizontal measurement collected from top of bankfull (left bank) directly out to where it would meet the toe of bank. This was collected at each surveyed cross-section.
RB_Height	*Right Bank Height (ft)*. Vertical measurement from toe of bank directly straight up to top of bankfull.
Water_Width	*Wetted (water)* stream width (ft.) or low flow channel width at the time of the survey at stream cross-sections.
Incised	Each cross-section was examined for incised banks.

Table continued on next page.

Table F.1 (Continued)

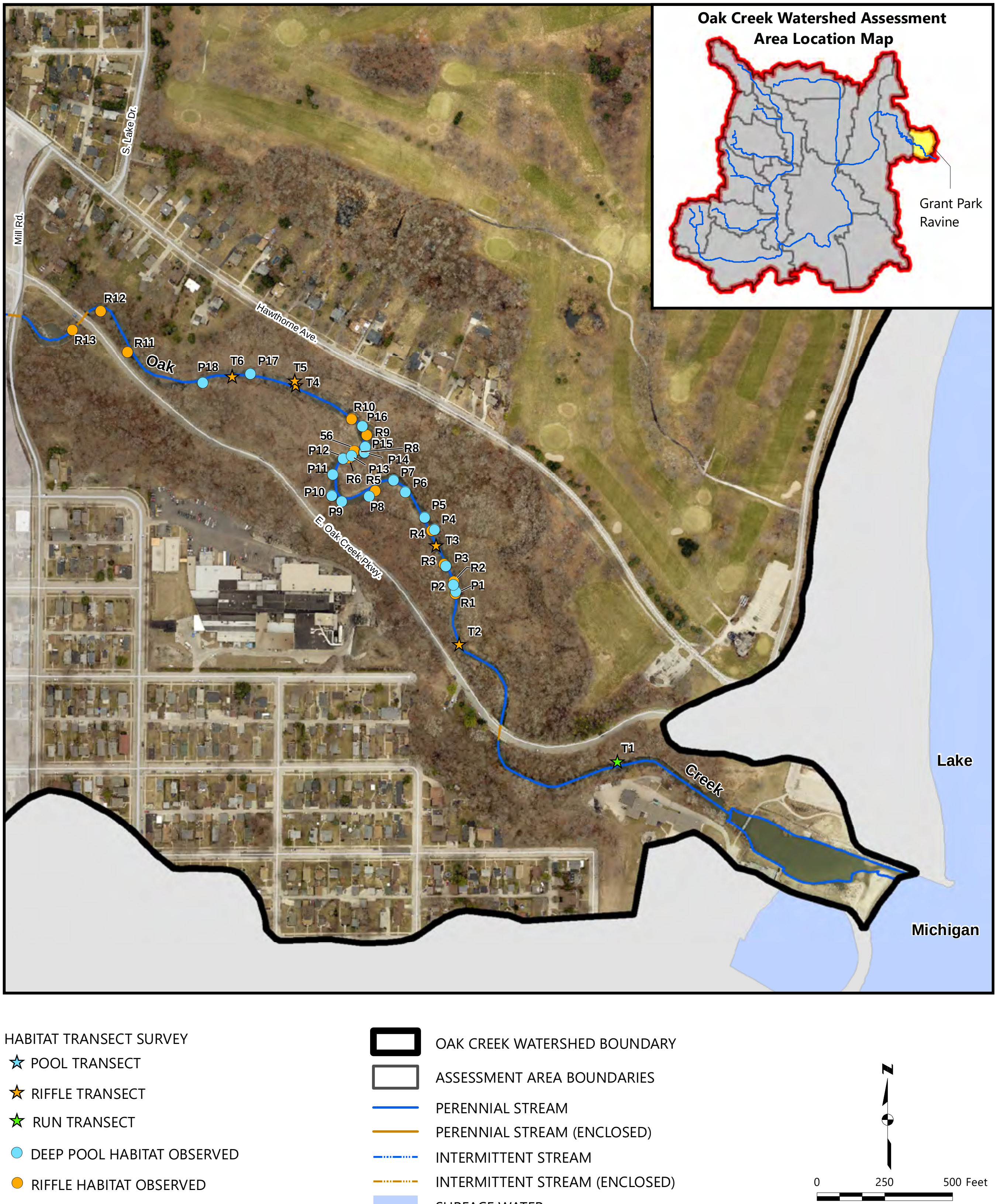
Parameters	Transect/Cross-Section Features
IncisedHeight	*Incised Height (ft.)* was collected at stream cross-sections where the stream channel is substantially disconnected from its floodplain. This is a vertical measurement from thalweg of the stream channel to the height of the lowest bank.
IncisedWidth	*Incised Width (ft.)* was collected at cross-sections where the stream is substantially disconnected from its floodplain. This is a horizontal measurement from top of lowest bank height to the opposite bank.

Additional Inventory Features	Descriptions
BankErosion	*Streambank Erosion (ft.)* identified within the stream systems. Erosional bank (i.e., right or left), average and maximum eroding height, estimated length, and average eroding depth were recorded at moderate to severe streambank erosion sites.
StreamCrossing	*A structure*, either a bridge, culvert, or dam crossing, identified along with its measurements during the instream field survey.
StormwaterOutfall	Stormwater drainage system pipe outlets were identified. Includes storm sewer outfalls, stormwater pond outlets, or drainage ditch culverts. Pipe diameter, location, condition, and material are noted.
SurveyPoint	*Additional point features* identified and marked within the stream systems. Features include beaver dams, dams, woody debris jams, drain tiles, fish beds, gully and rill erosion, groundwater discharge, minor streambank erosion, mussel and mussel shells, sediment accumulation, trash, and weirs.
Pool	A *substantial pool* or deep point within the water column identified. Maximum water depth and width are measured in feet.
Riffle	Portions of the water column where water velocity is fast, stream depths are relatively shallow, and the water surface gradient is relatively steep. Measurements (ft) include riffle width, maximum depth and length.

Source: SEWRPC

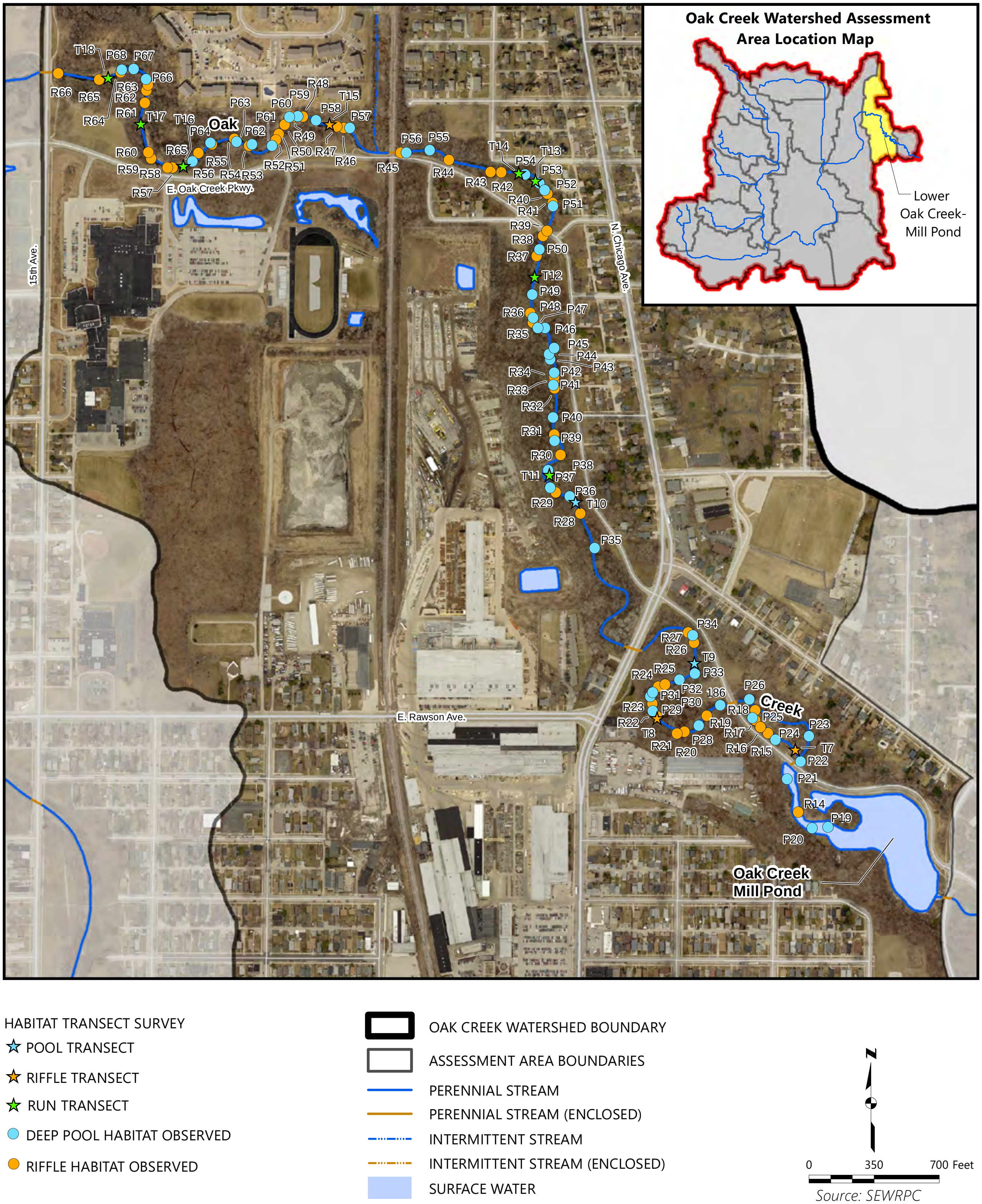
APPENDIX F-1
LOCATIONS OF INSTREAM TRANSECT SURVEYS AND OBSERVED DEEP POOLS AND RIFFLES BY ASSESSMENT AREA

Map F.1
Locations of Instream Transect Surveys and Observed Deep Pools and Riffles Within the Grant Park Ravine Assessment Area



Source: SEWRPC

Map F.2
Locations of Instream Habitat Transect Surveys and Observed Deep Pools and Riffles Within the Lower Oak Creek – Mill Pond Assessment Area



Source: SEWRPC

Map F.3
Locations of Instream Habitat Transect Surveys and Observed Deep Pools and Riffles Within the Lower Oak Creek Assessment Area

HABITAT TRANSECT SURVEY

- POOL TRANSECT
- RIFFLE TRANSECT
- RUN TRANSECT
- DEEP POOL HABITAT OBSERVED
- RIFFLE HABITAT OBSERVED

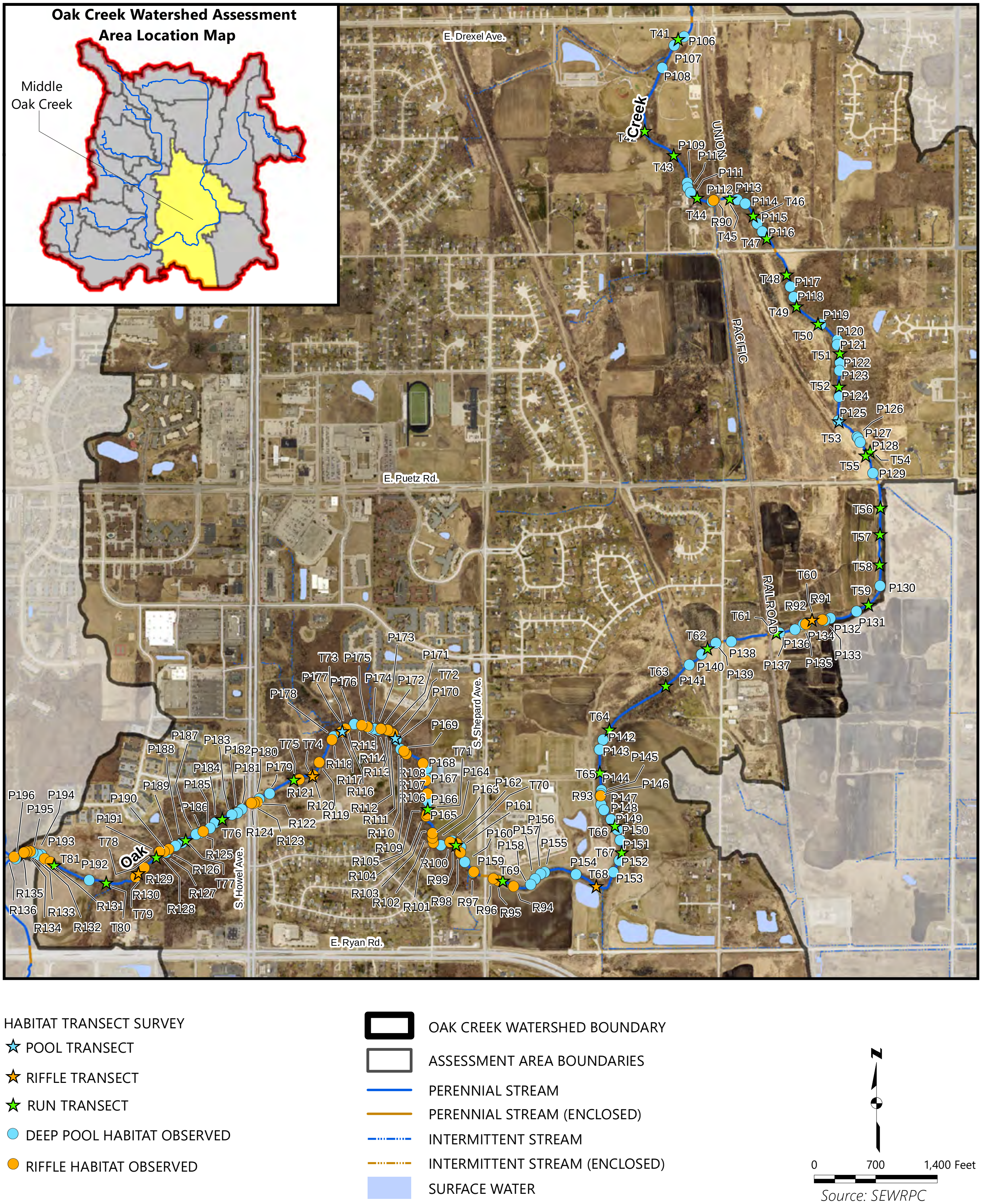
OAK CREEK WATERSHED BOUNDARY
ASSESSMENT AREA BOUNDARIES
PERENNIAL STREAM
PERENNIAL STREAM (ENCLOSED)
INTERMITTENT STREAM
INTERMITTENT STREAM (ENCLOSED)
SURFACE WATER

N

0 500 1,000 Feet

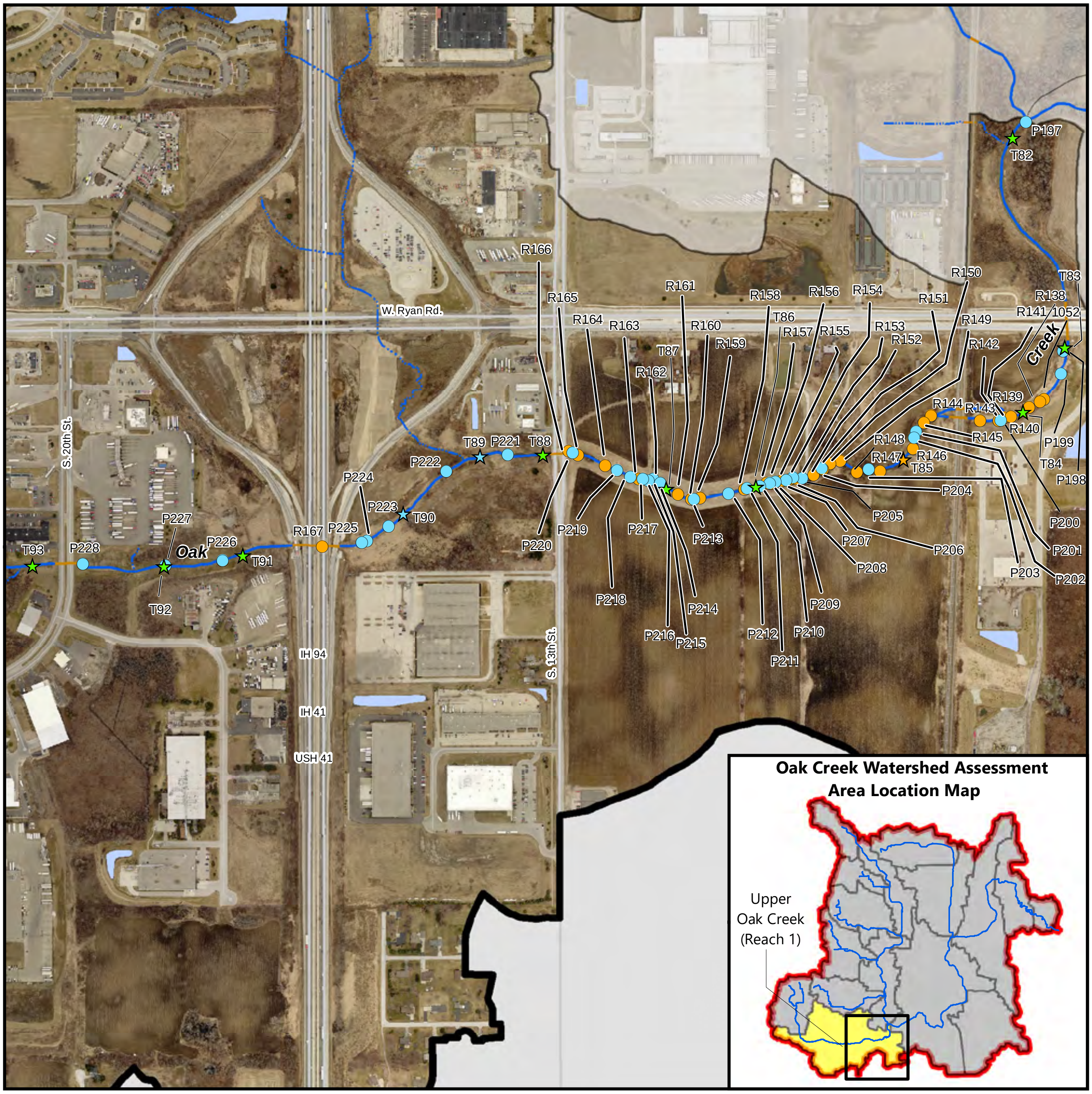
Source: SEWRPC

Map F.4
Locations of Instream Habitat Transect Surveys and Observed Deep Pools and Riffles Within the Middle Oak Creek Assessment Area



Source: SEWRPC

Map F.5
Location of Instream Habitat Transect Surveys and Observed Deep Pools and Riffles Within the Upper Oak Creek Assessment Area (Reach 1)



HABITAT TRANSECT SURVEY

- POOL TRANSECT
- RIFFLE TRANSECT
- RUN TRANSECT
- DEEP POOL HABITAT OBSERVED
- RIFFLE HABITAT OBSERVED

OAK CREEK WATERSHED BOUNDARY

ASSESSMENT AREA BOUNDARIES

PERENNIAL STREAM

PERENNIAL STREAM (ENCLOSED)

INTERMITTENT STREAM

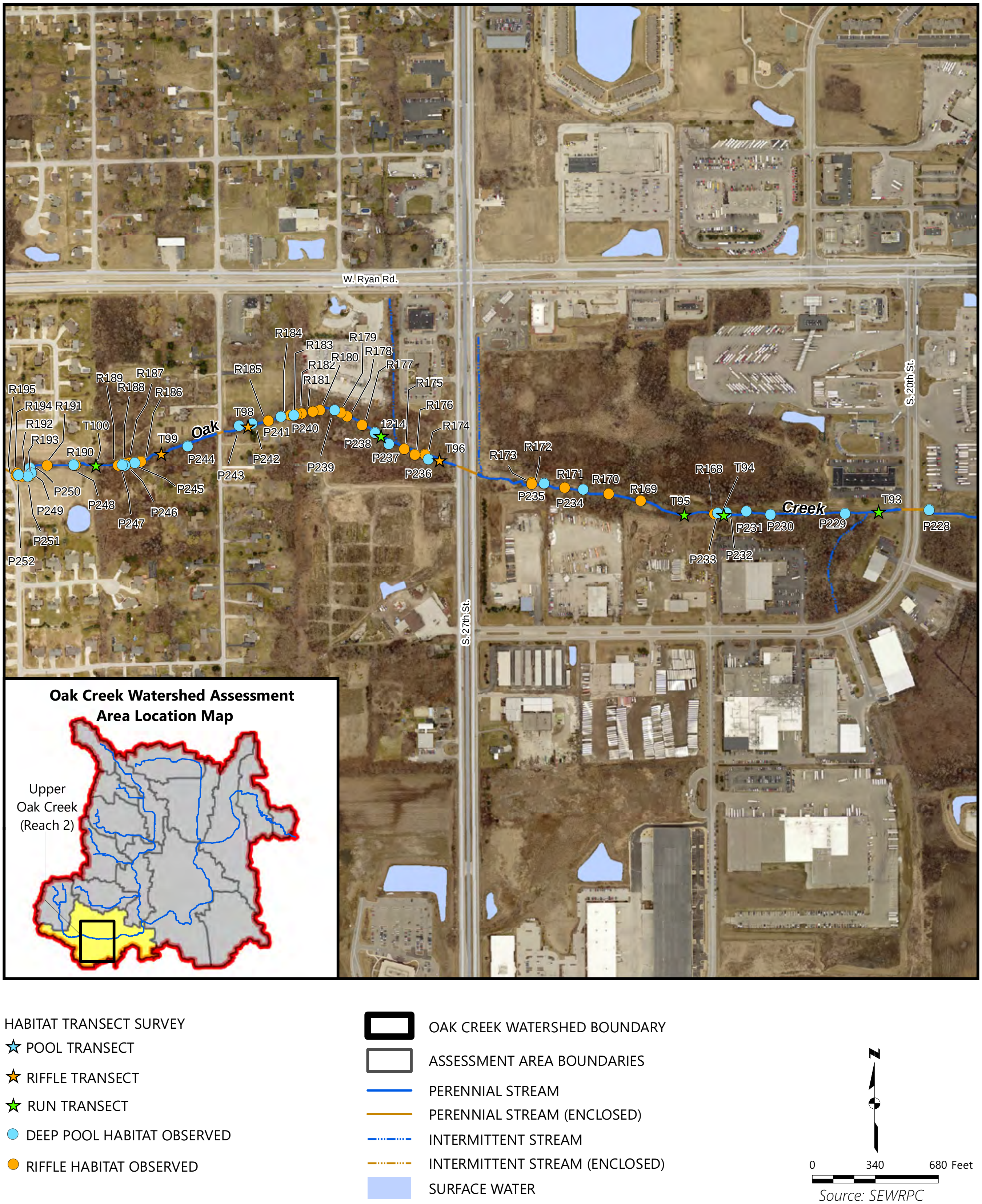
INTERMITTENT STREAM (ENCLOSED)

SURFACE WATER

0 390 780 Feet

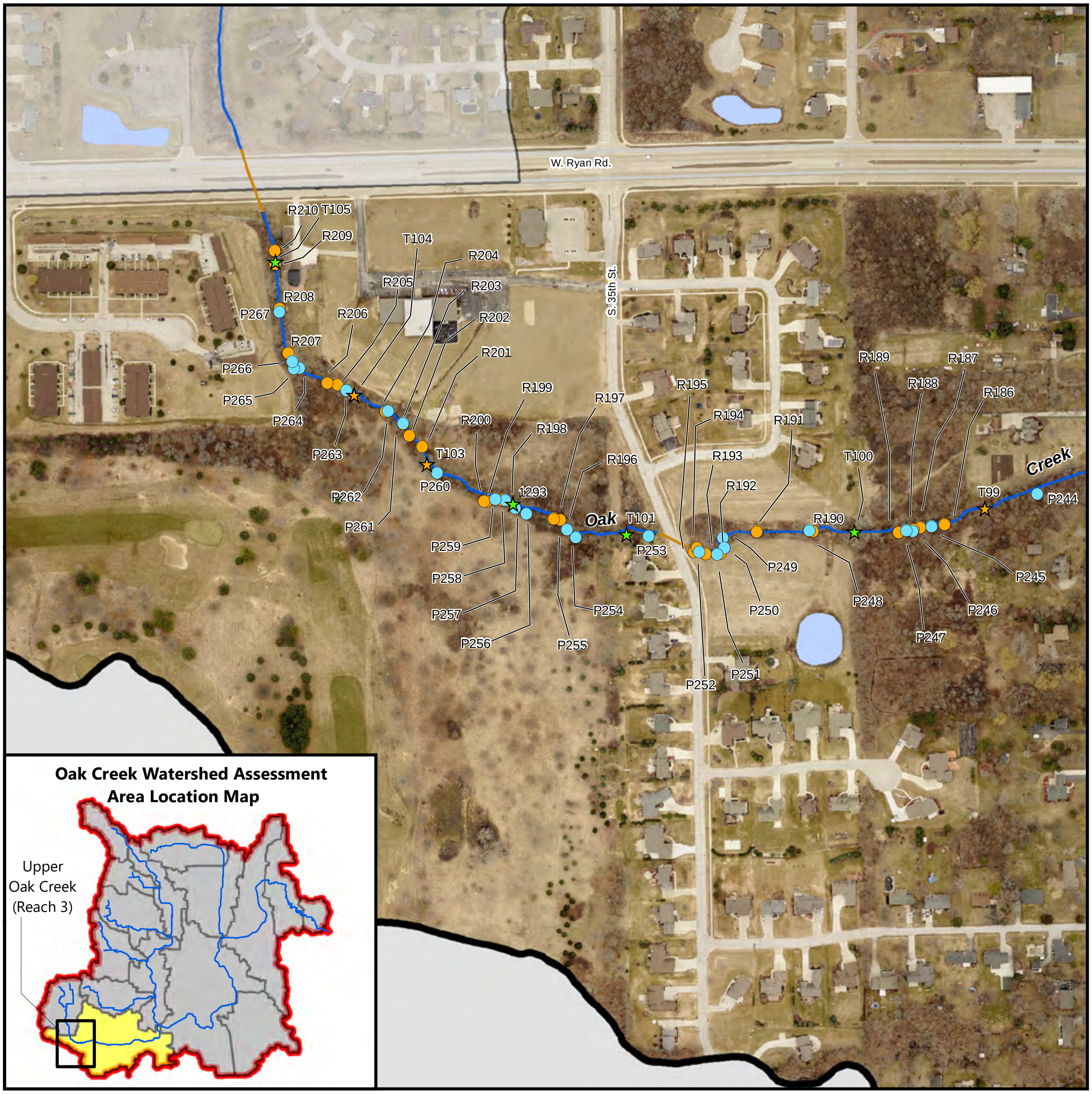
Source: SEWRPC

Map F.6
Location of Instream Habitat Transect Surveys and Observed Deep Pools and Riffles Within the Upper Oak Creek Assessment Area (Reach 2)



Source: SEWRPC

Map F.7
Location of Instream Habitat Transect Surveys and Observed Deep Pools and Riffles Within the Upper Oak Creek Assessment Area (Reach 3)



HABITAT TRANSECT SURVEY

☆ POOL TRANSECT

☆ RIFFLE TRANSECT

☆ RUN TRANSECT

● DEEP POOL HABITAT OBSERVED

● RIFFLE HABITAT OBSERVED

OAK CREEK WATERSHED BOUNDARY

ASSESSMENT AREA BOUNDARIES

PERENNIAL STREAM

PERENNIAL STREAM (ENCLOSED)

INTERMITTENT STREAM

INTERMITTENT STREAM (ENCLOSED)

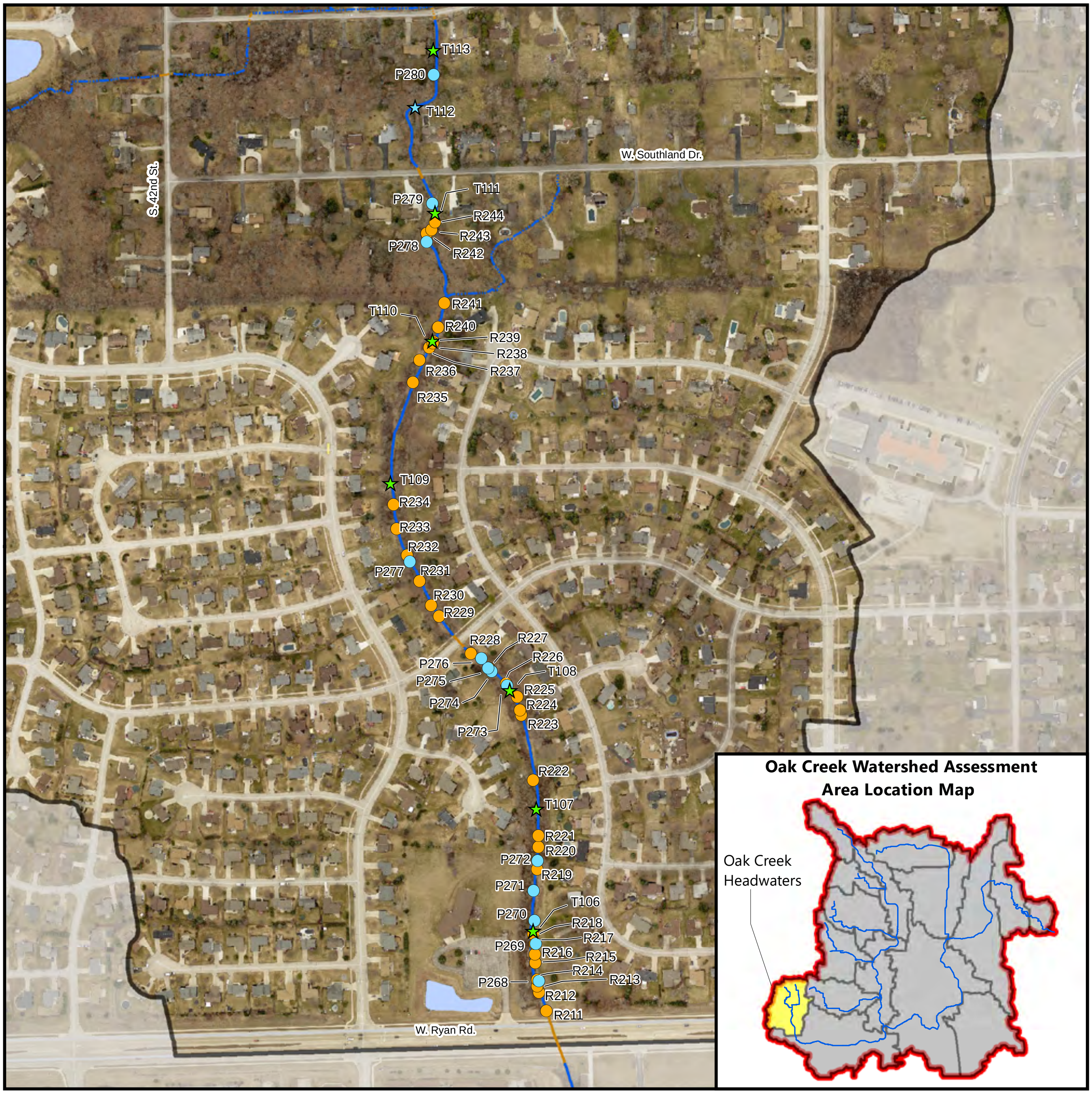
SURFACE WATER

N

0 190 380 Feet

Source: SEWRPC

Map F.8
Location of Instream Habitat Transect Surveys and Observed Deep Pools and Riffles Within the Oak Creek Headwaters Assessment Area



HABITAT TRANSECT SURVEY

- POOL TRANSECT
- RIFFLE TRANSECT
- RUN TRANSECT
- DEEP POOL HABITAT OBSERVED
- RIFFLE HABITAT OBSERVED

OAK CREEK WATERSHED BOUNDARY

ASSESSMENT AREA BOUNDARIES

PERENNIAL STREAM

PERENNIAL STREAM (ENCLOSED)

INTERMITTENT STREAM

INTERMITTENT STREAM (ENCLOSED)

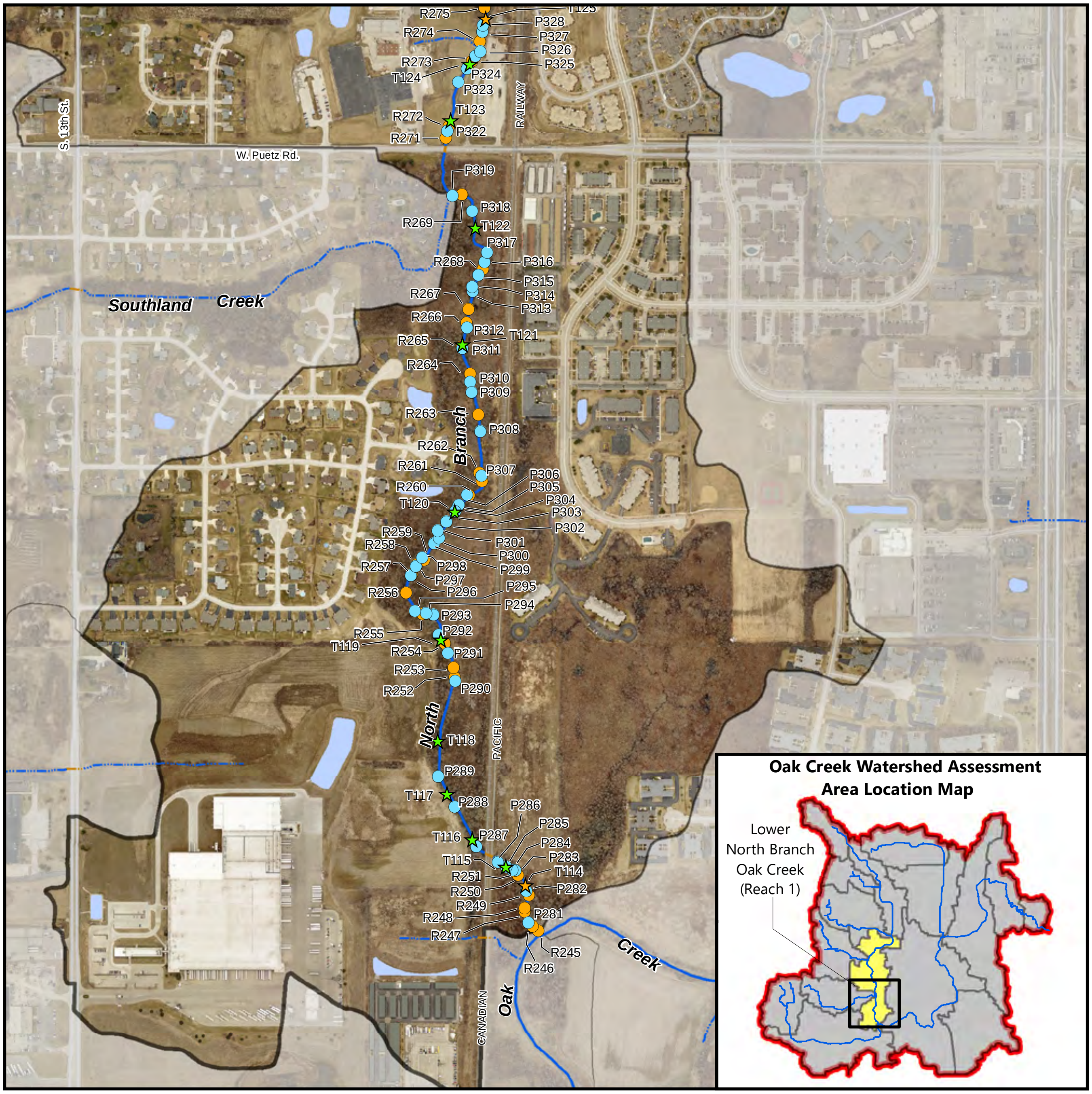
SURFACE WATER

N

0 250 500 Feet

Source: SEWRPC

Map F.9
Location of Instream Habitat Transect Surveys and Observed Deep Pools and Riffles Within the Lower North Branch Oak Creek Assessment Area (Reach 1)



HABITAT TRANSECT SURVEY
- POOL TRANSECT
- RIFFLE TRANSECT
- RUN TRANSECT
- DEEP POOL HABITAT OBSERVED
- RIFFLE HABITAT OBSERVED

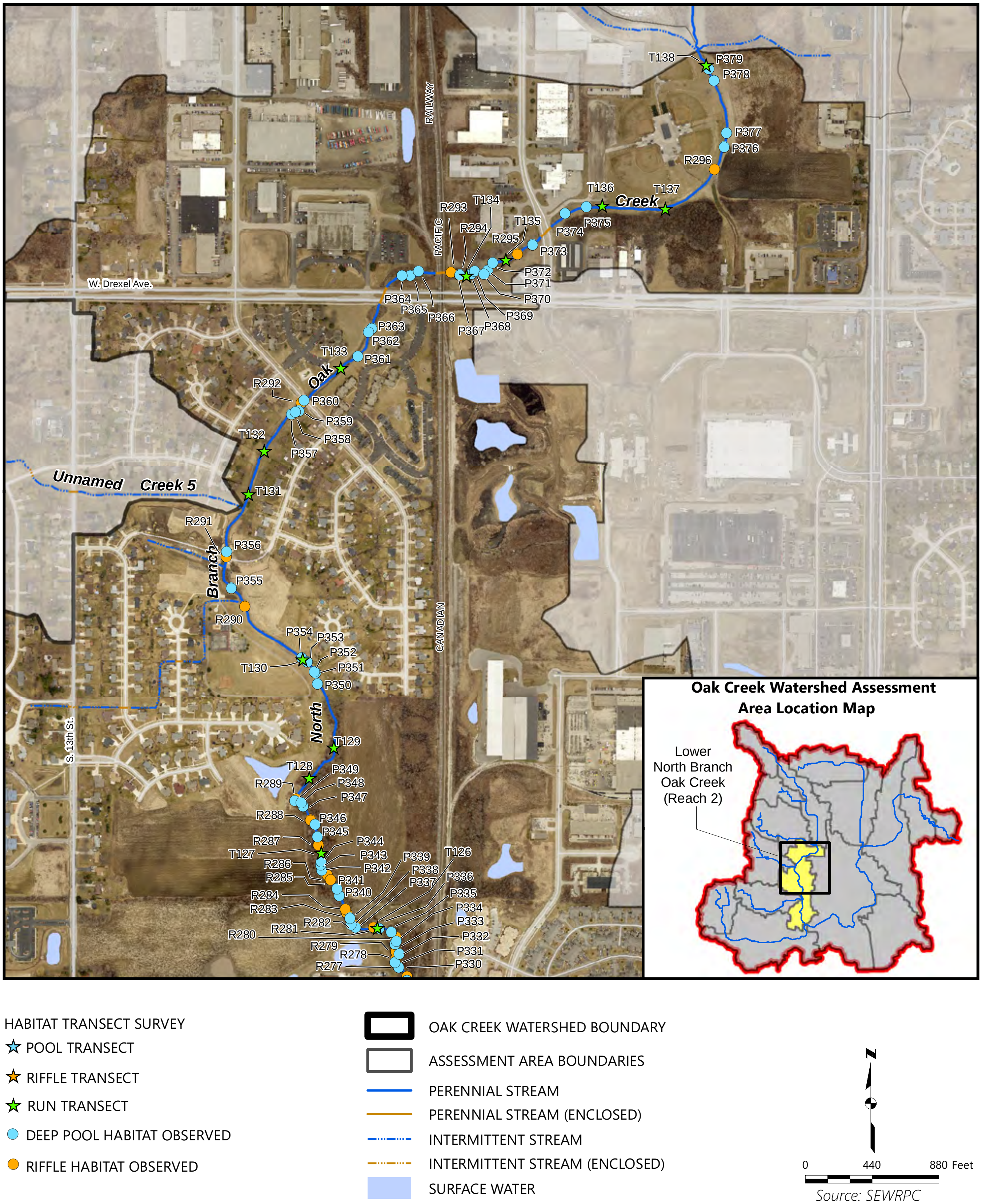
- OAK CREEK WATERSHED BOUNDARY
- ASSESSMENT AREA BOUNDARIES
- PERENNIAL STREAM
- PERENNIAL STREAM (ENCLOSED)
- INTERMITTENT STREAM
- INTERMITTENT STREAM (ENCLOSED)
- SURFACE WATER

N

0 400 800 Feet

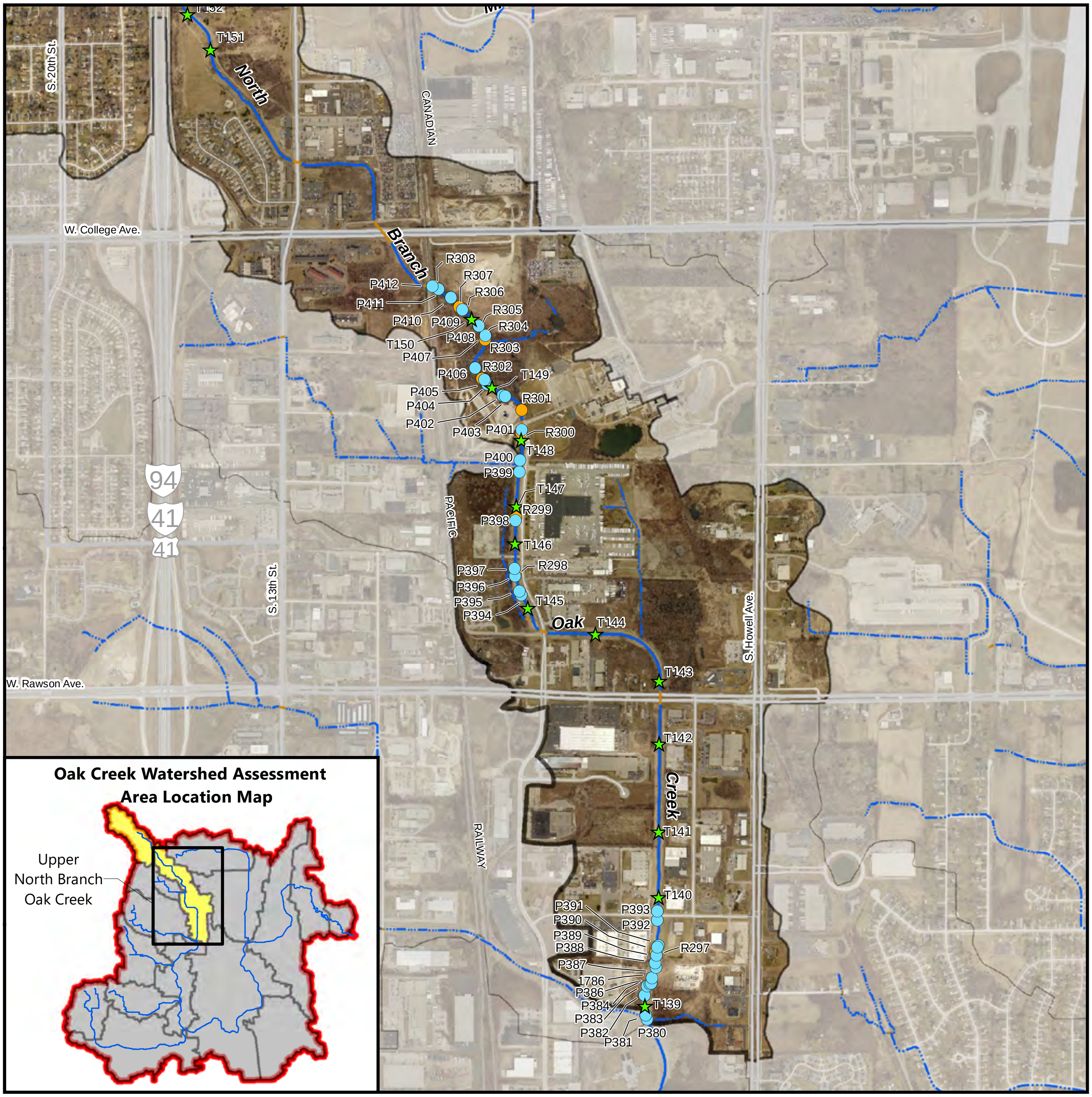
Source: SEWRPC

Map F.10
Location of Instream Habitat Transect Surveys and Observed Deep Pools and Riffles Within the Lower North Branch Oak Creek Assessment Area (Reach 2)



Source: SEWRPC

Map F.11
Location of Instream Habitat Transect Surveys and Observed Deep Pools and Riffles Within the Upper North Branch Oak Creek Assessment Area



HABITAT TRANSECT SURVEY
- POOL TRANSECT
- RIFFLE TRANSECT
- RUN TRANSECT
- DEEP POOL HABITAT OBSERVED
- RIFFLE HABITAT OBSERVED

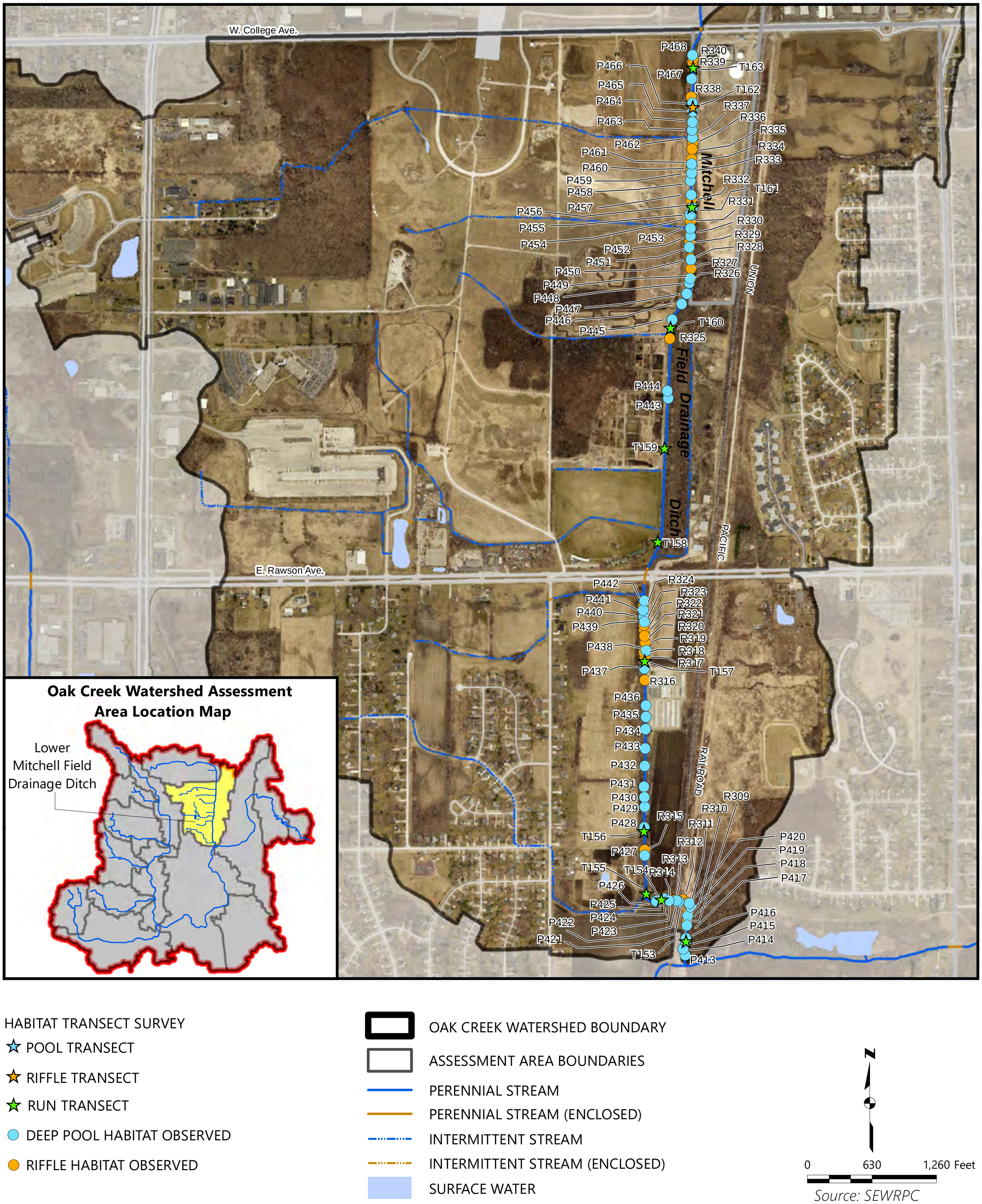
- OAK CREEK WATERSHED BOUNDARY
- ASSESSMENT AREA BOUNDARIES
- PERENNIAL STREAM
- PERENNIAL STREAM (ENCLOSED)
- INTERMITTENT STREAM
- INTERMITTENT STREAM (ENCLOSED)
- SURFACE WATER

N

0 750 1,500 Feet

Source: SEWRPC

Map F.12
Location of Instream Habitat Transect Surveys and Observed Deep Pools and Riffles Within the Lower Mitchell Field Drainage Ditch Assessment Area



Source: SEWRPC

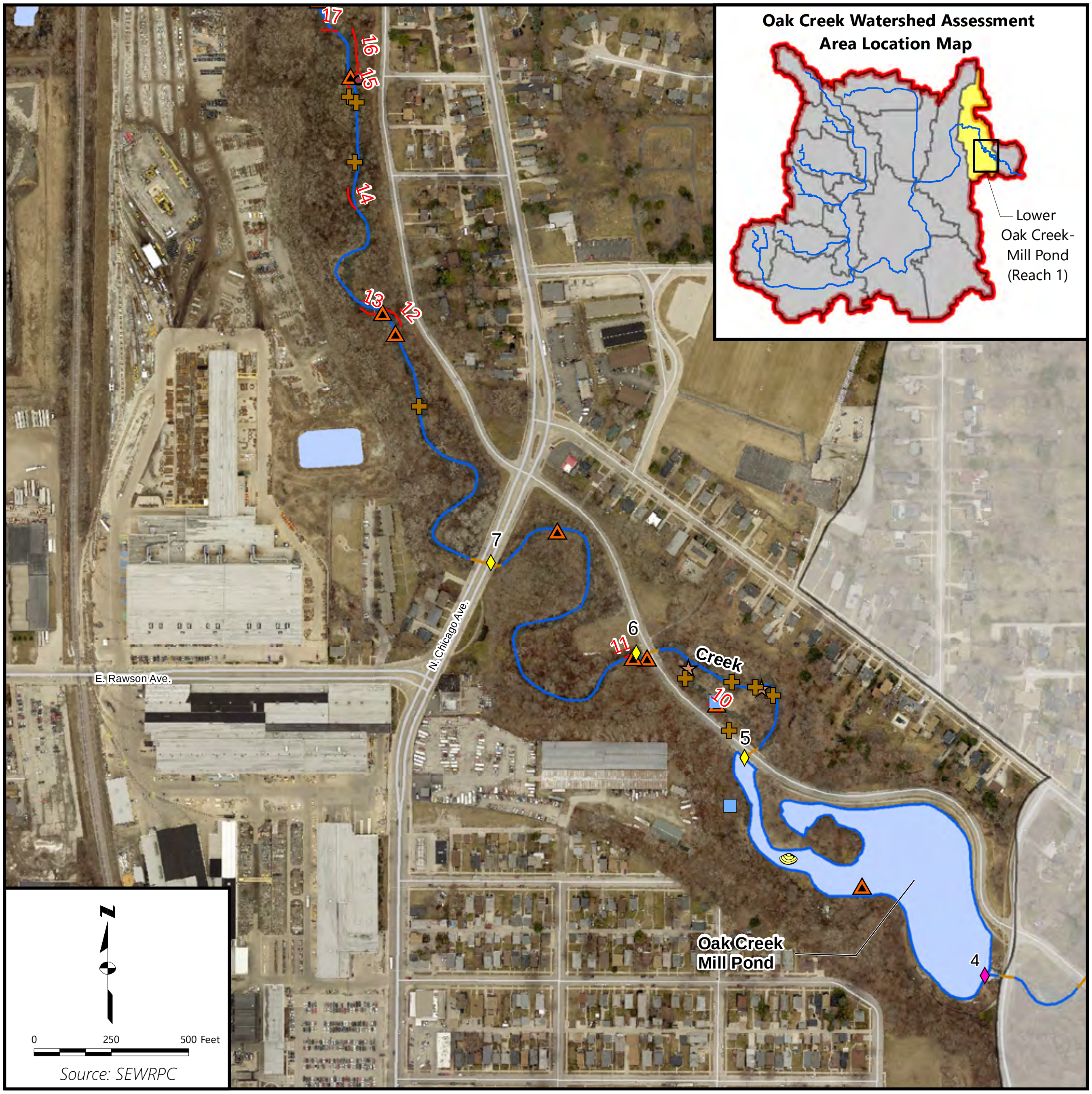
APPENDIX F-2
LOCATIONS OF STREAM SURVEY INVENTORY DATA BY ASSESSMENT AREA

Map F.13
Stream Survey Inventory Within the Grant Park Ravine Assessment Area

- BRIDGE
- CULVERT
- DAM
- DROP STRUCTURE/WEIR
- ROCK WEIR
- WOODY DEBRIS JAM
- BEAVER DAM/ACTIVITY
- TRIBUTARY OR WETLAND DRAINAGE
- POND OUTLET
- GROUNDWATER SEEPAGE/SPRING
- DRAIN TILE
- POTENTIAL FISH BED OR SPAWNING SITE
- MUSSEL
- STREAMBANK EROSION
- MINOR BANK, GULLY, OR RILL EROSION
- TRASH IN STREAM
- OAK CREEK WATERSHED BOUNDARY
- ASSESSMENT AREA BOUNDARIES
- PERENNIAL STREAM
- PERENNIAL STREAM (ENCLOSED)
- INTERMITTENT STREAM
- INTERMITTENT STREAM (ENCLOSED)

Note: Identification numbers for streambank erosion sites correspond to the "Erosion ID" provided in Appendix D. Identification numbers for bridges, culverts, and dams correspond to "ID Numbers" provided in Appendix H.

Map F.14
Stream Survey Inventory for the Lower Oak Creek – Mill Pond Assessment Area (Reach 1)



- BRIDGE
- CULVERT
- DAM
- DROP STRUCTURE/WEIR
- ROCK WEIR
- WOODY DEBRIS JAM
- BEAVER DAM/ACTIVITY
- TRIBUTARY OR WETLAND DRAINAGE
- POND OUTLET
- GROUNDWATER SEEPAGE/SPRING
- DRAIN TILE
- POTENTIAL FISH BED OR SPAWNING SITE
- MUSSEL
- STREAMBANK EROSION
- MINOR BANK, GULLY, OR RILL EROSION
- TRASH IN STREAM

Note: Identification numbers for streambank erosion sites correspond to the "Erosion ID" provided in Appendix D. Identification numbers for bridges, culverts, and dams correspond to "ID Numbers" provided in Appendix H.

- OAK CREEK WATERSHED BOUNDARY
- ASSESSMENT AREA BOUNDARIES
- PERENNIAL STREAM
- PERENNIAL STREAM (ENCLOSED)
- INTERMITTENT STREAM
- INTERMITTENT STREAM (ENCLOSED)

Map F.15
Stream Survey Inventory for the Lower Oak Creek – Mill Pond Assessment Area (Reach 2)

- BRIDGE
- CULVERT
- DAM
- DROP STRUCTURE/WEIR
- ROCK WEIR
- WOODY DEBRIS JAM
- BEAVER DAM/ACTIVITY
- TRIBUTARY OR WETLAND DRAINAGE
- POND OUTLET
- GROUNDWATER SEEPAGE/SPRING
- DRAIN TILE

- POTENTIAL FISH BED OR SPAWNING SITE
- MUSSEL
- STREAMBANK EROSION
- MINOR BANK, GULLY, OR RILL EROSION
- TRASH IN STREAM

Note: Identification numbers for streambank erosion sites correspond to the "Erosion ID" provided in Appendix D. Identification numbers for bridges, culverts, and dams correspond to "ID Numbers" provided in Appendix H.

- OAK CREEK WATERSHED BOUNDARY
- ASSESSMENT AREA BOUNDARIES
- PERENNIAL STREAM
- PERENNIAL STREAM (ENCLOSED)
- INTERMITTENT STREAM
- INTERMITTENT STREAM (ENCLOSED)

Map F.16
Stream Survey Inventory for the Lower Oak Creek Assessment Area (Reach 1)

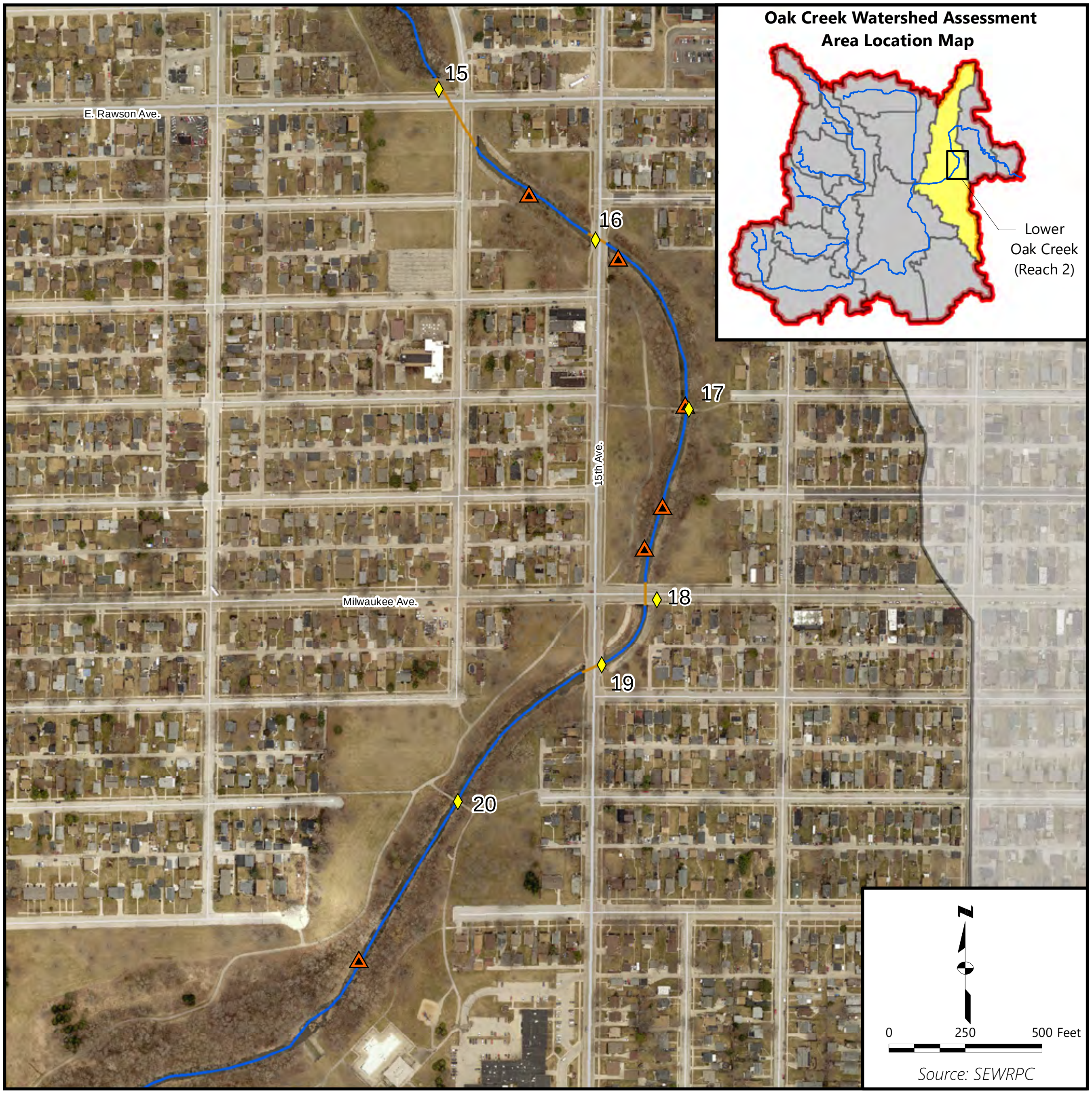
BRIDGE
CULVERT
DAM
DROP STRUCTURE/WEIR
ROCK WEIR
WOODY DEBRIS JAM
BEAVER DAM/ACTIVITY
TRIBUTARY OR WETLAND DRAINAGE
POND OUTLET
GROUNDWATER SEEPAGE/SPRING
DRAIN TILE

POTENTIAL FISH BED OR SPAWNING SITE
MUSSEL
STREAMBANK EROSION
MINOR BANK, GULLY, OR RILL EROSION
TRASH IN STREAM

Note: Identification numbers for streambank erosion sites correspond to the "Erosion ID" provided in Appendix D. Identification numbers for bridges, culverts, and dams correspond to "ID Numbers" provided in Appendix H.

OAK CREEK WATERSHED BOUNDARY
ASSESSMENT AREA BOUNDARIES
PERENNIAL STREAM
PERENNIAL STREAM (ENCLOSED)
INTERMITTENT STREAM
INTERMITTENT STREAM (ENCLOSED)

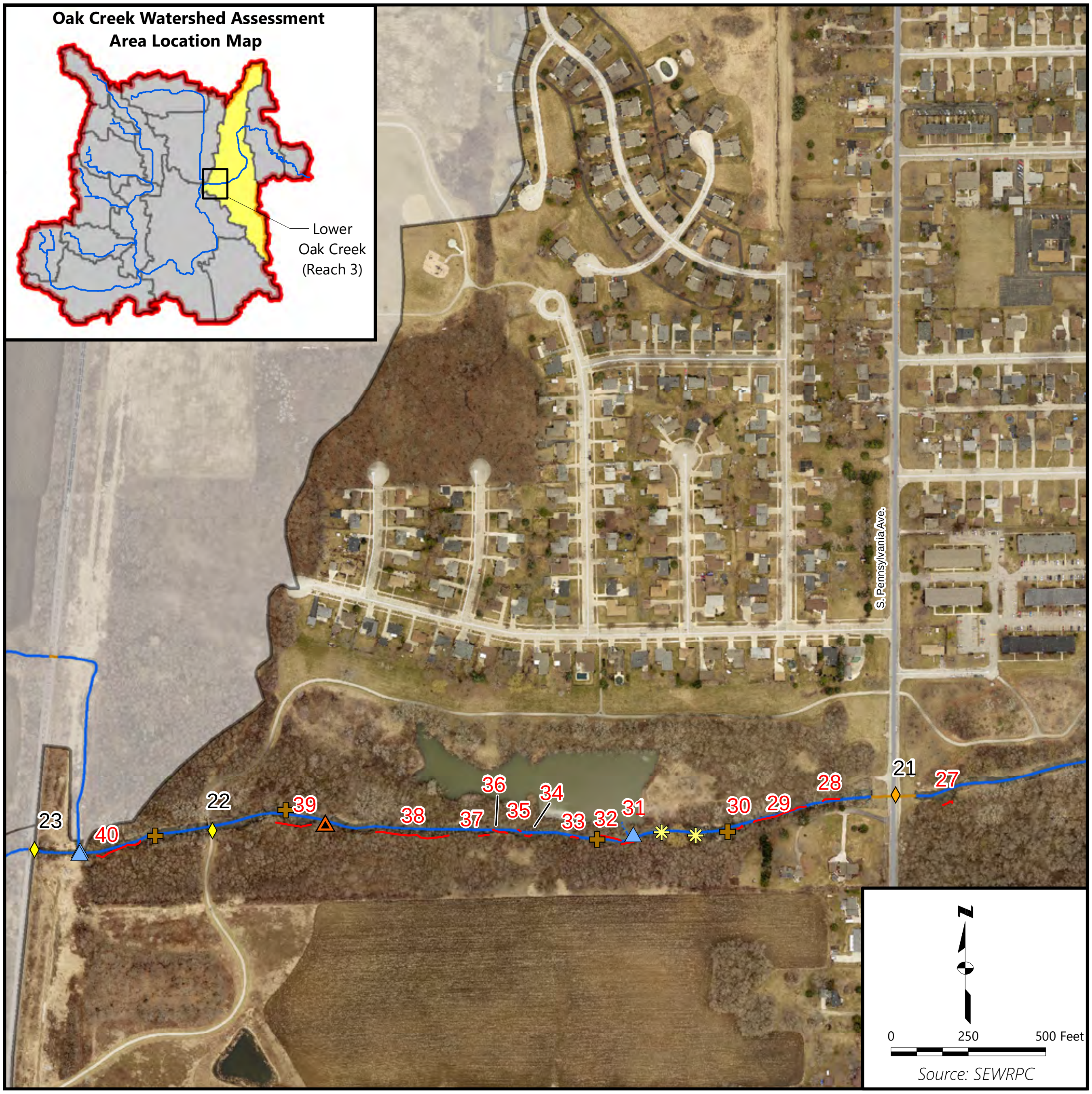
Map F.17
Stream Survey Inventory for the Lower Oak Creek Assessment Area (Reach 2)



- BRIDGE
- CULVERT
- DAM
- DROP STRUCTURE/WEIR
- ROCK WEIR
- WOODY DEBRIS JAM
- BEAVER DAM/ACTIVITY
- TRIBUTARY OR WETLAND DRAINAGE
- POND OUTLET
- GROUNDWATER SEEPAGE/SPRING
- DRAIN TILE
- POTENTIAL FISH BED OR SPAWNING SITE
- MUSSEL
- STREAMBANK EROSION
- MINOR BANK, GULLY, OR RILL EROSION
- TRASH IN STREAM
- OAK CREEK WATERSHED BOUNDARY
- ASSESSMENT AREA BOUNDARIES
- PERENNIAL STREAM
- PERENNIAL STREAM (ENCLOSED)
- INTERMITTENT STREAM
- INTERMITTENT STREAM (ENCLOSED)

Note: Identification numbers for streambank erosion sites correspond to the "Erosion ID" provided in Appendix D. Identification numbers for bridges, culverts, and dams correspond to "ID Numbers" provided in Appendix H.

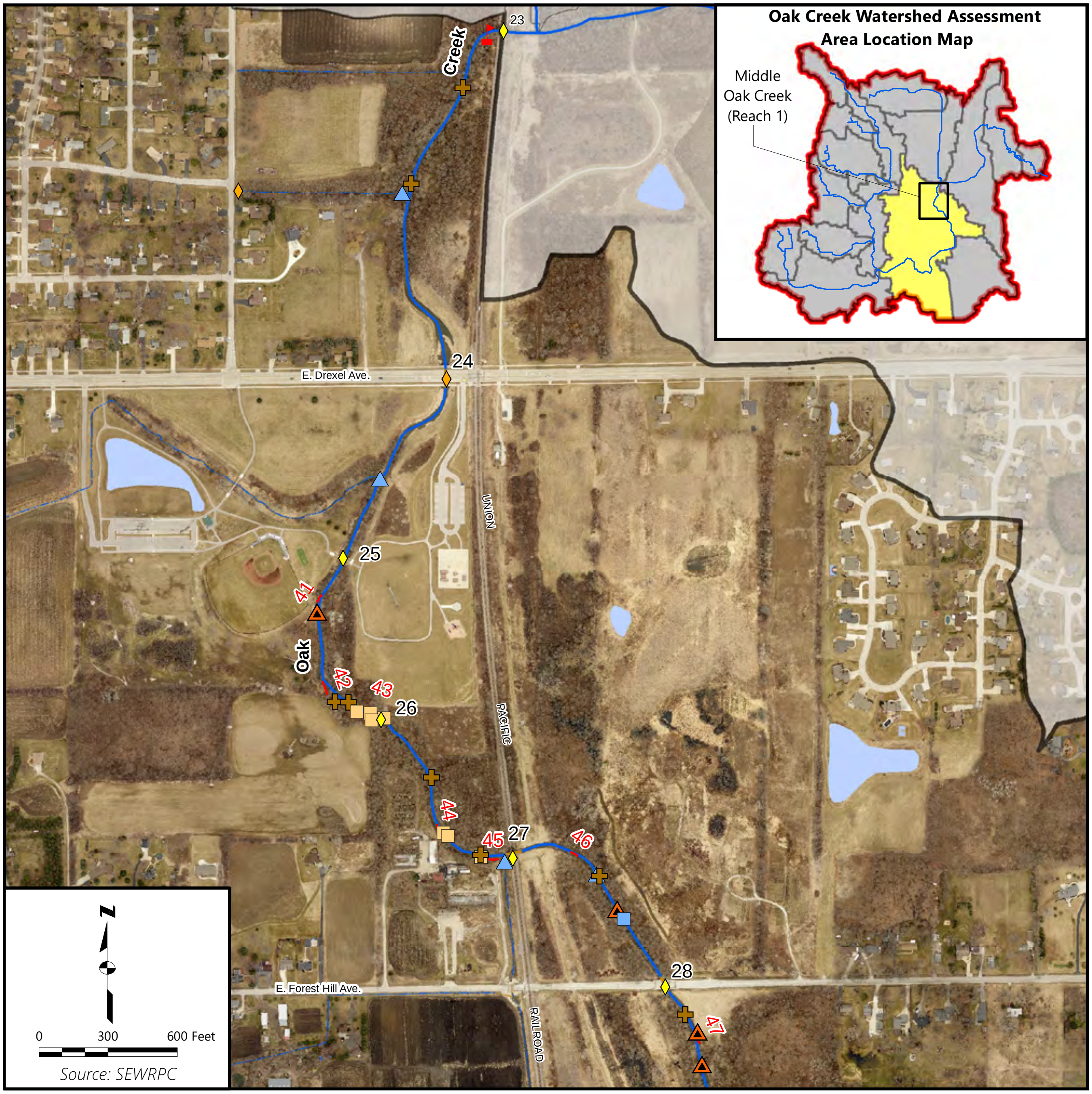
Map F.18
Stream Survey Inventory for the Lower Oak Creek Assessment Area (Reach 3)



BRIDGE
CULVERT
DAM
DROP STRUCTURE/WEIR
ROCK WEIR
WOODY DEBRIS JAM
BEAVER DAM/ACTIVITY
TRIBUTARY OR WETLAND DRAINAGE
POND OUTLET
GROUNDWATER SEEPAGE/SPRING
DRAIN TILE
POTENTIAL FISH BED OR SPAWNING SITE
MUSSEL
STREAMBANK EROSION
MINOR BANK, GULLY, OR RILL EROSION
TRASH IN STREAM
OAK CREEK WATERSHED BOUNDARY
ASSESSMENT AREA BOUNDARIES
PERENNIAL STREAM
PERENNIAL STREAM (ENCLOSED)
INTERMITTENT STREAM
INTERMITTENT STREAM (ENCLOSED)

Note: Identification numbers for streambank erosion sites correspond to the "Erosion ID" provided in Appendix D. Identification numbers for bridges, culverts, and dams correspond to "ID Numbers" provided in Appendix H.

Map F.19
Stream Survey Inventory for the Middle Oak Creek Assessment Area (Reach 1)



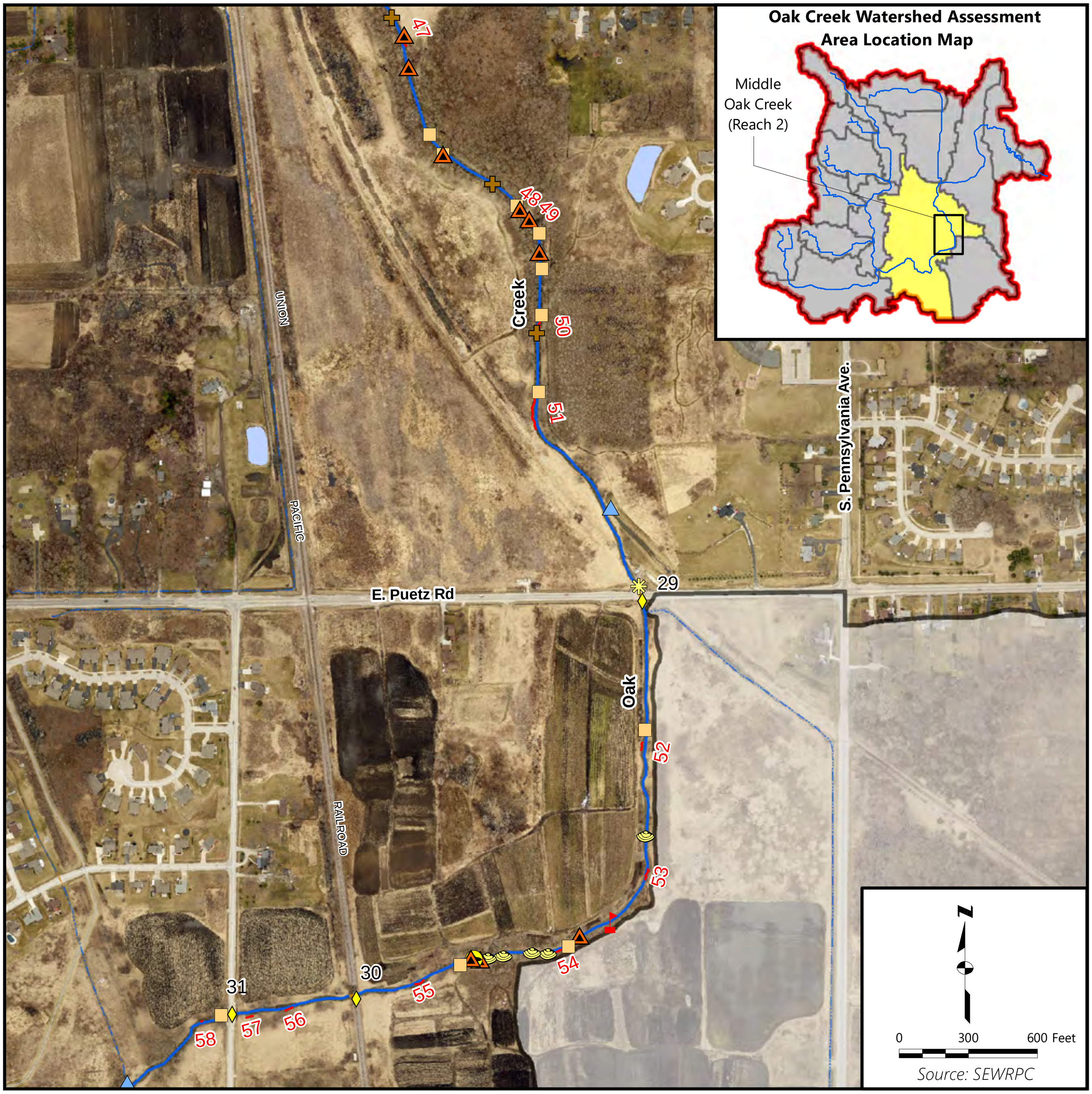
BRIDGE
CULVERT
DAM
DROP STRUCTURE/WEIR
ROCK WEIR
WOODY DEBRIS JAM
BEAVER DAM/ACTIVITY
TRIBUTARY OR WETLAND DRAINAGE
POND OUTLET
GROUNDWATER SEEPAGE/SPRING
DRAIN TILE

POTENTIAL FISH BED OR SPAWNING SITE
MUSSEL
STREAMBANK EROSION
MINOR BANK, GULLY, OR RILL EROSION
TRASH IN STREAM

Note: Identification numbers for streambank erosion sites correspond to the "Erosion ID" provided in Appendix D. Identification numbers for bridges, culverts, and dams correspond to "ID Numbers" provided in Appendix H.

OAK CREEK WATERSHED BOUNDARY
ASSESSMENT AREA BOUNDARIES
PERENNIAL STREAM
PERENNIAL STREAM (ENCLOSED)
INTERMITTENT STREAM
INTERMITTENT STREAM (ENCLOSED)

Map F.20
Stream Survey Inventory for the Middle Oak Creek Assessment Area (Reach 2)



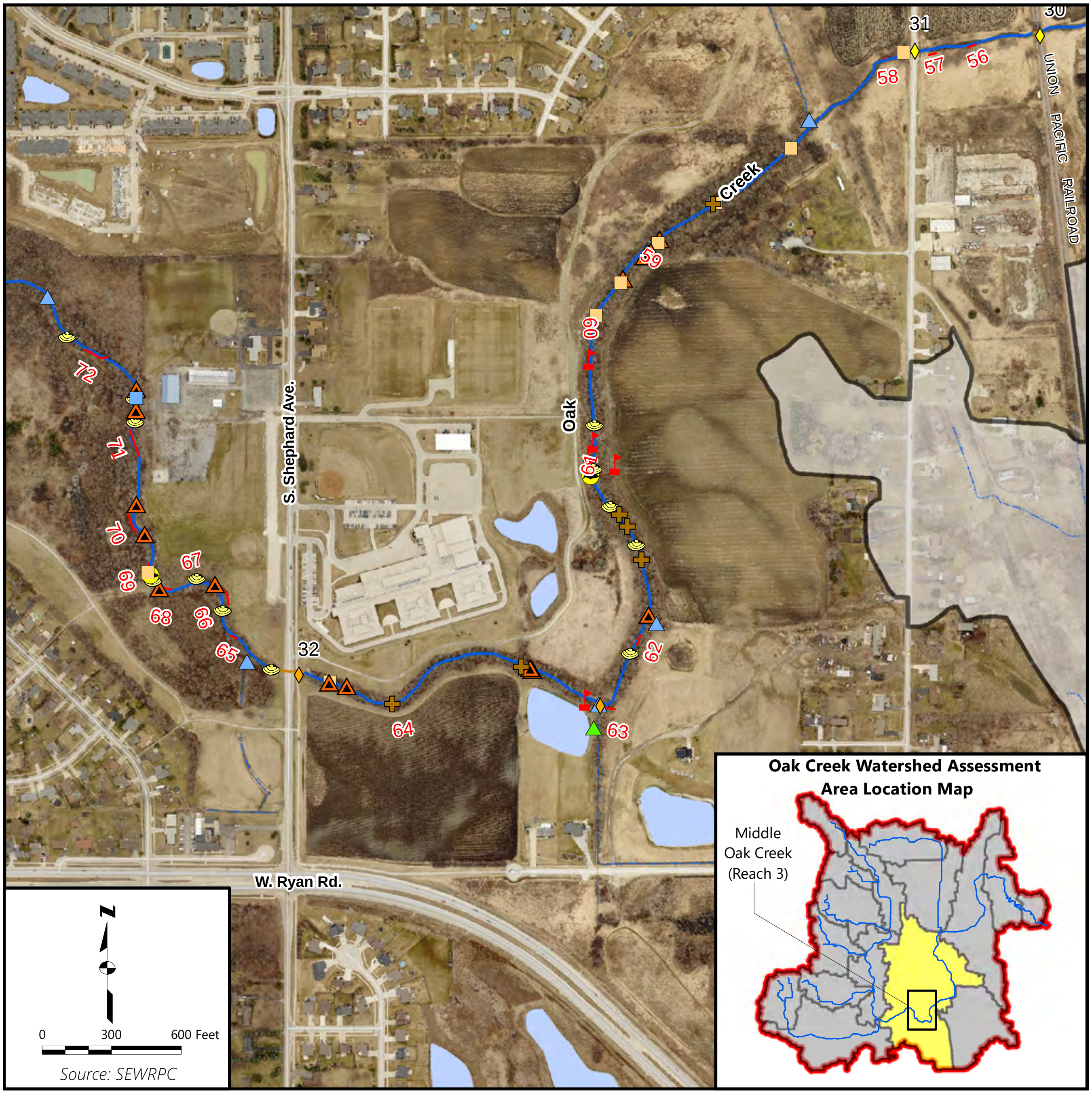
BRIDGE
CULVERT
DAM
DROP STRUCTURE/WEIR
ROCK WEIR
WOODY DEBRIS JAM
BEAVER DAM/ACTIVITY
TRIBUTARY OR WETLAND DRAINAGE
POND OUTLET
GROUNDWATER SEEPAGE/SPRING
DRAIN TILE

POTENTIAL FISH BED OR SPAWNING SITE
MUSSEL
STREAMBANK EROSION
MINOR BANK, GULLY, OR RILL EROSION
TRASH IN STREAM

Note: Identification numbers for streambank erosion sites correspond to the "Erosion ID" provided in Appendix D. Identification numbers for bridges, culverts, and dams correspond to "ID Numbers" provided in Appendix H.

OAK CREEK WATERSHED BOUNDARY
ASSESSMENT AREA BOUNDARIES
PERENNIAL STREAM
PERENNIAL STREAM (ENCLOSED)
INTERMITTENT STREAM
INTERMITTENT STREAM (ENCLOSED)

Map F.21
Stream Survey Inventory for the Middle Oak Creek Assessment Area (Reach 3)



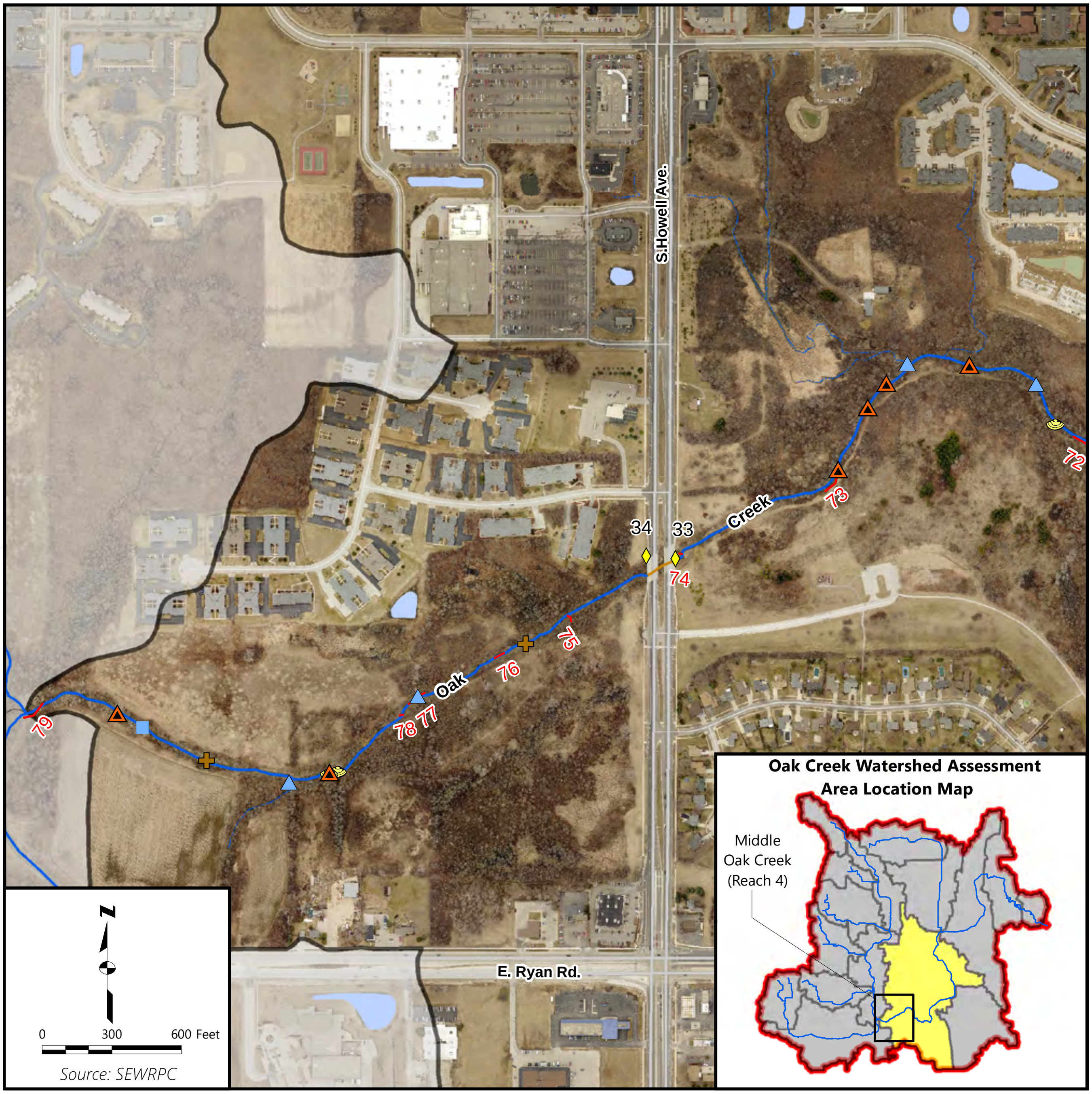
BRIDGE
CULVERT
DAM
DROP STRUCTURE/WEIR
ROCK WEIR
WOODY DEBRIS JAM
BEAVER DAM/ACTIVITY
TRIBUTARY OR WETLAND DRAINAGE
POND OUTLET
GROUNDWATER SEEPAGE/SPRING
DRAIN TILE

POTENTIAL FISH BED OR SPAWNING SITE
MUSSEL
STREAMBANK EROSION
MINOR BANK, GULLY, OR RILL EROSION
TRASH IN STREAM

Note: Identification numbers for streambank erosion sites correspond to the "Erosion ID" provided in Appendix D. Identification numbers for bridges, culverts, and dams correspond to "ID Numbers" provided in Appendix H.

OAK CREEK WATERSHED BOUNDARY
ASSESSMENT AREA BOUNDARIES
PERENNIAL STREAM
PERENNIAL STREAM (ENCLOSED)
INTERMITTENT STREAM
INTERMITTENT STREAM (ENCLOSED)

Map F.22
Stream Survey Inventory for the Middle Oak Creek Assessment Area (Reach 4)



- BRIDGE
- CULVERT
- DAM
- DROP STRUCTURE/WEIR
- ROCK WEIR
- WOODY DEBRIS JAM
- BEAVER DAM/ACTIVITY
- TRIBUTARY OR WETLAND DRAINAGE
- POND OUTLET
- GROUNDWATER SEEPAGE/SPRING
- DRAIN TILE

- POTENTIAL FISH BED OR SPAWNING SITE
- MUSSEL
- STREAMBANK EROSION
- MINOR BANK, GULLY, OR RILL EROSION
- TRASH IN STREAM

Note: Identification numbers for streambank erosion sites correspond to the "Erosion ID" provided in Appendix D. Identification numbers for bridges, culverts, and dams correspond to "ID Numbers" provided in Appendix H.

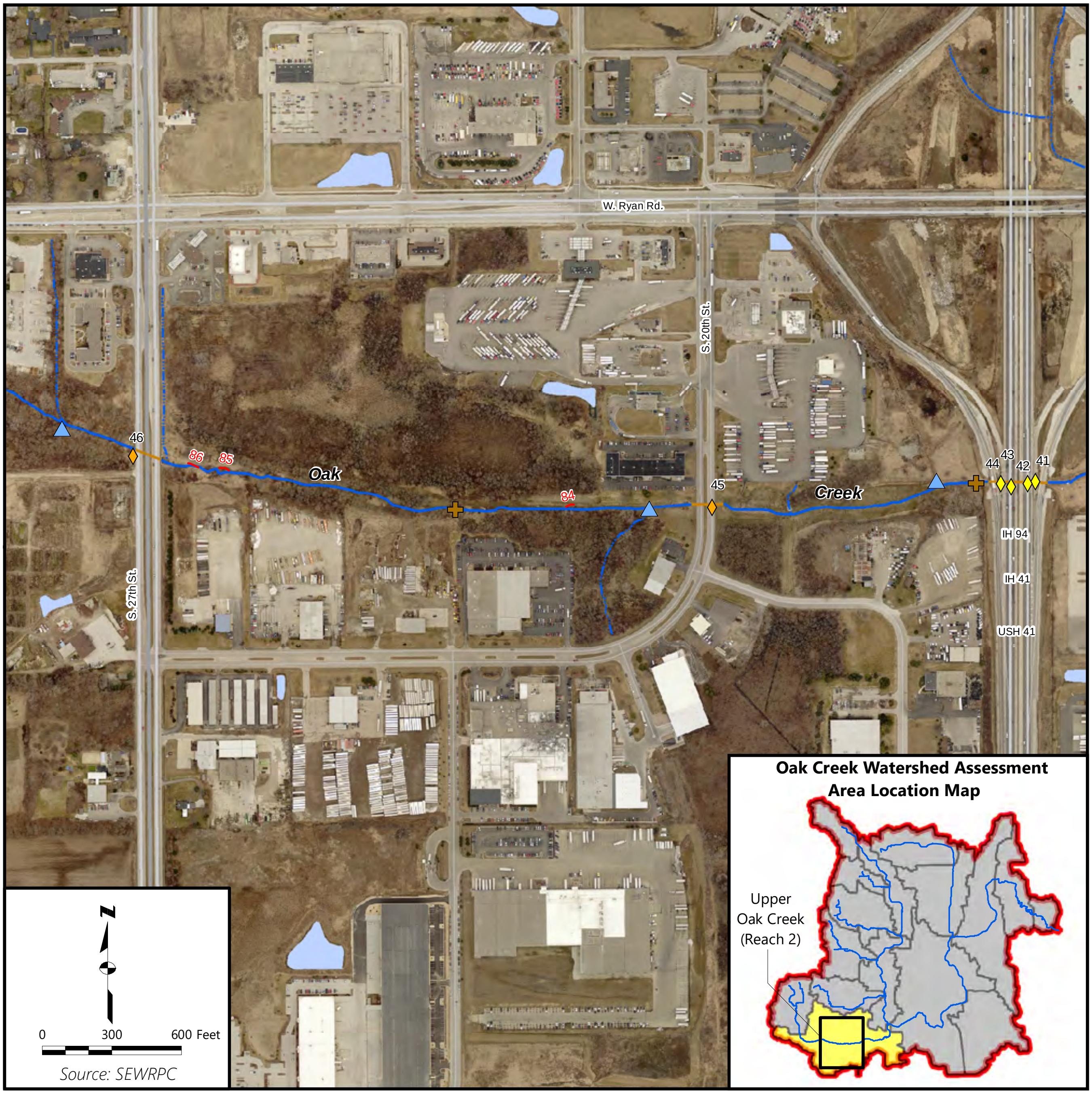
- OAK CREEK WATERSHED BOUNDARY
- ASSESSMENT AREA BOUNDARIES
- PERENNIAL STREAM
- PERENNIAL STREAM (ENCLOSED)
- INTERMITTENT STREAM
- INTERMITTENT STREAM (ENCLOSED)

Map F.23
Stream Survey Inventory for Upper Oak Creek Assessment Area (Reach 1)

- BRIDGE
- CULVERT
- DAM
- DROP STRUCTURE/WEIR
- ROCK WEIR
- WOODY DEBRIS JAM
- BEAVER DAM/ACTIVITY
- TRIBUTARY OR WETLAND DRAINAGE
- POND OUTLET
- GROUNDWATER SEEPAGE/SPRING
- DRAIN TILE
- POTENTIAL FISH BED OR SPAWNING SITE
- MUSSEL
- STREAMBANK EROSION
- MINOR BANK, GULLY, OR RILL EROSION
- TRASH IN STREAM
- OAK CREEK WATERSHED BOUNDARY
- ASSESSMENT AREA BOUNDARIES
- PERENNIAL STREAM
- PERENNIAL STREAM (ENCLOSED)
- INTERMITTENT STREAM
- INTERMITTENT STREAM (ENCLOSED)

Note: Identification numbers for streambank erosion sites correspond to the "Erosion ID" provided in Appendix D. Identification numbers for bridges, culverts, and dams correspond to "ID Numbers" provided in Appendix H.

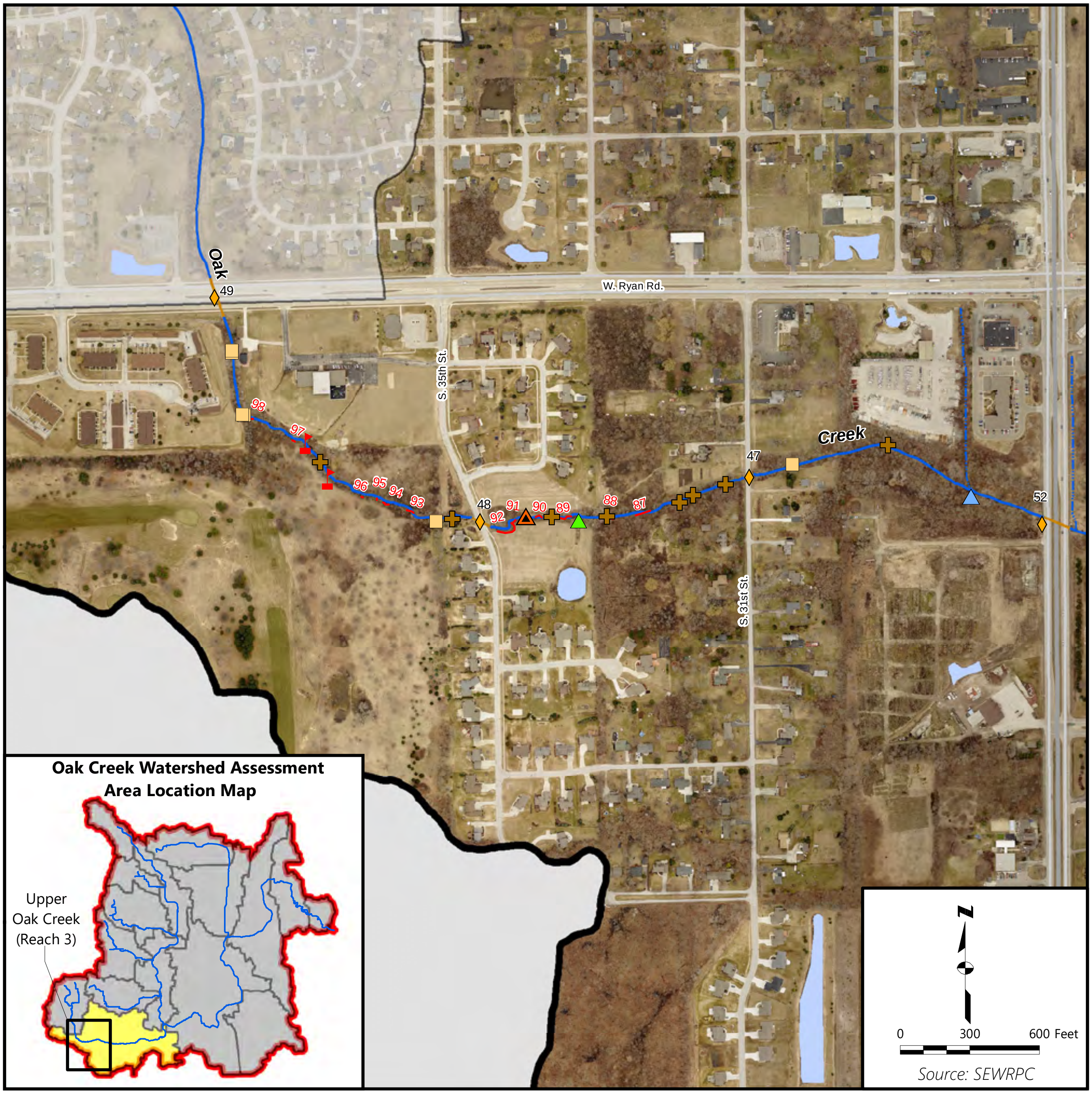
Map F.24
Stream Survey Inventory for Upper Oak Creek Assessment Area (Reach 2)



BRIDGE
CULVERT
DAM
DROP STRUCTURE/WEIR
ROCK WEIR
WOODY DEBRIS JAM
BEAVER DAM/ACTIVITY
TRIBUTARY OR WETLAND DRAINAGE
POND OUTLET
GROUNDWATER SEEPAGE/SPRING
DRAIN TILE
POTENTIAL FISH BED OR SPAWNING SITE
MUSSEL
STREAMBANK EROSION
MINOR BANK, GULLY, OR RILL EROSION
TRASH IN STREAM
OAK CREEK WATERSHED BOUNDARY
ASSESSMENT AREA BOUNDARIES
PERENNIAL STREAM
PERENNIAL STREAM (ENCLOSED)
INTERMITTENT STREAM
INTERMITTENT STREAM (ENCLOSED)

Note: Identification numbers for streambank erosion sites correspond to the "Erosion ID" provided in Appendix D. Identification numbers for bridges, culverts, and dams correspond to "ID Numbers" provided in Appendix H.

Map F.25
Stream Survey Inventory for Upper Oak Creek Assessment Area (Reach 3)



BRIDGE
CULVERT
DAM
DROP STRUCTURE/WEIR
ROCK WEIR
WOODY DEBRIS JAM
BEAVER DAM/ACTIVITY
TRIBUTARY OR WETLAND DRAINAGE
POND OUTLET
GROUNDWATER SEEPAGE/SPRING
DRAIN TILE

POTENTIAL FISH BED OR SPAWNING SITE
MUSSEL
STREAMBANK EROSION
MINOR BANK, GULLY, OR RILL EROSION
TRASH IN STREAM

Note: Identification numbers for streambank erosion sites correspond to the "Erosion ID" provided in Appendix D. Identification numbers for bridges, culverts, and dams correspond to "ID Numbers" provided in Appendix H.

OAK CREEK WATERSHED BOUNDARY
ASSESSMENT AREA BOUNDARIES
PERENNIAL STREAM
PERENNIAL STREAM (ENCLOSED)
INTERMITTENT STREAM
INTERMITTENT STREAM (ENCLOSED)

Map F.26
Stream Survey Inventory for the Oak Creek Headwaters Assessment Area (Reach 1)

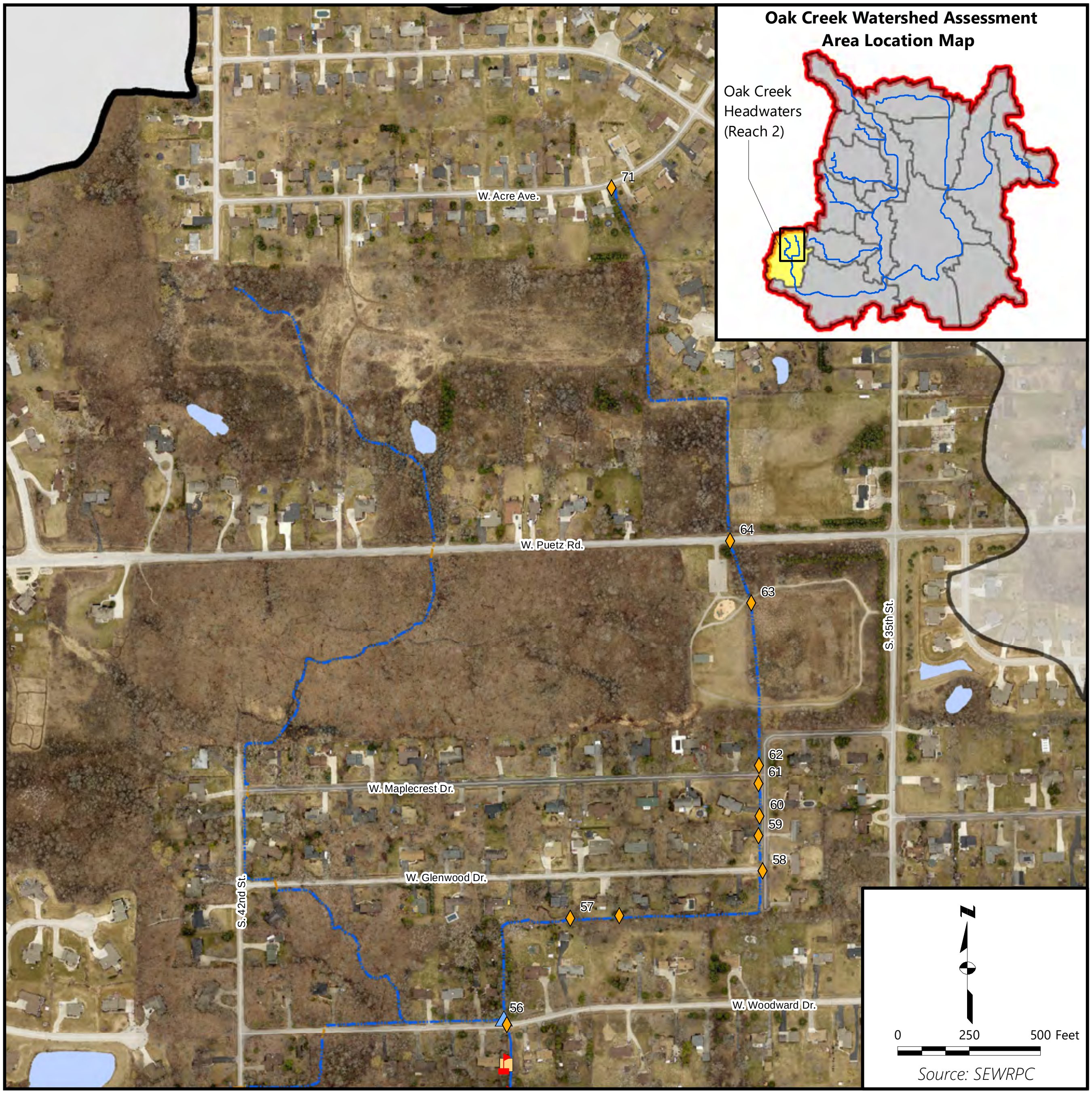
BRIDGE
CULVERT
DAM
DROP STRUCTURE/WEIR
ROCK WEIR
WOODY DEBRIS JAM
BEAVER DAM/ACTIVITY
TRIBUTARY OR WETLAND DRAINAGE
POND OUTLET
GROUNDWATER SEEPAGE/SPRING
DRAIN TILE

POTENTIAL FISH BED OR SPAWNING SITE
MUSSEL
STREAMBANK EROSION
MINOR BANK, GULLY, OR RILL EROSION
TRASH IN STREAM

Note: Identification numbers for streambank erosion sites correspond to the "Erosion ID" provided in Appendix D. Identification numbers for bridges, culverts, and dams correspond to "ID Numbers" provided in Appendix H.

OAK CREEK WATERSHED BOUNDARY
ASSESSMENT AREA BOUNDARIES
PERENNIAL STREAM
PERENNIAL STREAM (ENCLOSED)
INTERMITTENT STREAM
INTERMITTENT STREAM (ENCLOSED)

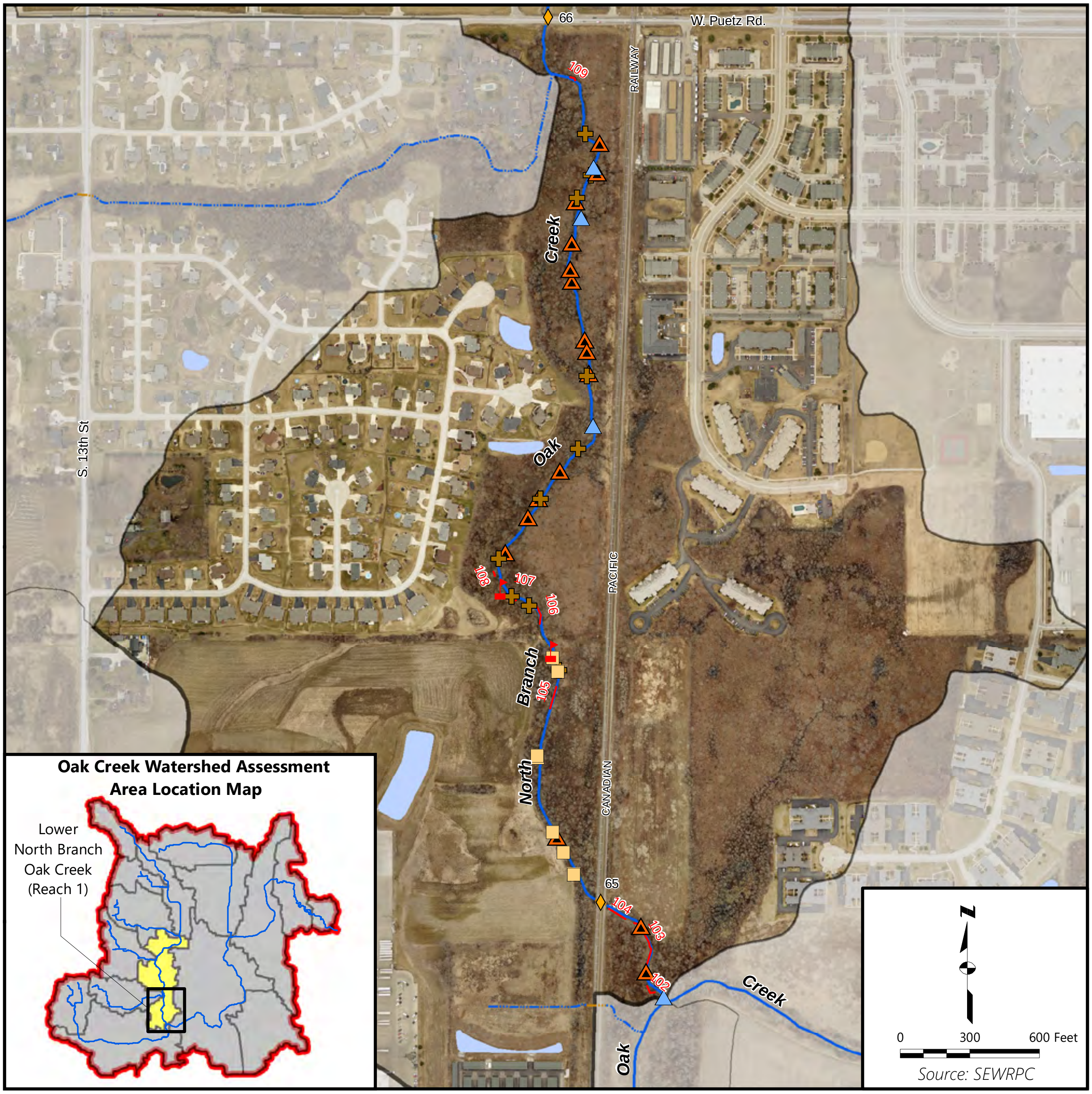
Map F.27
Stream Survey Inventory for the Oak Creek Headwaters Assessment Area (Reach 2)



- BRIDGE
- CULVERT
- DAM
- DROP STRUCTURE/WEIR
- ROCK WEIR
- WOODY DEBRIS JAM
- BEAVER DAM/ACTIVITY
- TRIBUTARY OR WETLAND DRAINAGE
- POND OUTLET
- GROUNDWATER SEEPAGE/SPRING
- DRAIN TILE
- POTENTIAL FISH BED OR SPAWNING SITE
- MUSSEL
- STREAMBANK EROSION
- MINOR BANK, GULLY, OR RILL EROSION
- TRASH IN STREAM
- OAK CREEK WATERSHED BOUNDARY
- ASSESSMENT AREA BOUNDARIES
- PERENNIAL STREAM
- PERENNIAL STREAM (ENCLOSED)
- INTERMITTENT STREAM
- INTERMITTENT STREAM (ENCLOSED)

Note: Identification numbers for streambank erosion sites correspond to the "Erosion ID" provided in Appendix D. Identification numbers for bridges, culverts, and dams correspond to "ID Numbers" provided in Appendix H.

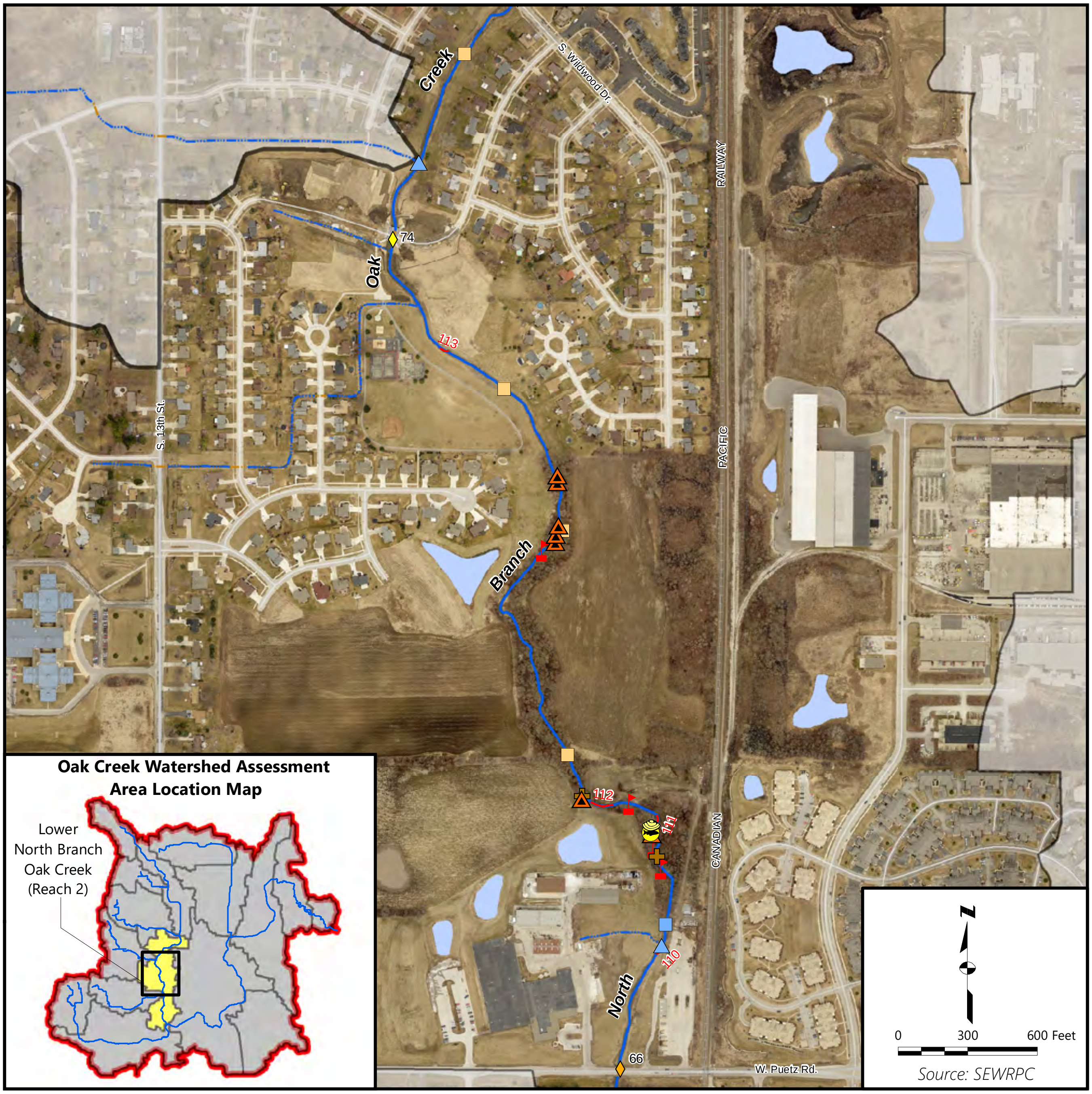
Map F.28
Stream Survey Inventory for the Lower North Branch Oak Creek Assessment Area (Reach 1)



- BRIDGE
- CULVERT
- DAM
- DROP STRUCTURE/WEIR
- ROCK WEIR
- WOODY DEBRIS JAM
- BEAVER DAM/ACTIVITY
- TRIBUTARY OR WETLAND DRAINAGE
- POND OUTLET
- GROUNDWATER SEEPAGE/SPRING
- DRAIN TILE
- POTENTIAL FISH BED OR SPAWNING SITE
- MUSSEL
- STREAMBANK EROSION
- MINOR BANK, GULLY, OR RILL EROSION
- TRASH IN STREAM
- OAK CREEK WATERSHED BOUNDARY
- ASSESSMENT AREA BOUNDARIES
- PERENNIAL STREAM
- PERENNIAL STREAM (ENCLOSED)
- INTERMITTENT STREAM
- INTERMITTENT STREAM (ENCLOSED)

Note: Identification numbers for streambank erosion sites correspond to the "Erosion ID" provided in Appendix D. Identification numbers for bridges, culverts, and dams correspond to "ID Numbers" provided in Appendix H.

Map F.29
Stream Survey Inventory for the Lower North Branch Oak Creek Assessment Area (Reach 2)



- BRIDGE
- CULVERT
- DAM
- DROP STRUCTURE/WEIR
- ROCK WEIR
- WOODY DEBRIS JAM
- BEAVER DAM/ACTIVITY
- TRIBUTARY OR WETLAND DRAINAGE
- POND OUTLET
- GROUNDWATER SEEPAGE/SPRING
- DRAIN TILE
- POTENTIAL FISH BED OR SPAWNING SITE
- MUSSEL
- STREAMBANK EROSION
- MINOR BANK, GULLY, OR RILL EROSION
- TRASH IN STREAM
- OAK CREEK WATERSHED BOUNDARY
- ASSESSMENT AREA BOUNDARIES
- PERENNIAL STREAM
- PERENNIAL STREAM (ENCLOSED)
- INTERMITTENT STREAM
- INTERMITTENT STREAM (ENCLOSED)

Note: Identification numbers for streambank erosion sites correspond to the "Erosion ID" provided in Appendix D. Identification numbers for bridges, culverts, and dams correspond to "ID Numbers" provided in Appendix H.

Map F.30
Stream Survey Inventory for the Lower North Branch Oak Creek Assessment Area (Reach 3)

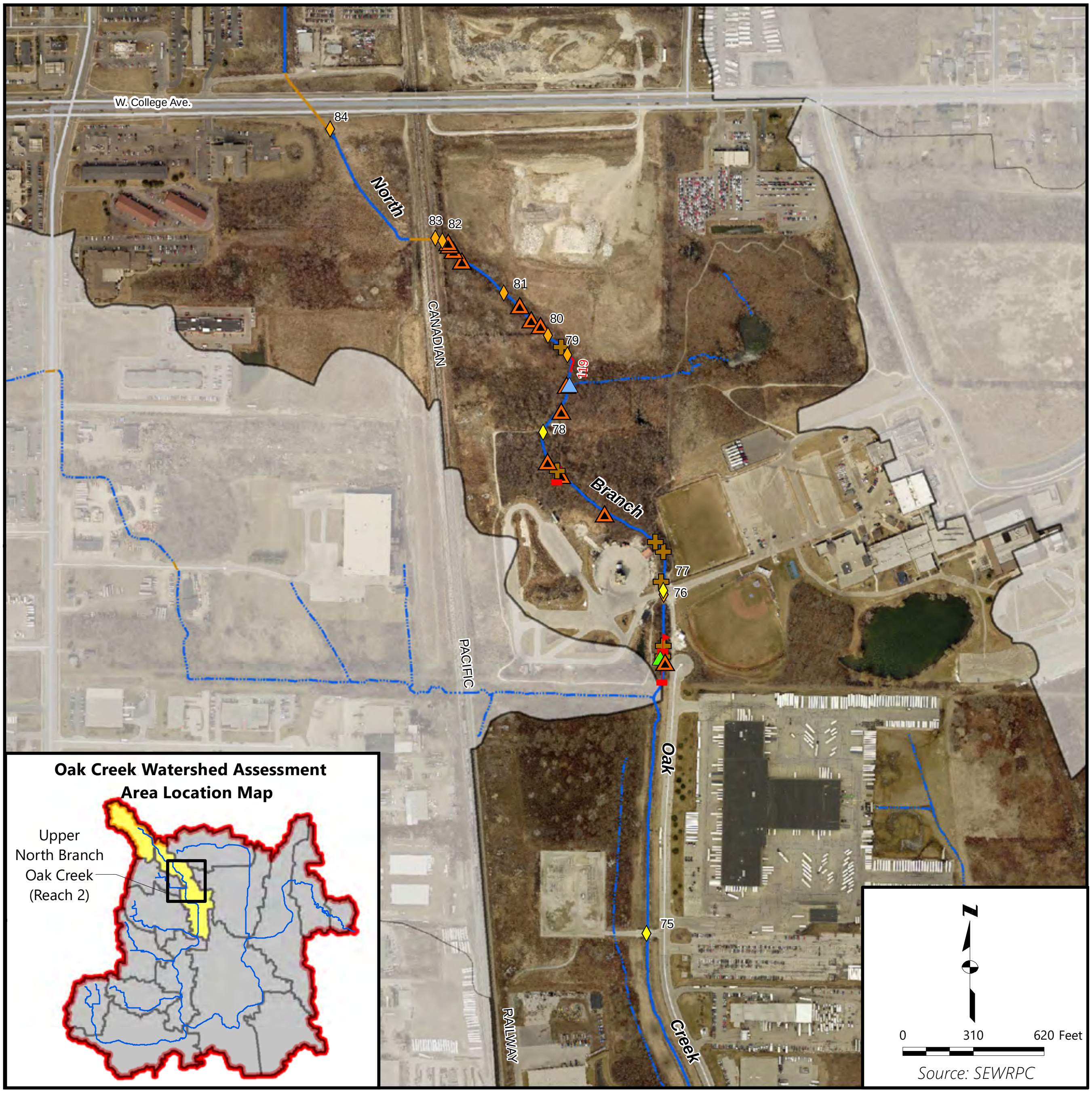
- BRIDGE
- CULVERT
- DAM
- DROP STRUCTURE/WEIR
- ROCK WEIR
- WOODY DEBRIS JAM
- BEAVER DAM/ACTIVITY
- TRIBUTARY OR WETLAND DRAINAGE
- POND OUTLET
- GROUNDWATER SEEPAGE/SPRING
- DRAIN TILE
- POTENTIAL FISH BED OR SPAWNING SITE
- MUSSEL
- STREAMBANK EROSION
- MINOR BANK, GULLY, OR RILL EROSION
- TRASH IN STREAM
- OAK CREEK WATERSHED BOUNDARY
- ASSESSMENT AREA BOUNDARIES
- PERENNIAL STREAM
- PERENNIAL STREAM (ENCLOSED)
- INTERMITTENT STREAM
- INTERMITTENT STREAM (ENCLOSED)

Note: Identification numbers for streambank erosion sites correspond to the "Erosion ID" provided in Appendix D. Identification numbers for bridges, culverts, and dams correspond to "ID Numbers" provided in Appendix H.

Map F.31
Stream Survey Inventory for the Upper North Branch Oak Creek Assessment Area (Reach 1)

Note: Identification numbers for streambank erosion sites correspond to the "Erosion ID" provided in Appendix D. Identification numbers for bridges, culverts, and dams correspond to "ID Numbers" provided in Appendix H.

Map F.32
Stream Survey Inventory for the Upper North Branch Oak Creek Assessment Area (Reach 2)



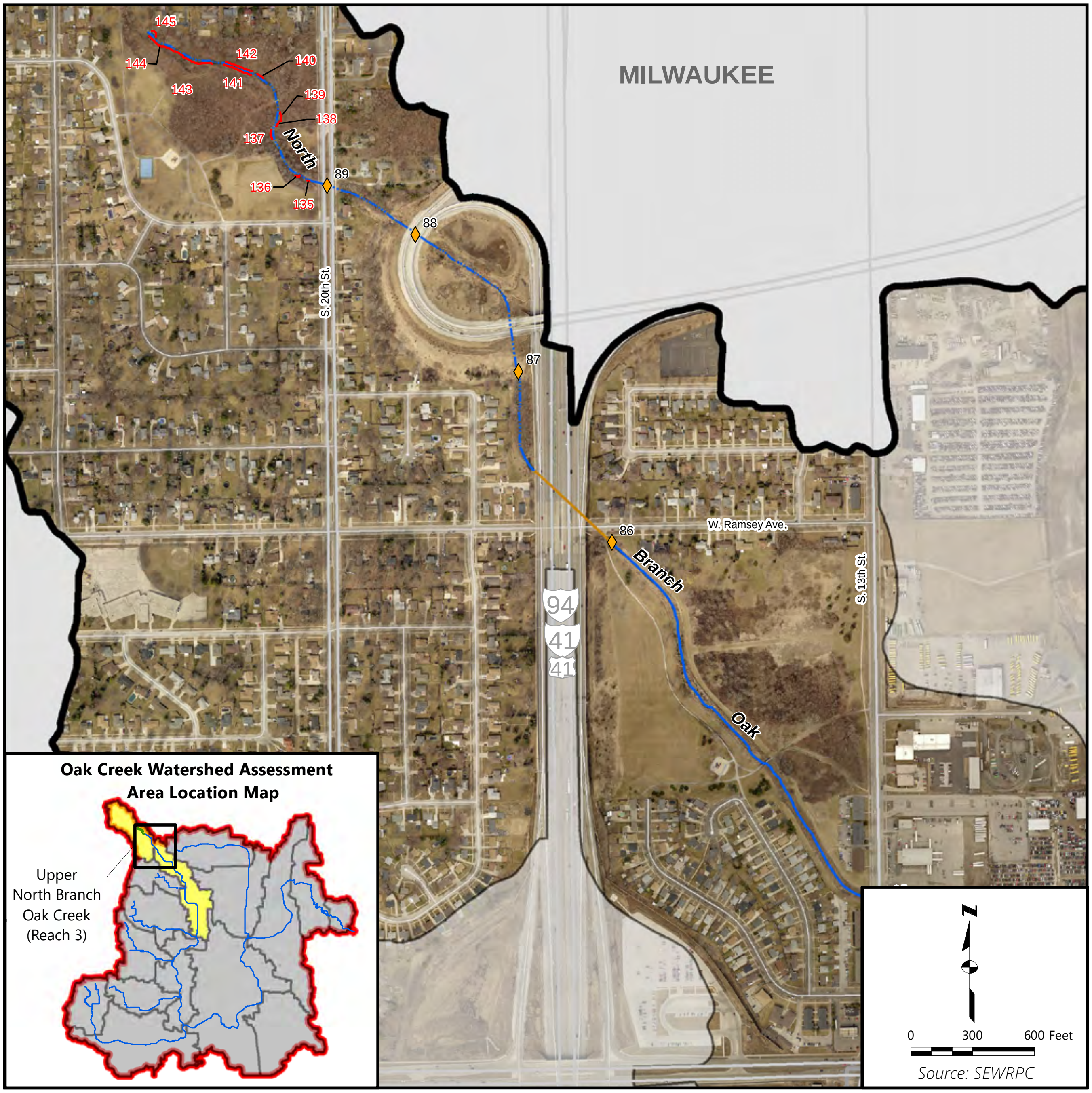
BRIDGE
CULVERT
DAM
DROP STRUCTURE/WEIR
ROCK WEIR
WOODY DEBRIS JAM
BEAVER DAM/ACTIVITY
TRIBUTARY OR WETLAND DRAINAGE
POND OUTLET
GROUNDWATER SEEPAGE/SPRING
DRAIN TILE

POTENTIAL FISH BED OR SPAWNING SITE
MUSSEL
STREAMBANK EROSION
MINOR BANK, GULLY, OR RILL EROSION
TRASH IN STREAM

Note: Identification numbers for streambank erosion sites correspond to the "Erosion ID" provided in Appendix D. Identification numbers for bridges, culverts, and dams correspond to "ID Numbers" provided in Appendix H.

OAK CREEK WATERSHED BOUNDARY
ASSESSMENT AREA BOUNDARIES
PERENNIAL STREAM
PERENNIAL STREAM (ENCLOSED)
INTERMITTENT STREAM
INTERMITTENT STREAM (ENCLOSED)

Map F.33
Stream Survey Inventory for the Upper North Branch Oak Creek Assessment Area (Reach 3)

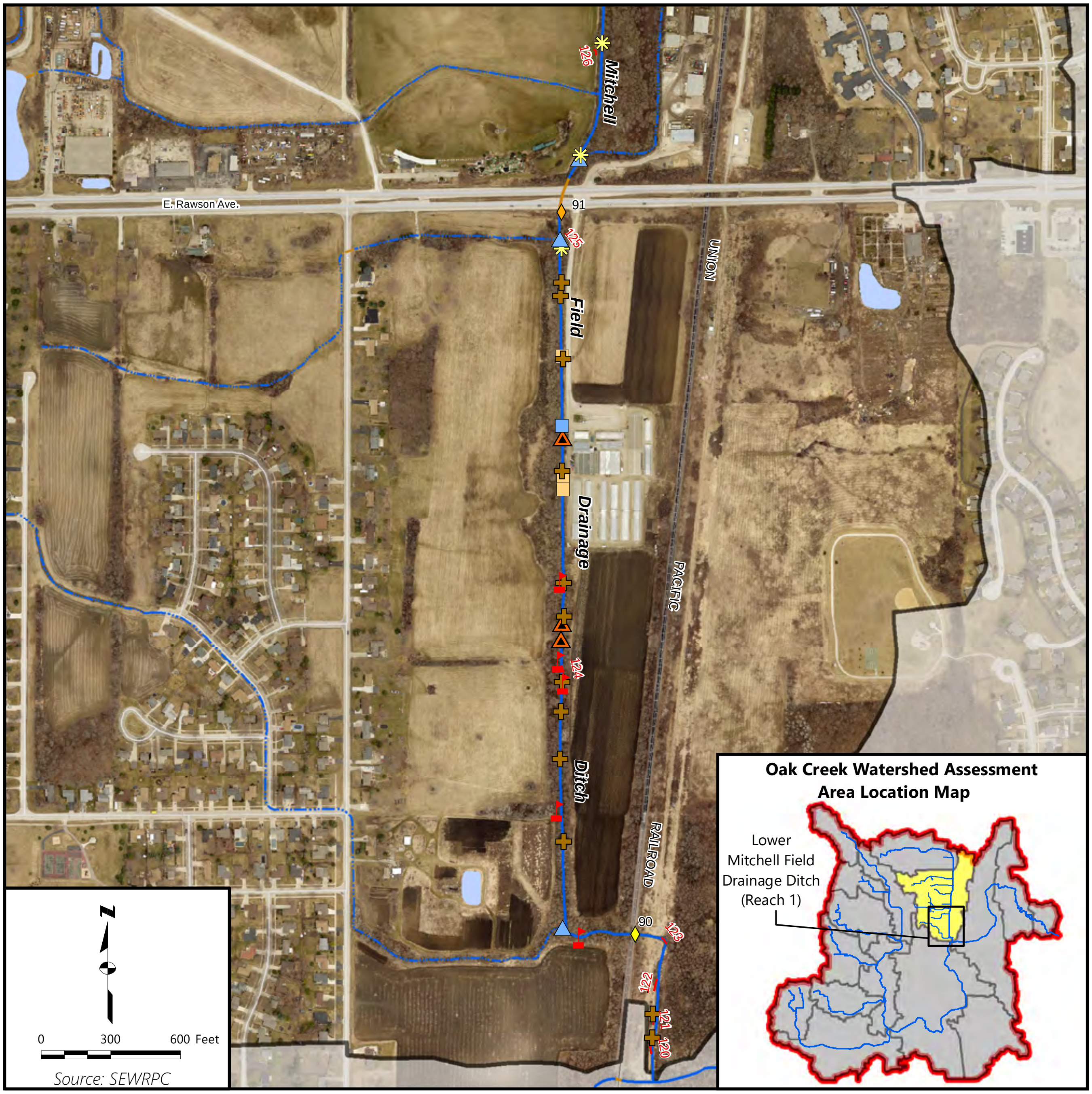


- BRIDGE
- CULVERT
- DAM
- DROP STRUCTURE/WEIR
- ROCK WEIR
- WOODY DEBRIS JAM
- BEAVER DAM/ACTIVITY
- TRIBUTARY OR WETLAND DRAINAGE
- POND OUTLET
- GROUNDWATER SEEPAGE/SPRING
- DRAIN TILE
- POTENTIAL FISH BED OR SPAWNING SITE
- MUSSEL
- STREAMBANK EROSION
- MINOR BANK, GULLY, OR RILL EROSION
- TRASH IN STREAM

Note: Identification numbers for streambank erosion sites correspond to the "Erosion ID" provided in Appendix D. Identification numbers for bridges, culverts, and dams correspond to "ID Numbers" provided in Appendix H.

- OAK CREEK WATERSHED BOUNDARY
- ASSESSMENT AREA BOUNDARIES
- PERENNIAL STREAM
- PERENNIAL STREAM (ENCLOSED)
- INTERMITTENT STREAM
- INTERMITTENT STREAM (ENCLOSED)

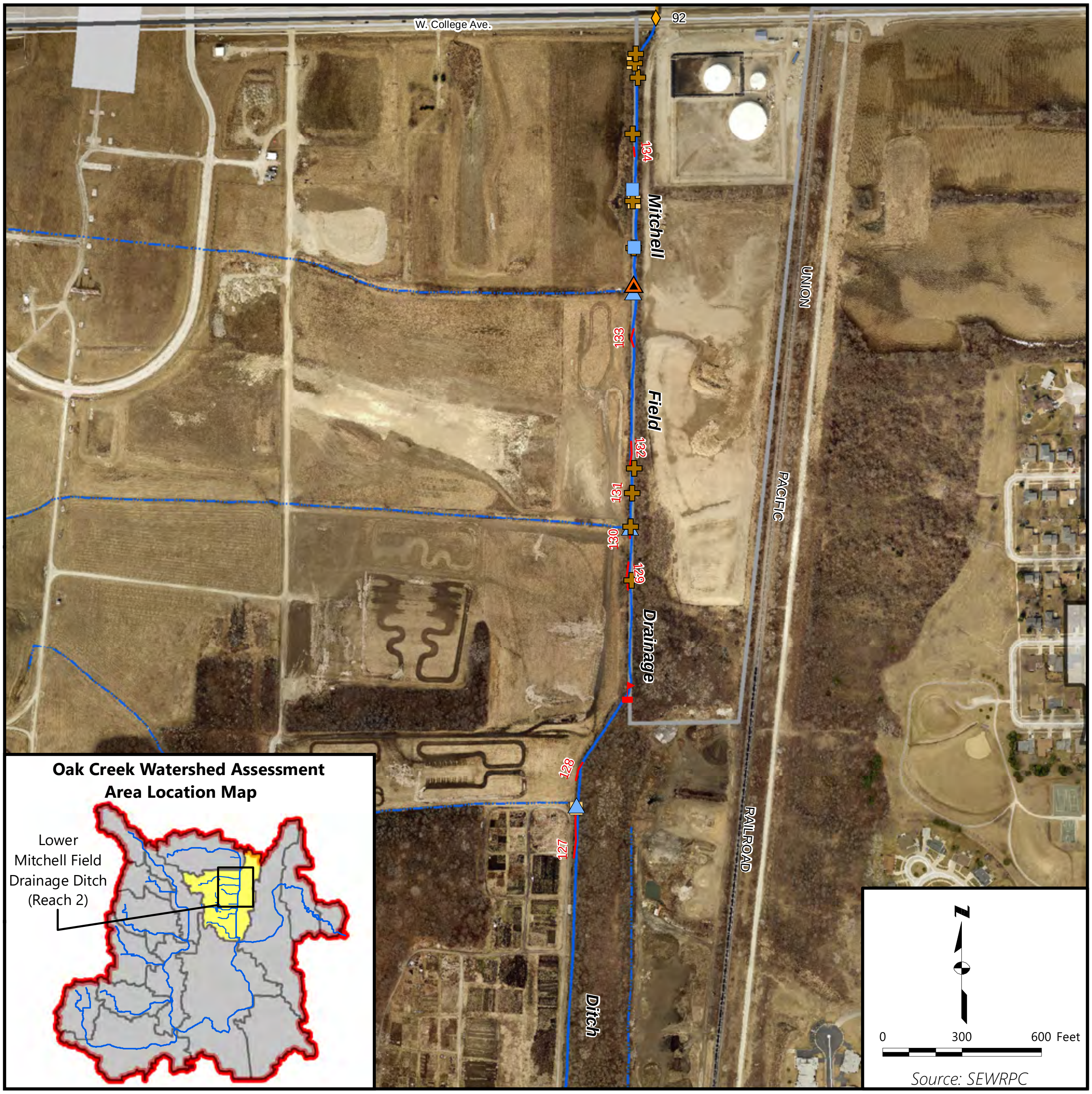
Map F.34
Stream Survey Inventory for the Lower Mitchell Field Drainage Ditch Assessment Area (Reach 1)



- BRIDGE
- CULVERT
- DAM
- DROP STRUCTURE/WEIR
- ROCK WEIR
- WOODY DEBRIS JAM
- BEAVER DAM/ACTIVITY
- TRIBUTARY OR WETLAND DRAINAGE
- POND OUTLET
- GROUNDWATER SEEPAGE/SPRING
- DRAIN TILE
- POTENTIAL FISH BED OR SPAWNING SITE
- MUSSEL
- STREAMBANK EROSION
- MINOR BANK, GULLY, OR RILL EROSION
- TRASH IN STREAM
- OAK CREEK WATERSHED BOUNDARY
- ASSESSMENT AREA BOUNDARIES
- PERENNIAL STREAM
- PERENNIAL STREAM (ENCLOSED)
- INTERMITTENT STREAM
- INTERMITTENT STREAM (ENCLOSED)

Note: Identification numbers for streambank erosion sites correspond to the "Erosion ID" provided in Appendix D. Identification numbers for bridges, culverts, and dams correspond to "ID Numbers" provided in Appendix H.

Map F.35
Stream Survey Inventory for the Lower Mitchell Field Drainage Ditch Assessment Area (Reach 2)



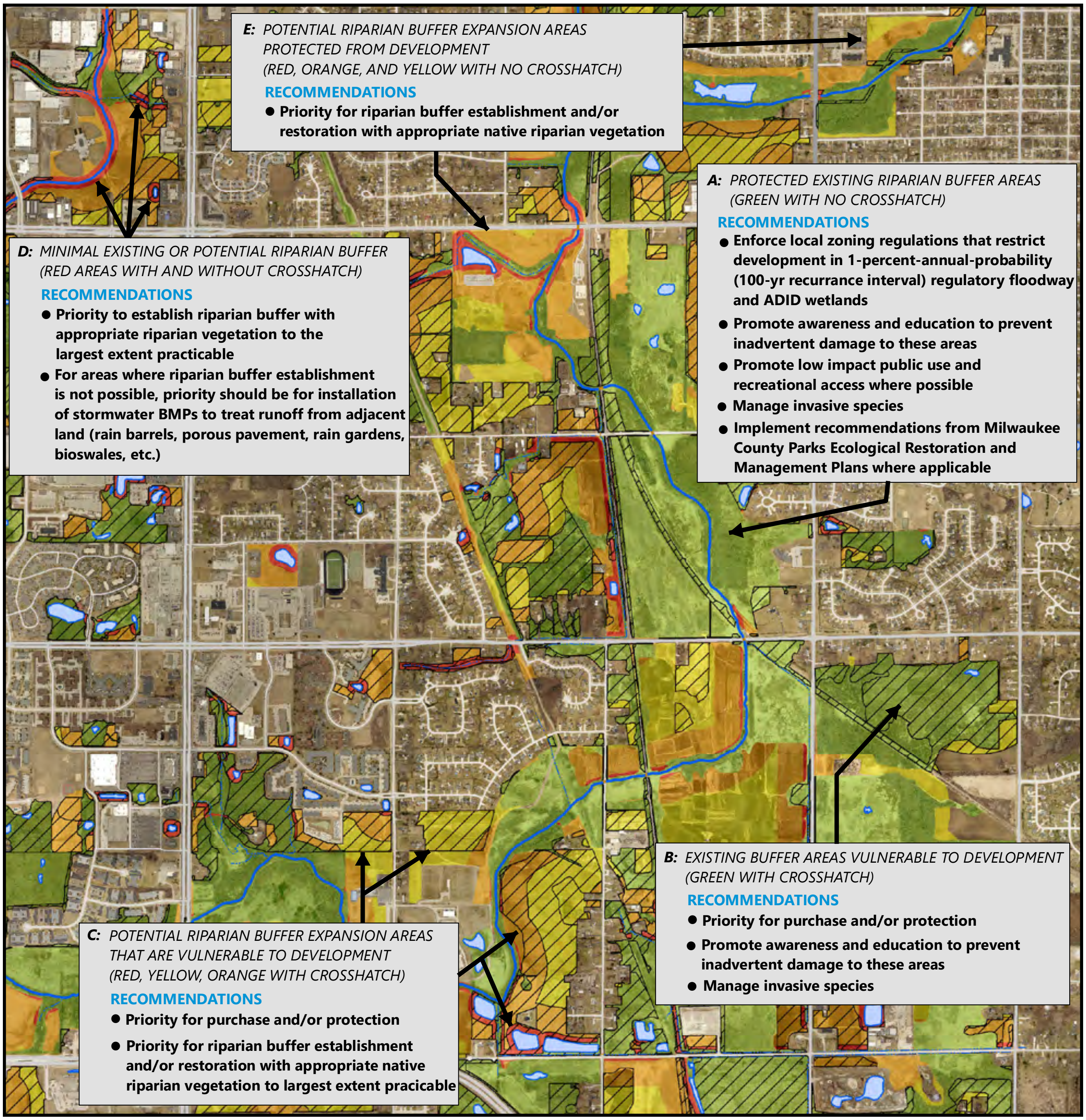
- BRIDGE
- CULVERT
- DAM
- DROP STRUCTURE/WEIR
- ROCK WEIR
- WOODY DEBRIS JAM
- BEAVER DAM/ACTIVITY
- TRIBUTARY OR WETLAND DRAINAGE
- POND OUTLET
- GROUNDWATER SEEPAGE/SPRING
- DRAIN TILE
- POTENTIAL FISH BED OR SPAWNING SITE
- MUSSEL
- STREAMBANK EROSION
- MINOR BANK, GULLY, OR RILL EROSION
- TRASH IN STREAM
- OAK CREEK WATERSHED BOUNDARY
- ASSESSMENT AREA BOUNDARIES
- PERENNIAL STREAM
- PERENNIAL STREAM (ENCLOSED)
- INTERMITTENT STREAM
- INTERMITTENT STREAM (ENCLOSED)

Note: Identification numbers for streambank erosion sites correspond to the "Erosion ID" provided in Appendix D. Identification numbers for bridges, culverts, and dams correspond to "ID Numbers" provided in Appendix H.

EXISTING AND POTENTIAL RIPARIAN BUFFER AREAS

APPENDIX G

Figure G.1
Examples of Areas that Should be Identified in Maps G.1 Through G.22 to Implement Recommendations



LANDS UNDER SOME FORM OF PROTECTION (NOT CROSS HATCHED)

- EXISTING RIPARIAN BUFFERS (DELINEATED BY SEWRPC STAFF USING 2015 DIGITAL ORTHOPHOTOGRAPHY)
- 75-FOOT MINIMUM RECOMMENDED BUFFER WIDTH
- 400-FOOT MINIMUM CORE HABITAT WIDTH FOR WILDLIFE PROTECTION
- 1,000-FOOT OPTIMAL CORE HABITAT WIDTH FOR WILDLIFE PROTECTION

VULNERABLE LANDS (CROSS HATCHED)

- EXISTING OR POTENTIAL RIPARIAN BUFFER LANDS WITH NO FORM OF PUBLIC INTEREST OWNERSHIP

- PERENNIAL STREAM
- PERENNIAL STREAM (ENCLOSED)
- INTERMITTENT STREAM
- INTERMITTENT STREAM (ENCLOSED)
- SURFACE WATER

N

0 750 1,500 Feet

Source: SEWRPC

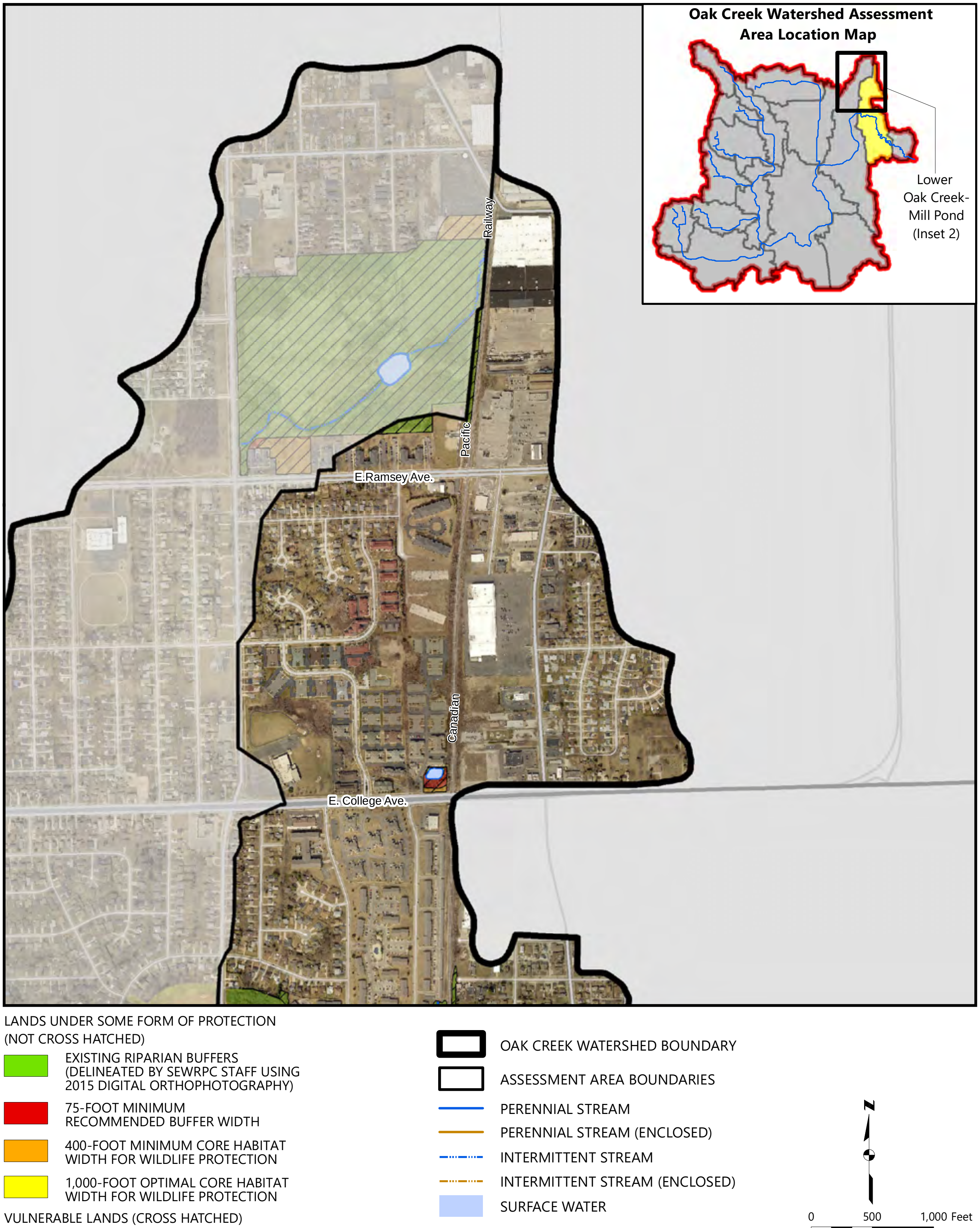
Map G.1
Existing and Potential Riparian Buffer Areas Within the Grant Park Ravine Assessment Area: 2015

Source: SEWRPC

Map G.2
Existing and Potential Riparian Buffer Areas Within the Lower Oak Creek – Mill Pond Assessment Area (Inset 1): 2015

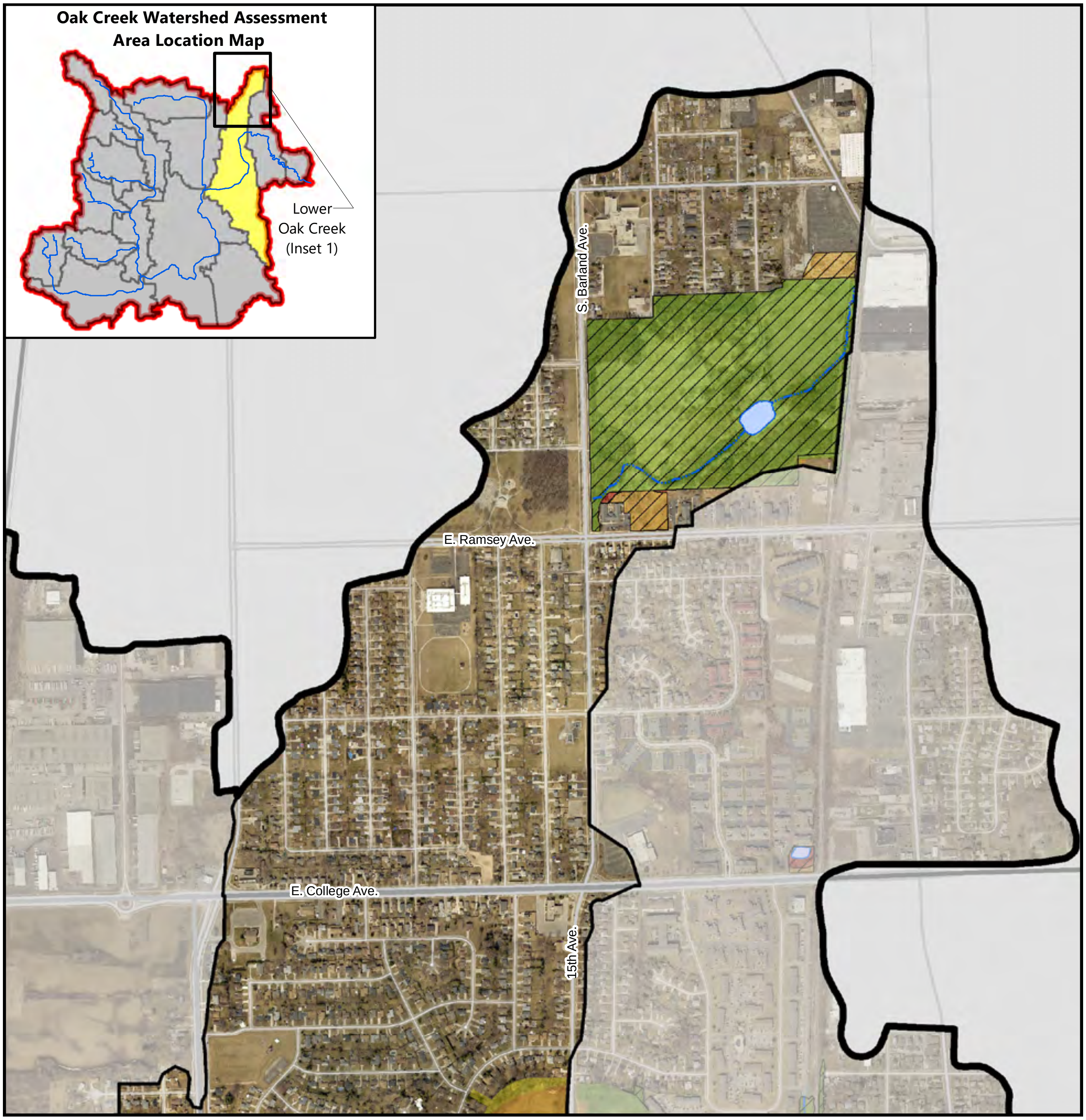
Source: SEWRPC

Map G.3
Existing and Potential Riparian Buffer Areas Within the Lower Oak Creek – Mill Pond Assessment Area (Inset 2): 2015



Source: SEWRPC

Map G.4
Existing and Potential Riparian Buffer Areas Within the Lower Oak Creek Assessment Area (Inset 1): 2015



LANDS UNDER SOME FORM OF PROTECTION (NOT CROSS HATCHED)

- EXISTING RIPARIAN BUFFERS (DELINEATED BY SEWRPC STAFF USING 2015 DIGITAL ORTHOPHOTOGRAPHY)
- 75-FOOT MINIMUM RECOMMENDED BUFFER WIDTH
- 400-FOOT MINIMUM CORE HABITAT WIDTH FOR WILDLIFE PROTECTION
- 1,000-FOOT OPTIMAL CORE HABITAT WIDTH FOR WILDLIFE PROTECTION

VULNERABLE LANDS (CROSS HATCHED)

- EXISTING OR POTENTIAL RIPARIAN BUFFER LANDS WITH NO FORM OF PUBLIC INTEREST OWNERSHIP

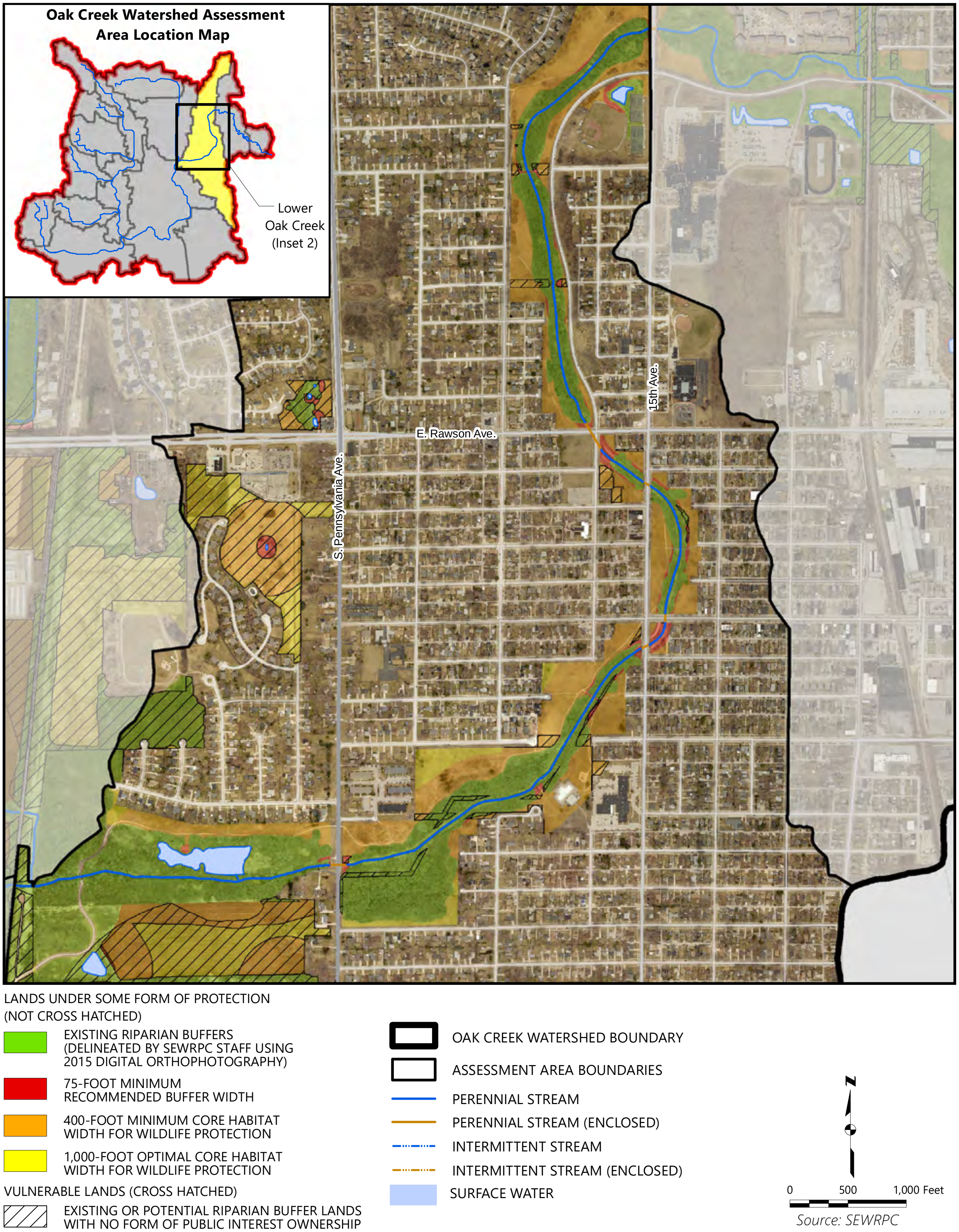
- OAK CREEK WATERSHED BOUNDARY
- ASSESSMENT AREA BOUNDARIES
- PERENNIAL STREAM
- PERENNIAL STREAM (ENCLOSED)
- INTERMITTENT STREAM
- INTERMITTENT STREAM (ENCLOSED)
- SURFACE WATER

N

0 500 1,000 Feet

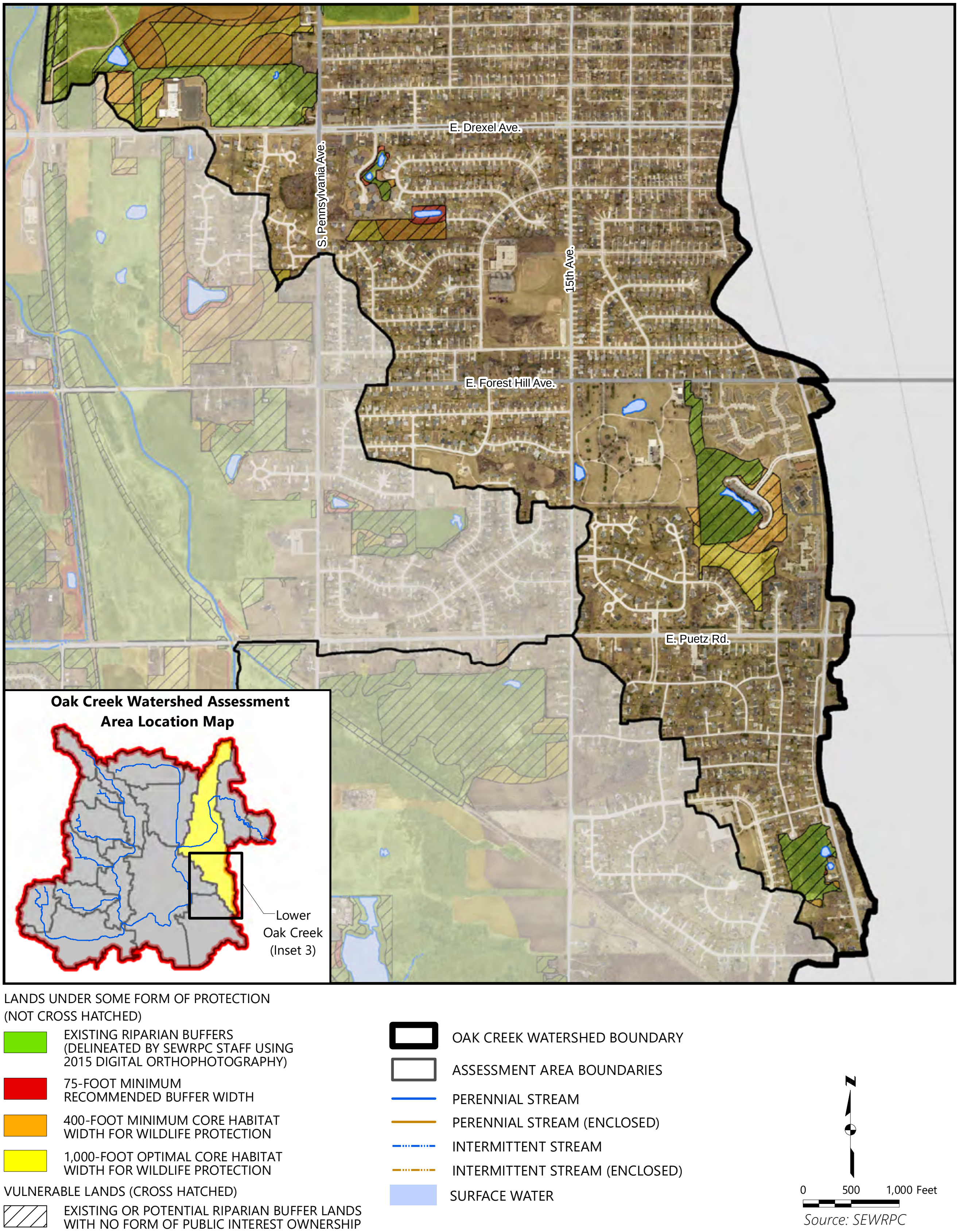
Source: SEWRPC

Map G.5
Existing and Potential Riparian Buffer Areas Within the Lower Oak Creek Assessment Area (Inset 2): 2015



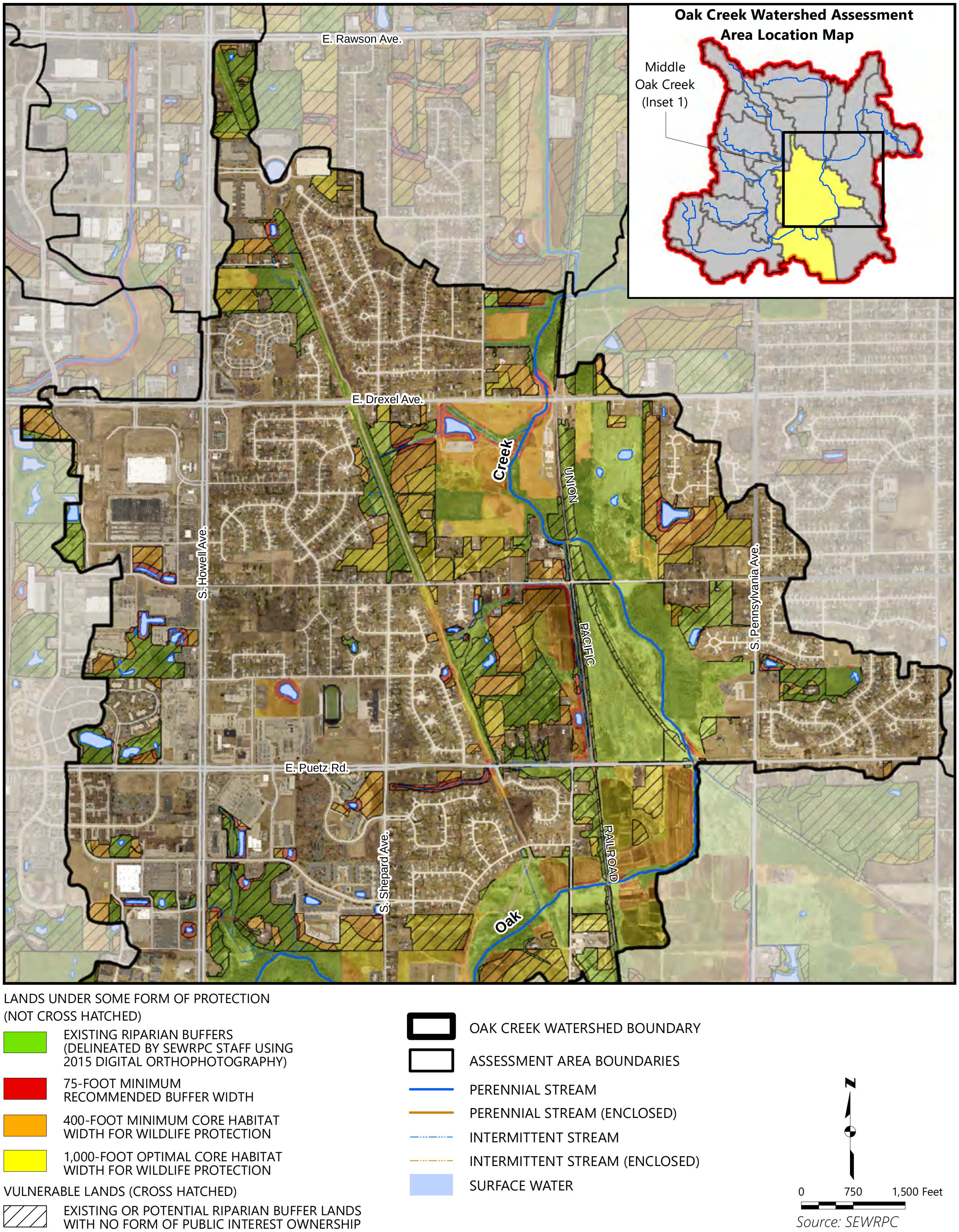
Source: SEWRPC

Map G.6
Existing and Potential Riparian Buffer Areas Within the Lower Oak Creek Assessment Area (Inset 3): 2015



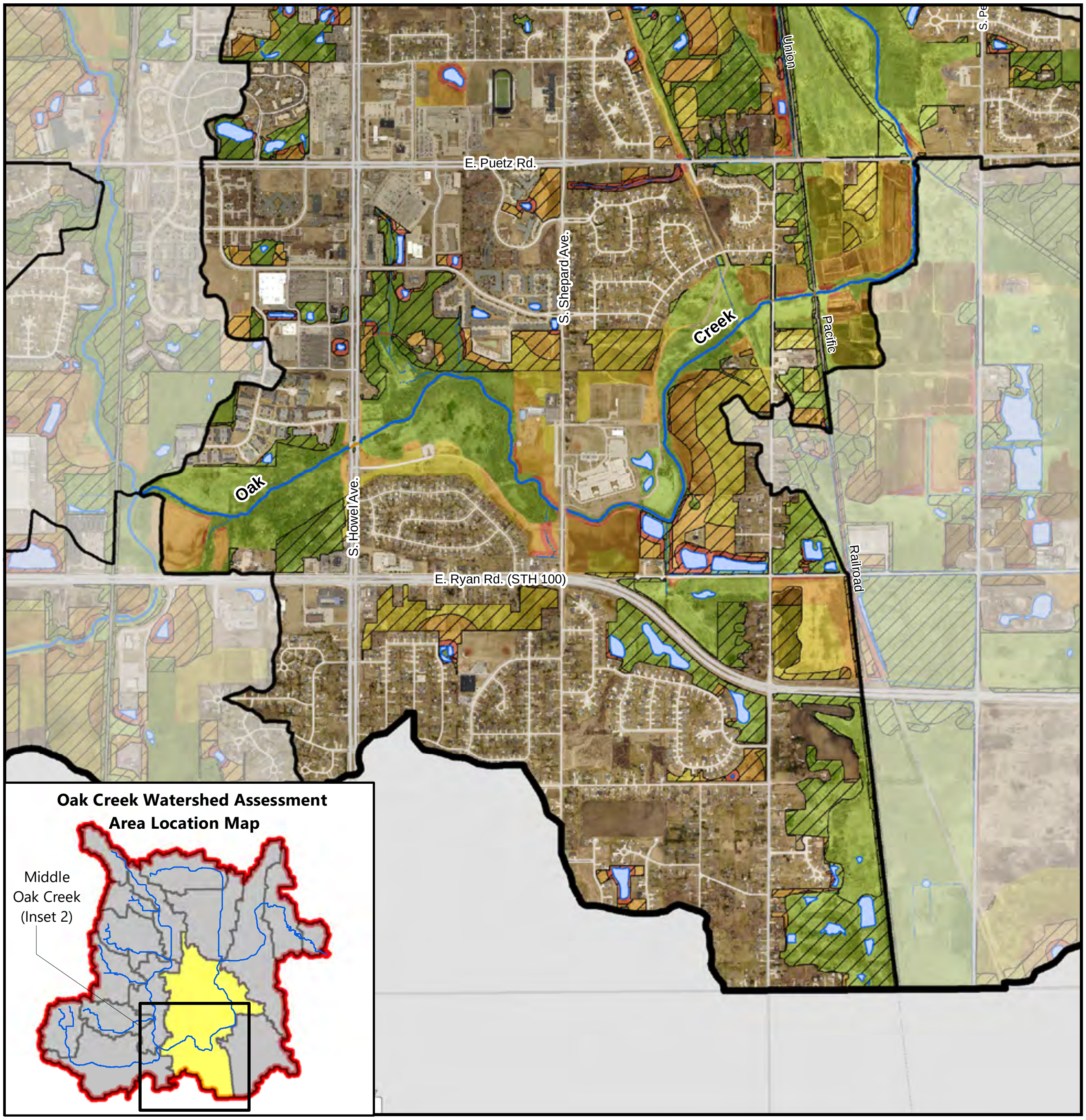
Source: SEWRPC

Map G.7
Existing and Potential Riparian Buffer Areas Within the Middle Oak Creek Assessment Area (Inset 1): 2015



Source: SEWRPC

Map G.8
Existing and Potential Riparian Buffer Areas Within the Middle Oak Creek Assessment Area (Inset 2): 2015



LANDS UNDER SOME FORM OF PROTECTION (NOT CROSS HATCHED)

- EXISTING RIPARIAN BUFFERS (DELINEATED BY SEWRPC STAFF USING 2015 DIGITAL ORTHOPHOTOGRAPHY)
- 75-FOOT MINIMUM RECOMMENDED BUFFER WIDTH
- 400-FOOT MINIMUM CORE HABITAT WIDTH FOR WILDLIFE PROTECTION
- 1,000-FOOT OPTIMAL CORE HABITAT WIDTH FOR WILDLIFE PROTECTION

VULNERABLE LANDS (CROSS HATCHED)

- EXISTING OR POTENTIAL RIPARIAN BUFFER LANDS WITH NO FORM OF PUBLIC INTEREST OWNERSHIP

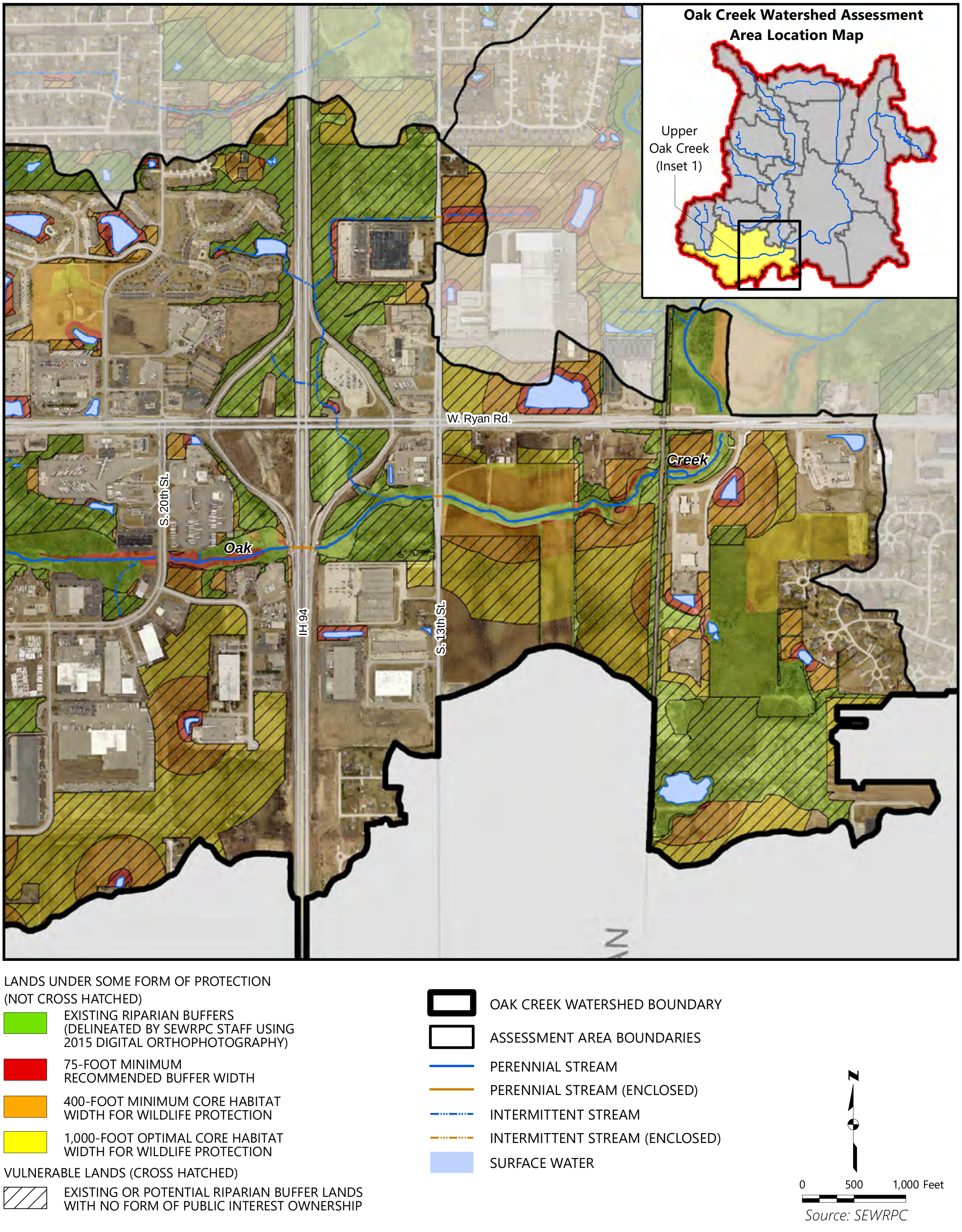
- OAK CREEK WATERSHED BOUNDARY
- ASSESSMENT AREA BOUNDARIES
- PERENNIAL STREAM
- PERENNIAL STREAM (ENCLOSED)
- INTERMITTENT STREAM
- INTERMITTENT STREAM (ENCLOSED)
- SURFACE WATER

N

0 750 1,500 Feet

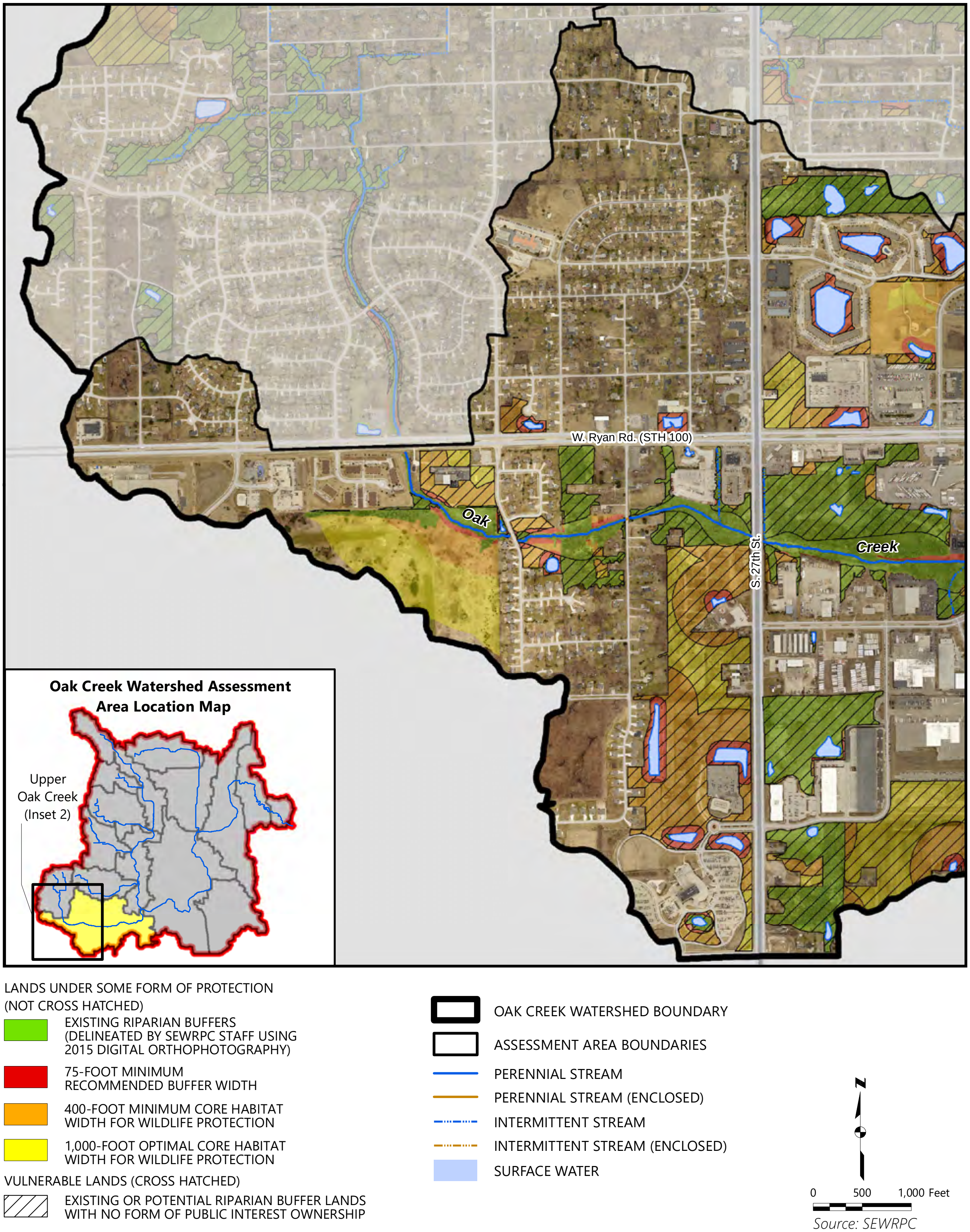
Source: SEWRPC

Map G.9
Existing and Potential Riparian Buffer Areas Within the Upper Oak Creek Assessment Area (Inset 1): 2015



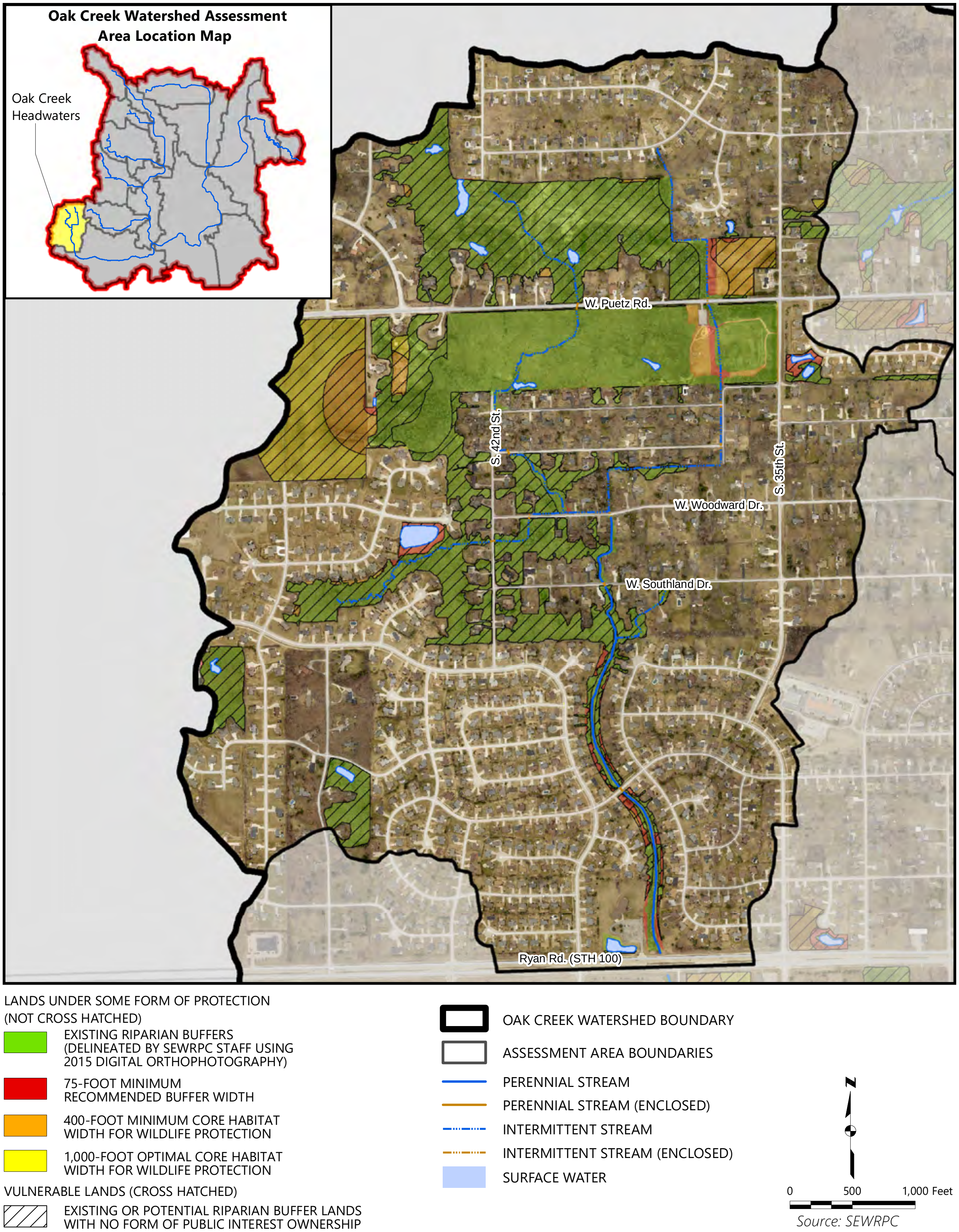
Source: SEWRPC

Map G.10
Existing and Potential Riparian Buffer Areas Within the Upper Oak Creek Assessment Area (Inset 2): 2015



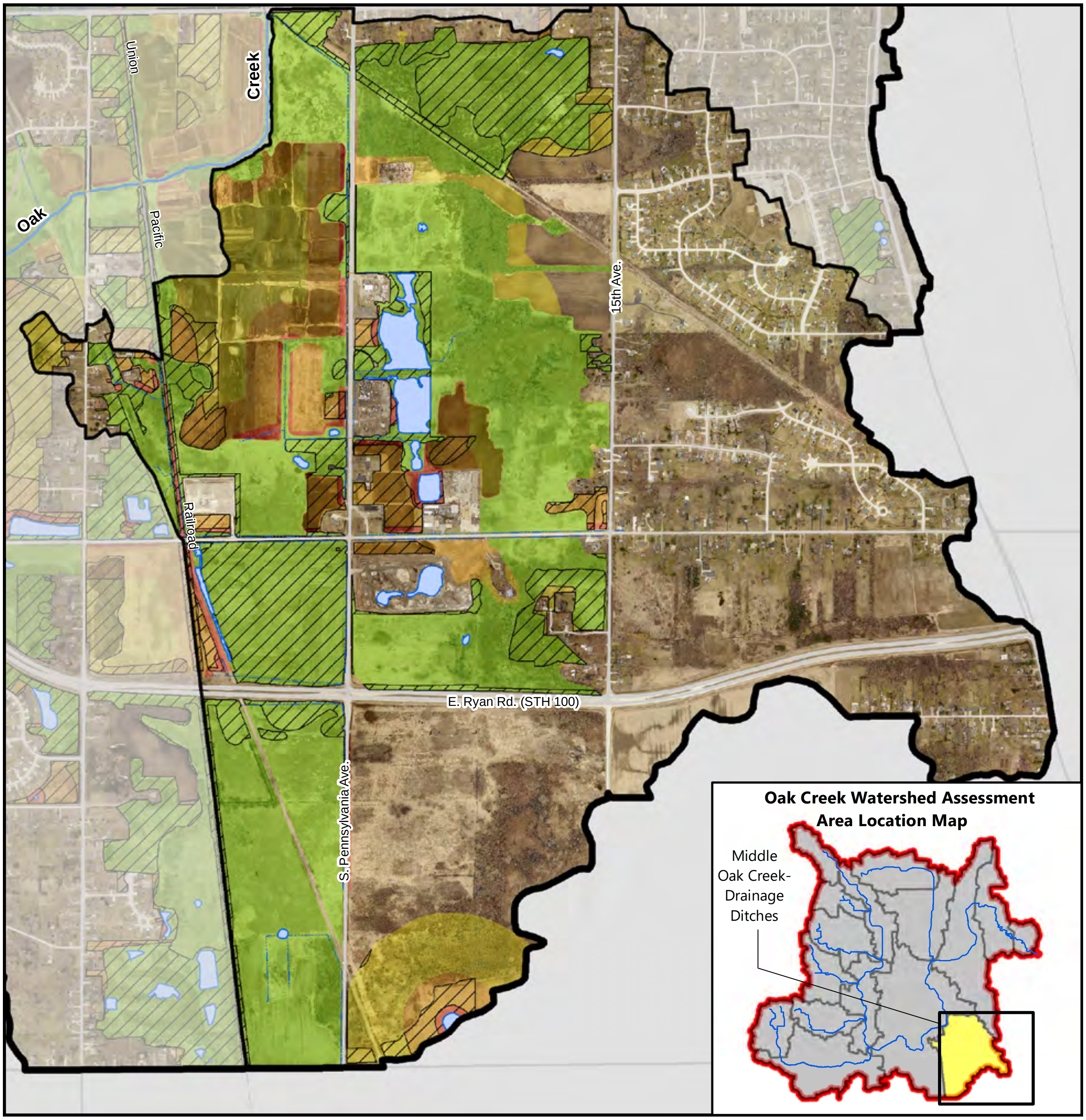
Source: SEWRPC

Map G.11
Existing and Potential Riparian Buffer Areas Within the Oak Creek Headwaters Assessment Area: 2015



Source: SEWRPC

Map G.12
Existing and Potential Riparian Buffer Areas Within the Middle Oak Creek – Drainage Ditches Assessment Area: 2015



LANDS UNDER SOME FORM OF PROTECTION (NOT CROSS HATCHED)

- EXISTING RIPARIAN BUFFERS (DELINEATED BY SEWRPC STAFF USING 2015 DIGITAL ORTHOPHOTOGRAPHY)
- 75-FOOT MINIMUM RECOMMENDED BUFFER WIDTH
- 400-FOOT MINIMUM CORE HABITAT WIDTH FOR WILDLIFE PROTECTION
- 1,000-FOOT OPTIMAL CORE HABITAT WIDTH FOR WILDLIFE PROTECTION

VULNERABLE LANDS (CROSS HATCHED)

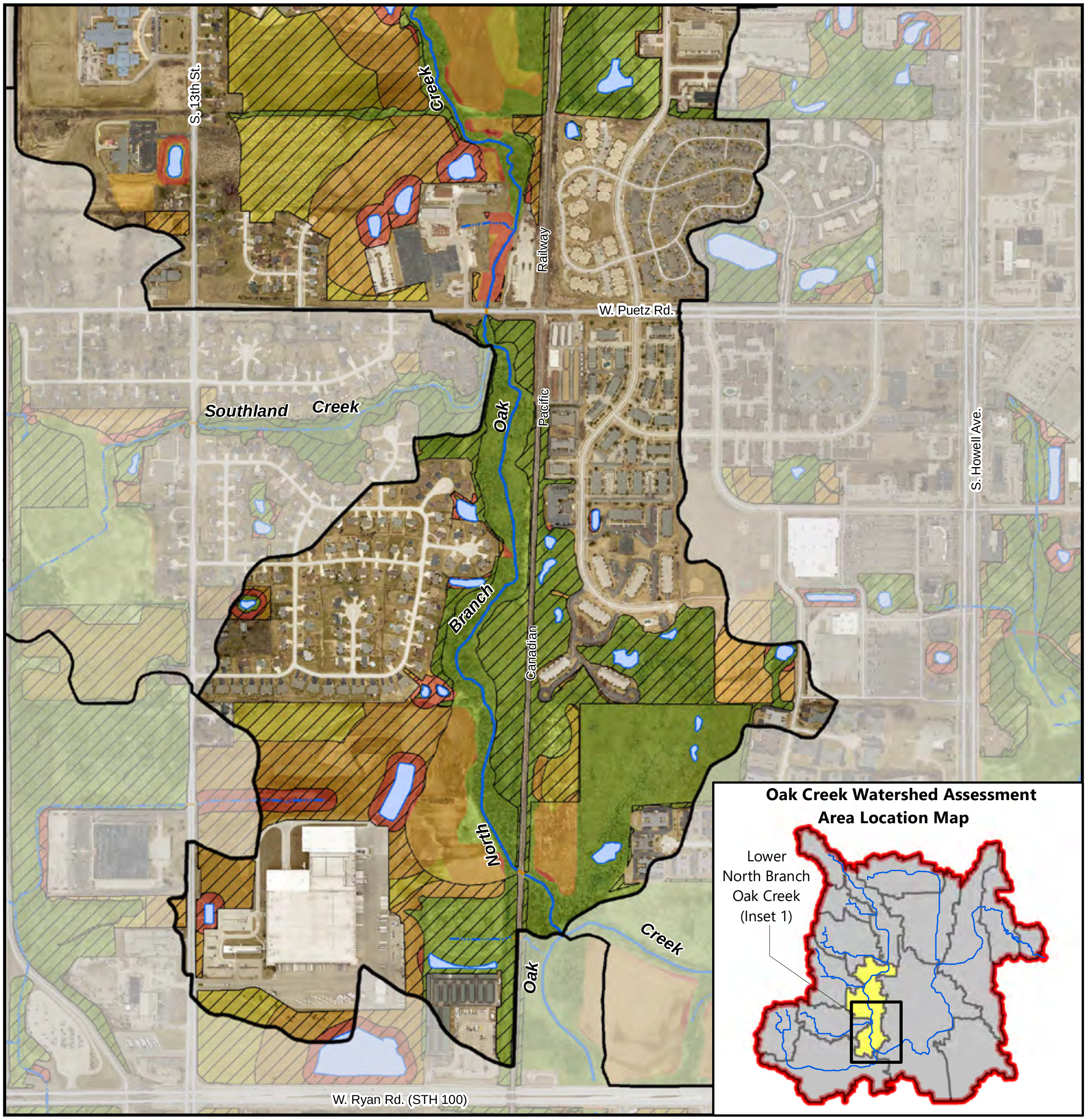
- EXISTING OR POTENTIAL RIPARIAN BUFFER LANDS WITH NO FORM OF PUBLIC INTEREST OWNERSHIP

- OAK CREEK WATERSHED BOUNDARY
- ASSESSMENT AREA BOUNDARIES
- PERENNIAL STREAM
- PERENNIAL STREAM (ENCLOSED)
- INTERMITTENT STREAM
- INTERMITTENT STREAM (ENCLOSED)
- SURFACE WATER

0 500 1,000 Feet

Source: SEWRPC

Map G.13
Existing and Potential Riparian Buffer Areas Within the Lower North Branch Oak Creek Assessment Area (Inset 1): 2015



LANDS UNDER SOME FORM OF PROTECTION (NOT CROSS HATCHED)

- EXISTING RIPARIAN BUFFERS (DELINEATED BY SEWRPC STAFF USING 2015 DIGITAL ORTHOPHOTOGRAPHY)
- 75-FOOT MINIMUM RECOMMENDED BUFFER WIDTH
- 400-FOOT MINIMUM CORE HABITAT WIDTH FOR WILDLIFE PROTECTION
- 1,000-FOOT OPTIMAL CORE HABITAT WIDTH FOR WILDLIFE PROTECTION

VULNERABLE LANDS (CROSS HATCHED)

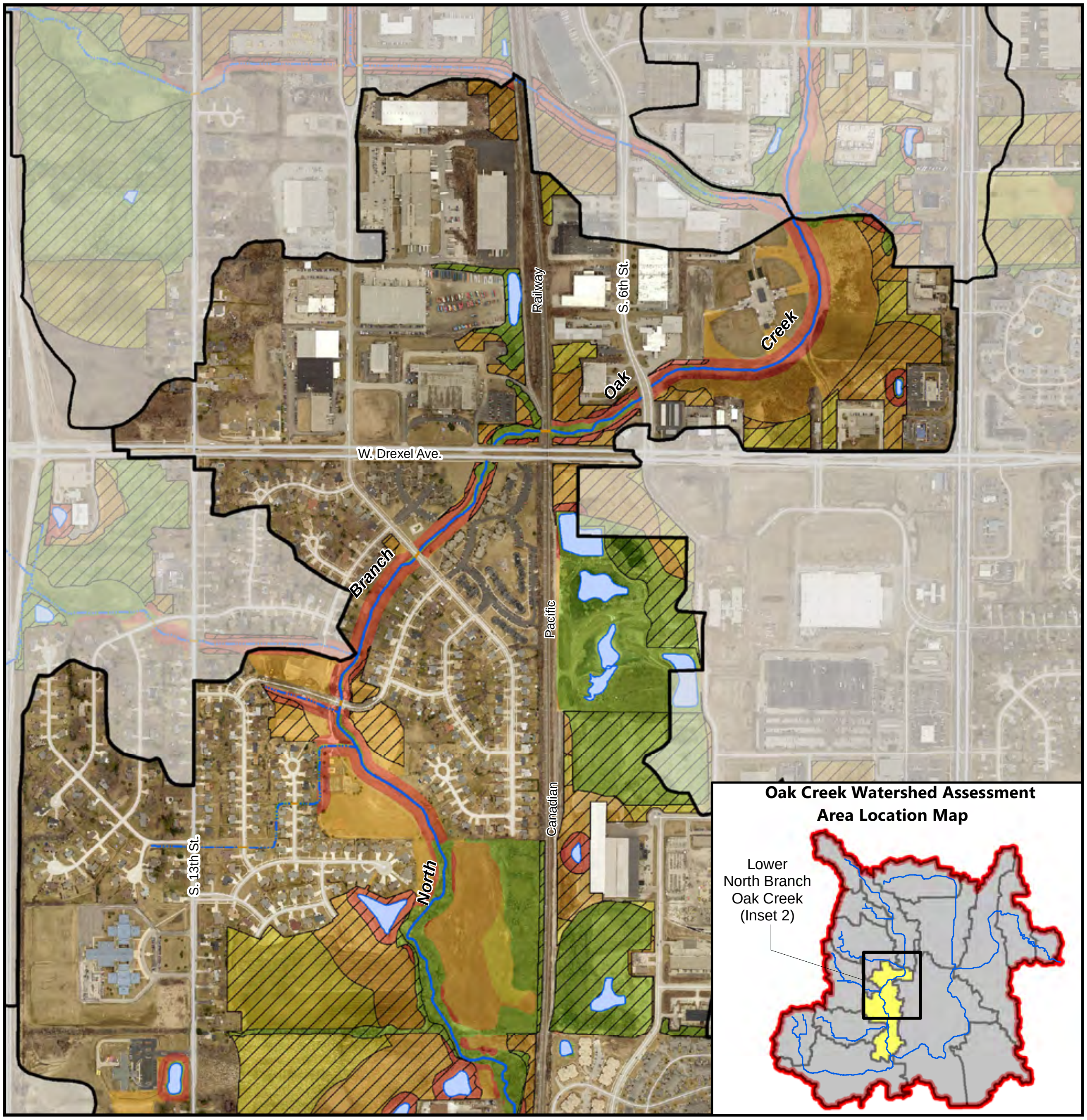
- EXISTING OR POTENTIAL RIPARIAN BUFFER LANDS WITH NO FORM OF PUBLIC INTEREST OWNERSHIP

- OAK CREEK WATERSHED BOUNDARY
- ASSESSMENT AREA BOUNDARIES
- PERENNIAL STREAM
- PERENNIAL STREAM (ENCLOSED)
- INTERMITTENT STREAM
- INTERMITTENT STREAM (ENCLOSED)
- SURFACE WATER

0 500 1,000 Feet

Source: SEWRPC

Map G.14
Existing and Potential Riparian Buffer Areas Within the Lower North Branch Oak Creek Assessment Area (Inset 2): 2015



LANDS UNDER SOME FORM OF PROTECTION (NOT CROSS HATCHED)

- EXISTING RIPARIAN BUFFERS (DELINEATED BY SEWRPC STAFF USING 2015 DIGITAL ORTHOPHOTOGRAPHY)
- 75-FOOT MINIMUM RECOMMENDED BUFFER WIDTH
- 400-FOOT MINIMUM CORE HABITAT WIDTH FOR WILDLIFE PROTECTION
- 1,000-FOOT OPTIMAL CORE HABITAT WIDTH FOR WILDLIFE PROTECTION

VULNERABLE LANDS (CROSS HATCHED)

- EXISTING OR POTENTIAL RIPARIAN BUFFER LANDS WITH NO FORM OF PUBLIC INTEREST OWNERSHIP

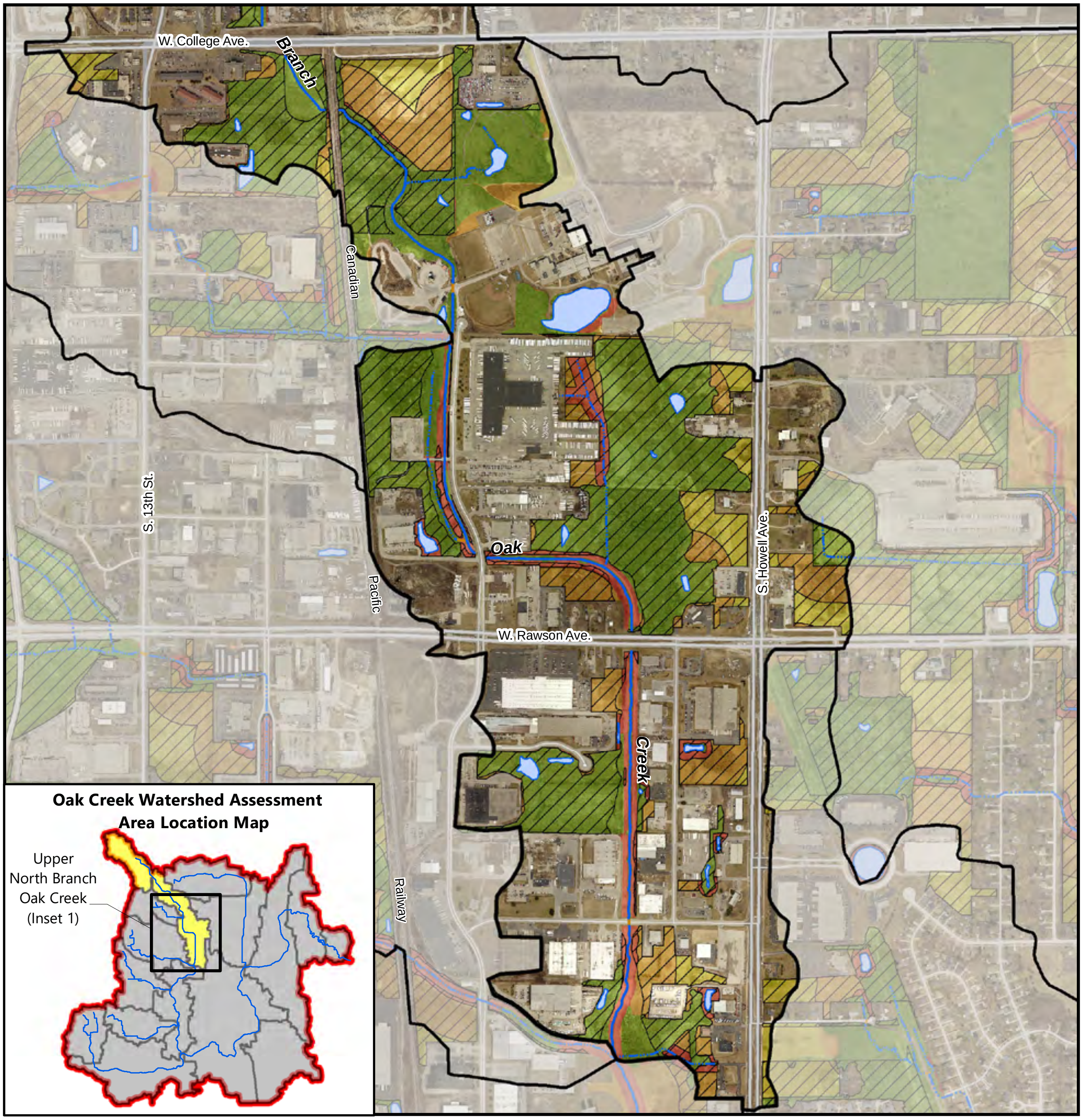
- OAK CREEK WATERSHED BOUNDARY
- ASSESSMENT AREA BOUNDARIES
- PERENNIAL STREAM
- PERENNIAL STREAM (ENCLOSED)
- INTERMITTENT STREAM
- INTERMITTENT STREAM (ENCLOSED)
- SURFACE WATER

N

0 500 1,000 Feet

Source: SEWRPC

Map G.15
Existing and Potential Riparian Buffer Areas Within the Upper North Branch Oak Creek Assessment Area (Inset 1): 2015



LANDS UNDER SOME FORM OF PROTECTION (NOT CROSS HATCHED)

- EXISTING RIPARIAN BUFFERS (DELINEATED BY SEWRPC STAFF USING 2015 DIGITAL ORTHOPHOTOGRAPHY)
- 75-FOOT MINIMUM RECOMMENDED BUFFER WIDTH
- 400-FOOT MINIMUM CORE HABITAT WIDTH FOR WILDLIFE PROTECTION
- 1,000-FOOT OPTIMAL CORE HABITAT WIDTH FOR WILDLIFE PROTECTION

VULNERABLE LANDS (CROSS HATCHED)

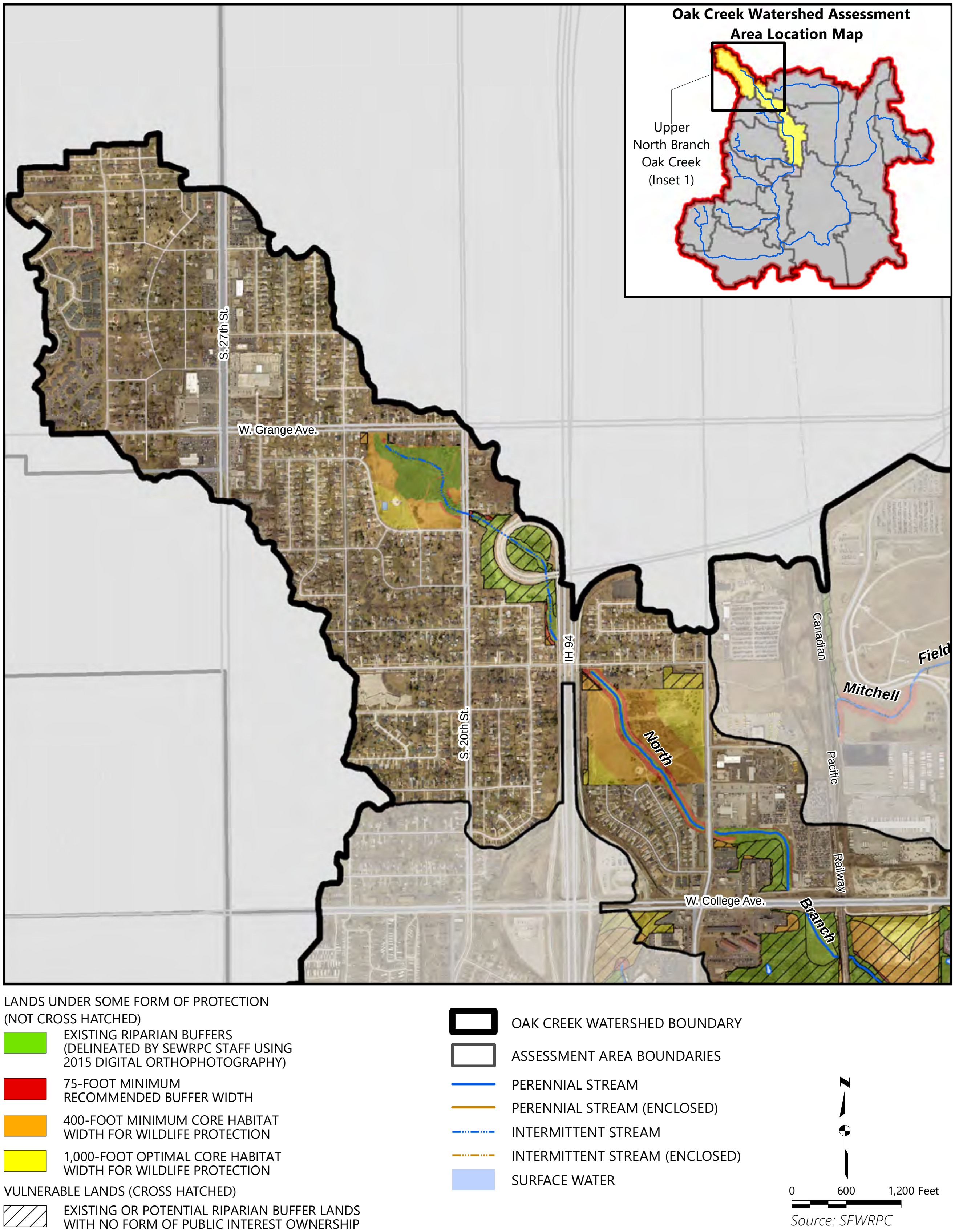
- EXISTING OR POTENTIAL RIPARIAN BUFFER LANDS WITH NO FORM OF PUBLIC INTEREST OWNERSHIP

- OAK CREEK WATERSHED BOUNDARY
- ASSESSMENT AREA BOUNDARIES
- PERENNIAL STREAM
- PERENNIAL STREAM (ENCLOSED)
- INTERMITTENT STREAM
- INTERMITTENT STREAM (ENCLOSED)
- SURFACE WATER

0 600 1,200 Feet

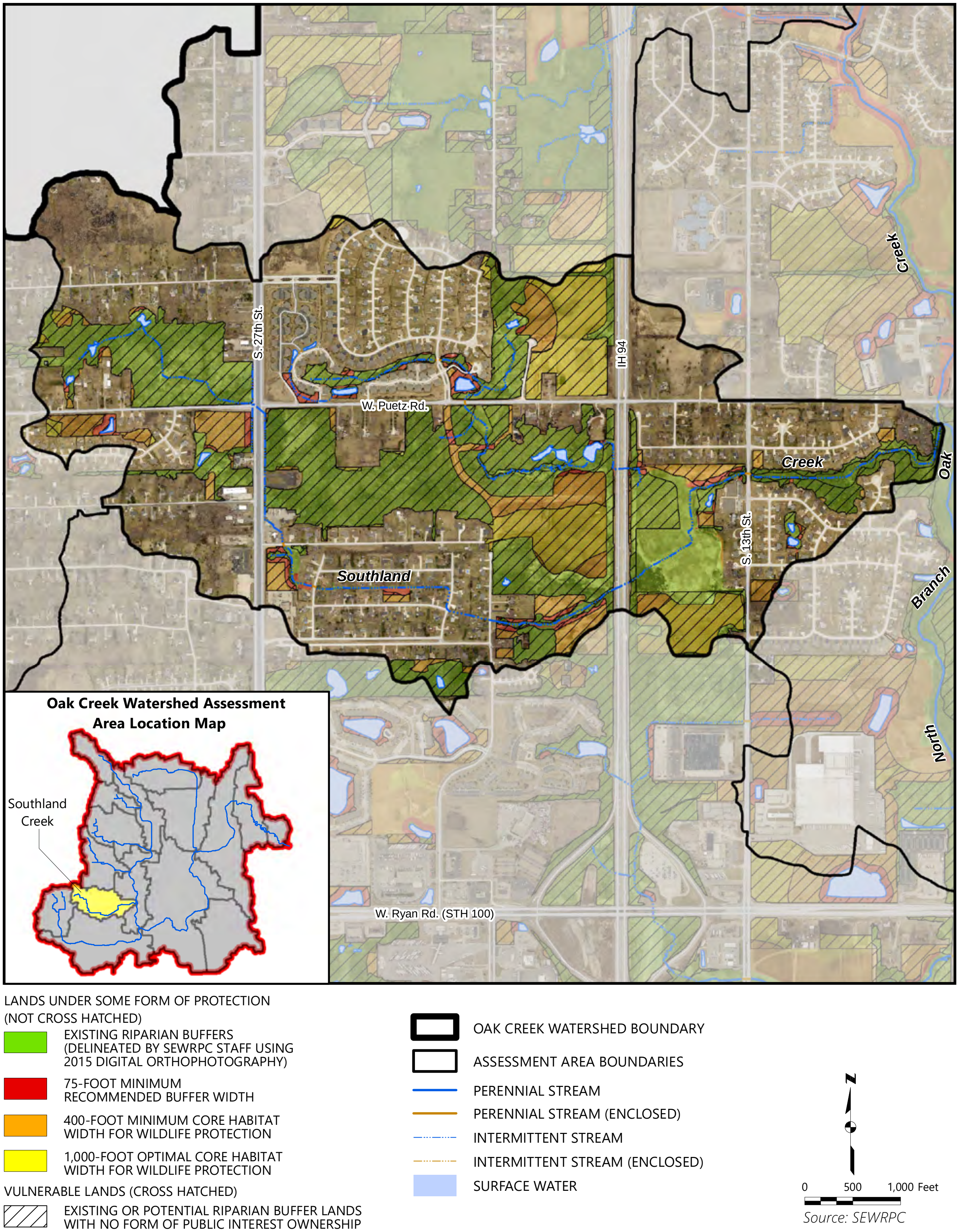
Source: SEWRPC

Map G.16
Existing and Potential Riparian Buffer Areas Within the Upper North Branch Oak Creek Assessment Area (Inset 2): 2015



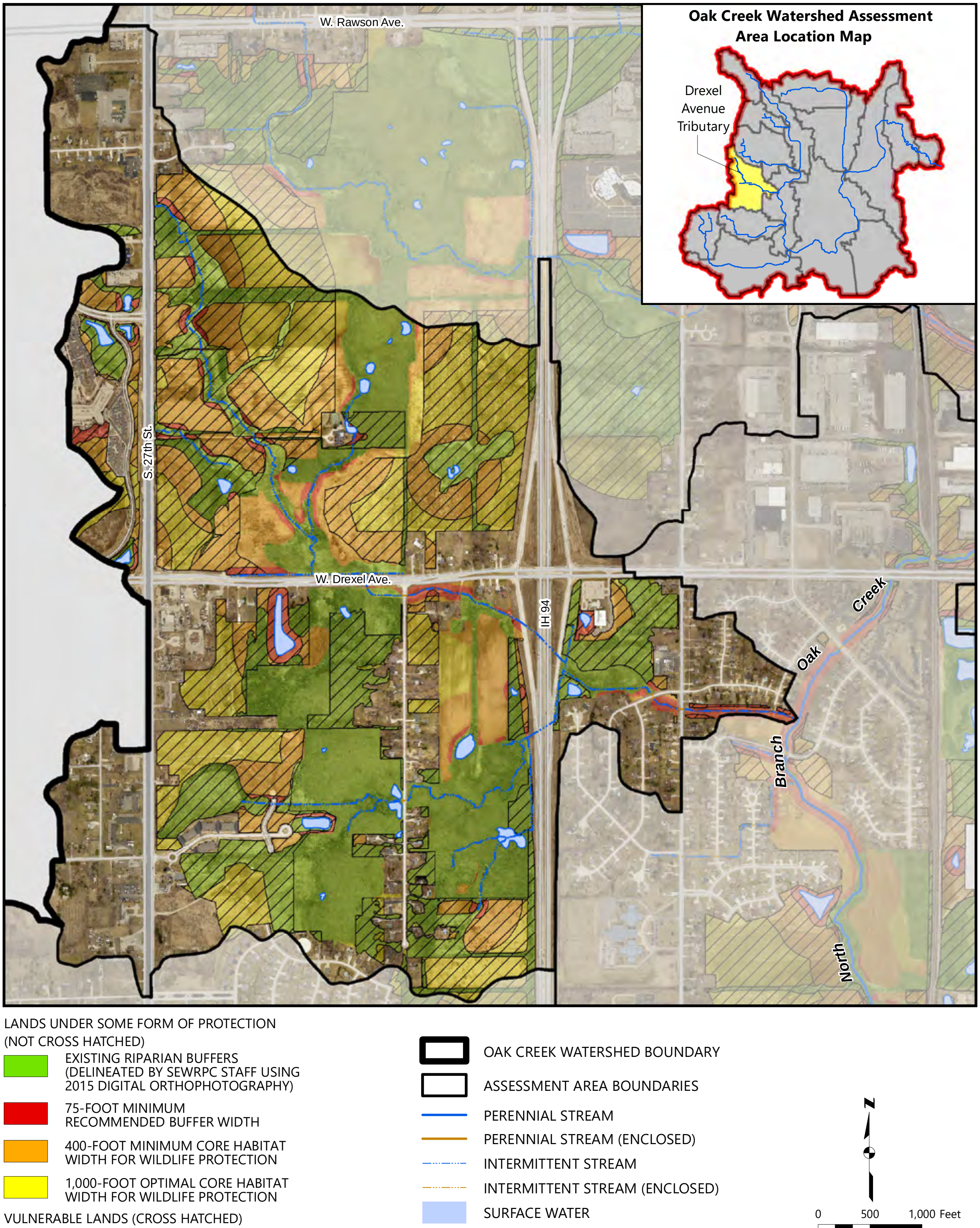
Source: SEWRPC

Map G.17
Existing and Potential Riparian Buffer Areas Within the Southland Creek Assessment Area: 2015



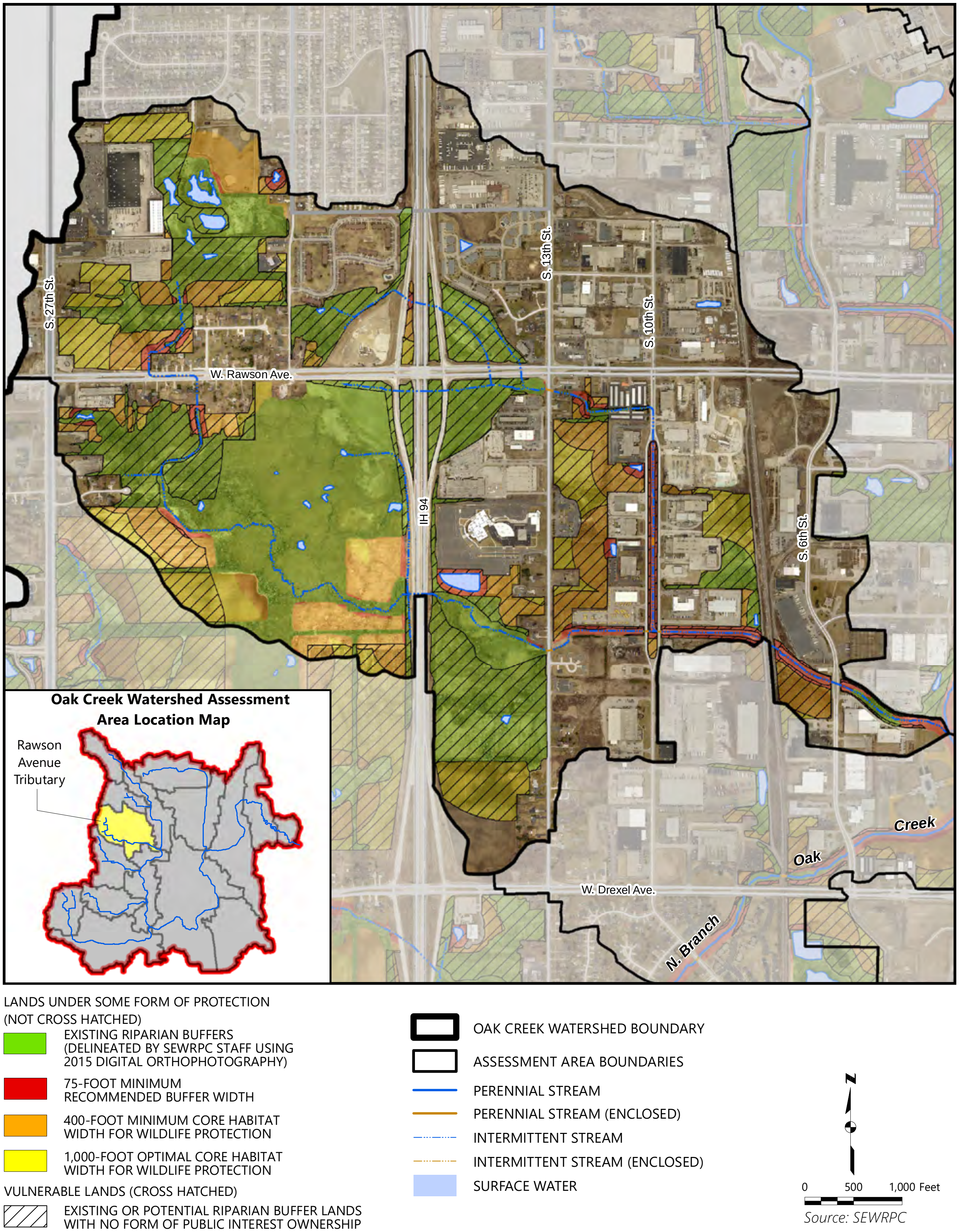
Source: SEWRPC

Map G.18
Existing and Potential Riparian Buffer Areas Within the Drexel Avenue Tributary Assessment Area: 2015



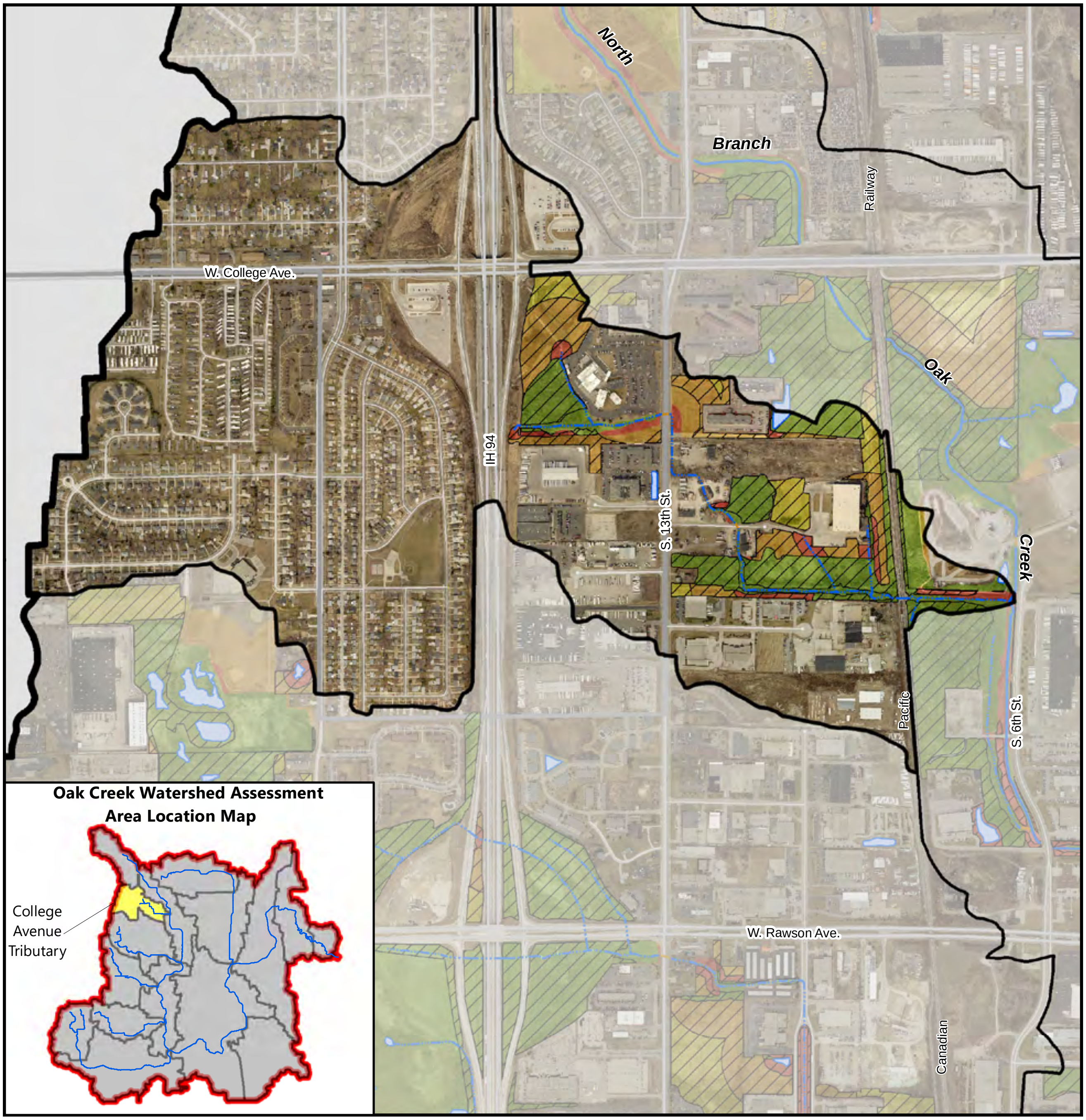
Source: SEWRPC

Map G.19
Existing and Potential Riparian Buffer Areas Within the Rawson Avenue Tributary Assessment Area: 2015



Source: SEWRPC

Map G.20
Existing and Potential Riparian Buffer Areas Within the College Avenue Tributary Assessment Area: 2015



LANDS UNDER SOME FORM OF PROTECTION (NOT CROSS HATCHED)

- EXISTING RIPARIAN BUFFERS (DELINEATED BY SEWRPC STAFF USING 2015 DIGITAL ORTHOPHOTOGRAPHY)
- 75-FOOT MINIMUM RECOMMENDED BUFFER WIDTH
- 400-FOOT MINIMUM CORE HABITAT WIDTH FOR WILDLIFE PROTECTION
- 1,000-FOOT OPTIMAL CORE HABITAT WIDTH FOR WILDLIFE PROTECTION

VULNERABLE LANDS (CROSS HATCHED)

- EXISTING OR POTENTIAL RIPARIAN BUFFER LANDS WITH NO FORM OF PUBLIC INTEREST OWNERSHIP

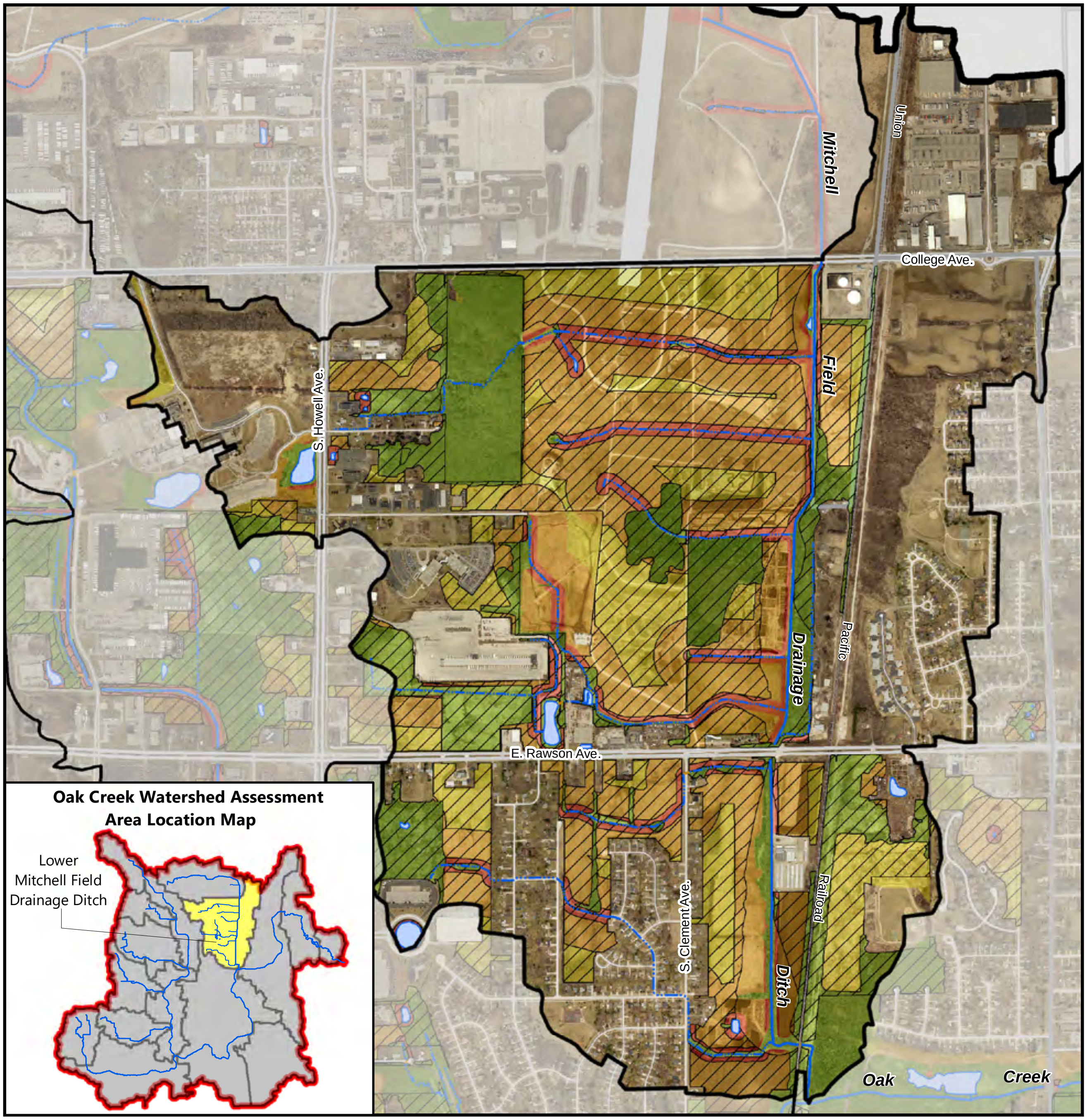
- OAK CREEK WATERSHED BOUNDARY
- ASSESSMENT AREA BOUNDARIES
- PERENNIAL STREAM
- PERENNIAL STREAM (ENCLOSED)
- INTERMITTENT STREAM
- INTERMITTENT STREAM (ENCLOSED)
- SURFACE WATER

N

0 500 1,000 Feet

Source: SEWRPC

Map G.21
Existing and Potential Riparian Buffer Areas Within the Lower Mitchell Field Drainage Ditch Assessment Area: 2015



LANDS UNDER SOME FORM OF PROTECTION (NOT CROSS HATCHED)

- EXISTING RIPARIAN BUFFERS (DELINEATED BY SEWRPC STAFF USING 2015 DIGITAL ORTHOPHOTOGRAPHY)
- 75-FOOT MINIMUM RECOMMENDED BUFFER WIDTH
- 400-FOOT MINIMUM CORE HABITAT WIDTH FOR WILDLIFE PROTECTION
- 1,000-FOOT OPTIMAL CORE HABITAT WIDTH FOR WILDLIFE PROTECTION

VULNERABLE LANDS (CROSS HATCHED)

- EXISTING OR POTENTIAL RIPARIAN BUFFER LANDS WITH NO FORM OF PUBLIC INTEREST OWNERSHIP

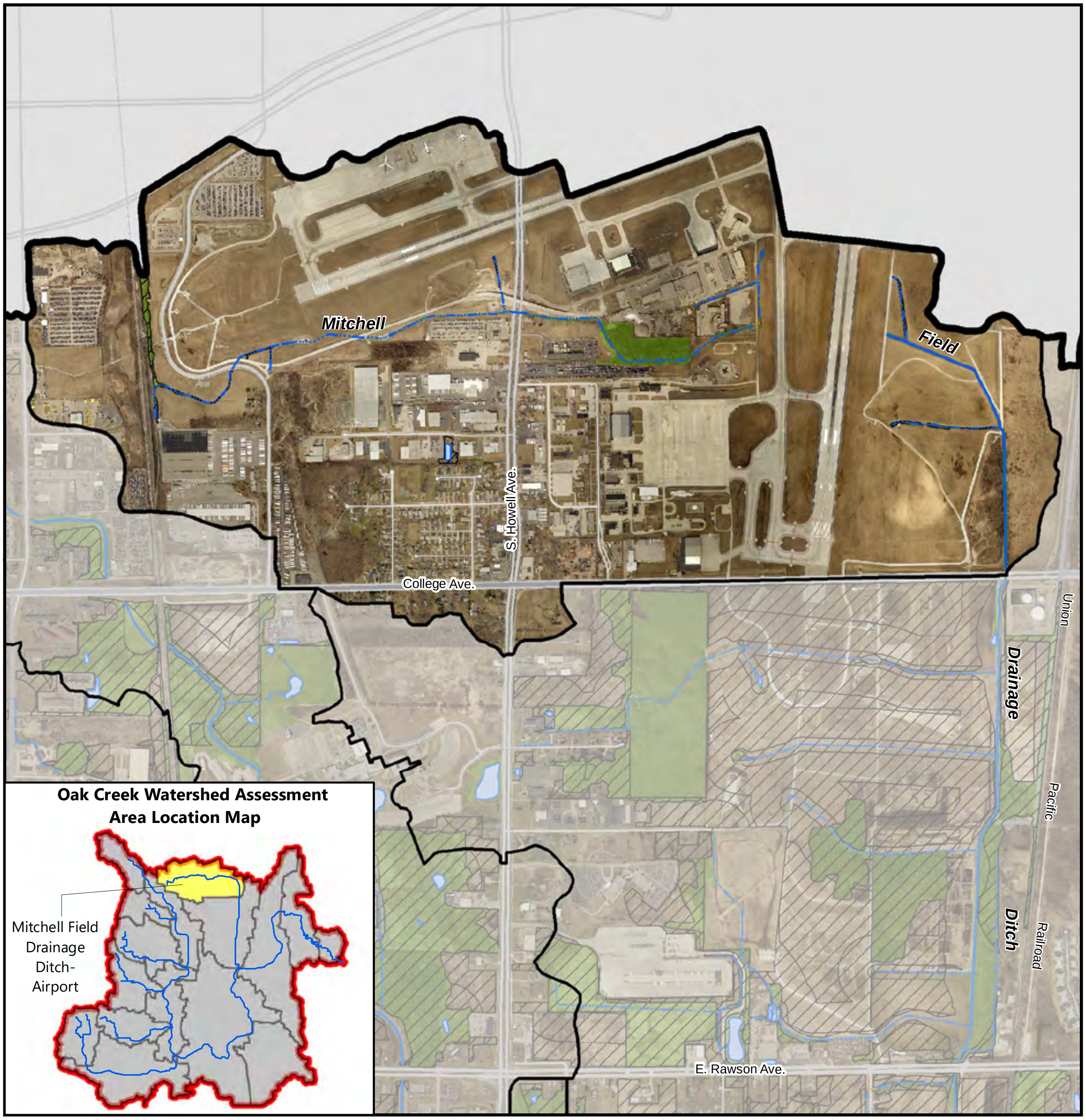
- OAK CREEK WATERSHED BOUNDARY
- ASSESSMENT AREA BOUNDARIES
- PERENNIAL STREAM
- PERENNIAL STREAM (ENCLOSED)
- INTERMITTENT STREAM
- INTERMITTENT STREAM (ENCLOSED)
- SURFACE WATER

N

0 600 1,200 Feet

Source: SEWRPC

Map G.22
Existing and Potential Riparian Buffer Areas Within the Mitchell Field Drainage Ditch – Airport Assessment Area: 2015



LANDS UNDER SOME FORM OF PROTECTION (NOT CROSS HATCHED)

- EXISTING RIPARIAN BUFFERS (DELINEATED BY SEWRPC STAFF USING 2015 DIGITAL ORTHOPHOTOGRAPHY)
- 75-FOOT MINIMUM RECOMMENDED BUFFER WIDTH
- 400-FOOT MINIMUM CORE HABITAT WIDTH FOR WILDLIFE PROTECTION
- 1,000-FOOT OPTIMAL CORE HABITAT WIDTH FOR WILDLIFE PROTECTION

VULNERABLE LANDS (CROSS HATCHED)

- EXISTING OR POTENTIAL RIPARIAN BUFFER LANDS WITH NO FORM OF PUBLIC INTEREST OWNERSHIP

- OAK CREEK WATERSHED BOUNDARY
- ASSESSMENT AREA BOUNDARIES
- PERENNIAL STREAM
- PERENNIAL STREAM (ENCLOSED)
- INTERMITTENT STREAM
- INTERMITTENT STREAM (ENCLOSED)
- SURFACE WATER

N

0 600 1,200 Feet

Source: SEWRPC

Managing the Water's Edge

Making Natural Connections

Problem Statement:

Despite significant research related to buffers, there remains no consensus as to what constitutes optimal riparian buffer design or proper buffer width for effective pollutant removal, water quality protection, prevention of channel erosion, provision of fish and wildlife habitat, enhancement of environmental corridors, augmentation of stream baseflow, and water temperature moderation.

Southeastern Wisconsin Regional Planning Commission

Our purpose in this document is to help protect and restore water quality, wildlife, recreational opportunities, and scenic beauty.

This material was prepared in part with funding from the U.S. Environmental Protection Agency Great Lakes National Program Office provided through CMAP, the Chicago Metropolitan Agency for Planning.

Introduction

Perhaps no part of the landscape offers more variety and valuable functions than the natural areas bordering our streams and other waters.

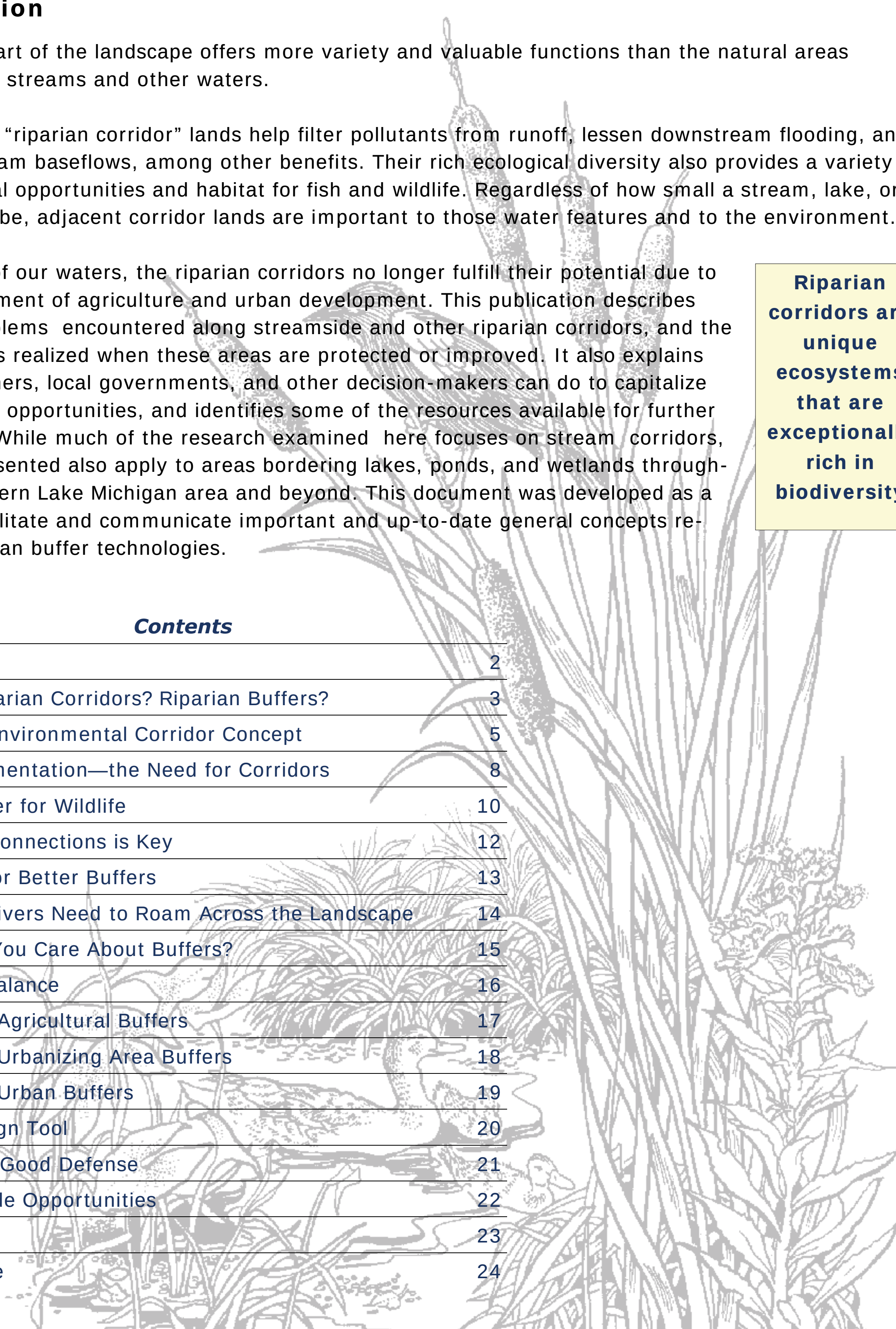
These unique "riparian corridor" lands help filter pollutants from runoff, lessen downstream flooding, and maintain stream baseflows, among other benefits. Their rich ecological diversity also provides a variety of recreational opportunities and habitat for fish and wildlife. Regardless of how small a stream, lake, or wetland may be, adjacent corridor lands are important to those water features and to the environment.

Along many of our waters, the riparian corridors no longer fulfill their potential due to the encroachment of agriculture and urban development. This publication describes common problems encountered along streamside and other riparian corridors, and the many benefits realized when these areas are protected or improved. It also explains what landowners, local governments, and other decision-makers can do to capitalize on waterfront opportunities, and identifies some of the resources available for further information. While much of the research examined here focuses on stream corridors, the ideas presented also apply to areas bordering lakes, ponds, and wetlands throughout the southern Lake Michigan area and beyond. This document was developed as a means to facilitate and communicate important and up-to-date general concepts related to riparian buffer technologies.

Riparian corridors are unique ecosystems that are exceptionally rich in biodiversity

Contents

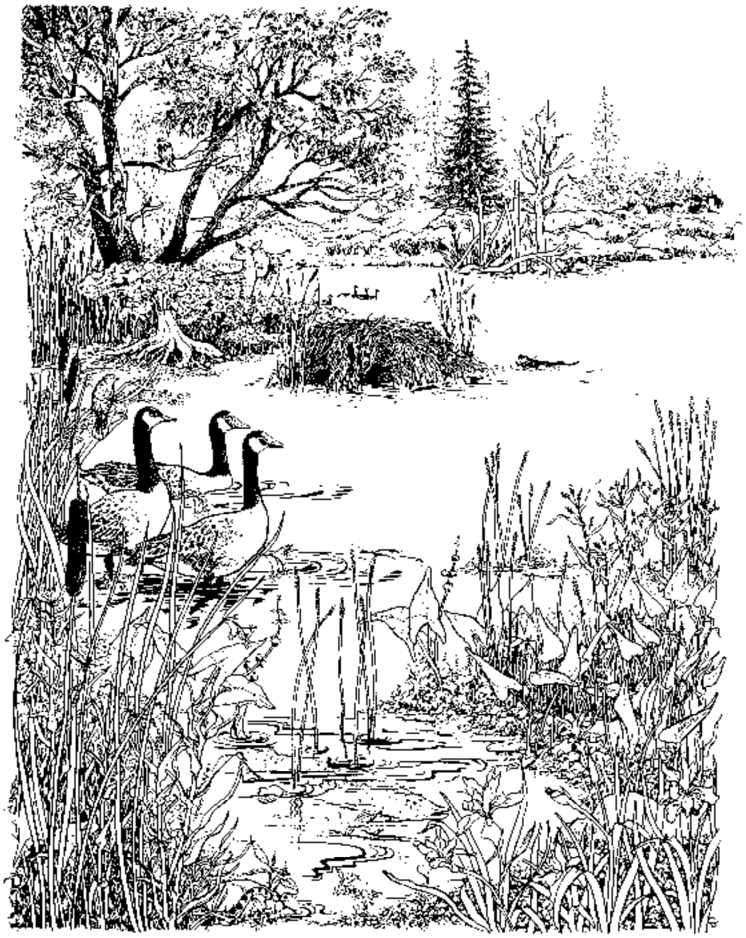
Introduction	2
What are Riparian Corridors? Riparian Buffers?	3
Beyond the Environmental Corridor Concept	5
Habitat Fragmentation—the Need for Corridors	8
Wider is Better for Wildlife	10
Maintaining Connections is Key	12
Basic Rules for Better Buffers	13
Creeks and Rivers Need to Roam Across the Landscape	14
Why Should You Care About Buffers?	15
A Matter of Balance	16
Case Study—Agricultural Buffers	17
Case Study—Urbanizing Area Buffers	18
Case Study—Urban Buffers	19
A Buffer Design Tool	20
Buffers are a Good Defense	21
Buffers Provide Opportunities	22
Summary	23
More to Come	24



University of Wisconsin—Extension

What Are Riparian Corridors? Riparian Buffer Zones?

The word riparian comes from the Latin word *ripa*, which means bank. However, in this document we use riparian in a much broader sense and refer to land adjoining any water body including ponds, lakes, streams, and wetlands. This term has two additional distinct meanings that refer to 1) the "natural or relatively undisturbed" corridor lands adjacent to a water body inclusive of both wetland and upland flora and fauna and 2) a buffer zone or corridor lands in need of protection to "buffer" the effects of human impacts such as agriculture and residential development.



University of Wisconsin—Extension

The word buffer literally means something that cushions against the shock of something else (noun), or to lessen or cushion that shock (verb). Other useful definitions reveal that a buffer can be something that serves to separate features, or that is capable of neutralizing something, like filtering pollutants from stormwater runoff. Essentially, buffers and buffering help protect against adverse effects.

Riparian buffer zones function as core habitat as well as travel corridors for many wildlife species.

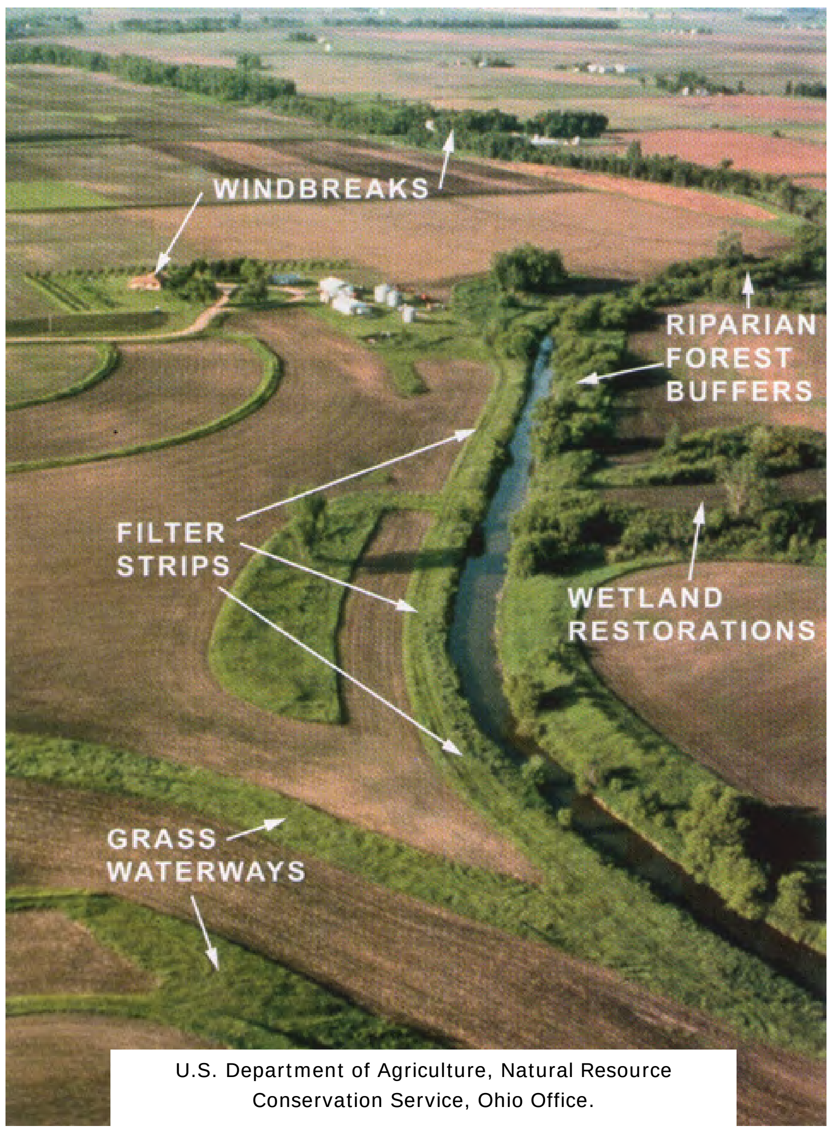
Riparian buffers are zones adjacent to waterbodies such as lakes, rivers, and wetlands that simultaneously protect water quality and wildlife, including both aquatic and terrestrial habitat. These zones minimize the impacts of human activities on the landscape and contribute to recreation, aesthetics, and quality of life. **This document summarizes how to maximize both water quality protection and conservation of aquatic and terrestrial wildlife populations using buffers.**

What Are Riparian Corridors? Riparian Buffer Zones?

Buffers **can** include a range of complex vegetation structure, soils, food sources, cover, and water features that offer a variety of habitats contributing to diversity and abundance of wildlife such as mammals, frogs, amphibians, insects, and birds. Buffers can consist of a variety of canopy layers and cover types including ephemeral (temporary-wet for only part of year) wetlands/seasonal ponds/spring pools, shallow marshes, deep marshes, wetland meadows, wetland mixed forests, grasslands, shrubs, forests, and/or prairies. Riparian zones are areas of transition between aquatic and terrestrial ecosystems, and they can potentially offer numerous benefits to wildlife and people such as pollution reduction and recreation.

In the water resources literature, riparian buffers are referred to in a number of different ways. Depending on the focus and the intended function of a buffer, or a buffer-related feature, buffers may be referred to as stream corridors, critical transition zones, riparian management areas, riparian management zones, floodplains, or green infrastructure.

It is important to note that within an agricultural context, the term buffer is used more generally to describe filtering best management practices most often at the water's edge. Other practices which can be interrelated may also sometimes be called buffers. These include grassed waterways, contour buffer strips, wind breaks, field border, shelterbelts, windbreaks, living snow fence, or filter strips. These practices may or may not be adjacent to a waterway as illustrated in the photo to the right. For example, a grassed waterway is designed to filter sediment and reduce erosion and may connect to a riparian buffer. These more limited-purpose practices may link to multipurpose buffers, but by themselves, they are not adequate to provide the multiple functions of a riparian buffer as defined here.



U.S. Department of Agriculture, Natural Resource Conservation Service, Ohio Office.

Beyond the Environmental Corridor Concept

The term "environmental corridors" (also known as "green infrastructure") refers to an interconnected green space network of natural areas and features, public lands, and other open spaces that provide natural resource value. Environmental corridor planning is a process that promotes a systematic and strategic approach to land conservation and encourages land use planning and practices that are good for both nature and people. It provides a framework to guide future growth, land development, and land conservation decisions in appropriate areas to protect both community and natural resource assets.

Environmental corridors are an essential planning tool for protecting the most important remaining natural resource features in Southeastern Wisconsin and elsewhere. Since development of the environmental corridor concept, there have been significant advancements in landscape ecology that have furthered understanding of the spatial and habitat needs of multiple groups of organisms. In addition, advancements in pollutant removal practices, stormwater control, and agriculture have increased our understanding of the effectiveness and limitations of environmental corridors. In protecting water quality and providing aquatic and terrestrial habitat, there is a need to better integrate new technologies through their application within riparian buffers.

SEWRPC has embraced and applied the environmental corridor concept developed by Philip Lewis (Professor Emeritus of Landscape Architecture at the University of Wisconsin-Madison) since 1966 with the publication of its first regional land use plan. Since then, SEWRPC has refined and detailed the mapping of environmental corridors, enabling the corridors to be incorporated directly into regional, county, and community plans and to be reflected in regulatory measures. The preservation of environmental corridors remains one of the most important recommendations of the regional plan. Corridor preservation has now been embraced by numerous county and local units of government as well as by State and Federal agencies. The environmental corridor concept conceived by Lewis has become an important part of the planning and development culture in Southeastern Wisconsin.

Beyond the Environmental Corridor Concept

Environmental corridors are divided into the following three categories.

- **Primary environmental corridors** contain concentrations of our most significant natural resources. They are at least 400 acres in size, at least two miles long, and at least 200 feet wide.

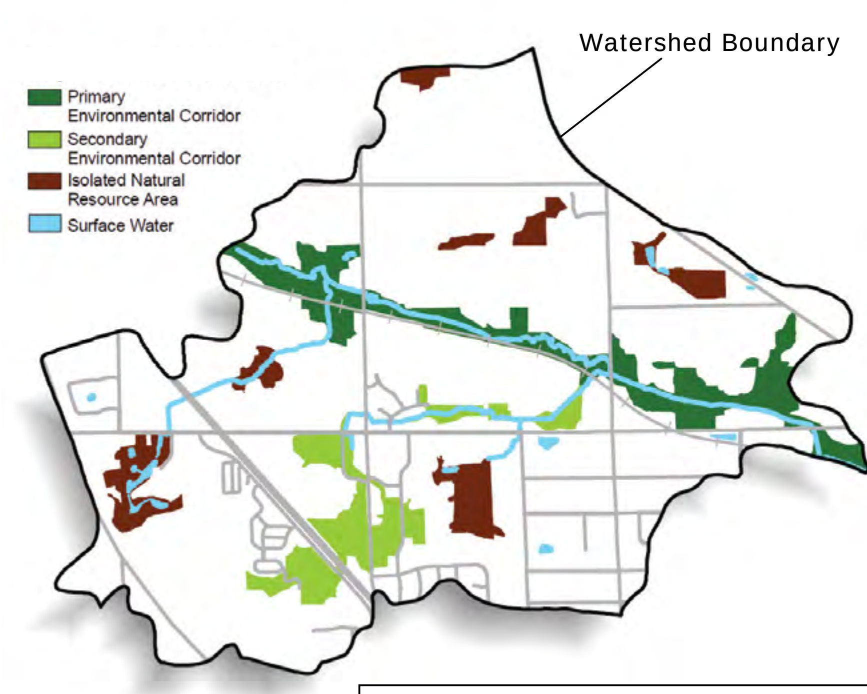
- **Secondary environmental corridors** contain significant but smaller concentrations of natural resources. They are at least 100 acres in size and at least one mile long, unless serving to link primary corridors.

- **Isolated natural resource areas** contain significant remaining resources that are not connected to environmental corridors. They are at least five acres in size and at least 200 feet wide.

Key Features of Environmental Corridors

- Lakes, rivers, and streams
- Undeveloped shorelands and floodlands
- Wetlands
- Woodlands
- Prairie remnants
- Wildlife habitat
- Rugged terrain and steep slopes
- Unique landforms or geological formations
- Unfarmed poorly drained and organic soils
- Existing outdoor recreation sites
- Potential outdoor recreation sites
- Significant open spaces
- Historical sites and structures
- Outstanding scenic areas and vistas

Beyond the Environmental Corridor Concept

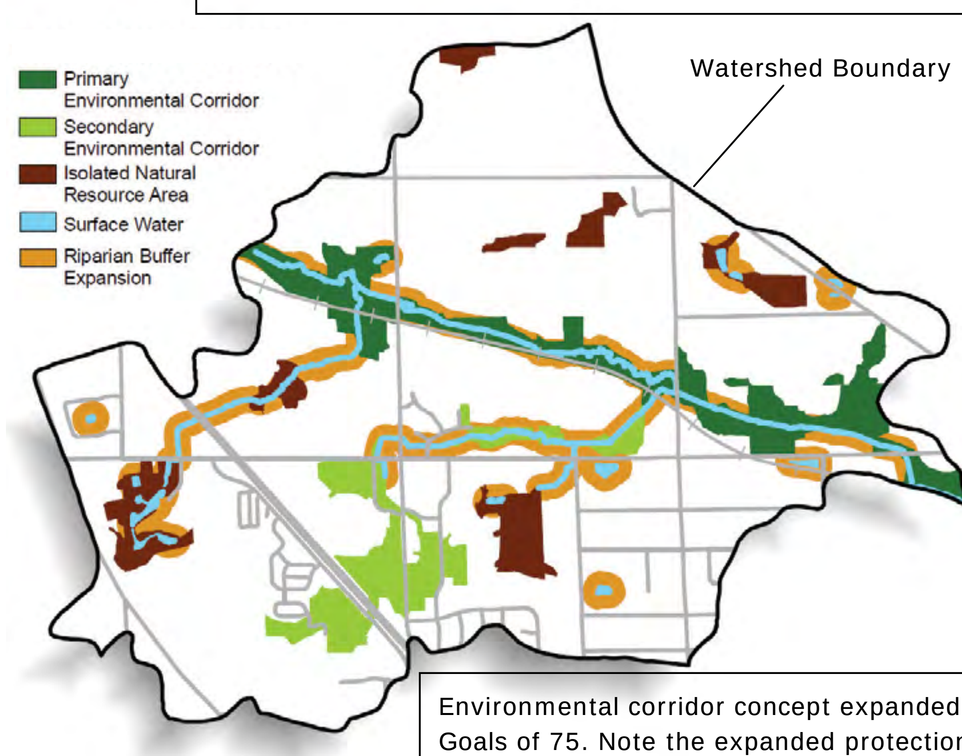


The Minimum Goals of **75** within a Watershed

75% minimum of total stream length should be naturally vegetated to protect the functional integrity of the water resources. (Environment Canada, How Much Habitat is Enough? A Framework for Guiding Habitat Rehabilitation in Great lakes Areas of Concern, Second Edition, 2004)

75 foot wide minimum riparian buffers from the top edge of each stream bank should be naturally vegetated to protect water quality and wildlife. (SEWRPC Planning Report No 50, A Regional Water Quality Management Plan for the Greater Milwaukee Watersheds, December 2007)

Example of how the environmental corridor concept is applied on the landscape. For more information see "Plan on It!" series **Environmental Corridors: Lifelines of the Natural Resource Base** at http://www.sewrpc.org/SEWRPC/LandUse/EnvironmentalCorridors.htm



Environmental corridor concept expanded to achieve the Goals of 75. Note the expanded protection in addition to the connection of other previously isolated areas.

Habitat Fragmentation—The Need for Corridors

Southeastern Wisconsin is a complex mosaic of agricultural and urban development. Agricultural lands originally dominated the landscape and remain a major land use. However, such lands continue to be converted to urban uses. Both of these dominant land uses fragment the landscape by creating islands or isolated pockets of wetland, woodland, and other natural lands available for wildlife preservation and recreation. By recognizing this fragmentation of the landscape, we can begin to mitigate these impacts.

New developments should incorporate water quality and wildlife enhancement or improvement objectives as design criteria by looking at the potential for creating linkages with adjoining lands and water features.

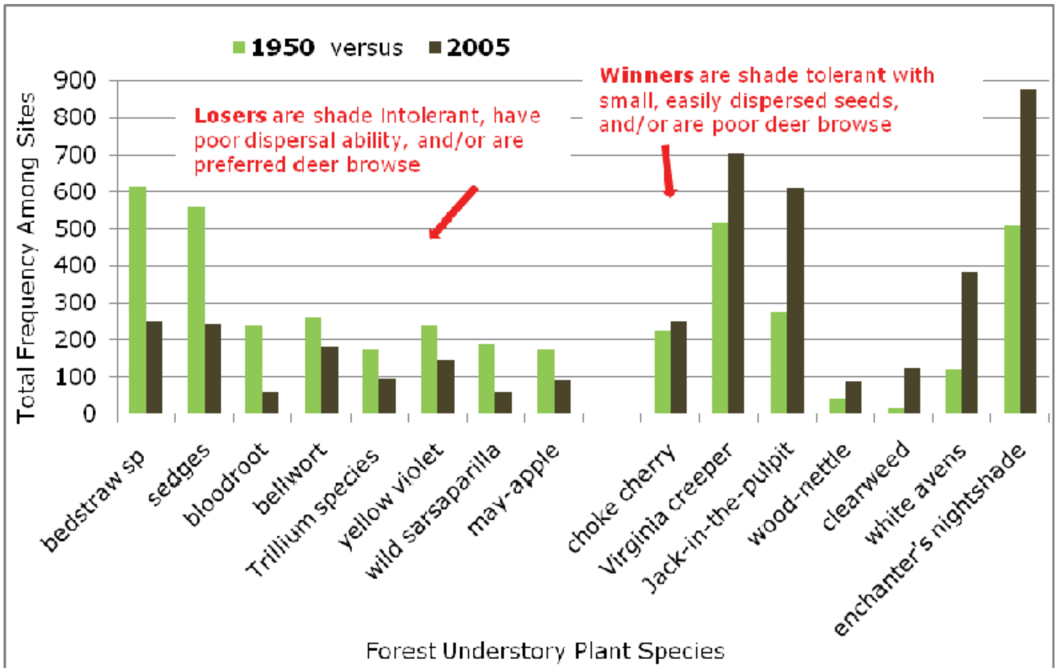
At the time of conversion of agricultural lands to urban uses, there are opportunities to re-create and expand riparian buffers and environmental corridors reconnecting uplands and waterways and restoring ecological integrity and scenic beauty locally and regionally. For example, placement of roads and other infrastructure across stream systems could be limited so as to maximize continuity of the riparian buffers. This can translate into significant cost savings in terms of reduced road maintenance, reduced salt application, and limited bridge or culvert maintenance and replacements. This simple practice not only saves the community significant amounts of money, but also improves and protects quality of life. Where necessary road crossings do occur, they can be designed to provide for safe fish and wildlife passage.

Overland travel routes for wildlife are often unavailable, discontinuous, or life endangering within the highly fragmented landscapes of Southeastern Wisconsin and elsewhere.

State Threatened Species: Blanding's turtle

Habitat Fragmentation—The Need for Corridors

Forest understory plant species abundance among stands throughout Southern Wisconsin



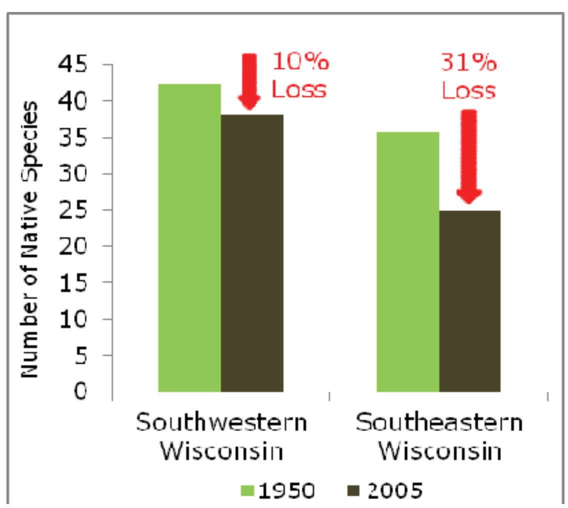
Forest fragmentation has led to significant plant species loss within Southern Wisconsin

(Adapted from David Rogers and others, 2008, Shifts in Southern Wisconsin Forest Canopy and Understory Richness, Composition, and Heterogeneity, Ecology, 89 (9): 2482-2492)

"...these results confirm the idea that large intact habitat patches and landscapes better sustain native species diversity. It also shows that people are a really important part of the system and their actions play an increasingly important role in shaping patterns of native species diversity and community composition. Put together, it is clear that one of the best and most cost effective actions we can take toward safeguarding native diversity of all types is to protect, enhance and create corridors that link patches of natural habitat."
Dr. David Rogers, Professor of Biology at the University of Wisconsin-Parkside

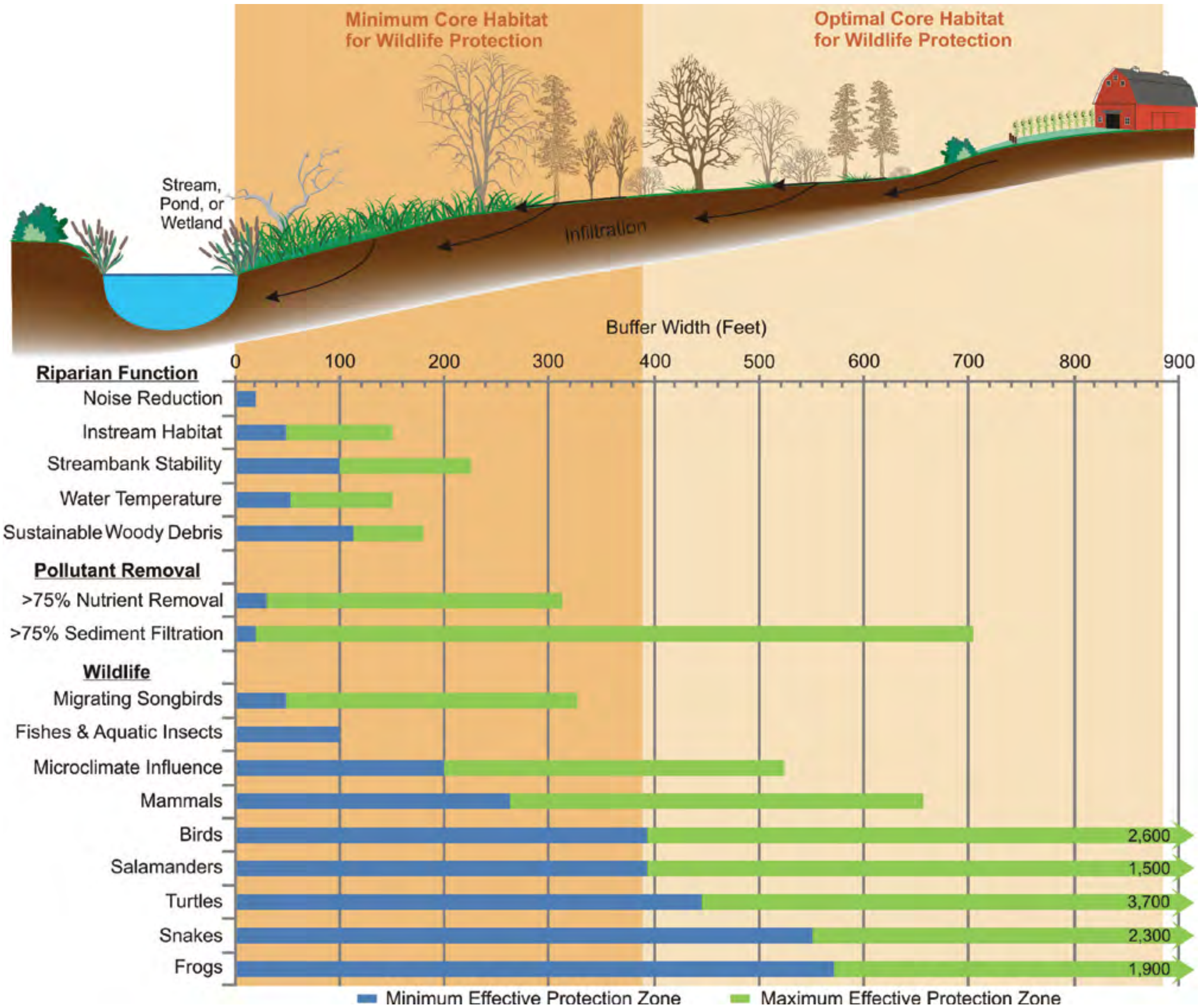
Since the 1950s, forests have increasingly become more fragmented by land development, both agricultural and urban, and associated roads and infrastructure, which have caused these forests to become isolated "islands of green" on the landscape. In particular, there has been significant loss of forest understory plant species over time (shrubs, grasses, and herbs covering the forest floor.) It is important to note that **these forests lost species diversity even when they were protected as parks or natural areas**.

One major factor responsible for this decline in forest plant diversity is that routes for native plants to re-colonize isolated forest islands are largely cut-off within fragmented landscapes. For example, the less fragmented landscapes in Southwestern Wisconsin lost fewer species than the more fragmented stands in Southeastern Wisconsin. In addition, the larger-sized forests and forests with greater connections to surrounding forest lands lost fewer species than smaller forests in fragmented landscapes.



Wider is Better for Wildlife

Why? Because buffer size is the engine that drives important natural functions like food availability and quality, access to water, habitat variety, protection from predators, reproductive or resting areas, corridors to safely move when necessary, and help in maintaining the health of species' gene pools to prevent isolation and perhaps extinction.



One riparian buffer size does not fit all conditions or needs. There are many riparian buffer functions and the ability to effectively fulfill those functions is largely dependent on width. Determining what buffer widths are needed should be based on what functions are desired as well as site conditions. For example, as shown above, water temperature protection generally does not require as wide a buffer as provision of habitat for wildlife. Based on the needs of wildlife species found in Wisconsin, the minimum core habitat buffer width is about 400 feet and the optimal width for sustaining the majority of wildlife species is about 900 feet. Hence, the value of large undisturbed parcels along waterways which are part of, and linked to, an environmental corridor system. The minimum effective buffer width distances are based on data reported in the scientific literature and the quality of available habitats within the context of those studies.

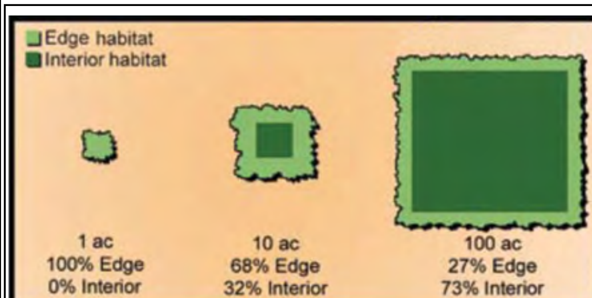
Wider is Better for Wildlife

Wildlife habitat needs change within and among species. **Minimum Core Habitat and Optimum Core Habitat distances were developed from numerous studies to help provide guidance for biologically meaningful buffers to conserve wildlife biodiversity.** These studies documented distances needed for a variety of biological (life history) needs to sustain healthy populations such as breeding, nesting, rearing young, foraging/feeding, perching (for birds), basking (for turtles), and overwintering/dormancy/hibernating. These life history needs require different types of habitat and distances from water, for example, one study found that Blanding's turtles needed approximately 60-foot-wide buffers for basking, 375 feet for overwintering, and up to 1,200 feet for nesting to bury their clutches of eggs. Some species of birds like the Blacked-capped chickadee or white breasted nuthatch only need about 50 feet of buffer, while others like the wood duck or great blue heron require 700-800 feet for nesting. Therefore, **understanding habitat needs for wildlife species is an important consideration in designing riparian buffers.**

Although *Ambystoma* salamanders require standing water for egg laying and juvenile development, most other times of the year they can be found more than 400 feet from water foraging for food.

Wisconsin Species	Mimimum Core Habitat (feet)	Optimum Core Habitat (feet)	Number of Studies
Frogs	571	1,043	9
Salamanders	394	705	14
Snakes	551	997	5
Turtles	446	889	27
Birds	394	787	45
Mammals	263	No data	11
Fishes and Aquatic Insects	100	No data	11
Mean	388	885	

This approach was adapted from *R.D. Semlitsch and J.R. Bodie, 2003, Biological Criteria for Buffer Zones around Wetlands and Riparian Habitats for Amphibian and Reptiles, Conservation Biology, 17(5):1219-1228*. These values are based upon studies examining species found in Wisconsin and represent mean linear distances extending outward from the edge of an aquatic habitat. The Minimum Core Habitat and Optimum Core Habitat reported values are based upon the mean minimum and mean maximum distances recorded, respectively. Due to a low number of studies for snake species, the recommended distances for snakes are based upon values reported by *Semlitsch and Bodie.*

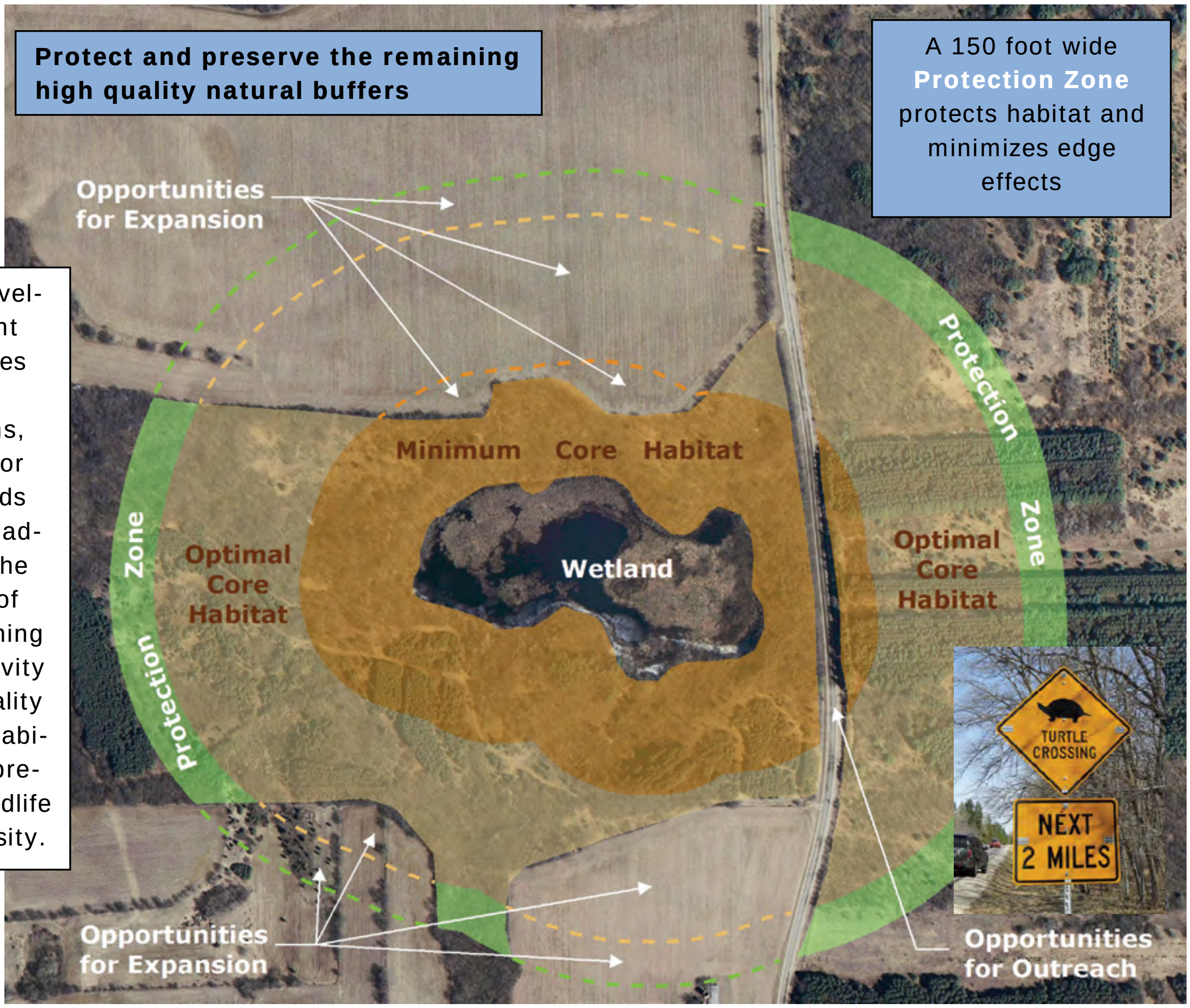


"***Large patches typically conserve a greater variety and quality of habitats, resulting in higher species diversity and abundance."*** *Larger patches contain greater amounts of interior habitat and less edge effects, which benefits interior species, by providing safety from parasitism, disease, and invasive species.*

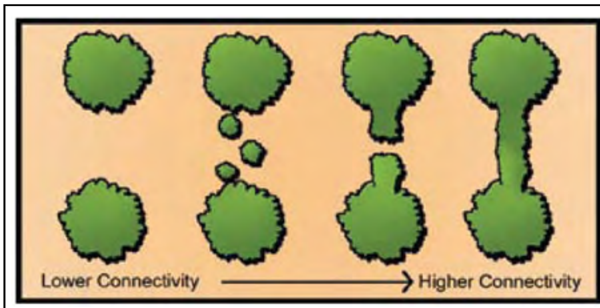
(Bentrup, G. 2008. Conservation buffers: design guidelines for buffers, corridors, and greenways. Gen. Tech. Rep. SRS-109. Asheville, NC: Department of Agriculture, Forest Service, Southern Research Station)

Maintaining Connections is Key

Like humans, all forms of wildlife require access to clean water. Emerging research has increasingly shown that, in addition to water, more and more species such as amphibians and reptiles cannot persist without landscape connectivity between quality wetland and upland habitats. Good connectivity to upland terrestrial habitats is essential for the persistence of healthy sustainable populations, because these areas provide vital feeding, overwintering, and nesting habitats found nowhere else. Therefore, both aquatic and terrestrial habitats are essential for the preservation of biodiversity and they should ideally be managed together as a unit.



Land development practices near streams, lakes, or wetlands need to address the issue of maintaining connectivity with quality upland habitats to preserve wildlife biodiversity.



Increasing connectivity among quality natural landscapes (wetlands, woodlands, prairies) can benefit biodiversity by providing access to other areas of habitat, increasing gene flow and population viability, enabling recolonization of patches, and providing habitat (Bentrup 2008).

Basic Rules to Better Buffers

There are opportunities to improve buffer functions to improve water quality and wildlife habitat, even in urban situations

- Channelized ditch
- Historic floodplain fill
- Invasive species dominate

- Meandered stream
- Reconnected floodplain
- Wetland diversity added
- Native species restored

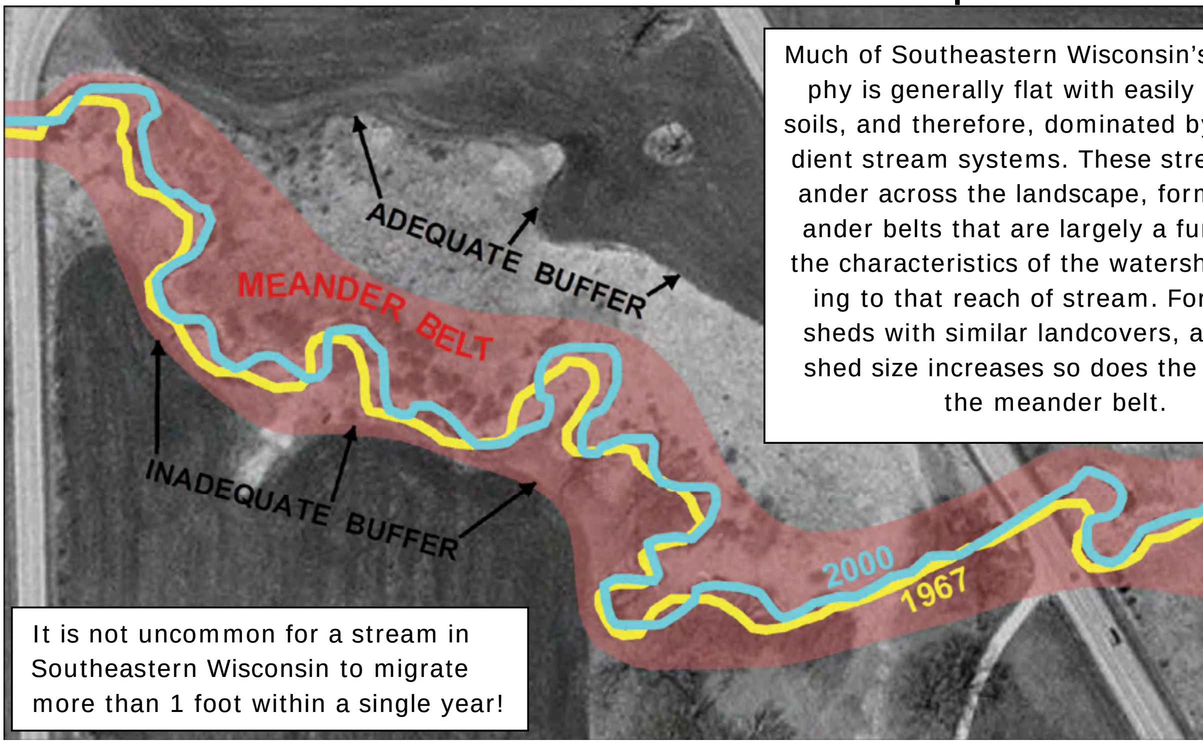
Protecting the integrity of native species in the region is an objective shared by many communities. The natural environment is an essential component of our existence and contributes to defining our communities and neighborhoods. Conservation design and open space development patterns in urbanizing areas and farm conservation programs in rural areas have begun to address the importance of maintaining and restoring riparian buffers and connectivity among corridors.

How wide should the buffer be? Unfortunately, there is no one-size-fits all buffer width adequate to protect water quality, wildlife habitat, and human needs. Therefore, the answer to this question depends upon the predetermined needs of the landowner and community objectives or goals. As riparian corridors become very wide, their pollutant removal (buffering) effectiveness may reach a point of diminishing returns compared to the investment involved. However, the prospects for species diversity in the corridor keep increasing with buffer width. For a number of reasons, 400- to 800-foot-wide buffers are not practical along all lakes, streams, and wetlands within Southeastern Wisconsin. Therefore, communities should develop guidelines that remain flexible to site-specific needs to achieve the most benefits for water resources and wildlife as is practical.

Key considerations to better buffers/corridors:

- Wider buffers are better than narrow buffers for water quality and wildlife functions
- Continuous corridors are better than fragmented corridors for wildlife
- Natural linkages should be maintained or restored
- Linkages should not stop at political boundaries
- Two or more corridor linkages are better than one
- Structurally diverse corridors (e.g., diverse plant structure or community types, upland and wetland complexes, soil types, topography, and surficial geology) are better than corridors with simple structures
- Both local and regional spatial and temporal scales should be considered in establishing buffers
- Corridors should be located along dispersal and migration routes
- Corridors should be located and expanded around rare, threatened, or endangered species
- Quality habitat should be provided in a buffer whenever possible
- Disturbance (e.g. excavation or clear cutting vegetation) of corridors should be minimized during adjacent land use development
- Native species diversity should be promoted through plantings and active management
- Non-native species invasions should be actively managed by applying practices to preserve native species
- Fragmentation of corridors should be reduced by limiting the number of crossings of a creek or river where appropriate
- Restoration or rehabilitation of hydrological function, streambank stability, instream habitat, and/or floodplain connectivity should be considered within corridors.
- Restoration or retrofitting of road and railway crossings promotes passage of aquatic organisms

Creeks and Rivers Need to Roam Across the Landscape



Much of Southeastern Wisconsin's topography is generally flat with easily erodible soils, and therefore, dominated by low gradient stream systems. These streams meander across the landscape, forming meander belts that are largely a function of the characteristics of the watershed draining to that reach of stream. For watersheds with similar landcovers, as watershed size increases so does the width of the meander belt.

It is not uncommon for a stream in Southeastern Wisconsin to migrate more than 1 foot within a single year!

Healthy streams naturally meander or migrate across a landscape over time. Streams are transport systems for water and sediment and are continually eroding and depositing sediments, which causes the stream to migrate. When the amount of sediment load coming into a stream is equal to what is being transported downstream—and stream widths, depths, and length remain consistent over time—it is common to refer to that stream as being in a state of **"dynamic equilibrium."** In other words the stream retains its physical dimensions (equilibrium), but those physical features are shifted, or migrate, over time (dynamic).

Room to Roam

Riparian buffer widths should take into account the amount of area that a stream needs to be able to self-adjust and maintain itself in a state of dynamic equilibrium. … These are generally greater than any minimum width needed to protect for pollutant removal alone.

Streams are highly sensitive, and they respond to changes in the amounts of water and sediment draining to them, which are affected by changing land use conditions. For example, streams can respond to increased discharges of water by increased scour (erosion) of bed and banks that leads to an increase in stream width and depth—or "degradation." Conversely, streams can respond to increased sedimentation (deposition) that leads to a decrease in channel width and depth—or "aggradation."

Why Should You Care About Buffers?

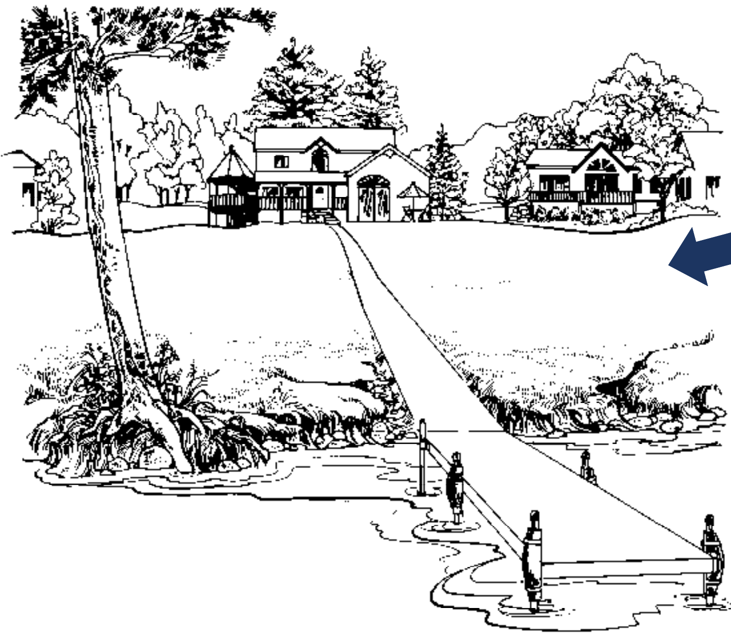
Economic Benefits:
- Increased value of riparian property
- Reduced lawn mowing time and expense
- Increased shade to reduce building cooling costs
- Natural flood mitigation protection for structures or crops
- Pollution mitigation (reduced nutrient and contaminant loading)
- Increased infiltration and groundwater recharge
- Prevented loss of property (land or structures) through erosion
- Greater human and ecological health through biodiversity

Recreational Benefits:
- Increased quality of the canoeing/kayaking experience
- Improved fishing and hunting quality by improving habitat
- Improved bird watching/wildlife viewing quality and opportunities
- Increased potential for expansion of trails for hiking and bicycling
- Opportunities made available for youth and others to locally reconnect with nature

Riparian buffers make sense and are profitable monetarily, recreationally, and aesthetically!

Social Benefits:
- Increased privacy
- Educational opportunities for outdoor awareness
- Improved quality of life at home and work
- Preserved open space/balanced character of a community
- Focal point for community pride and group activities
- Visual diversity
- Noise reduction

A Matter of Balance



University of Wisconsin—Extension

Although neatly trimmed grass lawns are popular, these offer limited benefits for water quality or wildlife habitat. A single house near a waterbody may not seem like a "big deal," but the cumulative effects of many houses can negatively impact streams, lakes, and wetlands.

All the lands within Southeastern Wisconsin ultimately flow into either the Mississippi River or the Great Lakes systems. The cumulative effects of agriculture and urban development in the absence of mitigative measures, ultimately affects water quality in those systems. Much of this development causes increases in water runoff from the land into wetlands, ponds, and streams. This runoff transports water, sediments, nutrients, and other pollutants into our waterways that can lead to a number of problems, including flooding that can cause crop loss or building damage; unsightly and/or toxic algae blooms; increased turbidity; damage to aquatic organisms from reduced dissolved oxygen, lethal temperatures, and/or concentrations of pollutants; and loss of habitat.

Riparian buffers are one of the most effective tools available for defending our waterways. Riparian buffers can be best thought of as forming a living, self-sustainable protective shield. This shield protects investments in the land and all things on it as well as our quality of life locally, regionally, and, ultimately, nationally. Combined with stormwater management, environmentally friendly yard care, effective wastewater treatment, conservation farming methods, and appropriate use of fertilizers and other agrichemicals, **riparian buffers complete the set of actions that we can take to minimize impacts to our shared water resources.**

Lakeshore buffers can take many forms, which require a balancing act between lake viewing, access, and scenic beauty. Lakeshore buffers can be integrated into a landscaping design that complements both the structural development and a lakeside lifestyle. Judicious placement of access ways and shoreline protection structures, and preservation or reestablishment of native vegetation, can enhance and sustain our use of the environment.

University of Wisconsin—Extension

Case Study—Agricultural Buffers

Agricultural nonpoint source pollution runoff continues to pose a threat to water quality and aquatic ecosystems within Wisconsin and elsewhere. In an effort to address this problem, the Wisconsin Buffer Initiative was formed with the goal of designing a buffer implementation program to achieve science-based, cost-effective, water quality improvements (report available online at http://www.soils.wisc.edu/extension/nonpoint/wbi.php).

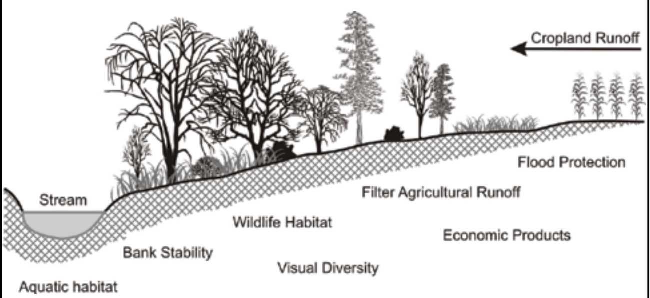
While it is true that riparian buffers alone may not always be able to reduce nutrient and sediment loading from agricultural lands, WBI researchers found that "…***riparian buffers are capable of reducing large percentages of the phosphorus and sediment that are currently being carried by Wisconsin streams. Even in watersheds with extremely high loads (top 10%), an average of about 70% of the sediment and phosphorus can be reduced through buffer implementation***." (*Diebel, M.J. and others, 2009, Landscape planning for agricultural nonpoint source pollution reduction III: Assessing Phosphorus and sediment reduction potential, Environmental Management, 43:69-83.*).

Challenge:
Buffers may take land out of cultivated crop production and require additional cost to install and maintain. Cost sharing, paid easements, and purchase of easements or development rights may sometimes be available to offset costs.

Benefits:
Buffers may offset costs by producing perennial crops such as hay, lumber, fiber, nuts, fruits, and berries. In addition, they provide visual diversity on the landscape, help maintain long-term crop productivity, and help support healthier fish populations for local enjoyment.

Federal and state natural resource agencies have long recognized the need to apply a wide range of Best Management Practices on agricultural lands to improve stream water quality. Although there are many tools available in the toolbox to reduce pollutant runoff from agricultural lands, such as crop rotations, nutrient and manure management, conservation tillage, and contour plowing, riparian buffers are one of the most effective tools to accomplish this task. Their multiple benefits and inter-connectedness from upstream to downstream make riparian buffers a choice with watershed-wide benefits.

Determine what benefits are needed.



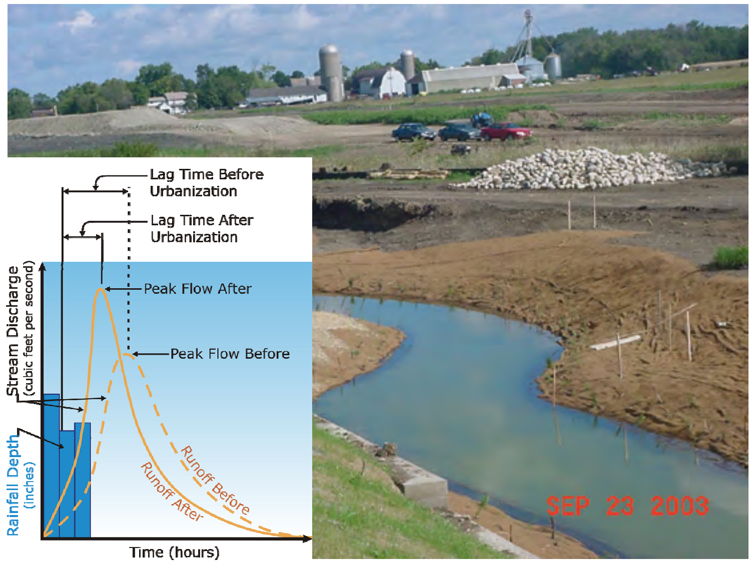
The USDA in *Agroforestry Notes* (AF Note-4, January 1997) outlines a four step process for designing riparian buffers for Agricultural lands:

1-Determine what buffers functions are needed
2-Identify the best types of vegetation to provide the needed benefits
3-Determine the minimum acceptable buffer width to achieve desired benefits
4-Develop an installation and maintenance plan

Drain tiles can bypass infiltration and filtration of pollutants by providing a direct pathway to the water and "around" a buffer. This is important to consider in design of a buffer system which integrates with other agricultural practices.

Case Study—Urbanizing Area Buffers

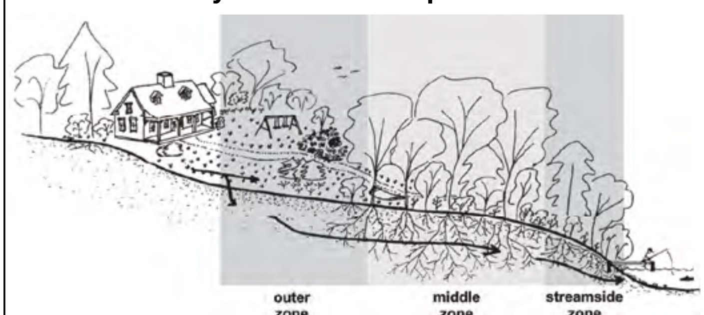
When development occurs near a waterbody, the area in driveways, rooftops, sidewalks, and lawns increases, while native plants and undisturbed soils decrease. As a result, the ability of the shoreland area to perform its natural functions (flood control, pollutant removal, wildlife habitat, and aesthetic beauty) is decreased. In the absence of mitigating measures, one the consequences of urban development is an increase in the amount of stormwater, which runs off the land instead of infiltrating into the ground. Therefore, **urbanization impacts the watershed, not only by reducing groundwater recharge, but also by changing stream hydrology** through increased stormwater runoff volumes and peak flows. This means less water is available to sustain the baseflow regime. The urban environment also contains increased numbers of pollutants and generates greater pollutant concentrations and loads than any other land use. This reflects the higher density of the human population and associated activities, which demand measures to protect the urban water system.



Comparison of hydrographs before and after urbanization. Note the rapid runoff and greater peak streamflow tied to watershed development. (Adapted from Federal Interagency Stream Restoration Working Group (FISRWG), Stream Corridor Restoration: Principles, Processes, and Practices, October 1998)

Mitigation of urban impacts may be as simple as not mowing along a stream corridor or changing land management and yard care practices, or as complex as changing zoning ordinances or widening riparian corridors through buyouts.

Anatomy of an urban riparian buffer



The most effective urban buffers have three zones:

Outer Zone-Transition area between the intact buffer and nearest permanent structure to capture sediment and absorb runoff.

Middle Zone-Area from top of bank to edge of lawn that is composed of natural vegetation that provides wildlife habitat as well as improved filtration and infiltration of pollutants.

Streamside Zone-Area from the water's edge to the top of the bank or uplands that provides critical connection between water, wetland, and upland habitats for wildlife as well as protect streams from bank erosion

(Fact sheet No. 6 Urban Buffer in the series Riparian Buffers for Northern New Jersey)

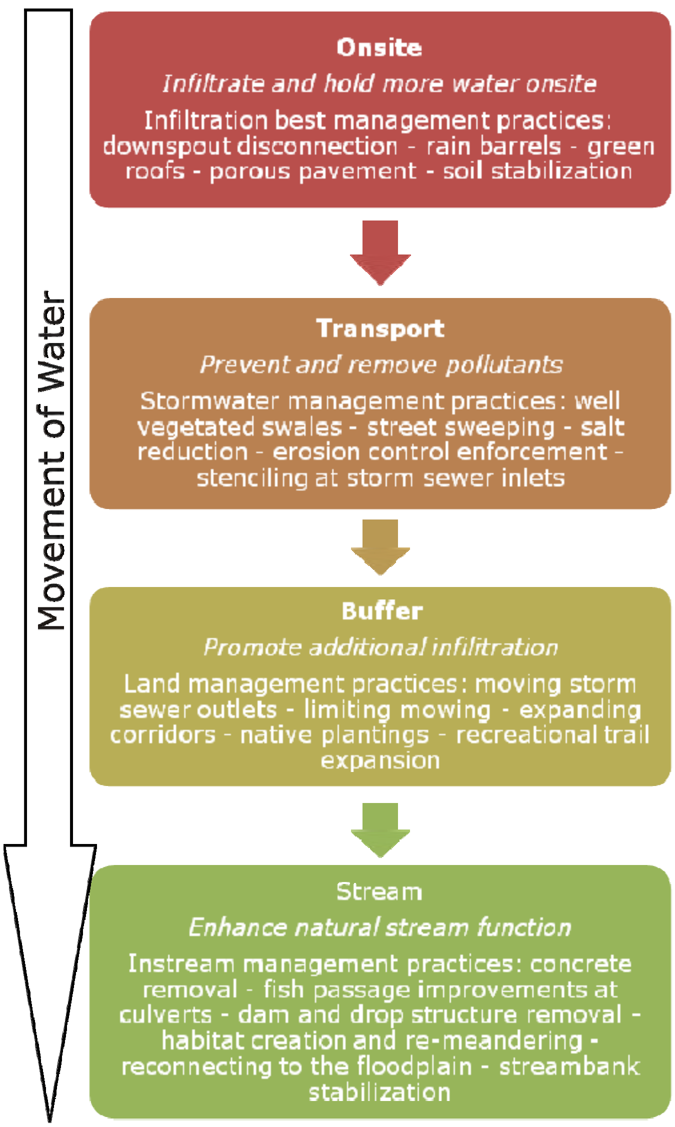
Challenge:
Urban development requires balancing flood protection, water quality protection, and the economic viability of the development.

Opportunities:
Buffers may offset costs by providing adequate space for providing long-term water quantity and water quality protection. In addition, they provide visual diversity on the landscape, wildlife habitat and connectedness, and help maintain property values.

Case Study—Urban Buffers

Placement of riparian buffers in established urban areas is a challenge that requires new and innovative approaches. In these areas, historical development along water courses limits options and requires balancing flood management protection versus water quality and environmental protection needs. Consequently, some municipalities have begun to recognize the connections between these objectives and are introducing programs to remove flood-prone structures and culverts from the stream corridors and allow recreation of the stream, restoring floodplains, and improving both the quality of life and the environment.

In urban settings it may be necessary to limit pollution and water runoff before it reaches the buffer.



Challenge:
There are many potential constraints to establishing, expanding, and/or managing riparian buffers within an urban landscape. Two major constraints to establishment of urban buffers include:

1) **Limited or confined space to establish buffers** due to encroachment by structures such as buildings, roadways, and/or sewer infrastructure;

2) **Fragmentation of the landscape** by road and railway crossings of creeks and rivers that disrupt the linear connectedness of buffers, limiting their ability to provide quality wildlife habitat.

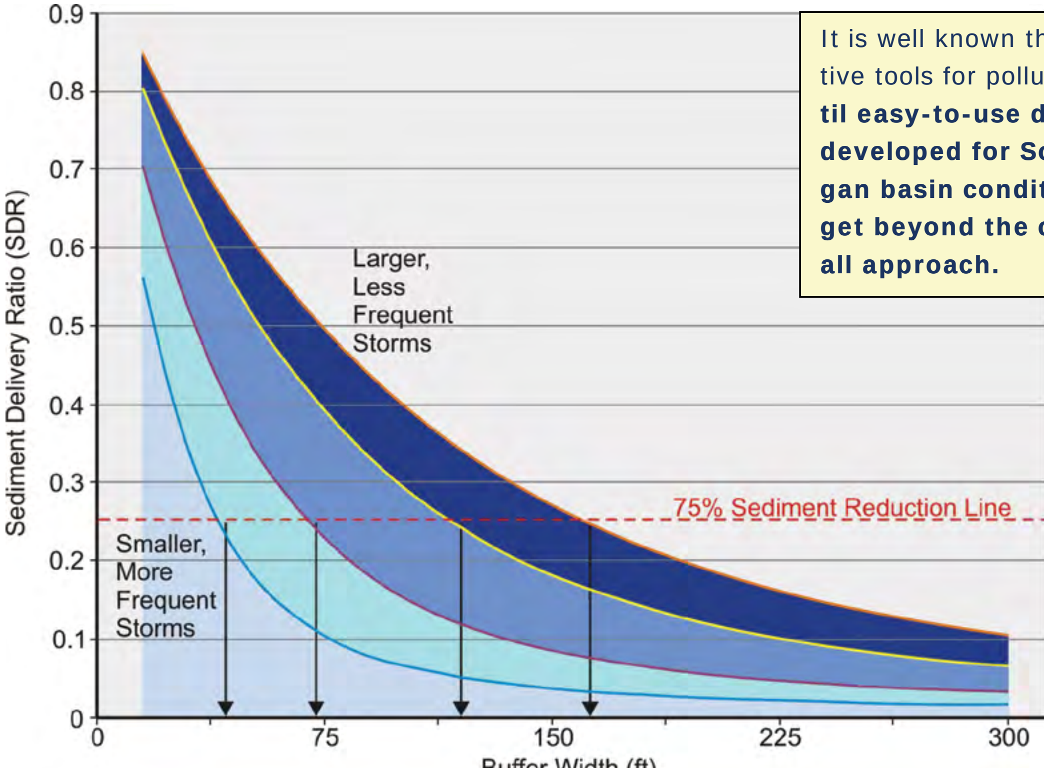
Much traditional stormwater infrastructure intercepts runoff and diverts it directly into creeks and rivers, bypassing any benefits of buffers to infiltrate or filter pollutants. This is important to consider in design of a buffer system for urban waterways, which begin in yards, curbsides, and construction sites, that are figuratively as close to streams as the nearest storm sewer inlet.

A Buffer Design Tool

Design aids are needed to help municipalities, property owners, and others take the "guesswork" out of determining adequate buffer widths for the purpose of water resource quality protection. While there are various complex mathematical models that can be used to estimate sediment and nutrient removal efficiencies, they are not easily applied by the people who need them including homeowners, farmers, businesses and developers.

To fill this gap, design aid tools are being developed using factors such as slope, soils, field length, incoming pollutant concentrations, and vegetation to allow the user to identify and test realistic buffer widths with respect to the desired percent pollutant load reduction and storm characteristics. By developing a set of relationships among factors that determine buffer effectiveness, the width of buffer needed to meet specific goals can be identified.

In the example below, 50-foot-wide buffers are necessary to achieve 75 % sediment removal during small, low intensity storms, while buffers more than 150 feet wide are necessary to achieve the same sediment reduction during more severe storms. Based on this information, decision-makers have the option of fitting a desired level of sediment removal into the context of their specific conditions. Under most conditions, a 75-foot width will provide a minimum level of protection for a variety of needs (SEWRPC PR No. 50, Appendix O.)



It is well known that buffers are effective tools for pollutant removal, but **until easy-to-use design aid tools are developed for Southern Lake Michigan basin conditions, we can never get beyond the current one size fits all approach.**

This generalized graph depicts an example of model output for an optimal buffer width to achieve a 75% sediment reduction for a range of soil and slope, vegetation, and storm conditions characteristic of North Carolina. *(Adapted from Muñoz-Carpena R., Parsons J.E.. 2005. VFSMOD-W: Vegetative Filter Strips Hydrology and Sediment Transport Modeling System v.2.x. Homestead, FL: University of Florida. http://carpena.ifas.ufl.edu/vfsmod/citations.shtml)*

Buffers Are A Good Defense

Today's natural resources are under threat. These threats are immediate as in the case of chemical accidents or manure spills, and chronic as in the case of stormwater pollution carrying everything from eroded soil, to fertilizer nutrients, to millions of drips from automobiles and other sources across the landscape. Non-native species have invaded, and continue to invade, key ecosystems and have caused the loss of native species and degradation of their habitats to the detriment of our use of important resources.

> ***"Riparian ecosystems are naturally resilient,*** *provide linear habitat connectivity, link aquatic and terrestrial ecosystems, and create thermal refugia for wildlife: all characteristics that can contribute to ecological adaptation to climate change."*
>
> *(N. E. Seavy and others, Why Climate Change Makes Riparian Restoration More Important Than Ever: Recommendations for Practice and Research, 2009, Ecological Restoration 27(3):330-338)*

A more subtle, but growing, concern is the case of stresses on the environment resulting from climate change. Buffers present an opportunity for natural systems to adapt to such changes by providing the space to implement protective measures while also serving human needs. **Because riparian buffers maintain an important part of the landscape in a natural condition, they offer opportunities for communities to adjust to our changing world.**

Well-managed riparian buffers are a good defense against these threats. In combination with environmental corridors, buffers maintain a sustainable reserve and diversity of habitats, plant and animal populations, and genetic diversity of organisms, all of which contribute to the long-term preservation of the landscape. Where they are of sufficient size and connectivity, riparian buffers act as reservoirs of resources that resist the changes that could lead to loss of species.

Refuge or protection from increased water temperatures as provided by natural buffers is important for the preservation of native cold-water, cool-water, and warm-water fishes and their associated communities.

Buffers Provide Opportunities

River, lake, and wetland systems and their associated riparian lands form an important element of the natural resource base, create opportunities for recreation, and contribute to attractive and well-balanced communities. These resources can provide an essential avenue for relief of stress among the population and improve quality of life in both urban and rural areas. Such uses also sustain industries associated with outfitting and supporting recreational and other uses of the natural environment, providing economic opportunities. Increasing access and assuring safe use of these areas enhances public awareness and commitment to natural resources. Research has shown that property values are higher adjoining riparian corridors, and that such natural features are among the most appreciated and well-supported parts of the landscape for protection.

We demand a lot from our riparian buffers!

Sustaining this range of uses requires our commitment to protect and maintain them.

Summary

The following guidance suggestions highlight key points to improve riparian corridor management and create a more sustainable environment.

Riparian corridors or buffers along our waters may contain varied features, but all are best preserved or designed to perform multiple important functions.

Care about buffers because of their many benefits. Riparian buffers make sense and are profitable monetarily, recreationally, aesthetically, as well as environmentally.

Enhance the environmental corridor concept. Environmental corridors are special resources which deserve protection. They serve many key riparian corridor functions, but in some cases, could also benefit from additional buffering.

Avoid habitat fragmentation of riparian corridors. It is important to preserve and link key resource areas, making natural connections and avoiding habitat gaps.

Employ the adage "wider is better" for buffer protection. While relatively narrow riparian buffers may be effective as filters for certain pollutants, that water quality function along with infiltration of precipitation and runoff and the provision of habitat for a host of species will be improved by expanding buffer width where feasible.

Allow creeks and rivers room to roam across the landscape. Streams are dynamic and should be buffered adequately to allow for natural movement over time while avoiding problems associated with such movement.

Consider and evaluate buffers as a matter of balance. Riparian buffers are a living, self-sustainable shield that can help balance active use of water and adjoining resources with environmental protection.

Agricultural buffers can provide many benefits. Riparian buffers in agricultural settings generally work well, are cost-effective, and can provide multiple benefits, including possibly serving as areas to raise certain crops.

Urban buffers should be preserved and properly managed. Though often space-constrained and fragmented, urban buffers are important remnants of the natural system. Opportunities to establish or expand buffers should be considered, where feasible, complemented by good stormwater management, landscaping, and local ordinances, including erosion controls.

A buffer design tool is needed and should be developed. Southeastern Wisconsin and the Southern Lake Michigan Basin would benefit from development of a specific design tool to address the water quality function of buffers. Such a tool would improve on the currently available general guidance on dimensions and species composition.

Buffers are a good defense. Combined with environmental corridors, riparian buffers offer a good line of defense against changes which can negatively impact natural resources and the landscape.

Managing the Water's Edge

MORE TO COME

Future editions in a riparian buffer planning series are being explored with the intent of focusing on key elements of this critical land and water interface. Topics may include:

- Information sharing and development of ordinances to integrate riparian buffers into existing land management plans and programs
- Integration of stormwater management practices and riparian buffer best management practices
- Application of buffers within highly constrained urban corridors with and without brownfield development
- Installation of buffers within rural or agricultural lands being converted to urban uses
- Utilization of buffers in agricultural areas and associated drainage systems
- Integration of riparian buffers into environmental corridors to support resources preservation, recreation and aesthetic uses
- Preservation of stream courses and drainageways to minimize maintenance and promote protection of infrastructure
- Guidance for retrofitting, replacement, or removal of infrastructure such as dams and road crossings, to balance transportation, recreation, aesthetic, property value, and environmental considerations.
- Protection of groundwater recharge and discharge areas
- Protection of high quality, sensitive coastal areas, including preservation of recreational potential

MORE INFORMATION

This booklet can be found at http://www.sewrpc.org/RBMG-no1 . Please visit the website for more information, periodic updates, and a list of complementary publications.

* * *

This publication may be printed without permission but please give credit to the Southeastern Wisconsin Regional Planning Commission for all uses,
W239 N1812 Rockwood Drive, Waukesha, WI, 53187-1607
262-547-6721.

www.sewrpc.org

Staff Acknowledgements:

Principal Author: Tom Slawski, PhD, Principal Planner

Michael Hahn, P.E., P.H., Chief Environmental Engineer
Laura Kletti, P.E., Principal Engineer
Gary Korb, Regional Planning Educator, UW-Extension/SEWRPC
Ed Schmidt, GIS Planning Specialist
Mike Scott, GIS Application Specialist
Sara Teske, Research Analyst
Jeff Thornton, PhD, Principal Planner

May 7, 2010

APPENDIX H

STREAM CROSSING DESCRIPTIONS, CONDITION, AND FISH PASSAGE ASSESSMENT FOR THE OAK CREEK WATERSHED

Table H.1

Structure Description, Location, Condition, and Fish Passage Rating Assessment for Oak Creek and its Principal Tributaries: 2016-2017

ID Number on Map 4.14	Crossing Name	Structure Description	River Mile	Culvert/ Bridge Length (feet)	Limiting Water Depth (feet)	Embedded Depth (feet)	General Condition	Description of Problem	Fish Passage Rating	Recommended Potential Actions
					Grant Park Ravine					
1	First Oak Creek Parkway Crossing	Concrete bridge with abutments	0.35	54.0	1.8	--	Fair, floodwalls eroding	None	Passable	None
2	Second Oak Creek Parkway Crossing	Concrete bottom arch bridge	0.88	44.0	2.0	0-2.2	Fair	None	Passable	None
3	Mill Road	Concrete open bottom arch bridge	0.94	44.2	0.3	--	Fair	None	Passable	None
					Lower Oak Creek – Mill Pond					
4	Mill Pond Dam	Masonry over concrete structure; 14-foot head	0.95	--	--	--	Fair	14-foot head is a complete fish passage impediment to all fish species; Masonry is deteriorating but the dam is structurally sound.	Impediment to Fish Passage	Explore dam removal options or installation of fish passage structure
5	Third Oak Creek Parkway Crossing	Concrete span bridge with abutments and side slopes	1.18	45.0	0-0.2	--	Good	Significant sediment fill in span #1	Passable	None
6	Fourth Oak Creek Parkway Crossing	Concrete bridge with abutments and side slopes	1.32	45.0	2.1	--	Good	None	Passable	None
7	Chicago Avenue (STH 32)	Concrete bridge with abutments	1.61	71.0	0.3	--	Good	None	Passable	None
8	Fifth Oak Creek Parkway Crossing	Concrete bridge with abutments and side slopes	2.14	44.0	0.6	--	Good	None	Passable	None
9	Walking Bridge	Wooden span bridge	2.24					None	Passable	None
10	Union Pacific Railway	Steel and concrete open bottom arch bridge	2.35	44.4	0.8	--	Poor, concrete cracking and eroding	None	Passable	None
11	15th Avenue	Concrete bridge with abutments and side slopes	2.84	60.0	0.5	--	Good	None	Passable	None
					Lower Oak Creek					
12	Walking Bridge	Concrete and steel span bridge	3.19	--	--	--	Good	None	Passable	None

Table continued on next page.

Table H.1 (Continued)

ID Number on Map 4.14	Crossing Name	Structure Description	River Mile	Culvert/ Bridge Length (feet)	Limiting Water Depth (feet)	Embedded Depth (feet)	General Condition	Description of Problem	Fish Passage Rating	Recommended Potential Actions
Lower Oak Creek (continued)										
15	Rawson Avenue and 16th Avenue	Three cell concrete box culvert, each cell 9.8-feet-wide, 10-feet-high	3.65	230.0 (cell #1), 256.0 (cell #2), 278.5 (cell #3)	0-0.8	1-2.1	Good	Triple cell culvert creates limiting water depths that may be too shallow for passage of some species; Extreme culvert length with no resting areas makes traversing culvert difficult for some species	Potential Impediment to Fish Passage	Retrofit culvert to direct flow into two culverts until additional capacity is needed in high flow events; Install strategically placed cobble and boulder substrates within culvert to provide resting areas; Explore installation of grade control downstream of culvert to increase water depths within culvert
16	15th Avenue	Concrete bridge with abutments	3.76	66.0	1.9	--	Fair, concrete cracking	None	Passable	None
17	Walking Bridge	Concrete span bridge	3.89	--	--	--	Fair	None	Passable	None
18	Milwaukee Avenue	Concrete bridge with abutments	4.01	67.0	1.1	--	Fair, concrete cracking	None	Passable	None
19	15th Avenue	Concrete bridge with abutments	4.06	70.0	0.7	--	Fair, concrete cracking	None	Passable	None
20	Walking Bridge	Concrete span bridge	4.18	--	--	--	Fair	None	Passable	None
21	Pennsylvania Avenue	Two cell concrete box culvert, each cell is 11.4-feet-wide, 10.5-feet-high	4.71	137.2	0.6-1.6	0-1.7	Good	None	Passable	None
22	Oak Leaf Trail	Steel and wood bridge with abutments and side slopes	5.14	10.6	0.3	--	Fair, rusting	None	Passable	None
Middle Oak Creek										
23	Union Pacific Railroad	Three span concrete bridge with abutments and side slopes	5.25	26.5	0-0.4	--	Fair	None	Passable	None
24	Drexel Avenue	Three cell concrete box culvert, each cell is 11.1-feet-wide, 16.5-feet-high	5.56	90.0	0.1-2.1	4.1-7.2	Good	Large debris accumulations have been observed at this location in the past, but have been removed	Passable	Monitor for debris accumulation
25	Walking Bridge-Abendschein Park	Steel and wood bridge with abutments and side slopes	5.63	11.5	1.5	--	Good	None	Passable	None
26	Walking Bridge-Abendschein Park	Steel and wood bridge with abutments and side slopes	5.72	11.3	2.4	--	Fair, rusted	None	Passable	None
27	Union Pacific Railroad (structure has been replaced since survey)	Concrete and steel bridge with abutments	6.06	24.7	0.3	--	Fair, concrete cracking	None	Passable	None

Table continued on next page.

Table H.1 (Continued)

ID Number on Map 4.14	Crossing Name	Structure Description	River Mile	Culvert/ Bridge Length (feet)	Limiting Water Depth (feet)	Embedded Depth (feet)	General Condition	Description of Problem	Fish Passage Rating	Recommended Potential Actions
Middle Oak Creek (continued)										
28	Forest Hill Avenue	Concrete bridge with abutments	6.25	33.0	1.8	--	Good	None	Passable	Monitor for debris accumulation
29	Puetz Road	Concrete bridge with abutments and side slopes	6.83	43.0	1.0	--	Fair, bridge deck cracking	Significant sediment deposition and beaver dam found just upstream of the bridge	Passable	Monitor for beaver activity and remove debris accumulation as needed
30	Union Pacific Railroad	Concrete and steel bridge with abutments	7.34	29.0[a]	1.8	--	Poor, concrete cracking and eroding	None	Passable	None
31	Nicholson Road	Concrete bridge with abutments and side slopes	7.44	47.5	0.3	--	Good	Structure itself is passable, however placement of rock across channel downstream of bridge may obstruct passage of some fish species	Potential Impediment to Fish Passage	Rearrange excess rubble to allow for better passage lanes
32	Shepard Avenue	Two cell concrete box culvert, each cell is 12.6-feet-wide, 10.9-feet-high	8.41	108.0	0.3	0-0.5	Good	Beaver activity and accumulation of large woody debris at the culvert inlet have been observed in the past but has been removed	Passable	Monitor for debris accumulation
33	Howell Avenue (northbound)	Three span concrete bridge with abutments and side slopes	9.22	57.2	0.2	--	Good	Channel is over-widened through crossing causing insufficient water depths during fair-weather flow conditions; Debris has accumulated in the channel downstream of the crossing	Potential Impediment to Fish Passage	Retrofit channel to direct flow to a "low-flow channel" to promote sufficient water depths during fair weather flow conditions while allowing overflow onto second "tier" when higher flows occur; Main channel should have widths similar to those upstream of crossing
34	Howell Avenue (southbound)	Concrete bridge with abutments and side slopes	9.24	57.2	0-0.2	--	Fair	Channel is over-widened through crossing causing insufficient water depths during base-flow conditions	Potential Impediment to Fish Passage	See above

Table continued on next page.

Table H.1 (Continued)

ID Number on Map 4.14	Crossing Name	Structure Description	River Mile	Culvert/ Bridge Length (feet)	Limiting Water Depth (feet)	Embedded Depth (feet)	General Condition	Description of Problem	Fish Passage Rating	Recommended Potential Actions
Upper Oak Creek										
35	Ryan Road/STH 100 (downstream crossing)	Three cell concrete box culvert; each cell is 11-feet-wide, 8-feet-high	10.06	223.0	--	2.9-6.0	Good	Culvert cells have excessive sediment build-up; Sediment accumulation is likely related-backwater effect from modification and relocation of the confluence of North Branch Oak Creek with the mainstem	Passable	Monitor sediment accumulation within and near culvert and remove as needed; Reinforce sediment accumulation at upstream end of culverts to direct fair weather flow into one cell; Explore a solution for more extensive problems caused by channel modifications in this immediate reach
36	Canadian Pacific Railroad	Two cell concrete box culvert; each cell is 11-feet-wide, 8-feet-high	10.24	112.0	0.3	1.2-3+	Good	Sediment accumulation within right cell (looking upstream) may become problem if continued	Passable	Install strategically placed cobble and boulder substrates within left cell of culvert along both walls to provide resting areas for passing fish
37	Canadian Pacific Railroad (old culvert on secondary channel)	One 12-foot-wide, 7-foot-high concrete box culvert (0.6-foot rise in the middle section) on top of one 4-foot-wide, 2.5-foot-high concrete box culverts (severely failing)	10.24	68.0	0	0	Poor, concrete failing	Concrete is failing and potentially compromising integrity of rail crossing; Structure is likely unnecessary considering the capacity of the double cell culvert discussed above (Structure 36)	Impediment to Fish Passage	Work with Canadian Pacific Railroad to consider options for removal and/or replacement
38	Private Farm Road	Primary 5-foot wide, 2.7-foot high corrugated metal pipe arch culvert conveys low-flow-Structure 36, secondary 4.7-foot wide, 3-foot high corrugated metal pipe arch culvert perched 3.5 feet at the inlet on the left bank of the stream that conveys high flow-Structure 37	10.25	50.0 (primary) 44.0 (secondary)	0.1 (primary) dry (secondary)	0	Poor	Concrete surrounding culvert is failing; Outlet is almost completely inundated by downstream ponding	Impediment to Fish Passage	Remove culverts replace with an appropriately sized culvert or bridge if crossing is still necessary
39	Private Farm Road (abandoned)	Abandoned wood and steel farm crossing; No longer usable	10.60	--	--	--	--	Structure has failed and is no longer in use; Rock placed across channel under bridge may obstruct passage of some fish species	Potential Impediment to Fish Passage	Remove structure and rearrange rock to allow for better passage lanes

Table continued on next page.

Table H.1 (Continued)

ID Number on Map 4.14	Crossing Name	Structure Description	River Mile	Culvert/ Bridge Length (feet)	Limiting Water Depth (feet)	Embedded Depth (feet)	General Condition	Description of Problem	Fish Passage Rating	Recommended Potential Actions
Upper Oak Creek (continued)										
40	13th Street (bridge has been replaced since survey)	Concrete bridge with abutments and side slopes	10.69	90.0	0.2	--	Good	Channel is over-widened through crossing causing insufficient water depths during base-flow conditions	Potential Impediment to Fish Passage	Retrofit a "low-flow channel" with narrower main channel to promote sufficient water depths during base-flow conditions while allowing overflow onto second "tier" when higher flows occur
41	IH 94 Northbound Off-Ramp	Three span concrete bridge with abutments and side slopes	10.96	30.0	0.2	--	Good	Significant cattail growth in the downstream channel	Passable	None
42	IH 94 Northbound Lanes	Three span concrete bridge with abutments and side slopes	10.97	80.0	0.2	--	Good	Lack of quality substrates	Passable	Add strategically placed large cobble or boulder along culvert walls to provide resting areas for passing fish
43	IH 94 Southbound Lanes	Three span concrete bridge with abutments and side slopes	10.99	77.0	0.2	--	Good	Lack of quality substrates	Passable	Add strategically placed large cobble or boulder along culvert walls to provide resting areas for passing fish
44	IH 94 Southbound On-Ramp	Three span concrete bridge with abutments and side slopes	11.00	30.0	0.8	--	Good	Lack of quality substrates	Passable	Add strategically placed large cobble or boulder along culvert walls to provide resting areas for passing fish
45	20th Street	One approximately 8-foot wide corrugated metal pipe arch culvert (height and embeddedness unknown due-excessive water depth)	11.23	140.0	4.8	unknown	Good	Upstream and downstream ponding and upstream debris above top of culvert indicate the culvert is undersized and is likely a fish passage impediment due to high velocities under high flow conditions	Potential Impediment to Fish Passage	Further investigation needed to determine suitability of culvert size
46	27th Street (STH 241)	Two cell concrete box culvert, each cell 12-feet-wide, 7-feet-high	11.70	129.5	0.1	1.0-1.8	Good	Sediment accumulation particularly in right cell (looking upstream) could become excessive; Flow is currently diverted to left cell which is desirable to maintain sufficient water depths	Passable	Reinforce existing sediment bar at inlet of right cell (looking upstream) to direct fair-weather flow to left cell and maintain sufficient water depths but allow flow into second cell when needed during high flows
47	31st Street	Two concrete ellipse culverts, each is 8.8-feet-wide, 5.6-feet-high	11.97	51.0	0.1-0.3	0.5-1.3	Fair, concrete cracking	One cell of the two-cell structure appears-be sufficient for majority of flow conditions; Sediment accumulations and shallow water depths may make passage difficult during extreme low-flow conditions	Potential Impediment to Fish Passage	Retrofit channel at culvert inlet to direct flow during fair-weather conditions to one cell and allow flow into second cell when needed during high flows

Table continued on next page.

Table H.1 (Continued)

ID Number on Map 4.14	Crossing Name	Structure Description	River Mile	Culvert/ Bridge Length (feet)	Limiting Water Depth (feet)	Embedded Depth (feet)	General Condition	Description of Problem	Fish Passage Rating	Recommended Potential Actions
Upper Oak Creek (continued)										
48	35th Street	Two cell concrete box culvert, each cell is 10-feet-wide, 5-feet-high	12.20	91.5	<0.1	0-1.5	Poor	Cell on right side of structure (looking upstream) is blocked by sediment accumulation on upstream end; All flow enters left cell and there is significant cross-flow from left cell to right cell through the joints in the cell wall; Majority of flow exits the right cell at downstream end of structure; Rock placement downstream of the left cell also causes fish passage impediment	Impediment to Fish Passage	Joints of culvert wall should be sealed to prevent cross-flow, Investigate adding grade control downstream of culvert to provide stability for streambanks and the culvert; Add strategically placed cobble and boulder substrates within culvert cells along both walls to provide resting areas for passing fish; Re-arrange rock placement downstream of crossing
49	Ryan Road (upstream)	One 8-foot-wide, 7-foot-high concrete box culvert	12.52	186.0	0.2	0-0.9	Good	Water depths within structure may become insufficient for fish passage during low-flow periods	Passable	Investigate potential for addition of downstream grade control to improve water depths through culvert during low-flow periods; Add strategically placed cobble and boulder substrates along both walls of the culvert to provide resting areas for passing fish
Oak Creek Headwaters										
50	Concrete Drop Structure No. 1	One 3.5-foot-head concrete drop structure	12.66	--	--	--	Poor	Concrete drop structure completely blocks flow during fair-weather flow conditions except for that which flows through crack in structure; Concrete is cracked and failing in multiple locations	Impediment to Fish Passage	Drop structure was likely installed to control head-cutting; If structure is removed, grade control through naturalized channel morphology is necessary; Investigate incorporating structure as grade control in regenerative stormwater conveyance project along this stream reach
51	Southwood Drive	One 9-foot-wide, 6-foot-high concrete box culvert	12.82	60.0	0.1	0.2-0.7	Good	Sediment accumulation at one location within culvert constricts flow; Water depths within structure may become insufficient for fish passage during low-flow periods	Passable	Add strategically placed cobble and boulder substrates within culvert cells along both walls to provide resting areas for passing fish; Consider downstream grade control to provide greater water depths through culvert
52	Concrete Drop Structure No. 2	One 1.3-foot-head concrete drop structure	12.86	--	--	--	Fair	Concrete drop structure completely blocks flow during fair-weather flow conditions	Impediment to Fish Passage	See recommended potential actions for structure ID 50

Table continued on next page.

Table H.1 (Continued)

ID Number on Map 4.14	Crossing Name	Structure Description	River Mile	Culvert/ Bridge Length (feet)	Limiting Water Depth (feet)	Embedded Depth (feet)	General Condition	Description of Problem	Fish Passage Rating	Recommended Potential Actions
Oak Creek Headwaters (continued)										
53	Concrete Drop Structure No. 3	One 1.3-foot head concrete drop structure	12.93	--	--	--	Fair	Concrete drop structure is perched about 18 inches above downstream water surface	Impediment to Fish Passage	See recommended potential actions for structure ID 50
54	Concrete Drop Structure No. 4	Concrete drop structure buried in sediment	13.05	--	--	--	Poor	Concrete drop structure blocks most flow in fair-weather conditions; Much of the structure is buried by sediment	Impediment to Fish Passage	See recommended potential actions for structure ID 50
55	Southland Drive	One 10-foot-wide, 6-foot-high concrete box culvert	13.16	43.2	0.2	0-0.4	Good	Culvert itself is passable but large accumulation of rock downstream of culvert is likely a fish passage obstruction for some species	Passable	Rearrange rock to allow for better passage lanes
56	Woodward Drive	One 10-foot-wide, 3.5-foot-high concrete box culvert	13.28	40.0	0	--	Fair	Stream has very little flow under normal conditions and becomes intermittent upstream of this crossing	Passable	None
57	Private Drive Enclosure	One 4-foot diameter corrugated metal pipe culvert	13.41	162.0	0.1	0-0.2	Fair, rusted	Ephemeral stream	--	Repair masonry on downstream end of culvert
58	Glenwood Drive	One 3.2-foot wide, 2-foot high concrete ellipse culvert	13.54	48.5	0.2	0.1	Fair	Ephemeral stream	--	None
59	Private Driveway	One 3-foot wide, 2-foot high corrugated metal pipe arch culvert	13.57	28.0	0.4	0-0.1	Good	Ephemeral stream	--	None
60	Private Driveway	One 3-foot wide, 2-foot high corrugated metal pipe arch culvert	13.58	26.0	0.3	0-0.1	Good	Ephemeral stream	--	None
61	Maplecrest Drive	One 2.5-foot wide, 1.6-foot high concrete ellipse culvert	13.61	48.0	0.5	0.1	Good	Ephemeral stream	--	None
62	Enclosure Upstream of Maplecrest Drive	1.4-foot concrete circular culvert at inlet, 1.8-foot concrete circular culvert at outlet	13.64	260.0	0	0	Good	Ephemeral stream	--	None
63	Franklin Woods Nature Center Path	One 3-foot wide, 2-foot high concrete ellipse culvert	13.73	16.0	1.1	0-0.1	Fair	Ephemeral stream	--	None

Table continued on next page.

Table H.1 (Continued)

ID Number on Map 4.14	Crossing Name	Structure Description	River Mile	Culvert/ Bridge Length (feet)	Limiting Water Depth (feet)	Embedded Depth (feet)	General Condition	Description of Problem	Fish Passage Rating	Recommended Potential Actions
Oak Creek Headwaters (continued)										
64	Puetz Road (headwaters)	2.5-foot diameter concrete pipe culvert	13.77	48.5	0	0	Good	Ephemeral stream	--	None
Lower North Branch Oak Creek										
65	Canadian Pacific Railroad	Two cell concrete box culvert' each cell is 20-feet-wide, 6.5-feet-high	0.10	55.0	0.1	0	Poor, concrete cracking and crumbling	Downstream weir associated with culvert structure is perched about 4 feet above downstream water surface; Concrete at multiple locations on structure is cracking and crumbling; Head-cutting at downstream end of structure is occurring	Impediment to Fish Passage	Work with Canadian Pacific Railroad to formulate plan to replace with structure at stream grade or retrofit a fish passage alternative such as a rock ramp retrofit for the channel immediately downstream; Head-cutting should be addressed
66	Puetz Road (culvert has been replaced since survey was completed)	Two cell concrete box culvert, each cell is 10-feet-wide, 8-feet-high	0.92	42.0	0.9	0-0.4	Poor, concrete eroded	Left wingwall (looking upstream) on downstream end of culvert has collapsed, wingwall on upstream end is failing	Passable	Culvert has been replaced since survey was completed; Conduct new fish passage assessment
67	Weatherly Drive	Concrete open bottom arch bridge	1.77	62.0	0.2	--	Good	Newly constructed bridge for the most part is a good model for designing a "fish friendly" crossing; Problem is related-excessive rock placed across the channel under the crossing that may create fish passage impediment	Passable	Rearrange rock placement to allow for better passage lanes
68	Wildwood Drive	Three span concrete bridge with abutments	2.00	51.5	0.3	--	Fair, concrete cracking	Sediment accumulation	Passable	Monitor sediment accumulation
69	Drexel Avenue	Three cell concrete box culvert, each cell is 10-feet-wide, 10-feet-high	2.17	123.0	--	2.8-4.1	Good	Beaver dams upstream and downstream of culvert may affect fish passage	Passable	Monitor beaver activity and remove dams if they begin to affect crossing
70	Canadian Pacific Railroad	Three cell concrete box culvert, each cell is 10-feet-wide, 10-feet-high	2.25	78.0	1.7	3.5-5.0	Good	None	Passable	None
71	S. 6th Street (downstream)	Concrete bridge with abutments	2.41	99.0	2.0	--	Fair/Poor, some failing concrete	None	Passable	General maintenance on deteriorating concrete

Table continued on next page.

Table H.1 (Continued)

ID Number on Map 4.14	Crossing Name	Structure Description	River Mile	Culvert/ Bridge Length (feet)	Limiting Water Depth (feet)	Embedded Depth (feet)	General Condition	Description of Problem	Fish Passage Rating	Recommended Potential Actions
Upper North Branch Oak Creek										
72	Marquette Avenue	Concrete bridge with abutments	3.05	58.0	1.8	--	Good	Water levels may be insufficient for passage during low-flow conditions	Passable	Retrofit a "low-flow channel" with narrower main channel to promote sufficient water depths during average flow conditions while allowing overflow onto second "tier" when higher flows occur
73	Rawson Avenue	Two cell concrete box culvert, each cell is 11.2-feet-wide, 9.1-feet-high	3.51	173.0	0.3-0.7	2.4-4.0	Good	Sediment accumulation	Passable	Monitor for excess sediment accumulation
74	S. 6th Street (upstream)	Two cell concrete box culvert, each cell is 10-feet-wide, 9-feet-high	3.86	125.0 (cell #1), 116.0 (cell #2)	0.1-0.6	0-1.9	Good	Crossing itself is passable but upstream there is a long and steep rock cascade that is likely a fish passage impediment for most species	Passable	Investigate slope modifications for upstream rock cascade
75	Access Road-Electrical Station	Two span concrete bridge with abutments	4.04	33.0	0.2	--	Good	None	Passable	None
76	MATC Drive	Two cell corrugated metal pipe culvert, each cell is 5-feet	4.32	89.5	--	0-0.3	Poor, culvert bottom failing due-rust	Major debris blockage on upstream side of culvert was fish passage impediment at time of survey	Impediment to Fish Passage	Remove debris jam
77	MATC Walking Bridge	Wood span bridge with concrete side walls	4.34	--	--	--	Fair	None	Passable	None
78	MATC Walking Bridge	Steel span bridge	4.51	--	--	--	Fair	None	Passable	None
79	Abandoned Private Crossing	One 10-foot wide, 9-foot high smooth metal pipe arch culvert	4.58	18.0	--	0.2	Poor, crushed and failing culvert, unsafe structure	Steel structure is collapsing and collecting debris which is causing a fish passage impediment; Structure is also a safety hazard and could collapse	Impediment to Fish Passage	Remove structure and naturalize streambanks to prevent erosion
80	Abandoned Private Crossing	One 10-foot wide, 8-foot high smooth metal pipe arch culvert	4.60	18.0	0.7	2.0	Poor, rusted and failing	Steel bridge is deteriorated and doesn't seem to be used	Passable	Remove structure and naturalize streambanks to prevent erosion
81	Abandoned Private Crossing	One 9.5-foot wide, 7.2 foot high smooth metal pipe arch culvert	4.65	18.7	0.15	2.0	Poor, bridge failing	Steel bridge is deteriorated and doesn't seem to be used	Passable	Remove structure and naturalize streambanks to prevent erosion
82	Abandoned Private Crossing	One 12-foot wide, 8-foot high smooth metal pipe arch culvert	4.72	16.0	0.2	3.5	Poor, rusted	Steel bridge is deteriorated and doesn't seem to be used	Passable	Remove structure and naturalize streambanks to prevent erosion

Table continued on next page.

Table H.1 (Continued)

ID Number on Map 4.14	Crossing Name	Structure Description	River Mile	Culvert/ Bridge Length (feet)	Limiting Water Depth (feet)	Embedded Depth (feet)	General Condition	Description of Problem	Fish Passage Rating	Recommended Potential Actions
Upper North Branch Oak Creek (continued)										
83	Canadian Pacific Railroad	One 5.6-foot wide open bottom arch culvert with corrugated metal top and stone face	4.74	96.0	--	--	Fair, rusting	Condition of interior of culvert is unknown	Passable	None
84	College Avenue	Two cell concrete box culvert, each cell is 12-feet-wide, 7-feet-high	4.92	317.0	--	0.6-3.2	Good	Heavy sediment accumulation upstream; Water level is only 1.5 feet below top of culvert; Condition of interior of culvert is unknown	Passable	Monitor sediment accumulations and capacity of structure to pass flows
85	13th Street	Three cell corrugated metal pipe arch culvert, each cell is 5.5-foot wide	5.21	123.0	--	0.1-1.0	Fair, culvert rusting and concrete cracking	Condition of interior of culvert is unknown	Passable	Consider span bridge when time for replacement
86	IH 94 Enclosure	One 12-foot-wide, 9-foot-high concrete box culvert (inlet), two cell concrete box culvert, each cell is 9-feet-wide, 5-feet-high (outlet)	5.65	515.0	--	1.0-2.5	Good/Fair	Likely not passable for most fish species due to excessive length and excessive velocities during higher flows	Potential Impediment to Fish Passage	None
87	IH 94 Airport Spur (downstream)	One 12-foot-wide, 8-foot-high concrete box culvert	5.85	343.0	0.9	0.6-2.9	Good	Likely not passable for most fish species due to excessive length and excessive velocities during higher flows	Potential Impediment to Fish Passage	None
88	IH 94 Airport Spur (upstream)	One 12-foot-wide, 8-foot-high concrete box culvert	6.00	190.0	0.1	1.7-3.0	Fair, concrete cracking along wingwall	None	Passable	None
89	20th Street	Two 7.2-foot wide, 5.5-foot high corrugated metal pipe arch culvert (inlet, approximately 13 feet long), Two 8.5-foot wide, 6.1-foot high corrugated metal pipe arch culvert (outlet)	6.09	136.0	--	--	Good	Debris accumulation within pipe culverts at upstream end	Impediment to Fish Passage	Clear debris blockages
Lower Mitchell Field Drainage Ditch										
90	Chicago and Northwestern Railroad	Three span concrete bridge with abutments and side slopes	0.14	27.5	0.3	--	Fair	None	Passable	None

Table continued on next page.

Table H.1 (Continued)

ID Number on Map 4.14	Crossing Name	Structure Description	River Mile	Culvert/ Bridge Length (feet)	Limiting Water Depth (feet)	Embedded Depth (feet)	General Condition	Description of Problem	Fish Passage Rating	Recommended Potential Actions
Lower Mitchell Field Drainage Ditch (continued)										
91	Rawson Avenue	One 12-foot-wide, 6-foot-high concrete box culvert	0.80	177.0	--	--	Good	Beaver dams were observed upstream and downstream of this culvert but have been removed	Passable	Monitor for beaver activity that may cause blockage
92	College Avenue	Three cell concrete box culvert, each cell is 8-feet-wide, 6-feet-high	1.83	136.0	0-0.6	0-1.2	Good	Minor debris and sediment accumulation at upstream end of culvert	Passable	Remove debris and monitor sediment accumulation

Notes The red indicates high priority and yellow color indicates moderate priority ratings to address fish passage issues in the watershed.
This table is not a complete inventory of stream crossings. Only structures that field crews were able to access are included.
Where sufficient hydraulic capacity allows, roughness in the form of appropriately sized cobble and boulder should be added to the interior of culverts, particularly along culvert walls.

[a] *Length of abutment, no bridge deck, just rails.*

Source: SEWRPC

Figure H.1
Stream Crossings Along Surveyed Reaches of Oak Creek, North Branch Oak Creek, and Mitchell Field Drainage Ditch: 2016

GRANT PARK RAVINE

First Oak Creek Parkway Crossing – RM 0.35

1

Second Oak Creek Parkway Crossing – RM 0.88

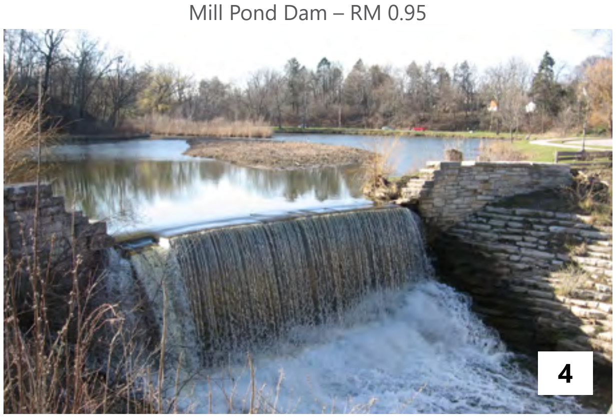
2

Mill Road – RM 0.94

3

LOWER OAK CREEK – MILL POND

Mill Pond Dam – RM 0.95



4

Third Oak Creek Parkway Crossing – RM 1.18

5

Figure H.1 (Continued)

LOWER OAK CREEK – MILL POND (continued)

Fourth Oak Creek Parkway Crossing – RM 1.32

6

Chicago Avenue (STH 32) – RM 0.35

7

Fifth Oak Creek Parkway Crossing – RM 2.14

8

Walking Bridge

9

Union Pacific Railway – RM 2.35

10

15th Avenue – RM 2.84

11

LOWER OAK CREEK

Walking Bridge – RM 3.19

12

Rawson Avenue and 16th Avenue – RM 3.65

15

Figure H.1 (Continued)

LOWER OAK CREEK (continued)

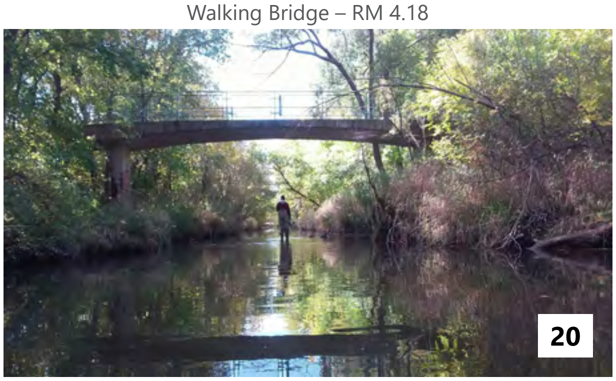
15th Avenue – RM 3.76

Walking Bridge – RM 3.89

Milwaukee Avenue – RM 4.01

15th Avenue – RM 4.06

Walking Bridge – RM 4.18



Pennsylvania Avenue – RM 4.71

Oak Leaf Trail – RM 5.14

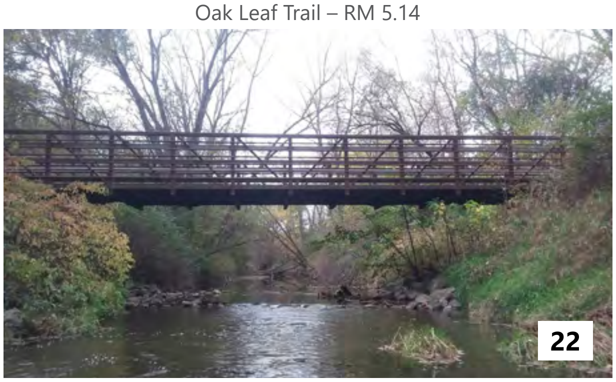


Figure H.1 (Continued)

MIDDLE OAK CREEK

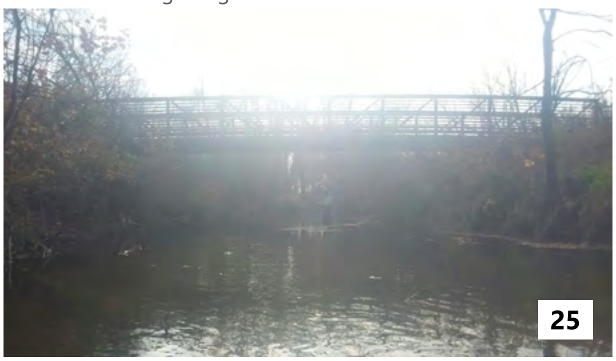
Union Pacific Railroad – RM 5.25

23

Drexel Avenue – RM 5.56

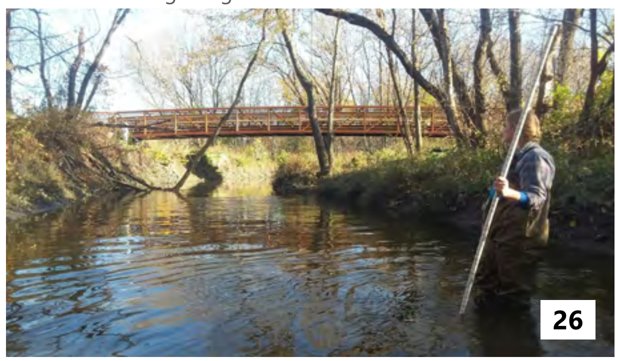
24

Walking Bridge-Abendschein Park – RM 5.63



25

Walking Bridge-Abendschein Park – RM 5.72



26

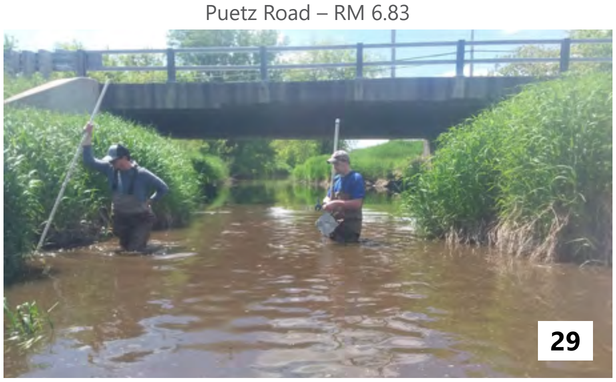
Union Pacific Railroad[a] – RM 6.06

27

Forest Hill Avenue – RM 6.25

28

Puetz Road – RM 6.83



29

Union Pacific Railroad – RM 7.34

30

Figure H.1 (Continued)

MIDDLE OAK CREEK (continued)

Nicholson Road – RM 7.44

31

Shepherd Avenue – RM 8.41

32

Howell Avenue (northbound) – RM 9.22

33

Howell Avenue (southbound) – RM 9.24

34

UPPER OAK CREEK

Ryan Road/STH 100 (downstream crossing) – RM 10.06

35

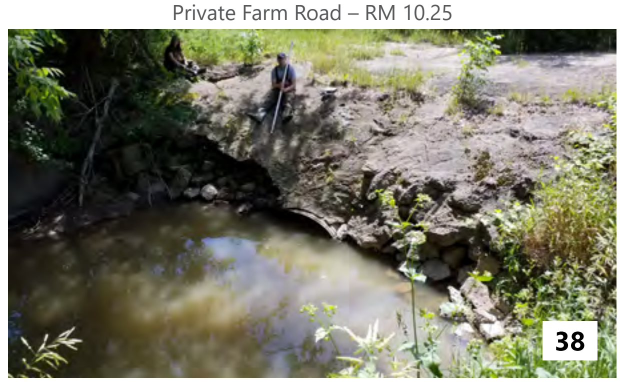
Canadian Pacific Railroad – RM 10.24

36

Canadian Pacific Railroad
(old culvert on secondary channel) – RM 10.24

37

Private Farm Road – RM 10.25



38

Figure H.1 (Continued)

UPPER OAK CREEK (continued)

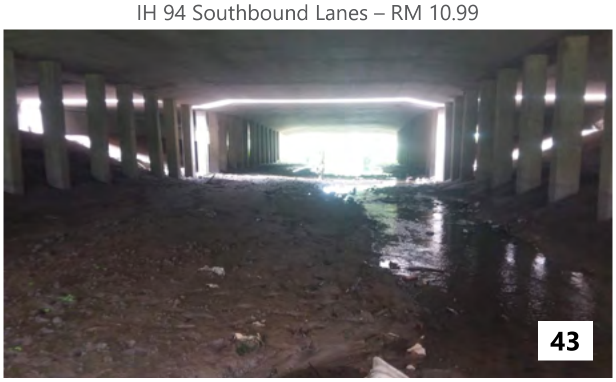
Private Farm Road (abandoned) – RM 10.60

13th Street[a] – RM 10.69

IH 94 Northbound Off-Ramp – RM 10.96

IH 94 Northbound Lanes – RM 10.97

IH 94 Southbound Lanes – RM 10.99



IH 94 Southbound On-Ramp – RM 11.00

20th Street – RM 11.23

27th Street (STH 241) – RM 11.70

Figure H.1 (Continued)

UPPER OAK CREEK (continued)

31st Street – RM 11.97

35th Street – RM 12.20

Ryan Road (upstream) – RM 12.52

OAK CREEK HEADWATERS

Concrete Drop Structure No. 1 – RM 12.66

Southwood Drive – RM 12.82

Concrete Drop Structure No. 2 – RM 12.86

Concrete Drop Structure No. 3 – RM 12.93

Figure H.1 (Continued)

OAK CREEK HEADWATERS (continued)

Concrete Drop Structure No. 4 – RM 13.05

Southland Drive – RM 13.16

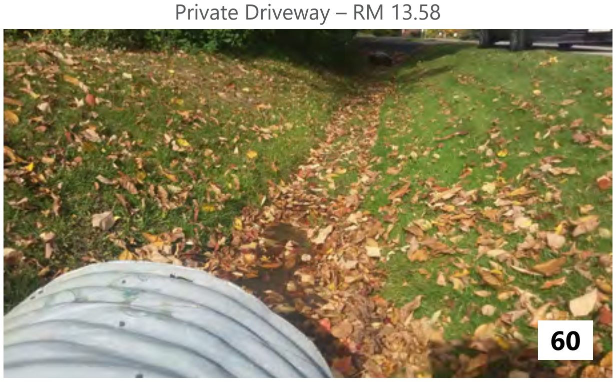
Woodward Drive – RM 13.28

Private Drive Enclosure – RM 13.41

Glenwood Drive – RM 13.54

Private Driveway – RM 13.57

Private Driveway – RM 13.58



Maplecrest Drive – RM 13.61

Figure H.1 (Continued)

OAK CREEK HEADWATERS (continued)

Enclosure Upstream of Maplecrest Drive – RM 13.64

Franklin Woods Nature Center Path – RM 13.73

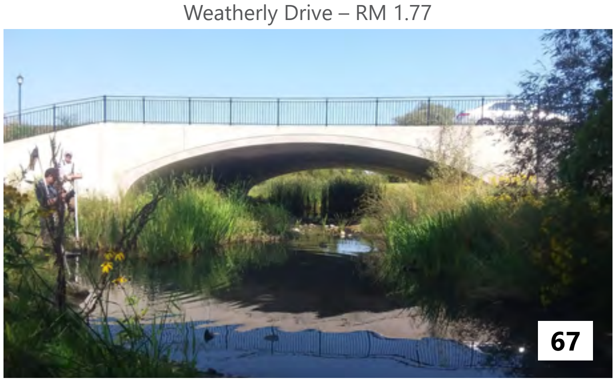
Puetz Road (headwaters) – RM 13.77

LOWER NORTH BRANCH OAK CREEK

Canadian Pacific Railroad – RM 0.10

Puetz Road[a] – RM 0.92

Weatherly Drive – RM 1.77



Wildwood Drive – RM 2.00

Figure H.1 (Continued)

LOWER NORTH BRANCH OAK CREEK (continued)

Drexel Avenue – RM 2.17

69

Canadian Pacific Railroad – RM 2.25

70

S. 6th Street (downstream) – RM 2.41

71

UPPER NORTH BRANCH OAK CREEK

Marquette Avenue – RM 3.05

72

Rawson Avenue – RM 3.51

73

S. 6th Street (upstream) – RM 3.86

74

Access Road to Electrical Station – RM 4.04

75

Figure H.1 (Continued)

UPPER NORTH BRANCH OAK CREEK (continued)

MATC Drive – RM 4.32

MATC Walking Bridge – RM 4.34

MATC Walking Bridge – RM 4.51

Abandoned Private Crossing – RM 4.58

Abandoned Private Crossing – RM 4.60

Figure H.1 (Continued)

UPPER NORTH BRANCH OAK CREEK (continued)

Abandoned Private Crossing – RM 4.65

Abandoned Private Crossing – RM 4.72

Canadian Pacific Railroad – RM 4.74

College Avenue – RM 4.92

13th Street – RM 5.21

IH 94 Enclosure – RM 5.65

IH94 Airport Spur (downstream) – RM 5.85

Figure H.1 (Continued)

UPPER NORTH BRANCH OAK CREEK (continued)

IH94 Airport Spur (upstream) – RM 6.00

20th Street – RM 6.09

LOWER MITCHELL FIELD DRAINAGE DITCH

Chicago and Northwestern Railroad – RM 0.14

Rawson Avenue – RM 0.80

College Avenue – RM 1.83

[a] *Structure has been replaced since survey.*

Source: SEWRPC

OAK CREEK MILL POND DAM PLANS AND PERMIT DOCUMENTS

APPENDIX I

Figure I.1
1932 Construction Plans for the Oak Creek Mill Pond Dam

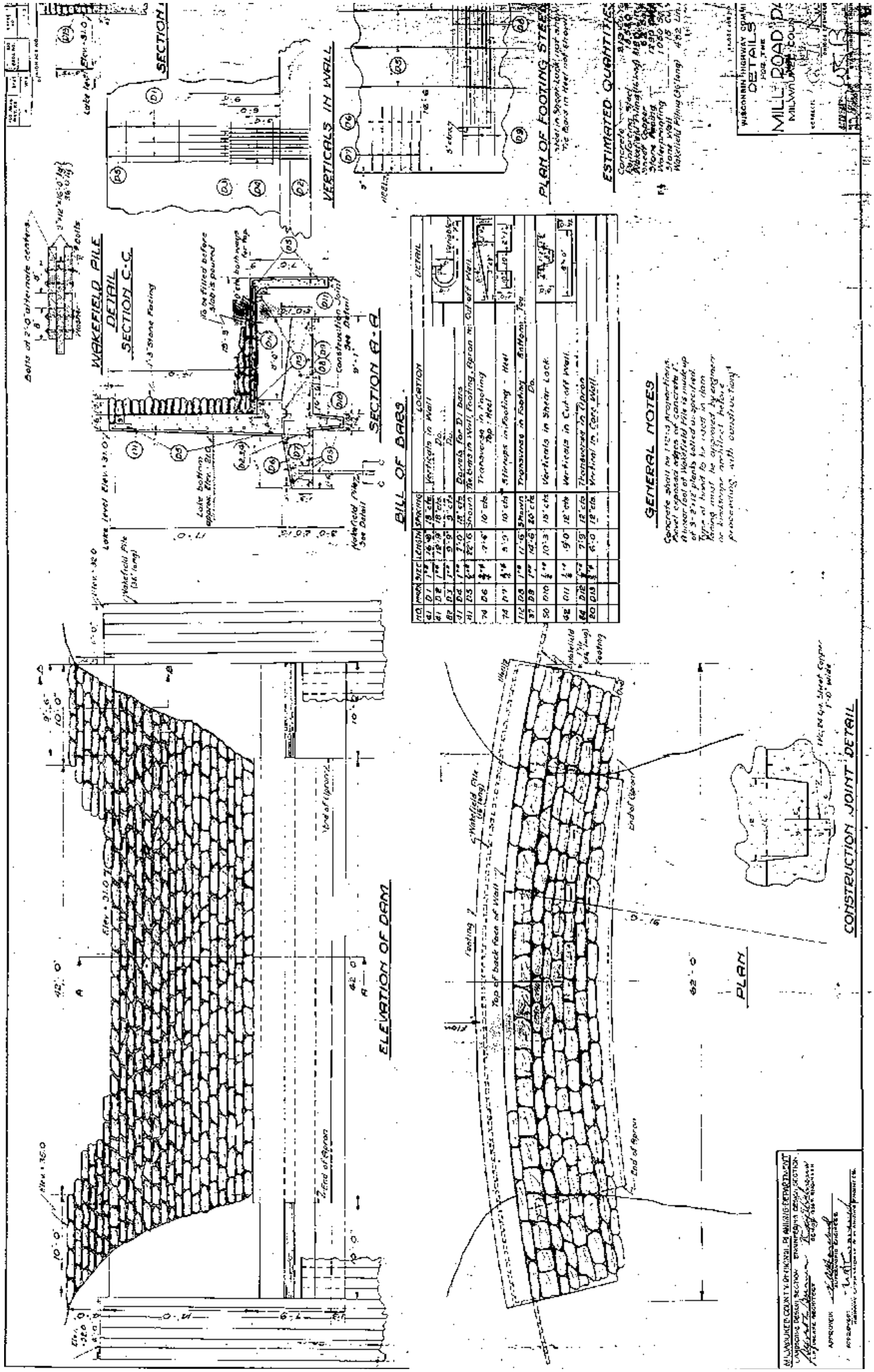


Figure I.2
1938 Construction Plans for the Sluice Gate for the Oak Creek Mill Dam

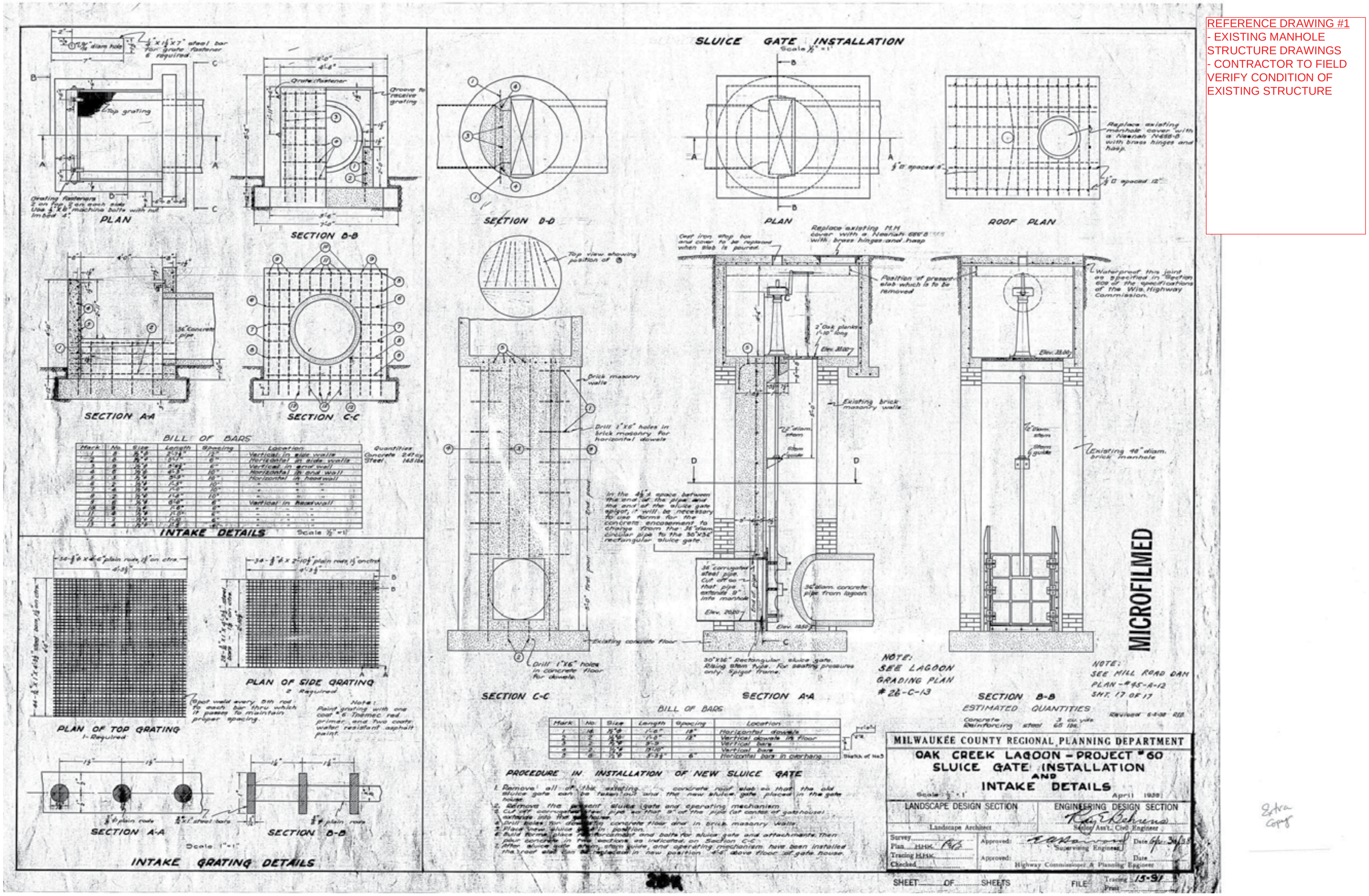
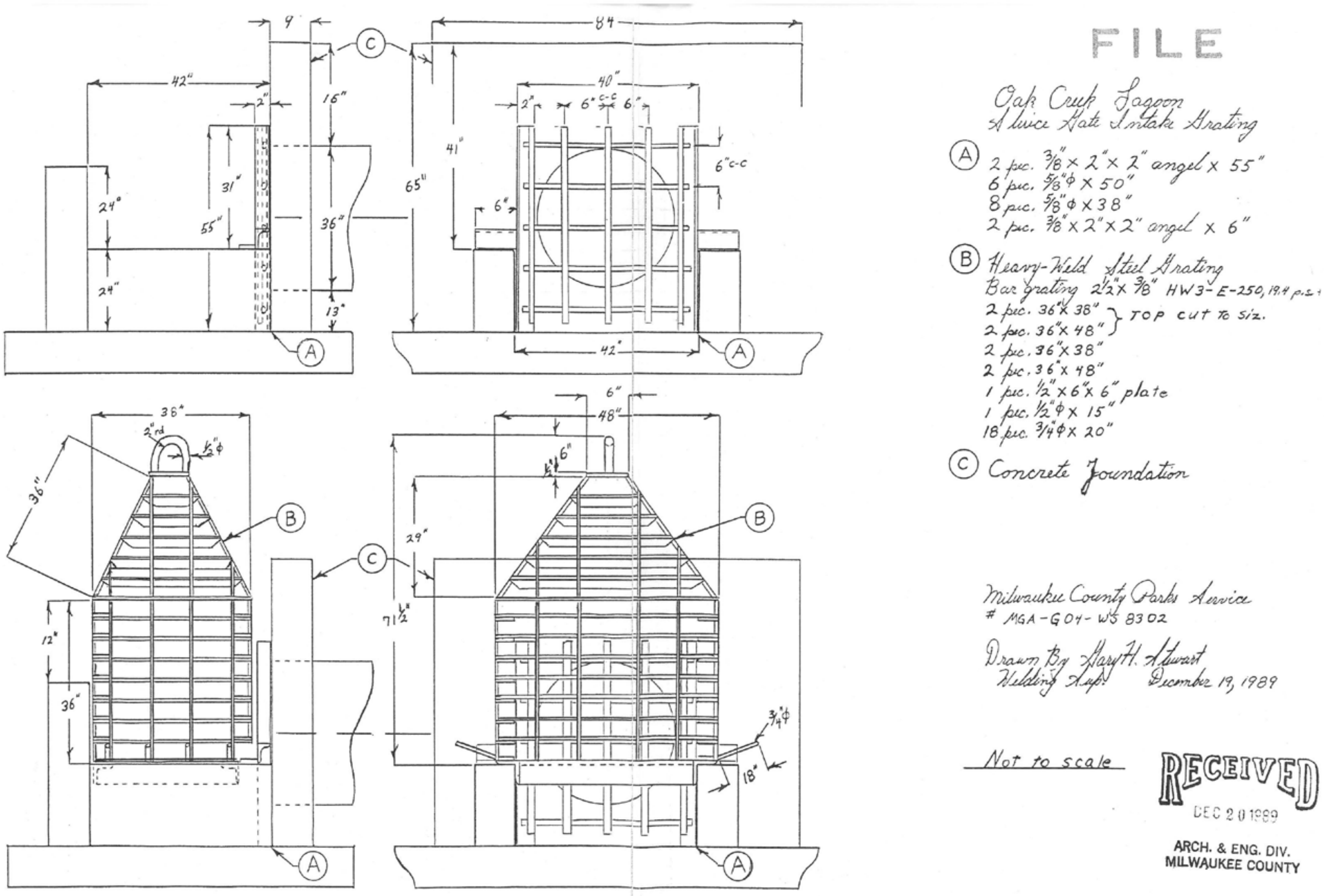


Figure I.3
1989 Design Plan for the Sluice Gate Intake Grate



Source: Milwaukee County

Figure I.4
Wisconsin Department of Natural Resources Correspondence

State of Wisconsin
DEPARTMENT OF NATURAL RESOURCES
Waukesha Service Center
141 NW Barstow St. Room 180
Waukesha, WI 53188

Scott Walker, Governor
Cathy Stepp, Secretary
Telephone 608-266-2621
Toll Free 1-888-936-7463
TTY Access via relay - 711

June 1, 2015

John Dargle, Director
Milwaukee County Department of Parks, Recreation and Culture
9480 Watertown Plank Road
Wauwatosa, WI 53226-3560

Subject: Time Extension for South Milwaukee Mill Dam (Field File 40.05, Milwaukee County)

Dear Mr. Dargle:

We received your letter which provides an update on Milwaukee County's actions related to the South Milwaukee Mill Dam and requests a time extension for the completion of directives. The Department of Natural Resources (Department) is extending the deadline for the directives with several conditions described below.

Timeline History

On November 19, 2012, the Department conducted an inspection of the South Milwaukee Mill Dam. The inspection report includes timeframes for addressing deficiencies and improving the safety and structural integrity of the dam. The timeframe for completing the gate repairs, investigation of masonry, benchmark installation and tree and brush removal was set for June 1, 2014.

On December 4, 2013 Steven A. Elver, P.E., S.E., of AECOM performed a field inspection of the masonry. The inspection report addressed repairs to the masonry stone. At that time Milwaukee County requested an extension to December 31, 2014 to allow time for additional funding to be acquired.

In late 2014 the County performed an in-depth evaluation of the sluice gate to determine why it was inoperable. At that time it was found that the lake drain inlet was covered with approximately 10' feet of sediment. Also the manhole containing the sluice gate makes the repair or replacement difficult in the confined space. At that time Milwaukee County requested an extension to December 31, 2015. The trees and brush have been removed and the directive modified to address the remaining stumps and roots greater than 1 inch.

Preliminary design plans were submitted to the Department in March 2015. The preliminary plans involved removing the existing manhole and constructing a new manhole with a new sluice gate. The manhole and gate would be connected to the existing lake drain intake pipe and the existing outfall pipe. The Department identified concerns with sediment management. Sediment sampling completed in 2001 identified Polycyclic Aromatic Hydrocarbons (PAHs). The Department is concerned that if the gate would be replaced and operated a significant amount of contaminated sediment would be transported downstream and into Lake Michigan.

On April 7, 2015 a conference call was held between Department staff, Milwaukee County staff and Chris Lewis of AECOM.

Extension and Conditions

The Department is extending the deadline for repairs to accommodate the preparation and findings of the Southeastern Wisconsin Regional Planning Commission (SEWRPC) Report of the Oak Creek Watershed. By December 31, 2018, the County shall complete the following:

- Submit Inspection, Operation and Maintenance plan (IOM).

- Inspect the dam regularly, monitoring for seepage and stability of masonry stone. Submit documentation of inspections yearly to the Department.
- Submit the published SEWRPC report.
- Identify long term costs associated with maintaining the dam and impoundment.
- Hold a public information meeting.
- Determine the long term disposition of the dam.

DIRECTIVES

The following deficiencies must be corrected by the dates given:

1.	Replace the two missing capstones and reset the shifted capstone on the left abutment.	September 1, 2019
2.	Establish benchmarks	September 1, 2019
3.	Removal of stumps and roots greater than one inch along embankments	September 1, 2019
4.	Repair or reconstruct sluice gate	September 1, 2019

Please note that repairs required under items 3 and 4 above must be designed by an engineer registered in the State of Wisconsin and plans must be submitted to this Department for review and approval before any work is performed on the dam.

If you are unable to meet the schedule proposed above, submit your own schedule, in writing, for completing the required modifications and repairs. In order for us to consider a schedule other than the one we have determined, you must submit your alternative schedule by **September 1, 2015**. If we do not hear from you by then, the schedule we have determined will be in effect.

If you have questions concerning this letter or the operation and maintenance of your dam, or are uncertain how to precede with the directives, please contact me at Nathan.Zoch @wisconsin.gov or (262) 574-2188.

Sincerely,

Nathan Zoch
Water Management Engineer

cc: Bill Sturtevant, P.E., State Dam Safety Engineer – DNR GEF II, WT/3 (via email)
Michelle Scott, South District Waterways Supervisor – DNR (via email)
Karl Stave, Milwaukee County (via email)
Jim Keegan, Milwaukee County Department of Parks and Rec. (via email)

Figure I.4 (Continued)

State of Wisconsin
DEPARTMENT OF NATURAL RESOURCES
Waukesha Service Center
141 NW Barstow St. Room 180
Waukesha, WI 53188

Scott Walker, Governor
Cathy Stepp, Secretary
Telephone 608-266-2621
Toll Free 1-888-936-7463
TTY Access via relay - 711

WISCONSIN
DEPT. OF NATURAL RESOURCES

December 29, 2014

John Dargle, Director
Milwaukee County Department of Parks
9480 Watertown Plank Road
Wauwatosa, WI 53226-3560

Subject: South Milwaukee Mill Dam, Directive Extension, Field File # 40.05, Milwaukee County

Dear Mr. Dargle:

We received your letter request for a time extension to be used for the completion of directives. Milwaukee County has requested a time extension from December 31, 2014 to **December 31, 2015** to allow the county time to obtain funding and to perform the necessary repairs to the South Milwaukee Mill Pond Dam.

The county has made significant progress toward completing the directives. The first step of the Tree and Brush removal has been completed. Removal of stumps and roots greater than one inch is needed to complete this directive. The sluice gate and inlet structure have been more closely inspected. Possible construction techniques and alternative methods for the repairs have been evaluated.

DIRECTIVES

The following deficiencies must be corrected by the dates given:

1. Replace the two missing capstones and reset the shifted capstone on the left abutment.	December 31, 2015
2. Establish Benchmarks	December 31, 2015
3. Removal of Stumps and Roots greater than one inch along embankments	December 31, 2015
4. Repair or reconstruct sluice gate	December 31, 2015

Please note that repairs required under items 3 and 4 above must be designed by an engineer registered in the State of Wisconsin and plans must be submitted to this Department for review and approval before any work is performed on the dam.

If you are unable to meet the schedule proposed above, submit your own schedule, in writing, for completing the required modifications and repairs. In order for us to consider a schedule other than the one we have determined, you must submit your alternative schedule by **December 1, 2015**. If we do not hear from you by then, the schedule we have determined will be in effect.

If you have questions concerning this letter or the operation and maintenance of your dam, or are uncertain how to precede with the directives, please contact me at Nathan.Zoch @wisconsin.gov or (262) 574-2188.

Sincerely,

Nathan Zoch
Water Management Engineer

dnr.wi.gov
wisconsin.gov

Naturally WISCONSIN

PRINTED ON RECYCLED PAPER

cc: Bill Sturtevant, State Dam Safety Engineer – DNR (WT/3)
Michelle Scott, South District Waterways Supervisor – DNR (via email)
Jill Organ, Milwaukee County Department of Parks and Rec. (via email)
Jim Keegan, Milwaukee County Department of Parks and Rec. (via email)

State of Wisconsin
DEPARTMENT OF NATURAL RESOURCES
2300 N. Dr. Martin Luther King, Jr. Drive
Milwaukee WI 53212-3128

Scott Walker, Governor
Cathy Stepp, Secretary
Telephone 608-266-2621
Toll Free 1-888-936-7463
TTY Access via relay - 711

November 27, 2012

James Keegan, Interim Director
Milwaukee County Department of Parks, Recreation and Culture
9480 Watertown Plank Road
Wauwatosa, WI 53226-3560

Subject: Dam Inspection Report for South Milwaukee Mill Dam
Field File 40.05, Key Sequence 1332, Milwaukee County

Dear Mr. Keegan:

This is the Department of Natural Resources' (Department) Dam Safety Report based on our inspection of the South Milwaukee Mill Dam on October 26 and November 19, 2012. This report identifies work that needs to be done on the dam and a schedule for when that work is to be completed. Please contact me if you have questions about the needed repairs or are uncertain how to proceed.

The South Milwaukee Mill Dam is classified as a small dam. It is located in the northeast one-quarter of the northeast one-quarter of U.S. Public Land Survey Section 11, Township 5 North, Range 22 East, in Oak Creek at the City of South Milwaukee, Milwaukee County. It consists of dolomite blocks to form a masonry-type retaining wall for a 35-foot long overflow spillway. The dam also has an earthen embankment which extends approximately 30 feet on either side of the spillway, from the impoundment to the downstream slopes to the channel. The dam also has a 36-inch drain pipe with a sluice gate that was designed to lower water levels for maintenance, as needed.

Wisconsin has an excellent record of safety regarding dams. Our safety standards are meant to protect the public and reduce the likelihood of dam failures; therefore, past failures have not resulted in death, injury, or significant property damage. However, I would like to caution you on one potential liability issue. Unfortunately, every year accidents are reported on or near code-compliant dams. My safety inspection does not address injury that could result from trespass or other inappropriate behavior on the dam site. Your insurance carrier may be able to assist you in protection from this type of liability.

EMBANKMENT REPAIRS **June 1, 2014**

Trees and brush were noted growing on several portions of the embankment. Removal of vegetation is important for a number of reasons and I have included our Fact Sheet on "Vegetation Control on Dams" for your information. All the trees and brush are to be removed from either side of the spillway, the side slopes between the spillway and Mill Road bridge, and the side slopes downstream of the Mill Road bridge.

The tree removal is extensive enough to require that plans and specifications be submitted by an engineer registered in the State of Wisconsin. The plans and specifications must be approved by this Department prior to initiation of the removal process. The plans shall include the complete removal of stumps and roots over one inch in diameter, filling of the holes with firmly compacted tight soils, and adding topsoil and grass seed to establish grass growth.

The embankment should then be mowed on a regular basis so that the growth does not exceed 6 inches at any time. Foot traffic has caused erosion and sparse grass at several locations on the embankment. Efforts should be made to maintain dense/healthy grass cover on the embankments.

INVESTIGATION OF "MASONRY" **June 1, 2014**

During the inspection, some deterioration and loss of the masonry-type section was observed at both abutments. The Department does not have adequate safety equipment to thoroughly inspect the condition of these components.

The extent of the investigation requires that an engineer registered in Wisconsin complete a structural evaluation of the spillway abutments and determine whether "masonry" repairs are required. The Department may establish additional timelines related to "masonry" repairs following the structural evaluation. If it is determined that repairs are necessary, submit the plans and specifications to this office for approval prior to initiating any work on the dam.

GATE REPAIRS **June 1, 2014**

The dam has a 36-inch drain pipe with a sluice gate that was designed to lower water levels for maintenance, as needed. The gate was not operated during the inspection and it is my understanding that the sluice gate is inoperable. Please ensure the gate is operable by the date shown. The operating mechanism for the gate must be kept in a secure yet accessible location.

It is important that the gate be "exercised" annually to ensure that it will work in the event of emergency or routine maintenance. Operation of the valve should be performed with great caution to avoid accidentally draining the impoundment. Open the valve a little and close it. Then open it a little more and close it. Keep this up until the valve is at least half open. This will be a sufficient test. Please test the valve and document its completion in writing by the date shown.

BENCHMARK INSTALLATION **June 1, 2014**

For the purpose of future surveys, at least two benchmarks should be established for the dam with one benchmark at a location off the dam and one at a location on the dam. The benchmarks must be tied to each other, in either National Geodetic Vertical Datum of 1929 (NGVD29) or North American Vertical Datum of 1988 (NAVD88). Benchmark 481-E which is located on the dam is still intact. I would like you to establish one benchmark at a location off the dam. After completing the work, please provide me with documentation from a registered land surveyor regarding the location and elevations. Documentation of an existing benchmark for nearby roads or bridges would also be sufficient.

SUMMARY OF REQUIREMENTS	**DATE**
Embankment Repairs	June 1, 2014
Investigation of "Masonry"	June 1, 2014
Gate Repairs	June 1, 2014
Benchmark Installation	June 1, 2014

If you are unable to meet the schedule proposed above, submit your own schedule, in writing, for completing the required modifications and repairs. In order for us to consider a schedule other than the one we have determined, you must submit your alternative schedule by **April 1, 2014**. If we do not hear from you by then, the schedule we have determined will be in effect.

Figure I.4 (Continued)

SUFFICIENCY RATING

Based upon the Department's Dam Safety Inspection, I completed a Sufficiency Rating for South Milwaukee Mill Dam. The Sufficiency Rating is a snapshot of the dam's physical condition. The dam is classified as **Conditionally Fair** because of the vegetation on the embankment, inoperable valve, and deterioration of the "masonry". By completing these items, it may be possible to change the classification to Satisfactory or Fair. The Sufficiency Rating helps the Dam Safety Program track progress of the dam and whether the Program is meeting its goal of promoting safe dams. The rating has no direct consequence of enforcement; however, not completing directives listed above could trigger enforcement.

Wisconsin Statutes prohibit the sale of real estate containing a dam unless the Department issues a permit for a transfer for the dam. There are limitations on the transfers of dams owned by a municipality or county. Please contact me if you are considering the sale of your property and dam.

If you have any questions concerning this report or the operation and maintenance of your dam, please call me at (414) 263-8641, email me at Tanya.Lourigan@wisconsin.gov, or write to the address above.

Thank you for your continued cooperation in maintaining safe dams in Wisconsin.

Sincerely,

Tanya L Lourigan

Tanya L. Lourigan, P.E.
Water Management Engineer
Milwaukee Service Center

cc: Milwaukee County Supervisor Patricia Jursik
Mayor Tom Zepecki – City of South Milwaukee
Mary Nelson
Bill Sturtevant – Department State Dam Safety Engineer

South Milwaukee Mill Dam (Field File # 40.05)
Photo Log
Inspection Report (November 27, 2012)

Photo #1 – Principal spillway
(November 19, 2012)

Photo #2 – Downstream stone apron
(November 19, 2012)

1

South Milwaukee Mill Dam (Field File # 40.05)
Photo Log
Inspection Report (November 27, 2012)

Photo #3 – Location of sluice gate and benchmark 481-E on right side of embankment
(October 26, 2012)

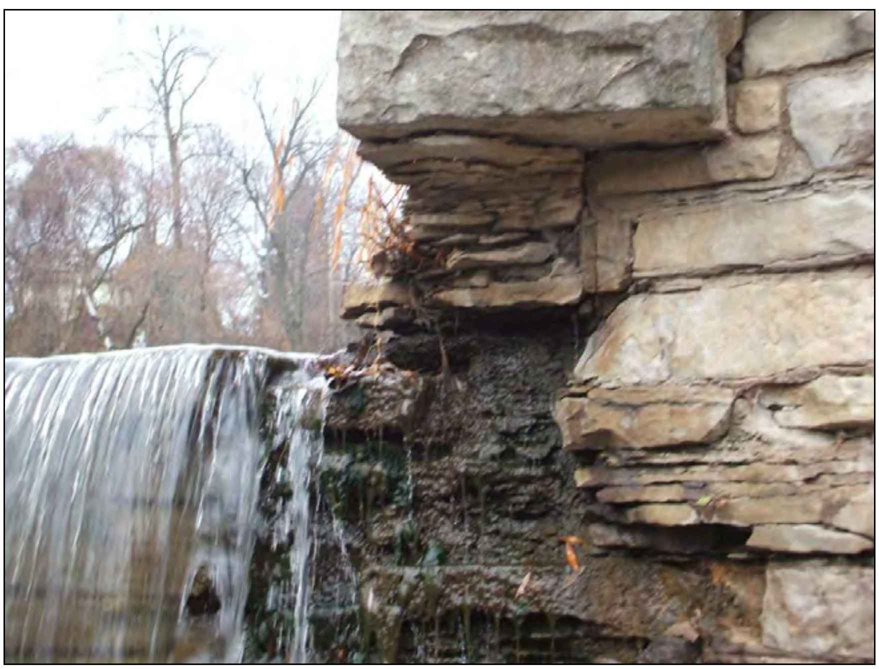


Photo #4 – Deterioration of dolomite stone near left abutment
(November 19, 2012)

2

South Milwaukee Mill Dam (Field File # 40.05)
Photo Log
Inspection Report (November 27, 2012)

Photo #5 – Deterioration of dolomite stone near left abutment
(November 19, 2012)

Photo #6 – Deterioration of dolomite stone near right abutment
(November 19, 2012)

3

South Milwaukee Mill Dam (Field File # 40.05)
Photo Log
Inspection Report (November 27, 2012)

Photo #7 – Deterioration of dolomite stone near right abutment
(November 19, 2012)

Photo #8 – Deterioration of dolomite stone on ride side of retaining wall
(November 19, 2012)

4

South Milwaukee Mill Dam (Field File # 40.05)
Photo Log
Inspection Report (November 27, 2012)

Photo #9 – Deterioration of dolomite stone on left side of retaining wall
(October 26, 2012)

Photo #10 – Trees and brush on right embankment
(October 26, 2012)

5

South Milwaukee Mill Dam (Field File # 40.05)
Photo Log
Inspection Report (November 27, 2012)

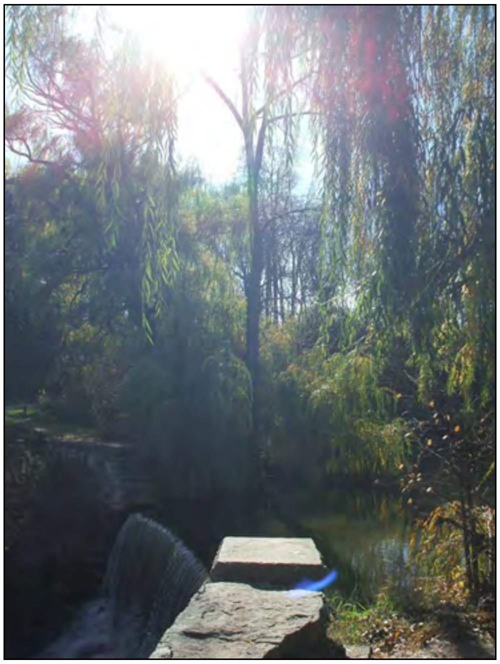


Photo #11 – Trees and brush on right embankment
(October 26, 2012)

Photo #12 – Trees and brush on left embankment
(October 26, 2012)

6

South Milwaukee Mill Dam (Field File # 40.05)
Photo Log
Inspection Report (November 27, 2012)

Photo #13 – Trees and vegetation on right side slope (embankment) between spillway and bridge (November 19, 2012)

Photo #14 – Trees and vegetation on left side slope (embankment) between spillway and bridge (November 19, 2012)

7

South Milwaukee Mill Dam (Field File # 40.05)
Photo Log
Inspection Report (November 27, 2012)

Photo #15 – Trees and brush on right downstream slope of embankment
(November 19, 2012)

Photo #16 – Trees and brush on left downstream slope of embankment
(November 19, 2012)

8

South Milwaukee Mill Dam (Field File # 40.05)
Photo Log
Inspection Report (November 27, 2012)

Photo #17 – Sparse grass on embankment caused by foot traffic
(October 26, 2012)

9

Figure I.4 (Continued)

Name of Dam: SOUTH MILWAUKEE MILL DAM **Date:** 10/26/12
Inspectors: TANYA LOURIGAN **F.F#:** 40.05
Owner's Name: MILWAUKEE COUNTY PARKS (JIM CIHA) **Key Seq #:** 1332
Street: 9480 WATERTOWN PLANK RD
City, State, Zip Code: WAUWATOSA, WI 53226-3560
County: MILWAUKEE **Phone:** (414) 257-4884
Weather and Site conditions: **Email:** jim.ciha@milwcnty.com

GENERAL

Item	N	P	Notes/ Observations	M	I	R
1 Monuments/Benchmarks	✓	✓				✓
Location: / Elevation: / Datum:			481E – LOCATED (101.05 FT PSC DATUM; 619.18 FT MSL DATUM) 481F – NOT LOCATED			
2 Pool Level						
Normal/Operating: / Maximum: / Minimum:			NO ESTABLISHED / REQUIRED POOL LEVELS NO SURVEY DONE FOR WATER LEVEL READINGS			
Staff Gage			NONE LOCATED			
3 Access Road	✓	✓				
			MILL ROAD BRIDGE			
4 Signage/ Security						
Portage/route:			NONE PRESENT – NOT REQUIRED			
Dam Warning:			NONE PRESENT – NOT REQUIRED (UNLESS ICE SKATING RESUMES)			
Downstream Hazard:	✓	✓	MILL RD BRIDGE / STEEP SIDE SLOPES			
Fencing/Railings/Catwalks:	✓		AESTHETIC FENCING; NOT FOR SECURITY/SAFETY			

Additional Comments:

CONSIDERED BARRIER STRUCTURE FOR AQUATIC INVASIVE SPECIES (AIS) / VIRAL HEMORRHAGIC SEPTICEMIA (VHS)

481E – BRONZE TABLET TOP NW CORNER OF VALVE PIT 45 FT SW OF RT U/S ABUTMENT TO DAM. NEED 2ND BENCHMARK.

FORMER MILLRACE ABANDONED YEARS AGO

N= Noted; P= Photo; M= Monitor
I= Investigate; R= Repair
F.F.= Field File; **RT** = Right; **LT** = Left
U/S = Upstream; **D/S** = Downstream

Action Suggestion **1.** Requires immediate action
2. Plan to do soon
3. Do when convenient

Dam Name: SOUTH MILWAUKEE MILL DAM **Dam Inspection Checklist** **F.F. #:** 40.05 **Date:** 10/26/12 **Page** 1 **of** 7

Figure I.4 (Continued)

GENERAL (Cont.)	
5 Hazard Section	
A. D/S Development	✓ ✓
Density:	LOW DENSITY
Distance:	D/S CHANNEL ~~IN~~ GRANT PARK; APPROX 1 MILE TO MOUTH @
Type (Residential, Commercial, Industrial):	LAKE MICHIGAN. WATER FILTRATION PLANT, YACHT CLUB, AND PEDESTRIAN BRIDGE AT MOUTH
B. Channel Crossing	✓ ✓
Type:	Bridge, Ford, Culvert, Trestle, Other (Explain) (Circle One) MILL ROAD BRIDGE CONCRETE ARCH
Dimensions:	DATA NOT COLLECTED
D/S distance:	APPROX 50 FT — 2 ADDTL CROSSINGS D/S
Traffic Level (Local, CTH, Rail Road, STH, Interstate, etc):	LOCAL (FLOOD DAMAGE TO BRIDGE SLOPES IN 2008) — OAK CREEK PARKWAY DATA NOT COLLECTED
C. Distance to nearest D/S community/impoundment:	✓
Name:	CITY OF SOUTH MILWAUKEE (GRANT PARK TO LAKE MICHIGAN)
D. Anticipated Hazard (based on landuse and zoning):	✓ LOW
E. Dam Failure Analysis	
Date Completed/Approved	
Is map available?	
Are map & profile adopted?	NOT REQUIRED
List adoption date:	
Verify validity of failure mode:	
Verify validity of DFA conclusions:	

F. Emergency Action Plan	Y	N	Comments, Explanation, and Description	M	I	R
1. Current plan posted?						
2. Understood by Operator?						
3. Warning systems?						
4. Certification of last test?						
5. Remote operation?			NOT REQUIRED			
6. Revision Date?						
7. Habitable structures?						
8: Recreation areas?						
9. Changed hazard potential?						
10. New development?						
11. Other comments?						

Additional Comments:

N= Noted; P= Photo; M= Monitor
I= Investigate; R= Repair
F.F.= Field File; **RT** = Right; **LT** = Left
U/S = Upstream; **D/S** = Downstream

Action Suggestion **1.** Requires immediate action
2. Plan to do soon
3. Do when convenient

Dam Name: SOUTH MILWAUKEE MILL DAM **Dam Inspection Checklist** **F.F. #:** 40.05 **Date:** 10/26/12 **Page** 2 **of** 7

Figure I.4 (Continued)

SPILLWAY--PRINCIPAL - FIXED CREST				Action		
Item	**N**	**P**	**Notes/ Observations**	**M**	**I**	**R**
1 Fixed Crest			No problem / Not applicable / Could not inspect			
A. Dimensions Top Width:	✓	✓	APPROX 36 IN ; CREST LENGTH 22 FT			
B. Materials	✓	✓	DOLOMITE STONE - SOME DETERIORATION	✓	✓	✓
C. Shape (sharp-crested, broad-crested, ogee, chute, gated, overflow, morning glory, dropbox, labyrinth)	✓	✓	BROAD CRESTED WEIR			
D. Debris Prevention (racks, booms, etc.):			NO DEBRIS COLLECTION DEVICES			
E. Concrete Condition *	✓	✓	U/S FACE - NOT ABLE TO INSPECT D/S FACE - NO MAJOR DETERIORATION OBSERVED	✓	✓	✓
F. Flashboards (none, number): Type (Metal, wood): Dimensions: Operability:			NONE			
G. Abutments Condition: * Seepage/wetness:	✓	✓	SOME DETERIORATION OF DOLOMITE STONE NONE OBSERVED (1986 INSPECTION NOTED SEEPAGE @ RT ABUTMENT)	✓	✓	✓
H. Drains	✓		No problem / Not applicable / Could not inspect			
Type: Weep holes, Relief drains, Other: Flow Rate:	✓	✓	DRAINPIPES - D/S LT (CHANNEL) BANK DO NOT APPEAR TO BE FUNCTIONING			
I. Other FLOWWAY	✓	✓	NO OBSERVED PROBLEMS			

N= Noted; P= Photo; M= Monitor
I= Investigate; R= Repair
F.F.= Field File; **RT** = Right; **LT** = Left
U/S = Upstream; **D/S** = Downstream

Action Suggestion 1. Requires immediate action
2. Plan to do soon
3. Do when convenient

Controlled = Gated **Uncontrolled** = Overflow

Additional Comments: FURTHER INVESTIGATION AND POSSIBLE REPAIRS NEEDED TO DETERIORATION OF SOME DOLOMITE STONE

* **Type of Concrete Problems:** Spalling, cracks, exposed rebar, misalignment, joints, bug holes, efflorescence, popouts, honeycombing, scaling, craze/map cracks, isolated crack, disintegration, other

Dam Name: SOUTH MILWAUKEE MILL DAM **Dam Inspection Checklist** **F.F.#:** 40.05 **Date:** 10/26/12 3 of 7

Figure I.4 (Continued)

SPILLWAY--PRINCIPAL - OUTLET EROSION CONTROL & UNDERMINING						
				Action		
Item	N	P	Notes/ Observations	M	I	R
1 Outlet Erosion Control	✓		No problem / Not applicable / ✓ Could not inspect VERY WELL			
A. Type (none, endwall, plunge pool, energy dissipation structure rock lined channel, apron)			DOLOMITE STONE APRON APPEARS OKAY			
B. Scour			NONE APPARENT			
C. Material a. Riprap: Avg Diameter: Condition (adequate, sparse, displaced, weathered): Bedding fabric- (Yes/ No): b. Concrete * Dimensions/Location:	✓	✓	DOLOMITE STONE PLACED IN D/S CHANNEL CONDITION - APPEARS ADEQUATE			
D. Sidewall/Headwall Misalignment: Location: Description:	✓	✓	SIDEWALL - SOME DETERIORATION OF DOLOMITE STONE	✓	✓	✓
E. Separated Joint / Loss of Joint Material: Location: Description:	✓	✓	SOME LOSS OF JOINT MATERIAL BETWEEN DOLOMITE	✓	✓	✓
F. Natural			N/A			
2 Undermining	✓		No problem / Not applicable / Could not inspect			
Location: Description:			NONE OBSERVED			

N= Noted; P= Photo; M= Monitor
I= Investigate; R= Repair
F.F.= Field File; RT = Right; LT = Left
U/S = Upstream; D/S = Downstream

Action Suggestion 1. Requires immediate action
2. Plan to do soon
3. Do when convenient

Controlled = Gated Uncontrolled = Overflow

Additional Comments:

FURTHER INVESTIGATION AND POSSIBLE REPAIRS NEEDED TO DETERIORATION OF DOLOMITE STONE

* Type of Concrete Problems: Spalling, cracks, exposed rebar, misalignment, joints, bug holes, efflorescence, popouts, honeycombing, scaling, craze/map cracks, isolated crack, disintegration, other

Dam Name: SOUTH MILWAUKEE MILL DAM **Dam Inspection Checklist** F.F.#: 40.05 Date: 10/26/12 Page 4 of 7

Figure I.4 (Continued)

LAKE DRAINS

(Low level outlet, not a principle or aux. spillway)

	Item	N	P	Notes/ Observations		Action M	Action I	Action R
1	**General**			None found	Does not have one			
	A. Type of lake drain (isolated control/intake tower, valve vault with outlet conduit valve in riser/drop inlet siphon): Size:	✓	✓	VALVE VAULT WITH OUTLET CONDUIT 36 INCH DIAMETER				✓
	B. Operated (Yes/ No)	✓	✓	NOT ABLE TO OPERATE			✓	✓
2	**Lake drain components**							
	A. Concrete structure Location: Description:* Condition:*			—				
	B. Valve control (operating device): No operating device; No stem Bent/Broken Stem; Access Other: Operability:	✓		DO NOT HAVE PLANS FOR VALVE CONTROL NOT ABLE TO OPERATE			✓	✓
	C. Valve/Sluice gate Quantity: a. Metal deterioration (surface rust, minor, moderate, extensive, other): Location: Flow rate: b. Misalignment c. Leakage - Flow rate	✓		ONE MANUAL SLUICE GATE NOT ABLE TO OBSERVE NOT ABLE TO OPERATE			✓	✓
	D. Outlet conduit Size: Material: Condition:			NOT LOCATED			✓	
	E. Energy dissipater Type (endwall, plunge pool impact basin, stilling basin, rock-lined channel, none): Condition:*	✓	✓	DOLOMITE STONE APRON APPEARS OKAY				

N= Noted; P= Photo; M= Monitor
I= Investigate; R= Repair
F.F.= Field File; RT = Right; LT = Le
U/S = Upstream; D/S = Downstream

Action Suggestion 1. Requires immediate action
2. Plan to do soon
3. Do when convenient

Additional Comments:
INVESTIGATE AND REPAIR VALVE CONTROL

* **Type of Concrete Problems:** Spalling, cracks, exposed rebar, misalignment, joints bug holes, efflorescence, popouts, honeycombing, scaling, craze/map cracks, isolated crack, disintegration, other

Dam Name: SOUTH MILWAUKEE MILL DAM **F.F.#:** 40.05 **Dam Inspection Checklist** **Date:** 10/26/12 **Page:** 5 of 7

Figure I.4 (Continued)

EMBANKMENTS

Description:

Item	N	P	Location on Embankment and Deficiency	Action M	Action I	Action R
1 Vegetation:			No problem			
A. Trees Quantity (<5,sparse,dense): Diameter: Location:	✓	✓	LARGE WILLOWS ON EMBANKMENT - U/S SLOPE TREES ON D/S SLOPE, D/S OF MILL RD BRIDGE			✓
B. Brush Quantity (sparse,dense): Location:	✓	✓	NOTABLE AMOUNT OF BRUSH ON EMBANKMENT D/S SLOPES (D/S OF MILL RD BRIDGE) & D/S (CHANNEL) BANKS			✓
C. Ground cover Type (grass, crown vetch,other): Quantity (bare, sparse,adequate, dense): Appearance (too tall, too short, good):	✓	✓	GRASS ADEQUATE ON CREST CHANNEL BANKS / SLOPES - GRASS, VEGETATION & DOLOMITE STONE VEGETATION NEEDS TO BE REMOVED ADDRESS EROSION FROM FOOT TRAFFIC			✓
2 Erosion			No problem / Not applicable / Could not inspect			
A. Wave erosion (Beaching): Scarp: Length/ Width: Location:	✓	✓	SOME CHANNEL BANK EROSION D/S RT TOE MONITOR FOR EVENTUAL REPAIRS	✓	✓	
B. Runoff Erosion (Gullies) Quantity: Length/ Width/ Depth: Location:	✓	✓	SOME BANK EROSION, INCLUDING RIPRAP ON U/S & D/S SIDES OF MILL RD BRIDGE MONITOR FOR EVENTUAL REPAIRS	✓	✓	
3 Instabilities			✓ No problem / Not applicable / Could not inspect			
A. Slides Transverse: Longitudinal: Scarp: Length/ Width: Crack Length/ Width:			NONE OBSERVED			
B. Cracks: Transverse: Longitudinal: Length/ Width/ Depth: Location: Other:			NONE OBSERVED			
C. Bulges/ Depressions Size: Height/ Depth:			NONE OBSERVED			
D. Slope (Too Steep) U/S, D/S			OK			

N= Noted; **P**= Photo; **M**= Monitor
I= Investigate; **R**= Repair
F.F.= Field File; **RT** = Right; **LT** = Left
U/S = Upstream; **D/S** = Downstream

Action Suggestion 1. Requires immediate action
2. Plan to do soon
3. Do when convenient

Additional Comments:

TREE AND BRUSH REMOVAL NEEDED; ADDRESS MINOR EROSION FROM FOOT TRAFFIC

Dam Inspection Checklist

Dam Name: SOUTH MILWAUKEE MILL DAM **F.F. #:** 40.05 **Date:** 10/26/12 **P** 6 **of** 7

Figure I.4 (Continued)

EMBANKMENTS (Cont.)

Item	N	P	Notes/ Observations			Action M	Action I	Action R
4 Slope Protection			No problem	Not applicable	Could not inspect			
A. Type (none, riprap, wave berm, concrete slabs, loose formed concrete/asphalt):	✓	✓	U/S SLOPE @ IMPOUNDMENT - NONE SOME LOCATIONS OF CHANNEL BANKS - RIPRAP					
B. Condition:	✓	✓	U/S SLOPE @ IMPOUNDMENT - OKAY SOME EROSION @ CHANNEL BANKS			✓		
5 Other			✓ No problem	Not applicable	Could not inspect			
A. Rodent burrows (few, many) Location:			NONE OBSERVED					
B. Ruts Length/ Width/ Depth: Location:			NONE OBSERVED					
C. Other			NONE OBSERVED					
6 Alignment			✓ No problem	Not applicable	Could not inspect			
A. Vertical Low area: Elevation Difference: Location:			NO OBSERVED PROBLEMS					
B. Horizontal			NO OBSERVED PROBLEMS					
C. Width Too narrow: Location:			NO OBSERVED PROBLEMS.					
7 Toe			✓ No problem	Not applicable	Could not inspect			
Cracks/Slumps:			NONE OBSERVED					
Embankment drains: Type/Flow: Location:			D/S LEFT BANK - DO NOT APPEAR TO BE FUNCTIONING					
Seepage/ Wetness: Hummocky:			NONE OBSERVED					
8 Seepage			✓ No problem	Not applicable	Could not inspect			
Wet area: Boil: Sinkhole: Aquatic vegetation: Rust colored deposits: Other: Sediment in Flow: Flowrate: Location:			NONE OBSERVED					

N= Noted; P= Photo; M= Monitor
I= Investigate; R= Repair
F.F.= Field File; RT = Right; LT = Left
U/S = Upstream; D/S = Downstream

Action Suggestion
1. Requires immediate action
2. Plan to do soon
3. Do when convenient

Additional Comments:

—

Dam Name: SOUTH MILWAUKEE MILL DAM **Dam Inspection Checklist** F.F. #: 40.05 Date: 10/26/12 Page 7 of 7

AECOM
4135 Technology Parkway
Sheboygan, Wisconsin 53083
www.aecom.com

920 458 8711 tel
920 458 0537 fax

February 3, 2014 Revised

Mr. Karl Stave
Project Manager
Milwaukee County
Department of Administrative Services
AE & ES Division
City Campus, Second Floor
2711 West Wells Street
Milwaukee, WI 53208

Subject: **Masonry Inspection Report of Mill Pond Dam in South Milwaukee, WI**
WDNR Dam Key Seq. No. 1332, Field File #40.05
AECOM Project Number 60313323

Dear Mr. Stave:

At your request, AECOM Technical Services, Inc. (AECOM) representative Steven A. Elver, P.E., S.E. completed a Masonry Inspection of Milwaukee Counties' Mill Pond Dam, as requested by the Wisconsin Department of Natural Resources (WDNR) in a letter dated November 27, 2012. The letter is addressed to James Keegan, Milwaukee County Parks Department. The Masonry Inspection included review of available records and a site inspection. A Site Location Plan and a Photographic Log are included in the attachments.

Dam Description

The Mill Pond Dam is located in Milwaukee Counties' Oak Creek Parkway, close to Lake Michigan, near Milwaukee Counties' Grant Park. The dam and spillway are just upstream of Mill Road, South Milwaukee, at Lat.42.91238930 and Long. -87.85333540. The dam was constructed in approximately 1930. That makes the dam over 80 years old.

There is a Warming House approximately 150 feet upstream of the dam. The warming house and surrounding area are being partially supported by a non-profit group called Friends of the Mill Pond & Oak Creek Watercoarse, Inc. www.smfomp.org They envision increased use of the pond as proposed maintenance and dredging are accomplished in the area.

The dam and curved spillway were constructed across Oak Creek not far upstream of Lake Michigan. The spillway drop is listed as 14 feet feet over the 22 foot long spillway. The exposed dam abutment walls and spillway are faced with dolomite stones. The spillway is a concrete retaining wall design, behind the stone masonry face. Original construction drawings for the dam show this concrete and stone face construction, including wood "wakefield" sheeting as a seepage cutoff underneath.

This dam is considered low hazard by the Wisconsin Department of Natural Resources (WDNR) and impounds 15 acre-feet of water. The dam has an estimated low hazard rating.

Prior Inspection Report Review, Recommendations and Follow Up

The most recent inspection of South Milwaukee Mill Pond Dam was led by WDNR staff Tanya Lourigan, P.E. on October 26 and November 19, 2012. I reviewed the WDNR Dam Inspection Report and Photographs, dated November 27, 2012. That report identifies Four Requirements, namely:

- Embankment repairs,
- Investigation of "Masonry",
- Gate Repairs, and
- Benchmark Installation.

This task addresses Investigation of "Masonry" only. We understand that Milwaukee County is addressing the other three WDNR requirements.

Field Inspection

Steven A. Elver, P.E., S.E., of AECOM performed a field inspection of South Milwaukee Mill Pond Dam masonry on December 4, 2013. After an early freeze across late November, 2013, the weather warmed up to 45 degrees F on December 4 and the inspection was completed with minimal snow and ice cover.

The inspection was visual in nature, with no sample gathering or testing of materials. Water was flowing over the spillway during the inspection, so observation of the downstream face of the spillway was limited.

Findings and Recommendations

Water was flowing approximately 6 inches deep in the tailrace below the dam, between the spillway and Mill Road Bridge. While walking across the creek below the spillway, I observed the riverbed. It appeared to be solid bedrock, with some gravel patches and dislodged stones on it.

The historic construction drawing of the dam shows plans for installing wakefield wood sheeting below the dam and spillway. It is not known if the sheeting was installed to the lengths listed on the drawings, or even at all. If the base of the spillway is on bedrock, the wakefield sheeting may have been left off and the details of bearing the footing may have been redesigned. Either way, this would not affect the masonry facing of the structure.

The masonry, both on the dam abutments and on the downstream embankment slopes, is constructed of a fairly durable dolomitic stone. However, in the harsh wet environment with freeze-thaw cycles, some of the stone is showing its age after 80 years of exposure. Refer to the photos attached for more information.

The spillway section was designed as an arched concrete dam, with masonry facing on the exposed surfaces. See photographs 4 and 22, plus the historic construction drawing attached. The structure looks as if it is well constructed and well founded, with no noticeble settlement cracking or leakage through the downstream face of either abutment. The stone masonry is a non-structural element of the dam.

Missing and weathered stones were observed in certain locations, including both ends of the spillway. Capstones on the abutment walls step down to blend in with capstone elevation across the spillway. The end capstones on top of the spillway were missing on both sides. On the left abutment (as viewed facing downstream), just above waterline, a large capstone has been partially displaced toward downstream, likely due to impact from floating debris passing over the spillway during high flow events in the past. Also on the left abutment, further from the spillway, two capstones are removed from the top of the masonry wall and stacked on a wood pallet nearby. The reason for these stones being set to the side is not apparent.

Several stones show signs of freeze-thaw weathering, wherein the stones get saturated with water, then freeze. The water expands and causes ever increasing cracks in the stone until it becomes smaller pieces and washes away.

The missing and deteriorated stonework should eventually be repaired by tuckpointing and replacing missing/weathered stones. This will slow down weathering where water is entering both the mortar joints and the cracked stones. Note that these repairs are to maintain the integrity of the masonry veneer, but not required for dam safety.

As an alternate to replacing damaged and missing stones, concrete could be used. For this to be a durable solution, each area needs to be properly cleaned out and prepared, with all loose material removed. Non-corrosive, drilled-in pins should be used to provide a positive bond to the sound concrete structure behind. Note that this will not have the same aesthetic appeal as the original stonework, which must be considered in any determination of this type of repair.

Summary and Conclusions

AECOM found the dam to be in good structural condition, with no serious leakage or cracking, scour or signs of imminent failure. The stone masonry abutment walls and spillway veneer show signs of weathering and should be repaired as part of regular maintenance.

In general, missing and weathered stones should be replaced and the masonry should be tuckpointed and rebuilt at some time within the next 10 years. We recommend replacing the missing cap stones and resetting the shifted capstone on the left abutment in year 2014. Tuckpointing of the abutment walls should be considered to be performed at the same time, as budget allows.

Please feel free to contact the undersigned at 414.944.6137 or Don Pirrung at 920.251.2822 should you require any clarification of the information presented herein. Two hard copies of these documents and one C-D of the documents should be forwarded to Tonya Lourigan of the WDNR Milwaukee office.

Yours Sincerely,

Steven A. Elver, P.E., S.E.
Principal Engineer

copy: Don Pirrung, AECOM Sheboygan
Jerry Krueger, AECOM Middleton

Attachments: Aerial View of Site
Photo Log

Figure I.5 (Continued)

South Milwaukee Mill Pond Dam Masonry Inspection
AECOM Project No. 60313323
Photos Taken December 4, 2013 by S. Elver

AECOM

Photo 1: Mill Pond Dam and Spillway

Photo 2: Mill Pond Dam and Spillway

K:\PROJECTS\60313323\Photo_Log.docx

Figure I.5 (Continued)

South Milwaukee Mill Pond Dam Masonry Inspection
AECOM Project No. 60313323
Photos Taken December 4, 2013 by S. Elver

Photo 3: Left Embankment between Spillway and Mill Road Bridge

Photo 4: Right Embankment between Spillway and Mill Road Bridge. Note concrete wall at curved spillway, arrow.

K:\PROJECTS\60313323\Photo_Log.docx

Figure I.5 (Continued)

South Milwaukee Mill Pond Dam Masonry Inspection
AECOM Project No. 60313323
Photos Taken December 4, 2013 by S. Elver

Photo 5: Looking across Mill Pond toward Spillway between large trees

Photo 6: Dam Spillway at arrow. Crank for low level gate operation in concrete pad, foreground.

K:\PROJECTS\60313323\Photo_Log.docx

South Milwaukee Mill Pond Dam Masonry Inspection
AECOM Project No. 60313323
Photos Taken December 4, 2013 by S. Elver

Photo 7: Right embankment with stone abutment

Photo 8: Right embankment with stone abutment. Mill Road Bridge over tailwater, beyond.

K:\PROJECTS\60313323\Photo_Log.docx

South Milwaukee Mill Pond Dam Masonry Inspection
AECOM Project No. 60313323
Photos Taken December 4, 2013 by S. Elver

Photo 9: Right embankment at end of spillway. Note missing stone on end of spillway and top of concrete under water (arrow)

Photo 10: Right embankment with stone and mortar

K:\PROJECTS\60313323\Photo_Log.docx

Figure I.5 (Continued)

South Milwaukee Mill Pond Dam Masonry Inspection
AECOM Project No. 60313323
Photos Taken December 4, 2013 by S. Elver

Photo 11: Right abutment stone and mortar, downstream. Note deteriorating and cracked stones.

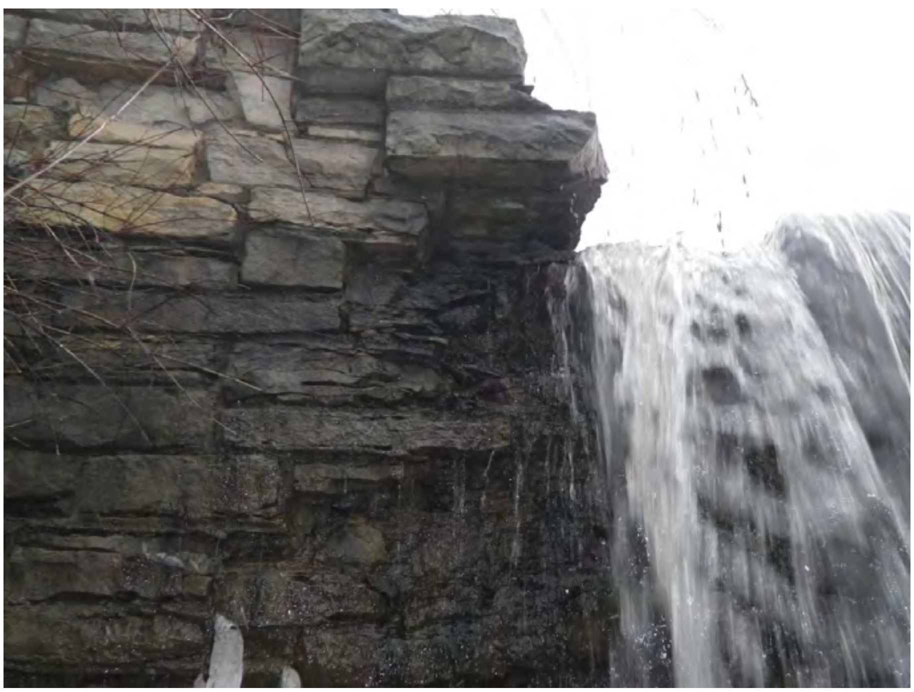


Photo 12: Right abutment downstream face at end of spillway. Note missing stone on spillway and weathered stone along edge

K:\PROJECTS\60313323\Photo_Log.docx

Figure I.5 (Continued)

South Milwaukee Mill Pond Dam Masonry Inspection
AECOM Project No. 60313323
Photos Taken December 4, 2013 by S. Elver

AECOM

Photo 13: Left abutment downstream face at end of spillway. Note missing stone on spillway end and deteriorated stone off spillway

Photo 14: Left abutment downstream face and stone paving on downstream slope

K:\PROJECTS\60313323\Photo_Log.docx

Figure I.5 (Continued)

South Milwaukee Mill Pond Dam Masonry Inspection
AECOM Project No. 60313323
Photos Taken December 4, 2013 by S. Elver

Photo 15: Left abutment downstream face. Note deteriorating stonework.

Photo 16: Left abutment downstream face. Note weathered stonework.

K:\PROJECTS\60313323\Photo_Log.docx

Figure I.5 (Continued)

South Milwaukee Mill Pond Dam Masonry Inspection
AECOM Project No. 60313323
Photos Taken December 4, 2013 by S. Elver

Photo 17: Spillway as viewed from left abutment. Note missing stones at corners.

Photo 18: Top of left abutment. Note missing capstone and shifted stone (arrow).

K:\PROJECTS\60313323\Photo_Log.docx

Figure I.5 (Continued)

South Milwaukee Mill Pond Dam Masonry Inspection
AECOM Project No. 60313323
Photos Taken December 4, 2013 by S. Elver

Photo 19: Left abutment at spillway, upstream side. Note shifted stone (arrow).

Photo 20: Left abutment, upstream side, showing cracking and shifting of joints near missing capstone. Note several cracked stones.

K:\PROJECTS\60313323\Photo_Log.docx

Figure I.5 (Continued)

South Milwaukee Mill Pond Dam Masonry Inspection
AECOM Project No. 60313323
Photos Taken December 4, 2013 by S. Elver

AECOM

Photo 21: Left abutment at spillway. Note concrete wall at arrow.

Photo 22: Left abutment upstream face. Note two missing capstones, stacked beyond.

K:\PROJECTS\60313323\Photo_Log.docx

Figure I.5 (Continued)

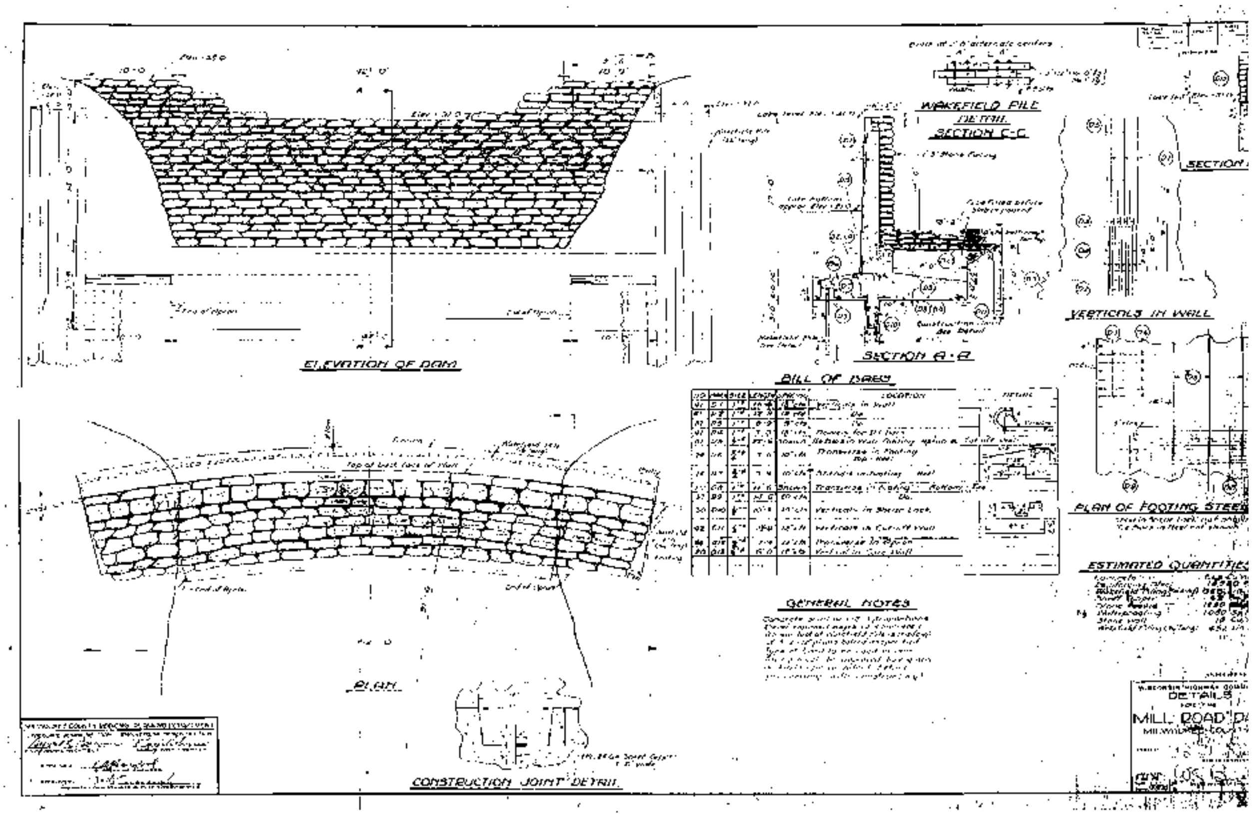


Figure I.5 (Continued)

Figure I.6
Repair Plans for the Oak Creek Mill Pond Dam Slide Gate

MILWAUKEE COUNTY DEPT. OF PARKS, RECREATION & CULTURE

MILL POND DAM SLIDE GATE REHABILITATION

MILL ROAD & OAK CREEK PARKWAY, SOUTH MILWAUKEE, WISCONSIN

Project : 9155-14650
Site: 687
Building: N/A
Date: 05/07/ 2015

DRAWINGS

COVER - SITE	CVR
EXISTING SITE CONDITIONS & GENERAL NOTES	C100
PROPOSED SITE PLAN	C101
STRUCTURE PLAN	C102
SITE DETAILS	C200
SITE DETAILS	C201
SOIL EROSION AND SEDIMENT CONTROL DETAILS	C202

CLIENT

MILWAUKEE CO. DEPT OF ADMIN SERVICES - AE & ES SECTION
CONTACT: Karl Stave
PHONE: 414-278-4863
2711 W. Wells Street, 2nd Floor
Milwaukee, Wisconsin 53208

CIVIL / STRUCTURAL

AECOM
PHONE: 414-944-6080
1555 N RiverCenter Drive, Suite 214
Milwaukee, WI 53212

OWNER

MILWAUKEE CO. DEPT OF ADMIN SERVICES - AE & ES SECTION
CONTACT: Kevin Haley
PHONE: 414-258-6242
9480 Watertown Plank Road
Waumatosa, Wisconsin 53226

DIRECTOR OF PARKS: ______________________

DAS DIRECTOR : ______________________

PROJECT MANAGER : ______________________

AECOM
WWW.AECOM.COM
AECOM TECHNICAL SERVICES, Inc.
414-944-6080

AECOM

PROJECT NUMBER: 60338307

SCALE:	DRAWN:	CJL	DATE: 05/07/2015
AS SHOWN	CHK'D/APPR'D	JJH	DATE: 05/07/2015

CVR

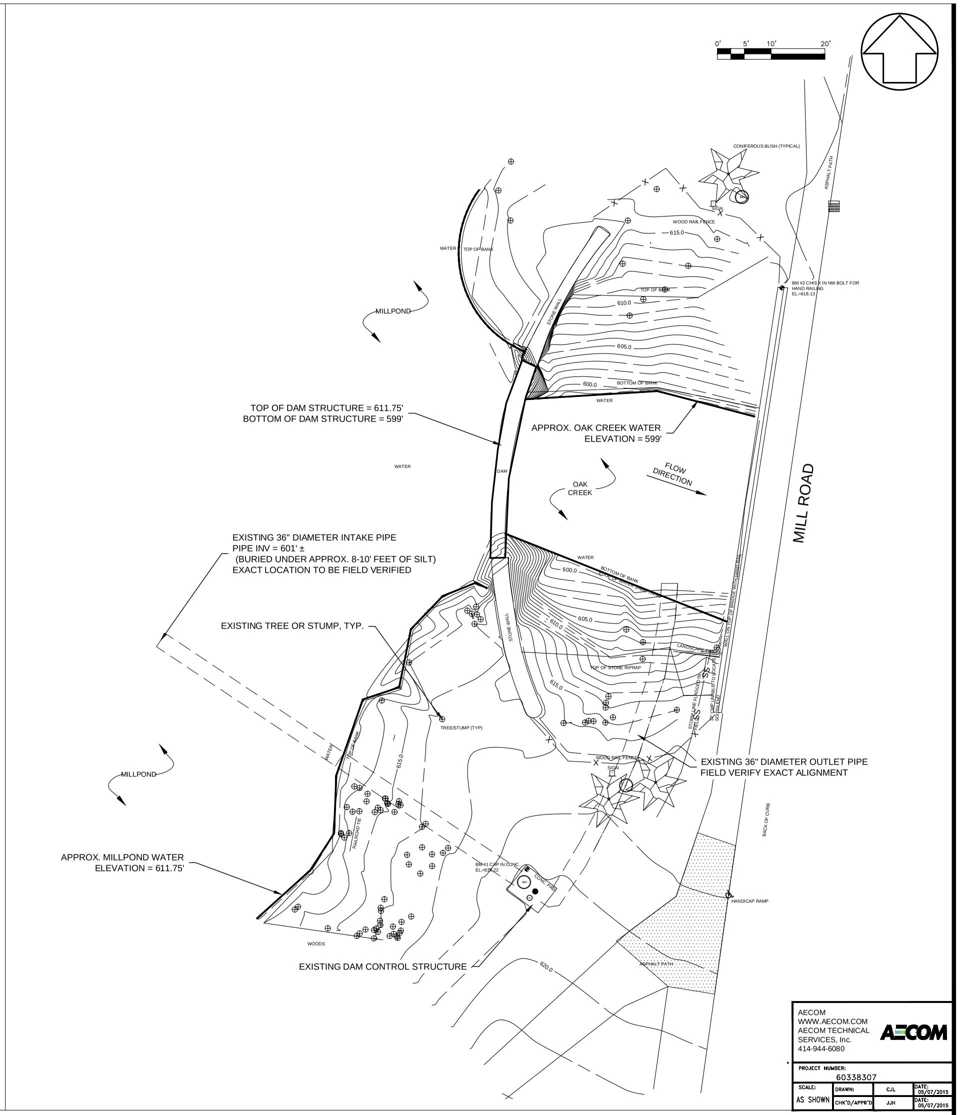
Figure I.6 (Continued)

GENERAL

1. ALL WORK SHALL BE PERFORMED PER THE STATE OF WISCONSIN COMMERCIAL BUILDING CODE (CURRENT EDITION) AND OTHER STATE, LOCAL AND REGIONAL REGULATIONS.
2. INSTALLATION OF EROSION CONTROLS AS SHOWN ON DRAWINGS AND PER THE SPECIFICATIONS. IF SITE WILL BE INACTIVE FOR MORE THAN 14 DAYS, TEMPORARY STABILIZATION OF SITE WILL BE REQUIRED.
3. SITE RESTORATION AFTER THE WORK IS COMPLETED TO CONSIST OF REPAIR TO EXISTING PAVEMENTS, GRADING, SEEDING AND MULCHING DISTURBED/DAMAGED AREAS DURING THE COURSE OF THE PROJECT. FOR SEEDING AND MULCHING SEE SPECIFICATIONS.
4. ALL OTHER WORK AS SHOWN ON DRAWINGS AND PER SPECIFICATIONS

CIVIL NOTES

1. ALL WORK SHALL BE PERFORMED IN ACCORDANCE WITH THE WISCONSIN DEPARTMENT OF TRANSPORTATION STANDARD SPECIFICATIONS, LATEST EDITION, WHICH ARE REFERENCED AS STANDARD SPECIFICATIONS. CONTRACTOR SHALL OBSERVE THE SCOPE OF WORK, CONTROL OF WORK, CONTROL OF MATERIALS, LEGAL RELATIONS AND RESPONSIBILITY TO THE PUBLIC, AND PROSECUTION AND PROGRESS. CONTRACTOR SHALL OBTAIN AND PAY FOR ALL PERMITS AND FEES REQUIRED BY FEDERAL, STATE, OR MUNICIPAL CODE
2. ALL WORK SHALL BE COORDINATED WITH THE OWNER.
3. CONTRACTOR SHALL NOTIFY UTILITY DIGGERS HOTLINE AT (800)-242-8811 AND THE MILWAUKEE COUNTY PARKS MAINTENANCE AT (414)-258-2322 FOR PRIVATE UTILITIES AND PROVIDE WRITTEN DOCUMENTATION OF CLEARANCE TO OWNER PRIOR TO COMMENCING WORK.
4. CONTRACTOR SHALL IMPLEMENT AND MAINTAIN ALL EROSION AND SEDIMENTATION CONTROL MEASURES IN CONFORMANCE WITH THE STANDARD SPECIFICATIONS.
5. EXISTING SITE TOPOGRAPHY, UTILITIES, LEGAL DESCRIPTION, RIGHT-OF-WAY, AND HORIZONTAL CONTROL SHOWN ON THE DRAWINGS WERE OBTAINED FROM RECORD DRAWINGS AND A SURVEY PREPARED BY OTHERS. AECOM DOES NOT WARRANT THE ACCURACY OR COMPLETENESS OF THE INFORMATION SHOWN.
6. NO BURNING OR INCINERATION OF RUBBISH WILL BE PERMITTED ON THE SITE.
7. FACILITIES TO REMAIN SHALL BE PROTECTED FROM DAMAGE AND, IF DAMAGED, SHALL BE REPLACED TO THE SATISFACTION OF THE OWNER. ANY EXISTING FACILITY WHICH IS REMOVED TO ACCOMMODATE CONSTRUCTION ACTIVITY OR DAMAGED DURING CONSTRUCTION SHALL BE REPLACED IN KIND.
8. THE CONTRACTOR SHALL PERFORM AND BE RESPONSIBLE FOR ALL CONSTRUCTION LAYOUT AND STAKING.
9. ALL WORK SHALL BE COMPLETED TO THE SATISFACTION OF THE OWNER AND THE ENGINEER.
10. CONTRACTOR IS SOLELY RESPONSIBLE FOR QUALITY CONTROL OF THE WORK. INSPECTION AND TESTING BY THE ENGINEER OR THE OWNER'S TESTING AGENCY ARE SOLELY AT THE DISCRETION OF THE OWNER, AND IN NO WAY RELIEVE THE CONTRACTOR OF SOLE RESPONSIBILITY FOR MAINTAINING A QUALITY CONTROL PROGRAM.
11. CONTRACTOR SHALL USE ADEQUATE NUMBERS OF SKILLED WORKMEN WHO ARE THOROUGHLY TRAINED, QUALIFIED, AND EXPERIENCED IN THE NECESSARY CRAFT AND WHO ARE COMPLETELY FAMILIAR WITH THE SPECIFIED REQUIREMENTS AND METHODS NEEDED FOR PROPER PERFORMANCE OF THE WORK.
12. CONTRACTOR SHALL PROVIDE ALL NECESSARY SUPERVISION, PLANNING, SCHEDULING, COORDINATION, INSPECTION, TESTING, AND CONTROL TO PERFORM THE WORK.
13. CONTRACTOR SHALL MAINTAIN AREAS FREE FROM ACCUMULATIONS OF WASTE, DEBRIS, AND RUBBISH CAUSED BY CONTRACTOR OPERATIONS.
14. CONTRACTOR SHALL REMOVE ALL CONSTRUCTION RELATED DEBRIS FROM AREAS OUTSIDE THE LIMITS OF THE CONTRACTOR'S WORK AREA ON A DAILY BASIS.
15. CONTRACTOR SHALL LEGALLY DISPOSE OF ALL WASTE DEBRIS, SOIL AND RUBBISH AT DUMP AREAS OFF OWNER'S PROPERTY.
16. THE ELEVATIONS SHOWN ON PLANS REFLECT PROPOSED FINISHED GRADES, UNLESS OTHERWISE INDICATED.
17. IT IS THE CONTRACTOR'S RESPONSIBILITY TO ASCERTAIN EXISTING FIELD CONDITIONS BEFORE BIDDING ON THE PROJECT, SPECIFICALLY AS THEY RELATE TO LUMP SUM ITEMS.
18. ALL GROUND SURFACE DRAINAGE THAT EXISTED PRIOR TO CONSTRUCTION SHALL BE RESTORED AS SHOWN ON THE PLANS AND/OR AS DIRECTED BY THE ENGINEER.
19. THE STANDARD SPECIFICATIONS, THESE CONSTRUCTION PLANS, AND SUBSEQUENT DETAILS ARE ALL TO BE CONSIDERED AS PART OF THE CONTRACT DOCUMENTS. INCIDENTAL ITEMS OR ACCESSORIES NECESSARY TO COMPLETE THIS WORK MAY NOT BE SPECIFICALLY NOTED BUT ARE TO BE CONSIDERED A PART OF THE CONTRACT.
20. NO PLANS SHALL BE USED FOR CONSTRUCTION UNLESS SPECIFICALLY MARKED "FOR CONSTRUCTION". THE CONTRACTOR SHALL VERIFY ALL DIMENSIONS AND CONDITIONS AFFECTING THEIR WORK WITH THE ACTUAL CONDITIONS AT THE JOB SITE. IF THERE ARE ANY DISCREPANCIES FROM WHAT IS SHOWN ON THE CONSTRUCTION PLANS, HE MUST IMMEDIATELY REPORT SAME TO THE ENGINEER BEFORE DOING ANY WORK, OTHERWISE THE CONTRACTOR ASSUMES FULL RESPONSIBILITY. IN THE EVENT OF DISAGREEMENT BETWEEN THE CONSTRUCTION PLANS, STANDARD SPECIFICATIONS AND/OR SPECIAL DETAILS, THE CONTRACTOR SHALL SECURE WRITTEN INSTRUCTIONS FROM THE ENGINEER PRIOR TO PROCEEDING WITH ANY PART OF THE WORK AFFECTED BY OMISSIONS OR DISCREPANCIES. FAILING TO SECURE SUCH INSTRUCTION, THE CONTRACTOR WILL BE CONSIDERED TO HAVE PROCEEDED AT HIS OWN RISK AND EXPENSE. IN THE EVENT OF ANY DOUBT OR QUESTION ARISING WITH RESPECT TO THE TRUE MEANING OF THE CONSTRUCTION PLANS OR SPECIFICATIONS, THE DECISION OF THE ENGINEER SHALL BE FINAL AND CONCLUSIVE.
21. ALL WORK PERFORMED UNDER THIS CONTRACT SHALL BE GUARANTEED AGAINST ALL DEFECTS IN MATERIALS AND WORKMANSHIP OF WHATEVER NATURE BY THE CONTRACTOR AND HIS SURETY FOR A PERIOD OF 12 MONTHS FROM THE DATE OF FINAL ACCEPTANCE OF THE WORK BY THE OWNER AND OTHER APPLICABLE GOVERNMENTAL AGENCIES.
22. BEFORE ACCEPTANCE BY THE OWNER AND FINAL PAYMENT, ALL WORK SHALL BE INSPECTED AND APPROVED BY THE OWNER OR HIS REPRESENTATIVE. FINAL PAYMENT WILL BE MADE AFTER ALL OF THE CONTRACTOR'S WORK HAS BEEN APPROVED AND ACCEPTED, AND IN ACCORDANCE WITH THE CONTRACT DOCUMENTS.
23. WHENEVER, DURING CONSTRUCTION OPERATIONS, ANY LOOSE MATERIAL IS DEPOSITED IN THE FLOW LINE OF DRAINAGE STRUCTURES, DITCHES, ETC. SUCH THAT THE NATURAL FLOW LINE OF WATER IS OBSTRUCTED, THIS LOOSE MATERIAL SHALL BE REMOVED AT THE CLOSE OF EACH WORKING DAY BY THE RESPONSIBLE PARTY. AT THE CONCLUSION OF CONSTRUCTION OPERATIONS, ALL DRAINAGE STRUCTURES AND FLOW LINES SHALL BE FREE FROM DIRT AND DEBRIS. THIS WORK SHALL BE CONSIDERED INCIDENTAL TO THE CONTRACT.
24. THE CONTRACTOR SHALL BE RESPONSIBLE FOR THE INSTALLATION AND MAINTENANCE OF ADEQUATE SIGNS, TRAFFIC CONTROL DEVICES AND WARNING DEVICES TO INFORM AND PROTECT THE PUBLIC DURING ALL PHASES OF CONSTRUCTION. BARRICADES AND WARNING SIGNS SHALL BE PROVIDED IN ACCORDANCE WITH THE STANDARD SPECIFICATIONS. ALL TRAFFIC CONTROL WORK SHALL BE DONE IN ACCORDANCE WITH THE "MANUAL ON UNIFORM TRAFFIC CONTROL DEVICES".
25. WHERE OVERHANGING BRANCHES INTERFERE WITH OPERATIONS OF CONSTRUCTION, SAID BRANCHES SHALL BE TRIMMED AND SEALED IN ACCORDANCE WITH THE STANDARD SPECIFICATIONS, AND THE COST OF SAME SHALL BE INCIDENTAL TO THE CONTRACT. TREES SHALL BE REMOVED ONLY AFTER RECEIVING APPROVAL OF THE OWNER.
26. DURING CONSTRUCTION OPERATIONS, THE CONTRACTOR SHALL INSURE POSITIVE SITE DRAINAGE AT THE CONCLUSION OF EACH DAY. SITE DRAINAGE MAY BE ACHIEVED BY DITCHING, PUMPING OR ANY OTHER ACCEPTABLE METHOD. THE CONTRACTOR'S FAILURE TO PROVIDE THE ABOVE WILL PRECLUDE ANY POSSIBLE ADDED COMPENSATION REQUESTED DUE TO DELAYS OR UNSUITABLE MATERIALS CREATED AS A RESULT THEREOF.
27. THE ENGINEER AND OWNER ARE NOT RESPONSIBLE FOR THE CONSTRUCTION MEANS, METHODS, TECHNIQUES, SEQUENCES OR PROCEDURES, TIME OF PERFORMANCE, PROGRAMS OR FOR ANY SAFETY PRECAUTIONS USED BY THE CONTRACTOR. THE CONTRACTOR IS SOLELY RESPONSIBLE FOR SAFE EXECUTION OF HIS / HER WORK IN ACCORDANCE WITH THE CONTRACT DOCUMENTS AND SPECIFICATIONS.
28. THE CONTRACTOR SHALL COMPLY WITH ALL STATE AND FEDERAL SAFETY REGULATIONS AS OUTLINED IN THE LATEST REVISIONS OF THE FEDERAL CONSTRUCTION SAFETY STANDARDS (SERIES 1926) AND WITH APPLICABLE PROVISIONS AND REGULATIONS OF THE OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION (OSHA) STANDARDS OF THE WILLIAMS STELGER OCCUPATIONAL HEALTH STATE SAFETY ACT OF 1970 (REVISED). THE CONTRACTOR, ENGINEER AND OWNER SHALL EACH BE RESPONSIBLE FOR HIS OWN RESPECTIVE AGENTS AND EMPLOYEES.
29. THE CONTRACTOR SHALL KEEP A SET OF "APPROVED" CONSTRUCTION PLANS ON THE JOB SITE, AND SHALL MAINTAIN (AS INDICATED HEREIN AND ELSEWHERE WITHIN THESE CONSTRUCTION NOTES, SPECIFICATIONS, AND PLANS) A LEGIBLE RECORD ON SAID PLANS OF ANY FIELD TILE ENCOUNTERED, ANY MODIFICATIONS/ALTERATIONS TO ALIGNMENT AND/OR TO PLANS AND SPECIFICATIONS OF PROPOSED IMPROVEMENTS, ETC. UPON COMPLETION OF THE CONTRACTOR'S WORK, SAID PLANS AND INFORMATION SHALL BE PROVIDED TO ENGINEER. FINAL CONTRACT PAYMENT SHALL NOT COME DUE UNTIL THIS INFORMATION IS RECEIVED BY THE ENGINEER.
30. OWNER WILL PROVIDE THE CONSTRUCTION PLANS TO THE CONTRACTOR AS ELECTRONIC FILES (AUTOCAD FORMAT).
31. ALL ELECTRONIC FILES TRANSFERRED BY AECOM ARE PROVIDED SOLELY FOR THE CONVENIENCE OF THE CONTRACTOR AND ARE WARRANTED ONLY TO THE EXTENT THAT THEY CONFORM TO THE ORIGINAL, HARD COPY PLOT(S) OR OTHER ORIGINALLY SEALED DOCUMENT(S) PRODUCED BY AECOM. DEVIATION IN ANY RESPECT SHALL RENDER THE ENTIRE CONTENTS VOID AND ALL ELECTRONIC FILE(S) ARE TRANSMITTED IN TRUST FOR THE SOLE USE OF THE CONTRACTOR AND ACCEPTANCE CONSTITUTES ASSUMPTION OF RESPONSIBILITY FOR ITS USE AND SAFEKEEPING. ANY USE BY THIRD PARTIES SHALL BE AT THE SOLE RISK OF THE CONTRACTOR. ANY ALTERATIONS TO OR TAMPERING WITH THE FILES SHALL CONSTITUTE THE AGREEMENT OF THE CONTRACTOR TO RELEASE DEFEND AND HOLD HARMLESS AECOM, FROM ALL CLAIMS AND CAUSES OF ACTION BY SAID CONTRACTOR AND THIRD PARTIES.



EXISTING SITE CONDITIONS & GENERAL NOTES

MILWAUKEE COUNTY DEPT. OF ADMIN SERVICES - AE & ES SECTION
CITY CAMPUS 2711 W. WELLS ST - 2ND FLOOR MILWAUKEE, WI 53208

OAK CREEK MILLPOND SLIDE GATE REHABILITATION
4400 N. ESTABROOK DRIVE
Milwaukee, Wisconsin

REVISIONS:

DATE: 05/07/2015
PROJECT: 9155-14650
SITE NO: N/A
BUILDING NO: N/A

C100

P:\60338307\900_Work\910-CAD\AECOM\Sheets\60338307_OCMillpond_Plansheets.dwg, 5/7/2015 11:24:04 AM, LEWIS, CHRISTOPHER (MILWAUKEE), STS_050801.stb

Figure I.6 (Continued)

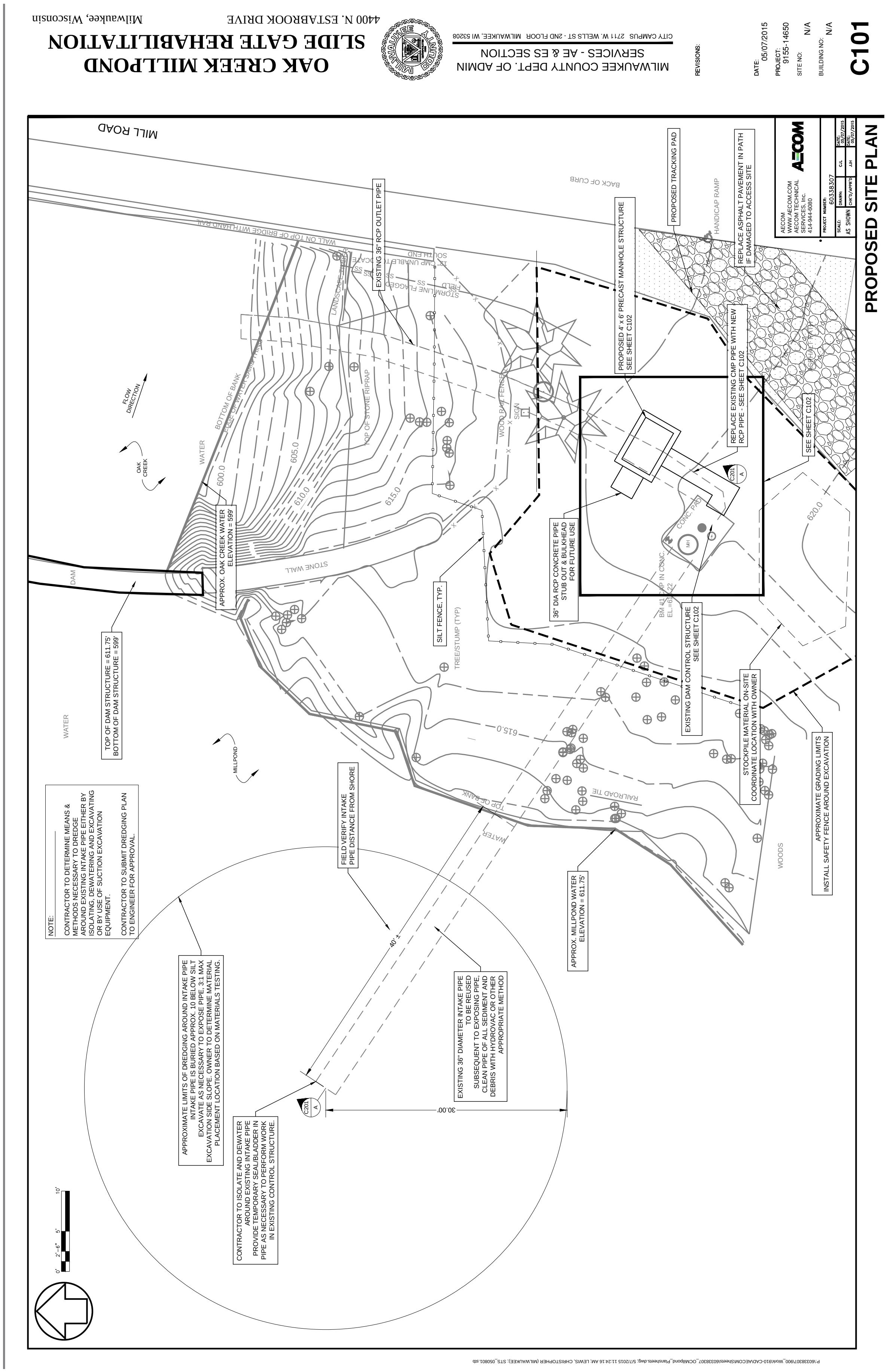


Figure I.6 (Continued)

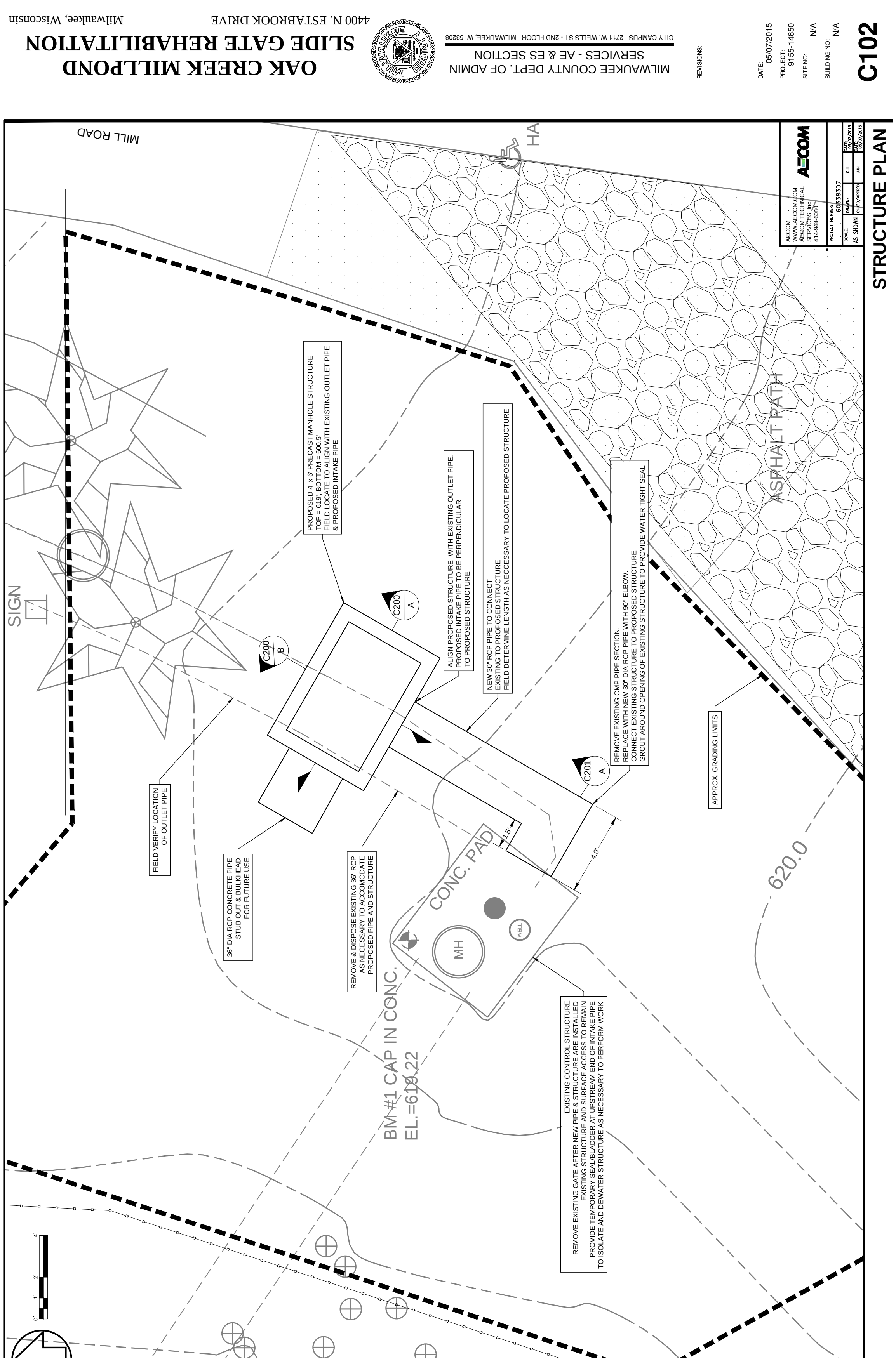


Figure I.6 (Continued)

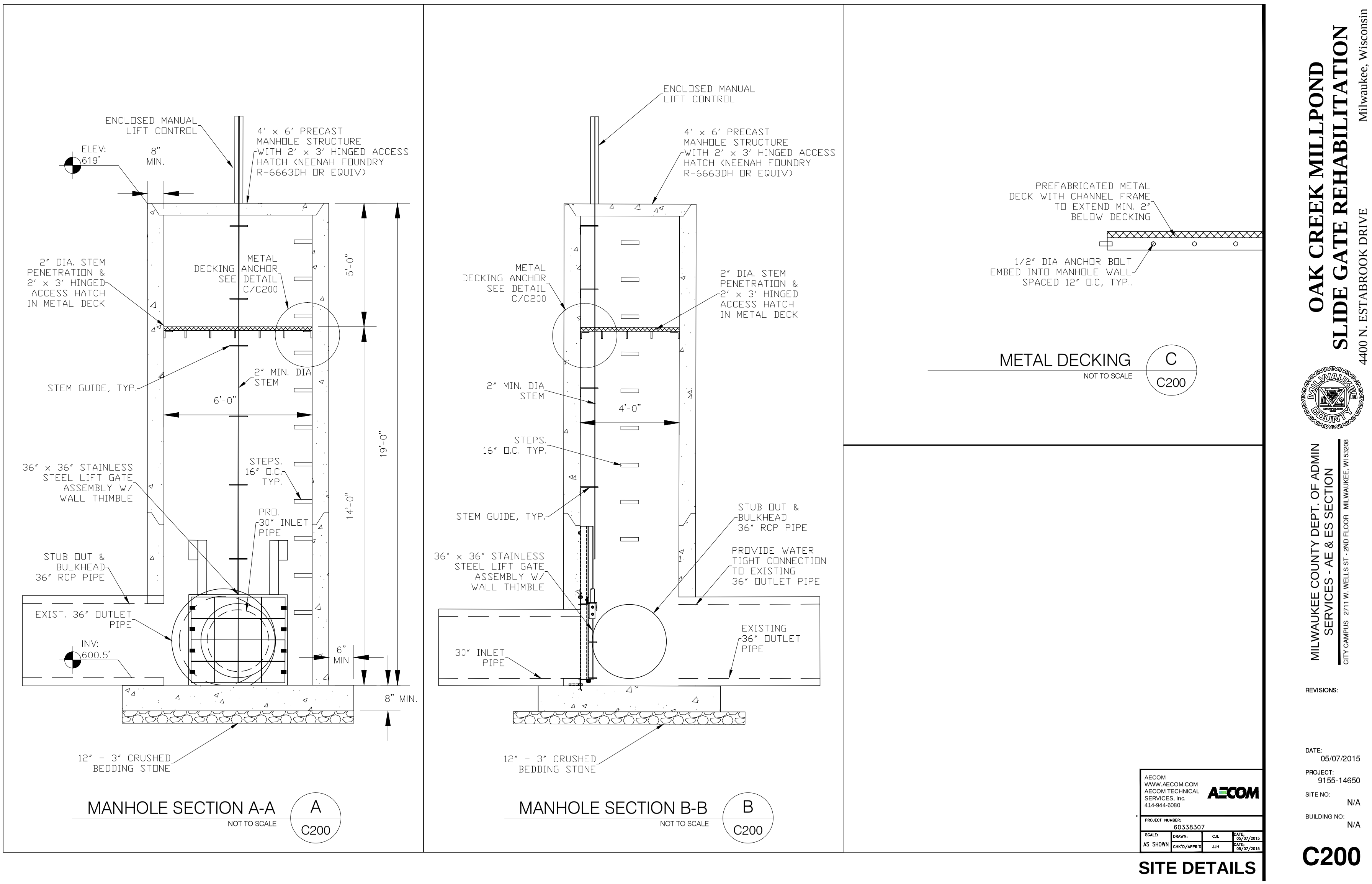


Figure I.6 (Continued)

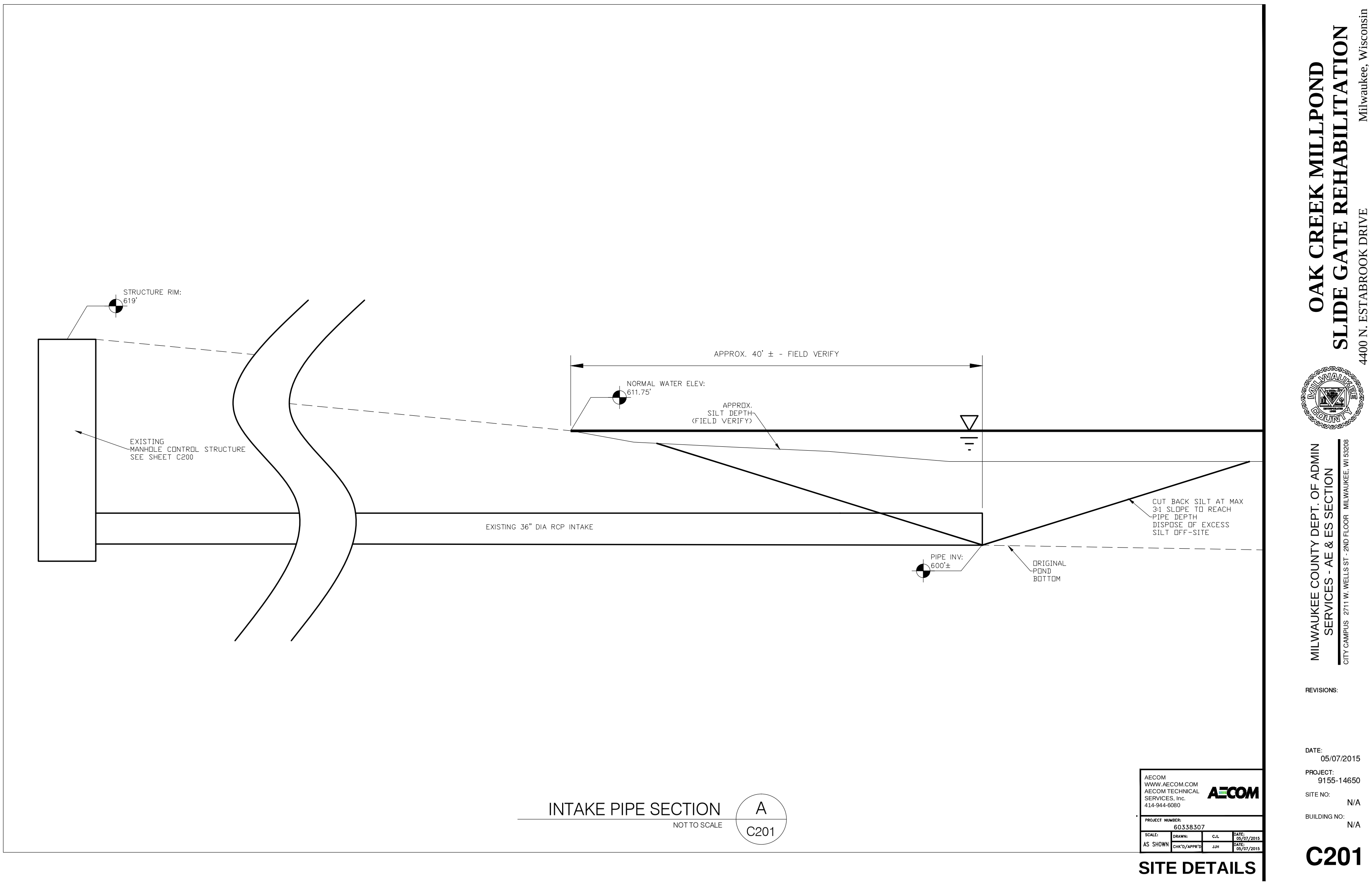
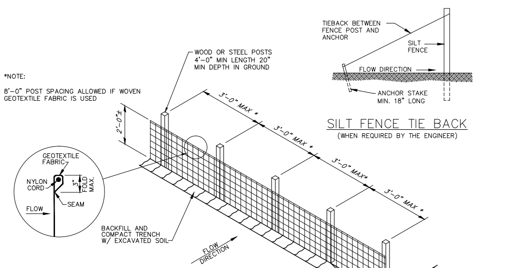


Figure I.6 (Continued)



SILT FENCE INSTALLATION GENERAL NOTES:

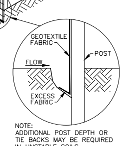
1. SILT FENCE SHALL BE IN ACCORDANCE WITH WISCONSIN DEPARTMENT OF NATURAL RESOURCES TECHNICAL STANDARD No. 1056

2. TRENCH SHALL BE A MINIMUM OF 4" WIDE & 6" DEEP TO BURY AND ANCHOR THE GEOTEXTILE FABRIC. FOLD MATERIAL TO FIT TRENCH AND BACKFILL & COMPACT TRENCH WITH EXCAVATED SOIL.

3. WOOD POSTS SHALL BE A MINIMUM SIZE OF 1 1/8" X 1 1/8" OF OAK OR HICKORY.

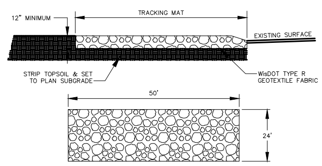
4. CONSTRUCT SILT FENCE FROM A CONTINUOUS ROLL IF POSSIBLE BY CUTTING LENGTHS TO AVOID JOINTS. IF A JOINT IS NECESSARY USE ONE OF THE FOLLOWING TWO METHODS:
A)TWIST METHOD -- OVERLAP THE ENDPOSTS AND TWIST, OR ROTATE, AT LEAST 180 DEGREES,
B) HOOK METHOD -- HOOK THE END OF EACH SILT FENCE LENGTH.

5. ATTACH THE FABRIC TO THE POSTS WITH WIRE STAPLES OR WOODEN LATH AND NAILS.



NOTE:
ADDITIONAL POST DEPTH OR TIE BACKS MAY BE REQUIRED IN UNSTABLE SOILS.

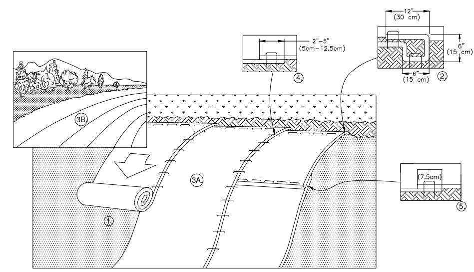
A / C201 SILT FENCE INSTALLATION DETAIL
NOT TO SCALE



EROSION CONTROL TRACK PAD GENERAL NOTES:

1. CONTRACTOR SHALL PROVIDE THE STONE TRACKING PAD IN ACCORDANCE WITH THE WISCONSIN DEPARTMENT OF NATURAL RESOURCES TECHNICAL STANDARD No. 1057.
2. TRACKING PAD SHALL BE INSTALLED PRIOR TO ANY TRAFFIC LEAVING THE SITE. IF CONDITIONS ARE SUCH THAT SEDIMENT IS NOT REMOVED FROM TIRES BY THE TRACKING PAD, THEN TIRES SHALL BE WASHED IN ACCORDANCE WITH WDNR TECHNICAL STANDARD No. 1057.
3. USE 3 TO 6 INCH CLEAR OR WASHED STONE. ALL MATERIAL TO BE RETAINED ON A 3-INCH SIEVE. MINIMUM 50' LENGTH, MINIMUM 12" THICK, AND SHALL BE THE FULL WIDTH OF THE EGRESS POINT.
4. SITES WITH A HIGH WATER TABLE, OR WHERE SATURATED CONDITIONS ARE EXPECTED, THE STONE TRACKING PAD SHALL BE UNDERLAIN WITH A WisDOT TYPE R GEOTEXTILE FABRIC TO PREVENT MIGRATION OF UNDERLYING SOIL INTO THE STONE.
5. SURFACE WATER MUST BE PREVENTED FROM PASSING THROUGH THE TRACKING PAD. FLOWS SHALL BE DIVERTED AWAY FROM TRACKING PADS OR CONVEYED UNDER AND AROUND THEM BY USING A VARIETY OF PRACTICES, SUCH AS CULVERTS, WATER BARS, OR OTHER SIMILAR PRACTICES.
6. THE ENTRANCE SHALL BE MAINTAINED IN A CONDITION WHICH WILL PREVENT TRACKING OF SEDIMENT ONTO PUBLIC RIGHT-OF-WAYS. THIS MAY REQUIRE PERIODIC TOP DRESSING WITH ADDITIONAL STONE AS CONDITIONS DEMAND AND/OR CLEANING OF ANY MEASURES USED TO TRAP SEDIMENT.
7. WHEELS SHALL BE CLEANED TO REMOVE SEDIMENT PRIOR TO ENTERING PUBLIC RIGHT-OF-WAYS. WHEN WASHING IS DONE, IT SHALL BE DONE IN AN AREA STABILIZED WITH AND WHICH DRAINS TO AN APPROVED SEDIMENT TRAPPING DEVICE.
8. ALL SEDIMENT SPILLED, DROPPED, WASHED, OR TRACKED ONTO A PUBLIC RIGHT-OF-WAY SHALL BE REMOVED IMMEDIATELY.
9. ACCESS PERMIT TO PUBLIC ROADS MUST BE OBTAINED PRIOR TO CONSTRUCTION.
10. EASEMENTS ARE SHOWN AT APPROXIMATE LOCATIONS.
11. CONTRACTOR SHALL REMOVE AND DISPOSE OF TRACK PAD MATERIAL AND STABILIZE THE AREA AT PROJECT COMPLETION.
SOLID WASTE CAP, LOCATED WITHIN SITE LIMITS.

B / C201 TRACKING PAD DETAIL
NOT TO SCALE



1. PREPARE SOIL BEFORE INSTALLING BLANKETS, INCLUDING ANY NECESSARY APPLICATION OF LIME, FERTILIZER, AND SEED. NOTE: WHEN USING CELL-O-SEED DO NOT SEED PREPARED AREA. CELL-O-SEED MUST BE INSTALLED WITH PAPER SIDE DOWN.

2. BEGIN AT THE TOP OF THE SLOPE BY ANCHORING THE BLANKET IN A 6" (15cm) DEEP X 6" (15cm) WIDE TRENCH WITH APPROXIMATELY 12" (30cm) OF BLANKET EXTENDED BEYOND THE UP-SLOPE PORTION OF THE TRENCH. ANCHOR THE BLANKET WITH A ROW OF STAPLES/STAKES APPROXIMATELY 12" (30cm) APART IN THE BOTTOM OF THE TRENCH. BACKFILL AND COMPACT THE TRENCH AFTER STAPLING. APPLY SEED TO COMPACTED SOIL AND FOLD REMAINING 12" (30cm) PORTION OF BLANKET BACK OVER SEED AND COMPACTED SOIL. SECURE BLANKET OVER COMPACTED SOIL WITH A ROW OF STAPLES/STAKES SPACED APPROXIMATELY 12" (30cm) APART ACROSS THE WIDTH OF THE BLANKET.

3. ROLL THE BLANKETS (A.) DOWN OR (B.) HORIZONTALLY ACROSS THE SLOPE. BLANKETS WILL UNROLL WITH APPROPRIATE SIDE AGAINST THE SOIL SURFACE. ALL BLANKETS MUST BE SECURELY FASTENED TO SOIL SURFACE BY PLACING STAPLES/STAKES IN APPROPRIATE LOCATIONS AS SHOWN IN THE STAPLE PATTERN GUIDE. WHEN USING OPTIONAL DOT SYSTEM , STAPLES/STAKES SHOULD BE PLACED THROUGH EACH OF THE COLORED DOTS CORRESPONDING TO THE APPROPRIATE STAPLE PATTERN.

4. THE EDGES OF PARALLEL BLANKETS MUST BE STAPLED WITH APPROXIMATELY 2"-5" (5cm-12.5cm) OVERLAP DEPENDING ON BLANKET TYPE. TO ENSURE PROPER SEAM ALIGNMENT, PLACE THE EDGE OF THE OVERLAPPING BLANKET (BLANKET BEING INSTALLED ON TOP) EVEN WITH THE COLORED SEAM STITCH ON THE PREVIOUSLY INSTALLED BLANKET.

5. CONSECUTIVE BLANKETS SPLICED DOWN THE SLOPE MUST BE PLACED END OVER END (SHINGLE STYLE) WITH AN APPROXIMATE 3" (7.5cm) OVERLAP. STAPLE THROUGH OVERLAPPED AREA, APPROXIMATELY 12" (30cm) APART ACROSS ENTIRE BLANKET WIDTH.

NOTE:
*IN LOOSE SOIL CONDITIONS, THE USE OF STAPLE OR STAKE LENGTHS GREATER THAN 6" (15cm) MAY BE NECESSARY TO PROPERLY SECURE THE BLANKETS.

SLOPE EROSION MAT SHALL BE IN ACCORDANCE WITH WISCONSIN DEPARTMENT OF NATURAL RESOURCES TECHNICAL STANDARD No. 1052.

C / C201 SLOPE EROSION MAT
NOT TO SCALE

AECOM
WWW.AECOM.COM
AECOM TECHNICAL SERVICES, Inc.
414-944-6080

PROJECT NUMBER: 60338307
SCALE: AS SHOWN | DRAWN: CJL | DATE: 05/07/2015
CHK'D/APPR'D: JJH | DATE: 05/07/2015

SOIL EROSION AND SEDIMENT CONTROL DETAILS

OAK CREEK MILLPOND
SLIDE GATE REHABILITATION
4400 N. ESTABROOK DRIVE
Milwaukee, Wisconsin

MILWAUKEE COUNTY DEPT. OF ADMIN
SERVICES - AE & ES SECTION
CITY CAMPUS 2711 W. WELLS ST - 2ND FLOOR MILWAUKEE, WI 53208

REVISIONS:

DATE: 05/07/2015
PROJECT: 9155-14650
SITE NO: N/A
BUILDING NO: N/A

C202

EMERGING POLLUTANTS IN SURFACE WATER: 2002-2009

APPENDIX J

Table J.1
Surface Water Quality Monitoring Results for Emerging Pollutants in the Mainstem of Oak Creek at 15th Avenue: 2002-2009

Compound	Samples Collected	Samples with Detections	Percent of Samples with Detections	Range of Concentrations (μg/l)[a]
		Antimicrobials		
Triclosan	32	1	3	<LOD-0.06[b]
		Aromatic Organic Compounds		
1,4-Dichlorobenzene	32	2	6	<LOD-0.026[b]
1-Naphthol	9	1	11	<LOD-0.0218[b]
3,4-Dichlorophenyl isocyanate	20	15	75	<LOD-32.5[b]
Benzophenone	32	8	25	<LOD-0.09[b]
Isopropylbenzene	32	0	0	<LOD
p-Cresol	32	8	25	<LOD-0.17[b]
Phenol	32	9	28	<LOD-0.86
		Corrosion Inhibitors		
5-Methyl-1H-benzotriazole	32	11	34	<LOD-0.9[b]
		Dyes		
9,10-Anthraquinone	32	23	72	<LOD-0.61
Carbazole	32	16	50	<LOD-0.328
		Flame Retardants		
Polybrominated diphenyl ether congener 47	20	0	0	<LOD
Triphenyl phosphate	32	9	28	<LOD-0.11[b]
Tris (2-butoxyethyl) phosphate	32	15	47	<LOD-0.59[b]
Tris (2-chloroethyl) phosphate	32	20	63	<LOD-0.42
Tris (dichloroisopropyl) phosphate	32	12	38	<LOD-0.24[b]
		Flavors and Fragrances		
Acetophenone	32	3	9	<LOD-0.2[b]
Camphor	32	12	38	<LOD-0.9[b]
D-Limonene	32	0	0	<LOD
Hexahydrohexamethyl cyclopentabenzopyran	32	1	3	<LOD-0.03[b]
Indole	32	4	6	<LOD-0.07[b]
Isoborneol	32	0	0	<LOD
Menthol	32	8	25	<LOD-0.16[b]
Methyl salicylate	32	5	16	<LOD-0.085[b]
		Food Preservatives		
3-tert-Butyl-4-hydroxyanisole	29	0	0	<LOD
		Hormone Precursors/Derivatives		
3-beta-Coprostanol	32	6	19	<LOD-3.2[b]
beta-Stigmastanol	32	3	9	<LOD-1.2
beta-Sitosterol	32	10	31	<LOD-4.3[b]
Cholesterol	32	19	59	<LOD-2.5[b]
		Polycyclic Aromatic Hydrocarbons		
1-Methylnaphthalene	35	13	37	<LOD-0.04[b]
2,6-Dimethylnaphthalene	32	13	41	<LOD-0.03[b]
2-Methylnaphthalene	35	15	43	<LOD-0.07[b]
9H-Fluorene	3	0	0	<LOD
Acenaphthene	3	0	0	<LOD
Acenaphthylene	3	0	0	<LOD
Anthracene	35	13	37	<LOD-0.18[b]
Benzo[a]anthracene	3	0	0	<LOD
Benzo[a]pyrene	35	13	37	<LOD-0.61
Benzo[b]fluoranthene	3	0	0	<LOD
Benzo[g,h,i]peryline	3	0	0	<LOD
Benzo[k]fluoranthene	3	0	0	<LOD

Table continued on next page.

Table J.1 (Continued)

Compound	Samples Collected	Samples with Detections	Percent of Samples with Detections	Range of Concentrations (μg/l)[a]
Polycyclic Aromatic Hydrocarbons (continued)				
Chrysene	3	0	0	<LOD
Dibenzo[a,h]anthracene	3	0	0	<LOD
Fluoranthene	35	26	74	<LOD-1.7
Indeno[1,2,3-cd]pyrene	3	0	0	<LOD
Naphthalene	35	14	40	<LOD-0.17[b]
Phenanthrene	35	23	66	<LOD-1.32
Pyrene	35	24	69	<LOD-1.15
Pharmaceutically Active Compounds				
Caffeine	32	20	63	<LOD-0.56
Cotinine	32	6	19	<LOD-0.360[b]
Isoquinoline	32	0	0	<LOD
Plasticizers				
4-Cumylphenol	32	4	13	<LOD-0.04[b]
Bisphenol A	26	11	42	<LOD-0.18[b]
Diethyl phthalate	20	1	5	<LOD-0.2[b]
Tributyl phosphate	32	27	84	<LOD-0.69
Triethyl citrate	32	1	3	<LOD-0.03[b]
Solvents				
Acetylhexamethyl tetrahydronaphthalene	32	0	0	<LOD
Isophorone	32	17	53	<LOD-18.2[b]
Tetrachloroethene	32	4	13	<LOD-0.01[b]
Tribromomethane	32	4	13	<LOD-0.07[b]
Surfactants				
4-n-Octophenol	32	0	0	<LOD
4-Nonylphenol	32	10	31	<LOD-2.0[b]
4-Nonylphenol diethoxylate	32	3	9	<LOD-4.5[b]
4-Nonylphenol monoethoxylate	32	20	0	<LOD
4-tert-Octylphenol	32	1	3	<LOD[c]
4-tert-Octylphenol diethoxylate	32	4	13	<LOD-0.5[b]
4-tert-Octylphenol monoethoxylate	32	1	3	<LOD-0.1[b]
Unclassified				
3-Methyl-1H-indole	32	3	9	<LOD-0.046[b]

[a] *<LOD indicates less than the limit of detection.*

[b] *Maximum concentration was estimated.*

[c] *This compound was detected but the concentration was not estimated.*

Source: U.S. Geological Survey and SEWRPC

APPENDIX K

PESTICIDES IN SURFACE WATER: 2002-2016

Table K.1
Surface Water Quality Monitoring Results for Pesticides in the Mainstem of Oak Creek at 15th Avenue: 2002-2016

Compound	2002-2009				2016			
	Samples Collected	Samples with Detections	Percent of Samples with Detections	Range of Concentrations (μg/l)[a]	Samples Collected	Samples with Detections	Percent of Samples with Detections	Range of Concentrations (μg/l)[a]
Fungicides								
Chloronitriles								
Chlorothalonil	--	--	--	--	9	0	0	<LOD
Dicarboximides								
Iprodione	9	0	0	<LOD	--	--	--	--
Phenylamides								
Metalaxyl	41	0	0	<LOD	9	0	0	<LOD
Strobiurins								
Azoxystrobin	--	--	--	--	9	0	0	<LOD
Triazoles								
Myclobutanil	9	0	0	<LOD	--	--	--	--
Propiconazole	--	--	--	--	9	0	0	<LOD
Herbicides and Transformation Products								
Amides/Anilides/Anilines								
Acetochlor	9	3	33	<LOD-0.09	9	0	0	<LOD
Acetochlor ethanesulfonic acid	--	--	--	--	9	0	0	<LOD
Acetochlor oxanilic acid	--	--	--	--	9	0	0	<LOD
Alachlor	9	1	11	<LOD-0.009	9	0	0	<LOD
2,6-Diethylalanine	9	0	0	<LOD	--	--	--	--
2-Chloro-2′,6′-diethylacetanilide	9	0	0	<LOD	--	--	--	--
Alachlor ethanesulfonic acid	--	--	--	--	9	0	0	<LOD
Alachlor oxanilic acid	--	--	--	--	9	0	0	<LOD
Benfluralin	9	2	22	<LOD-0.007[b]	9	0	0	<LOD
Dimethenamid	--	--	--	--	9	0	0	<LOD
Dimethenamid ethanesulfonic acid	--	--	--	--	9	0	0	<LOD
Dimethenamid oxanilic acid	--	--	--	--	9	0	0	<LOD
Ethalfluralin	--	--	--	--	9	0	0	<LOD
Fomesafen	--	--	--	--	9	0	0	<LOD
Metolachlor	20	8	40	<LOD-0.07[b]	9	0	0	<LOD
2-[(2-Ethyl-6-methylphenyl)amino]-1-propanol	2	0	0	<LOD	--	--	--	--
2-Ethyl-6-methylaniline	9	0	0	<LOD	--	--	--	--
Metolachlor ethanesulfonic acid	--	--	--	--	9	0	0	<LOD
Metolachlor oxanilic acid	--	--	--	--	9	0	0	<LOD

Table continued on next page.

Table K.1 (Continued)

Compound	2002-2009 Samples Collected	2002-2009 Samples with Detections	2002-2009 Percent of Samples with Detections	2002-2009 Range of Concentrations (μg/l)[a]	2016 Samples Collected	2016 Samples with Detections	2016 Percent of Samples with Detections	2016 Range of Concentrations (μg/l)[a]
Herbicides and Transformation Products (continued)								
Amides/Anilides/Anilines (continued)								
Pendimethalin	9	2	22	<LOD-0.046	9	0	0	<LOD
Propyzamide	9	0	0	<LOD	--	--	--	--
Trifluralin	9	5	56	<LOD-0.008[b]	9	0	0	<LOD
Aromatic Acids								
Aminopyralid	--	--	--	--	9	0	0	<LOD
Chloramben	--	--	--	--	9	0	0	<LOD
Clopyralid	--	--	--	--	9	0	0	<LOD
Dicamba	--	--	--	--	9	0	0	<LOD
Picloram	--	--	--	--	9	0	0	<LOD
Aryl Triazolinones								
Sulfentrazone	--	--	--	--	9	0	0	<LOD
Benzofurans								
Ethofumesate	--	--	--	--	9	0	0	<LOD
Benzonitriles								
Dichlorbenil	--	--	--	--	9	0	0	<LOD
Chloroarenes								
DCPA (Dacthal)	9	3	33	<LOD-0.0041	9	0	0	<LOD
Cyclodienes								
Flumetsulam	--	--	--	--	9	0	0	<LOD
Isoxazolidinones								
Clomazone	--	--	--	--	9	0	0	<LOD
Nitrophenyls								
Acifluorfen	--	--	--	--	9	0	0	<LOD
Oxidiazoles								
Oxadiazon	--	--	--	--	9	0	0	<LOD
Oxyacetamides								
Isoxaflutole	--	--	--	--	9	0	0	<LOD
RPA 202248	--	--	--	--	9	0	0	<LOD
Phenoxys								
2,4-D	--	--	--	--	9	7	78	<LOC-0.484
2,4-DB	--	--	--	--	9	0	0	<LOD
2,4,5-T	--	--	--	--	9	0	0	<LOD

Table continued on next page.

Table K.1 (Continued)

Compound	2002-2009				2016			
	Samples Collected	Samples with Detections	Percent of Samples with Detections	Range of Concentrations (μg/l)[a]	Samples Collected	Samples with Detections	Percent of Samples with Detections	Range of Concentrations (μg/l)[a]
Herbicides and Transformation Products (continued)								
Phenoxys (continued)								
Dichloroprop	--	--	--	--	9	0	0	<LOD
MCPA	--	--	--	--	9	0	0	<LOD
4-Chloro-2-methylphenol	9	5	56	<LOD-0.0130	--	--	--	--
MCPB	--	--	--	--	9	0	0	<LOD
Mecoprop	--	--	--	--	9	2	22	<LOD-0.0874
Silvex (Fenoprop)	--	--	--	--	9	0	0	<LOD
Pyridazinones								
Norfluazon	--	--	--	--	9	0	0	<LOD
Pyridines								
Fluroxypyr	--	--	--	--	9	0	0	<LOD
Imazapyr	--	--	--	--	9	5	56	<LOD-0.163
Imazethapyr	--	--	--	--	9	0	0	<LOD
Triclopyr	--	--	--	--	9	1	11	<LOD-0.209
Substituted Uracils								
Bromacil	32	7	22	<LOD-2.24	9	0	0	<LOD
Salflufenacil	--	--	--	--	9	0	0	<LOD
Thiadizines								
Bentazon	--	--	--	--	9	0	0	<LOD
Thiocarbimates								
Butylate	1	0	0	<LOD	--	--	--	--
Eptam	1	0	0	<LOD	9	0	0	<LOD
Triazines								
Atrazine	29	19	68	<LOD-0.49	9	1	11	<LOD-0.0581
Deethylatrazine	9	6	67	<LOD-0.098[b]	9	1	11	<LOD-0.765
Deisopropylatrazine	--	--	--	--	9	1	11	<LOD-0.0606
Diaminoatrazine	--	--	--	--	9	0	0	<LOD
Hexazinone	9	0	0	<LOD	9	0	0	<LOD
Prometon	37	16	43	<LOD-0.054	9	0	0	<LOD
Prometryn	9	0	0	<LOD	9	0	0	<LOD
Simazine	9	1	11	<LOD-0.048	9	0	0	<LOD
Terbuthylazine	9	0	0	<LOD	--	--	--	--

Table continued on next page.

Table K.1 (Continued)

	2002-2009				2016			
Compound	Samples Collected	Samples with Detections	Percent of Samples with Detections	Range of Concentrations (μg/l)[a]	Samples Collected	Samples with Detections	Percent of Samples with Detections	Range of Concentrations (μg/l)[a]
Herbicides and Transformation Products (continued)								
Triazolones								
Thiencarbazone-methyl	--	--	--	--	9	0	0	<LOD
Triazinones								
Metribuzin	9	0	0	<LOD	9	0	0	<LOD
Metribuzin DA	--	--	--	--	6	0	0	<LOD
Metribuzin DADK	--	--	--	--	6	0	0	<LOD
Triketones								
Bicyclopryone	--	--	--	--	9	0	0	<LOD
Mesotrione	--	--	--	--	9	0	0	<LOD
Tembotrione	--	--	--	--	9	0	0	<LOD
Ureas								
Diuron	--	--	--	--	9	4	44	<LOD-0.297
3,4-Dichloroaniline	8	4	50	<LOD-0.203	--	--	--	--
Halosulfuron-methyl	--	--	--	--	9	0	0	<LOD
Linuron	--	--	--	--	9	0	0	<LOD
Metsulfuron-methyl	--	--	--	--	9	0	0	<LOD
Nicosulfuron	--	--	--	--	9	0	0	<LOD
Sulfometuron-methyl	--	--	--	--	9	0	0	<LOD
Terbuthiuron	9	2	22	<LOD-0.014[b]	--	--	--	--
Herbicide Safeners[c]								
Unclassified								
Cyprosulfamide	--	--	--	--	9	0	0	<LOD
Insect Repellants								
Unclassified								
DEET (N,N-Diethyl-meta-toluamide)	32	22	69	<LOD-0.29	--	--	--	--
Insecticides and Transformation Products								
Carbimates								
Aldicarb	1	0	0	<LOD	--	--	--	--
Aldicarb sulfone	1	0	0	<LOD	9	0	0	<LOD
Aldicarb sulfoxide	1	0	0	<LOD	9	0	0	<LOD
Carbaryl	38	8	21	<LOD-0.267[b]	9	0	0	<LOD
Carbofuran	1	0	0	<LOD	9	0	0	<LOD
Methiocarb	1	0	0	<LOD	--	--	--	--

Table continued on next page.

Table K.1 (Continued)

Compound	2002-2009				2016			
	Samples Collected	Samples with Detections	Percent of Samples with Detections	Range of Concentrations (μg/l)[a]	Samples Collected	Samples with Detections	Percent of Samples with Detections	Range of Concentrations (μg/l)[a]
Insecticides and Transformation Products (continued)								
Carbimates (continued)								
Methomyl	1	0	0	<LOD	--	--	--	--
Oxamyl	1	0	0	<LOD	--	--	--	--
Propoxur	1	0	0	<LOD	--	--	--	--
Diamides								
Chlorantraniliprole	--	--	--	--	9	0	0	<LOD
Cyclaniliprole	--	--	--	--	9	0	0	<LOD
Neonicotinoids								
Acetamiprid	--	--	--	--	9	0	0	<LOD
Clothianidin	--	--	--	--	9	0	0	<LOD
Dinotefuran	--	--	--	--	9	0	0	<LOD
Flupyradifurone	--	--	--	--	9	0	0	<LOD
Imidacloprid	--	--	--	--	9	0	0	<LOD
Thiacloprid	--	--	--	--	9	0	0	<LOD
Thiamethoxam	--	--	--	--	9	0	0	<LOD
Organochlorides								
Dieldrin	9	0	0	<LOD	--	--	--	--
Pentachlorophenol	26	12	46	<LOD-3.1	--	--	--	--
Organophosphorus								
Azinphos-methyl	9	0	0	<LOD	--	--	--	--
Azinphos-methyl-oxon	9	0	0	<LOD	--	--	--	--
Chlorpyrifos	38	1	3	<LOD-0.02[b]	9	0	0	<LOD
Chlorpyrifos oxygen analog	9	0	0	<LOD	9	0	0	<LOD
Diazinon	38	5	13	<LOD-0.0455	9	0	0	<LOD
Diazoxon (Diazinon oxygen analog)	9	0	0	<LOD	9	0	0	<LOD
Dichlorvos	33	1	3	<LOD-0.02[b]	--	--	--	--
Dicrotophos	8	0	0	<LOD	--	--	--	--
Dimethoate	10	0	0	<LOD	9	0	0	<LOD
Ethion	9	0	0	<LOD	9	0	0	<LOD
Ethion monoxon	9	0	0	<LOD	9	0	0	<LOD
Fenamiphos	9	0	0	<LOD	9	0	0	<LOD
Fenamiphos sulfone	9	0	0	<LOD	9	0	0	<LOD
Fenamiphos sulfoxide	8	0	0	<LOD	9	0	0	<LOD

Table continued on next page.

Table K.1 (Continued)

Compound	2002-2009 Samples Collected	2002-2009 Samples with Detections	2002-2009 Percent of Samples with Detections	2002-2009 Range of Concentrations (μg/l)[a]	2016 Samples Collected	2016 Samples with Detections	2016 Percent of Samples with Detections	2016 Range of Concentrations (μg/l)[a]
Insecticides and Transformation Products (continued)								
Organophosphorus (continued)								
Fonofos	9	0	0	<LOD	--	--	--	--
Fonofos oxygen analog	7	0	0	<LOD	--	--	--	--
Isofenphos	9	0	0	<LOD	--	--	--	--
Malathion	10	1	10	<LOD-0.018[b]	9	0	0	<LOD
Malaoxon	9	0	0	<LOD	--	--	--	--
Methidathion	9	0	0	<LOD	--	--	--	--
Methyl-parathion	10	0	0	<LOD	9	0	0	<LOD
Methyl-paraoxon	9	0	0	<LOD	--	--	--	--
Parathion	1	0	0	<LOD	--	--	--	--
Phorate	10	0	0	<LOD	--	--	--	--
Phorate oxygen analog	9	0	0	<LOD	--	--	--	--
Phosmet	8	0	0	<LOD	--	--	--	--
Phosmet oxygen analog	7	0	0	<LOD	--	--	--	--
Phostebupirim (Tebupirimfos)	--	--	--	--	9	0	0	<LOD
Terbufos	10	0	0	<LOD	--	--	--	--
Terbufos oxygen analog sulfone	9	0	0	<LOD	--	--	--	--
Phenylpyrazoles								
Fipronil	9	0	0	<LOD	--	--	--	--
Desulfinylfipronil	9	0	0	<LOD	--	--	--	--
Desulfinylfipronil amide	9	3	33	<LOD-0.006[b]	--	--	--	--
Fipronil sulfide	9	1	11	<LOD-0.006[b]				
Fipronil sulfone	9	0	0	<LOD	--	--	--	--
Pyrethroids								
Bifenthrin	2	0	0	<LOD	--	--	--	--
Cis-Permethrin	9	0	0	<LOD	--	--	--	--
Cyfluthrin	11	0	0	<LOD	9	0	0	<LOD
Cyhalothrin	2	0	0	<LOD	9	0	0	<LOD
Cypermethrin	11	0	0	<LOD	9	0	0	<LOD
Esfenvalerate	2	0	0	<LOD	9	0	0	<LOD

[a] *<LOD indicates less than the limit of detection.*

[b] *Maximum concentration was estimated.*

[c] *Herbicide safeners are compounds that accelerate the decomposition of an herbicide.*

Source: U.S. Geological Survey, Wisconsin Department of Natural Resources, and SEWRPC

APPENDIX L

MACROINVERTEBRATE SURVEY DATA

Table L.1
Summary of Macroinvertebrate Data by Site in the Oak Creek Watershed: 1979-2015

Site Identification	Site Latitude	Site Longitude	Survey Date	Data Source	Number of Taxa Identified[a]	Total Number of Individuals
Lower Oak Creek						
10010371	42.907352	-87.84413	10/6/2003	SWIMS	7	173
10010371	42.907352	-87.84413	10/22/2015	SWIMS	19	172
UWP-OC-13	42.91	-87.8475	10/24/2015	UWP	15	416
UWP-OC-02	42.91222222	-87.85361111	10/24/2015	UWP	19	2,159
UWP-OC-03	42.91222222	-87.85194444	10/24/2015	UWP	15	431
431824	42.913113	-87.854355	10/8/1996	SWIMS	8	133
UWP-OC-01	42.915	-87.85638889	10/10/2015	UWP	13	353
413672	42.91531	-87.85753	5/17/1979	SWIMS	8	66
413672	42.91531	-87.85753	11/1/1979	SWIMS	7	125
413672	42.91531	-87.85753	10/8/1996	SWIMS	16	194
413672	42.91531	-87.85753	10/31/2008	SWIMS	18	134
413913	42.924778	-87.87097	10/8/1996	SWIMS	24	182
413913	42.924778	-87.87097	10/19/2012	SWIMS	20	168
413913	42.924778	-87.87097	10/22/2015	SWIMS	32	147
UWP-OC-04	42.92472222	-87.87083333	10/10/2015	UWP	18	1,664
04087204	42.925	-87.87	9/1/2004	BioData	35	337
04087204	42.925	-87.87	9/1/2004	USGS	30	286
04087204	42.925	-87.87	9/14/2007	USGS	36	175
04087204	42.925	-87.87	8/24/2010	USGS	35	305
04087204	42.925	-87.87	8/20/2013	USGS	21	207
10016379	42.91588	-87.87354	11/25/1985	SWIMS	6	133
10016397	42.916237	-87.873856	11/25/1985	SWIMS	5	32
10016263	42.909073	-87.87313	11/25/1985	SWIMS	21	103
10016205	42.908306	-87.87383	11/25/1985	SWIMS	12	116
10009331	42.90526	-87.88252	11/13/2000	SWIMS	30	173
10009331	42.90526	-87.88252	10/30/2002	SWIMS	20	196
10009331	42.90526	-87.88252	10/22/2015	SWIMS	29	186
413068	42.905155	-87.88118	10/8/1996	SWIMS	30	226
413068	42.905155	-87.88118	4/9/2009	SWIMS	27	191
UWP-OC-06	42.91777778	-87.86691472	10/10/2015	UWP	13	423
Middle Oak Creek						
UWP-OC-08	42.90527778	-88.88194444	10/10/2015	UWP	12	357
UWP-OC-07	42.90055556	-87.89305556	10/10/2015	UWP	19	503
413671	42.893375	-87.88951	5/17/1979	SWIMS	12	79
413671	42.893375	-87.88951	11/1/1979	SWIMS	6	24
413671	42.893375	-87.88951	11/25/1985	SWIMS	27	106
413671	42.893375	-87.88951	11/25/1985	SWIMS	13	114
413074	42.886314	-87.88568	11/25/1985	SWIMS	7	118
413074	42.886314	-87.88568	10/8/1996	SWIMS	24	231
413074	42.886314	-87.88568	10/9/1997	SWIMS	18	153
413074	42.886314	-87.88568	10/9/1997	SWIMS	30	247
413074	42.886314	-87.88568	11/5/2015	SWIMS	31	140
UWP-OC-12	42.88138889	-87.89222222	10/11/2015	UWP	18	340
Upper Oak Creek						
10016508	42.877575	-87.91029	11/25/1985	SWIMS	17	121
10016515	42.877586	-87.91016	10/8/1996	SWIMS	22	249
UWP-OC-10	42.87666667	-87.91333333	10/10/2015	UWP	16	327
10015873	42.870995	-87.92407	10/8/1996	SWIMS	11	165
10011237	42.8701	-87.930756	10/22/2015	SWIMS	16	131
413670	42.870247	-87.931366	5/17/1979	SWIMS	8	92
413670	42.870247	-87.931366	11/1/1979	SWIMS	5	116
413670	42.870247	-87.931366	10/7/2004	SWIMS	31	201
UWP-OC-11	42.87027778	-87.9325	10/10/2015	UWP	11	368
10044098	42.87289	-87.96491	10/22/2015	SWIMS	11	160

Table continued on next page.

Table L.1 (Continued)

Site Identification	Site Latitude	Site Longitude	Survey Date	Data Source	Number of Taxa Identified[a]	Total Number of Individuals
North Branch Oak Creek						
10039495	42.886864	-87.92453	11/5/2015	SWIMS	21	147
413833	42.88743	-87.92426	11/1/1979	SWIMS	9	20
413833	42.88743	-87.92426	10/9/1997	SWIMS	16	145
413833	42.88743	-87.92426	10/9/1997	SWIMS	16	146
10010544	42.8887	-87.92431	5/17/1979	SWIMS	7	86
10010544	42.8887	-87.92431	10/8/1996	SWIMS	17	152
10008115	42.88928	-87.92363	11/13/2000	SWIMS	30	161
UWP-OC-09	42.89944444	-87.92555556	10/11/2015	UWP	14	436
10044177	42.920517	-87.921364	11/5/2015	SWIMS	8	159
10016402	42.901806	-87.941956	10/9/1997	SWIMS	14	159
10016403	42.90181	-87.94196	10/9/1997	SWIMS	16	127
Mitchell Field Drainage Ditch						
10011281	42.907043	-87.892815	11/25/1985	SWIMS	21	122
10011281	42.907043	-87.892815	10/7/2004	SWIMS	34	187
10008241	42.91819	-87.89169	11/16/2001	SWIMS	22	186
10008241	42.91819	-87.89169	10/22/2015	SWIMS	11	138
413835	42.929996	-87.88998	10/8/1996	SWIMS	30	477

Note: Colors indicate surveys that were considered to share a common site when calculating the total sites and percent of sites in Table L.2.

[a] *The Data Source abbreviations are as follows: University of Wisconsin-Parkside (UWP), Wisconsin Department of Natural Resources Surface Water Integrated Monitoring System (SWIMS), the US Geological Survey BioData Retrieval system (BioData), and other US Geological Survey information sources (USGS).*

Source: University of Wisconsin Parkside, US Geological Survey, Wisconsin Department of Natural Resources, and SEWRPC

Table L.2
Macroinvertebrate Survey Data by Taxa in the Oak Creek Watershed; 1979-2015

Order	Family	Subfamily	Genus	Species	Number of Samples Detected	Percent of Samples Detected	Total Sites	Percent Sites
			Annelida					
Hirudinea[a]					6	8.8	6	20.0
Arhynchobdellida	Erpobdellidae				3	4.4	3	10.0
Arhynchobdellida	Erpobdellidae		Erpobdella	punctata	2	2.9	1	3.3
Arhynchobdellida	Erpobdellidae		Mooreobdella		1	1.5	1	3.3
Arhynchobdellida	Erpobdellidae		Mooreobdella	microstoma	1	1.5	1	3.3
Haplotaxida					8	11.8	6	20.0
Haplotaxida	Enchytraeidae				4	5.9	4	13.3
Haplotaxida	Lumbricidae				2	2.9	2	6.7
Haplotaxida	Naididae				8	11.8	6	20.0
Haplotaxida	Tubificidae				20	29.4	12	40.0
Haplotaxida	Tubificidae	Tubificinae without hairs			5	7.4	5	16.7
Lumbriculida	Lumbriculidae				2	2.9	2	6.7
Oligiochaeta[b]					4	5.9	4	13.3
Rhynchobdellida	Glossiphoniidae		Helobdella	stagnalis	6	8.8	6	20.0
			Arachnida					
Acari[c]					1	1.5	1	3.3
Araneae					3	4.4	3	10.0
Trombidiformes[d]					8	11.8	8	26.7
Trombidiformes	Hygrobatidae		Hygrobates		1	1.5	1	3.3
Trombidiformes	Limnesiidae		Limnesia		1	1.5	1	3.3
Trombidiformes	Sperchontidae		Sperchonopsis		1	1.5	1.5	3.3
			Crustacea					
Amphipoda					12	17.6	11	36.7
Amphipoda	Crangonuctidae		Crangonyx		7	10.3	6	20.0
Amphipoda	Crangonuctidae		Crangonyx	gracilis	1	1.5	1	3.3
Amphipoda	Crangonuctidae		Crangonyx	pseudogracilis	7	10.3	6	20.0
Amphipoda	Gammaridae		Gammarus	pseudolimnaeus	12	17.6	8	26.7
Amphipoda	Hyalellidae		Hyalella		14	20.6	8	26.7
Copepoda[e]					10	14.7	9	30.0
Decapoda					1	1.5	1	3.3
Decapoda	Cambaridae				1	1.5	1	3.3
Diplostraca[f]					7	10.3	6	20.0

Table continued on next page.

Table L.2 (Continued)

Order	Family	Subfamily	Genus	Species	Number of Samples Detected	Percent of Samples Detected	Total Sites	Percent Sites
Crustacea (continued)								
Isopoda					10	14.7	10	33.3
Isopoda	Asellidae				2	2.9	2	6.7
Isopoda	Asellidae		Caecidotea		9	13.2	5	16.7
Isopoda	Asellidae		Caecidotea	intermedia	44	64.7	22	73.3
Hydrozoa								
					4	5.9	4	13.3
Insecta								
Coleoptera	Dytiscidae				4	5.9	4	13.3
Coleoptera	Dytiscidae		Ilybius		1	1.5	1	3.3
Coleoptera	Elmidae				7	10.3	7	23.3
Coleoptera	Elmidae		Dubiraphia		15	22.1	11	36.7
Coleoptera	Elmidae		Dubiraphia	minima	4	5.9	4	13.3
Coleoptera	Elmidae		Dubiraphia	quadrinotata	11	16.2	7	23.3
Coleoptera	Elmidae		Dubiraphia	robusta	1	1.5	1	3.3
Coleoptera	Elmidae		Dubiraphia	vittata	3	4.4	1	3.3
Coleoptera	Elmidae		Macronychus		1	1.5	1	3.3
Coleoptera	Elmidae		Optioservus	fastiditus	2	2.9	2	6.7
Coleoptera	Elmidae		Stenelmis		33	48.5	12	40.0
Coleoptera	Elmidae		Stenelmis	crenata	20	29.4	12	40.0
Coleoptera	Haliplidae				3	4.4	3	10.0
Coleoptera	Hydrochidae		Hydrochus		1	1.5	1	3.3
Coleoptera	Hydrophilidae				1	1.5	1	3.3
Coleoptera	Limnichidae				2	2.9	2	6.7
Coleoptera	Staphylinidae				1	1.5	1	3.3
Collembola					7	10.3	6	20.0
Diptera					1	1.5	1	3.3
Diptera	Ceratopogonidae				8	11.8	7	23.3
Diptera	Ceratopogonidae		Bezzia/Palpomyia		2	2.9	2	6.7
Diptera	Ceratopogonidae		Culicoides		2	2.9	2	6.7
Diptera	Ceratopogonidae		Nilobezzia		2	2.9	2	6.7
Diptera	Ceratopogonidae		Probezzia		2	2.9	2	6.7
Diptera	Chironomidae				24	35.3	19	63.3
Diptera	Chironomidae		Pupa		5	7.4	5	16.7
Diptera	Chironomidae	Chironominae			11	16.2	9	30.0

Table continued on next page.

Table L.2 (Continued)

Order	Family	Subfamily	Genus	Species	Number of Samples Detected	Percent of Samples Detected	Total Sites	Percent Sites
Insecta (continued)								
Diptera	Chironomidae	Chironominae	Pupa		1	1.5	1	3.3
Diptera	Chironomidae	Chironominae	Chrionomus		10	14.7	8	26.7
Diptera	Chironomidae	Chironominae	Chrionomus	decorus group	1	1.5	1	3.3
Diptera	Chironomidae	Chironominae	Chironomus	stigmaterus	1	1.5	1	3.3
Diptera	Chironomidae	Chironominae	Cladotanytarsus	vanderwulpi group	1	1.5	1	3.3
Diptera	Chironomidae	Chironominae	Cryptochironomus		11	16.2	7	23.3
Diptera	Chironomidae	Chironominae	Dicrotendipes		9	13.2	8	26.7
Diptera	Chironomidae	Chironominae	Dicrotendipes	fumidus	1	1.5	1	3.3
Diptera	Chironomidae	Chironominae	Einfeldia		1	1.5	1	3.3
Diptera	Chironomidae	Chironominae	Glyptotendipes		1	1.5	1	3.3
Diptera	Chironomidae	Chironominae	Lauterborniella		1	1.5	1	3.3
Diptera	Chironomidae	Chironominae	Micropsectra		6	8.8	5	16.7
Diptera	Chironomidae	Chironominae	Micropsectra	pupa	2	2.9	2	6.7
Diptera	Chironomidae	Chironominae	Micropsectra/Tanytarsus		1	1.5	1	3.3
Diptera	Chironomidae	Chironominae	Microtendipes		2	2.9	2	6.7
Diptera	Chironomidae	Chironominae	Microtendipes	pedellus group	5	7.4	4	13.3
Diptera	Chironomidae	Chironominae	Parachironomus		1	1.5	1	3.3
Diptera	Chironomidae	Chironominae	Paratanytarsus		10	14.7	6	20.0
Diptera	Chironomidae	Chironominae	Paratanytarsus	pupa	1	1.5	1	3.3
Diptera	Chironomidae	Chironominae	Paratanytarsus	species A	5	7.4	5	16.7
Diptera	Chironomidae	Chironominae	Paratanytarsus	species B	7	10.3	6	20.0
Diptera	Chironomidae	Chironominae	Paratendipes		6	8.8	4	13.3
Diptera	Chironomidae	Chironominae	Phaenopsectra		5	7.4	5	16.7
Diptera	Chironomidae	Chironominae	Polypedilum		9	13.2	5	16.7
Diptera	Chironomidae	Chironominae	Polypedilum	flavum	12	17.6	8	26.7
Diptera	Chironomidae	Chironominae	Polypedilum	halterale group	1	1.5	1	3.3
Diptera	Chironomidae	Chironominae	Polypedilum	illinoense group	3	4.4	1	3.3
Diptera	Chironomidae	Chironominae	Polypedilum	scalaenum group	5	7.4	3	10.0
Diptera	Chironomidae	Chironominae	Polypedilum	species A	1	1.5	1	3.3
Diptera	Chironomidae	Chironominae	Polypedilum	tritum	2	2.9	1	3.3
Diptera	Chironomidae	Chironominae	Rheotanytarsus		7	10.3	5	16.7
Diptera	Chironomidae	Chironominae	Rheotanytarsus	exiguus group	2	2.9	2	6.7
Diptera	Chironomidae	Chironominae	Stenochironomus		3	4.4	3	10.0
Diptera	Chironomidae	Chironominae	Stictochironomus		30	44.1	15	50.0

Table continued on next page.

Table L.2 (Continued)

Order	Family	Subfamily	Genus	Species	Number of Samples Detected	Percent of Samples Detected	Total Sites	Percent Sites
Insecta (continued)								
Diptera	Chironomidae	Chironominae	Tanytarsus		5	7.4	4	13.3
Diptera	Chironomidae	Chironominae	Tribe Tanyarsini		1	1.5	1	3.3
Diptera	Chironomidae	Orthocladiinae			16	23.5	12	40.0
Diptera	Chironomidae	Orthocladiinae	Brillia		3	4.4	3	10.0
Diptera	Chironomidae	Orthocladiinae	Brilila	flavifrons	1	1.5	1	3.3
Diptera	Chironomidae	Orthocladiinae	Brilila	flavifrons group	6	8.8	4	13.3
Diptera	Chironomidae	Orthocladiinae	Chaetocladius		5	7.4	4	13.3
Diptera	Chironomidae	Orthocladiinae	Corynoneura		7	10.3	7	23.3
Diptera	Chironomidae	Orthocladiinae	Cricotopus		7	10.3	4	13.3
Diptera	Chironomidae	Orthocladiinae	Cricotopus	(subgenus)	2	2.9	1	3.3
Diptera	Chironomidae	Orthocladiinae	Cricotopus	pupa	3	4.4	3	10.0
Diptera	Chironomidae	Orthocladiinae	Cricotopus/Orthocladius		5	7.4	5	16.7
Diptera	Chironomidae	Orthocladiinae	Cricotopus	annulator complex	2	2.9	1	3.3
Diptera	Chironomidae	Orthocladiinae	Cricotopus	bicinctus	8	11.8	5	16.7
Diptera	Chironomidae	Orthocladiinae	Cricotopus	bicinctus group	8	11.8	8	26.7
Diptera	Chironomidae	Orthocladiinae	Cricotopus	fuscus group	1	1.5	1	3.3
Diptera	Chironomidae	Orthocladiinae	Cricotopus	infuscatus	2	2.9	2	6.7
Diptera	Chironomidae	Orthocladiinae	Cricotopus	infuscatus/triannulatus	4	5.9	2	6.7
Diptera	Chironomidae	Orthocladiinae	Cricotopus	intersectus group	1	1.5	1	3.3
Diptera	Chironomidae	Orthocladiinae	Cricotopus	tremulus group	3	4.4	3	10.0
Diptera	Chironomidae	Orthocladiinae	Cricotopus	trifascia	2	2.9	2	6.7
Diptera	Chironomidae	Orthocladiinae	Cricotopus	trifascia group	1	1.5	1	3.3
Diptera	Chironomidae	Orthocladiinae	Cryptocladopelma		1	1.5	1	3.3
Diptera	Chironomidae	Orthocladiinae	Eukiefferiella	claripennis group	2	2.9	2	6.7
Diptera	Chironomidae	Orthocladiinae	Hydorbaenus		1	1.5	1	3.3
Diptera	Chironomidae	Orthocladiinae	Limnophyes		6	8.8	6	20.0
Diptera	Chironomidae	Orthocladiinae	Nanocladius		5	7.4	4	13.3
Diptera	Chironomidae	Orthocladiinae	Nanocladius	c.f rectinervis	1	1.5	1	3.3
Diptera	Chironomidae	Orthocladiinae	Orthocladius		16	23.5	12	40.0
Diptera	Chironomidae	Orthocladiinae	Orthocladius	pupa	2	2.9	2	6.7
Diptera	Chironomidae	Orthocladiinae	Orthocladius	oliveri	3	4.4	2	6.7
Diptera	Chironomidae	Orthocladiinae	Parakiefferiella		4	5.9	4	13.3
Diptera	Chironomidae	Orthocladiinae	Parakiefferiella	pupa	1	1.5	1	3.3
Diptera	Chironomidae	Orthocladiinae	Parametirocnemus		7	10.3	6	20.0

Table continued on next page.

Table L.2 (Continued)

Order	Family	Subfamily	Genus	Species	Number of Samples Detected	Percent of Samples Detected	Total Sites	Percent Sites
			Insecta (continued)					
Diptera	Chironomidae	Orthocladiinae	Paratrichocladius		1	1.5	1.5	3.3
Diptera	Chironomidae	Orthocladiinae	Psectrocladius	pupa	1	1.5	1	3.3
Diptera	Chironomidae	Orthocladiinae	Rheocricotopus		3	4.4	3	10.0
Diptera	Chironomidae	Orthocladiinae	Rheocricotopus	robacki	2	2.9	1	3.3
Diptera	Chironomidae	Orthocladiinae	Thienemanniella		3	4.4	2	6.7
Diptera	Chironomidae	Tanypodinae			10	14.7	8	26.7
Diptera	Chironomidae	Tanypodinae	Conchapelopia		15	22.1	10	33.3
Diptera	Chironomidae	Tanypodinae	Macropelopia		1	1.5	1	3.3
Diptera	Chironomidae	Tanypodinae	Natarsia		1	1.5	1	3.3
Diptera	Chironomidae	Tanypodinae	Procladius		4	5.9	4	13.3
Diptera	Chironomidae	Tanypodinae	Psectrotanypus		3	4.4	3	10.0
Diptera	Chironomidae	Tanypodinae	Psectrotanypus	discolor	1	1.5	1	3.3
Diptera	Chironomidae	Tanypodinae	Rheopelopia		4	5.9	3	10.0
Diptera	Chironomidae	Tanypodinae	Tanypus		1	1.5	1	3.3
Diptera	Chironomidae	Tanypodinae	Thienemannimyia	group	1	1.5	1	3.3
Diptera	Chironomidae	Tanypodinae	Thienemannimyia	complex	1	1.5	1	3.3
Diptera	Chironomidae	Tanypodinae	Zavrelimyia		1	1.5	1	3.3
Diptera	Empididae				9	13.2	8	26.7
Diptera	Empididae			Pupa	1	1.5	1	3.3
Diptera	Empididae		Hemerodromia		22	32.4	13	43.3
Diptera	Empididae		Neoplasta		1	1.5	1	3.3
Diptera	Ephydridae				1	1.5	1	3.3
Diptera	Muscidae				1	1.5	1	3.3
Diptera	Psychodidae		Pericoma		1	1.5	1	3.3
Diptera	Simuliidae				4	5.9	4	13.3
Diptera	Simuliidae		Simulium		1	1.5	1	3.3
Diptera	Simuliidae		Simulium	aureum	1	1.5	1	3.3
Diptera	Simuliidae		Simulium	fibrinflatum	4	5.9	2	6.7
Diptera	Simuliidae		Simulium	fibrinflatum/jenningsi/luggeri	1	1.5	1	3.3
Diptera	Simuliidae		Simulium	jenningsi group	1	1.5	1	3.3
Diptera	Simuliidae		Simulium	venustum complex	1	1.5	1	3.3
Diptera	Simuliidae		Simulium	vittatum complex	15	22.1	10	33.3
Diptera	Syrphidae				1	1.5	1	3.3
Diptera	Syrphidae		Helophilus		1	1.5	1	3.3

Table continued on next page.

Table L.2 (Continued)

Order	Family	Subfamily	Genus	Species	Number of Samples Detected	Percent of Samples Detected	Total Sites	Percent Sites
Insecta (continued)								
Diptera	Tabanidae				1	1.5	1	3.3
Diptera	Tabanidae		Chrysops		4	5.9	4	13.3
Diptera	Tipulidae				2	2.9	2	6.7
Diptera	Tipulidae		Antocha		1	1.5	1	3.3
Diptera	Tipulidae		Erioptera		1	1.5	1	3.3
Diptera	Tipulidae		Pilaria		2	2.9	2	6.7
Diptera	Tipulidae		Tipula		7	10.3	5	16.7
Ephemeroptera	Baetidae				8	11.8	8	26.7
Ephemeroptera	Baetidae		Baetis		7	10.3	4	13.3
Ephemeroptera	Baetidae		Baetis	brunneicolor	8	11.8	6	20.0
Ephemeroptera	Baetidae		Baetis	flavistriga	4	5.9	1	3.3
Ephemeroptera	Baetidae		Baetis	flavistriga complex	7	10.3	5	16.7
Ephemeroptera	Baetidae		Baetis	intercalaris	15	22.1	7	23.3
Ephemeroptera	Baetidae		Callibaetis		3	4.4	2	6.7
Ephemeroptera	Caenidae				1	1.5	1	3.3
Ephemeroptera	Caenidae		Caenis		6	8.8	5	16.7
Ephemeroptera	Ephemeridae		Hexagenia	limbata	1	1.5	1	3.3
Ephemeroptera	Heptageniidae				6	8.8	5	16.7
Ephemeroptera	Heptageniidae		Stenacron	interpunctatum	29	42.6	14	46.7
Hemiptera	Belostomatidae		Belostoma	flumineum	1	1.5	1	3.3
Hemiptera	Corixidae				5	7.4	4	13.3
Hemiptera	Corixidae		Sigara		1	1.5	1	3.3
Hemiptera	Gerridae				1	1.5	1	3.3
Hemiptera	Mesoveliidae				1	1.5	1	3.3
Hemiptera	Nepidae		Ranatra		1	1.5	1	3.3
Hemiptera	Veliidae				1	1.5	1	3.3
Hemiptera	Veliidae		Microvelia	americana	1	1.5	1	3.3
Megaloptera	Sialidae		Sialis		1	1.5	1	3.3
Odonata	Aeschidae		Aeshna		2	2.9	2	6.7
Odonata	Calopterygidae				2	2.9	2	6.7
Odonata	Calopterygidae		Calopteryx		1	1.5	1	3.3
Odonata	Calopterygidae		Calopteryx	maculata	4	5.9	4	13.3
Odonata	Coenagrionidae				10	14.7	10	33.3
Odonata	Coenagrionidae		Coenagrion/Enallagma		1	1.5	1	3.3

Table continued on next page.

Table L.2 (Continued)

Order	Family	Subfamily	Genus	Species	Number of Samples Detected	Percent of Samples Detected	Total Sites	Percent Sites
Insecta (continued)								
Odonata	Coenagrionidae		Enallagma		6	8.8	5	16.7
Odonata	Coenagrionidae		Ischnura	verticalis	5	7.4	3	10.0
Plecoptera	Capniidae				1	1.5	1	3.3
Plecoptera	Taeniopterygidae		Taeniopteryx	nivalis	1	1.5	1	3.3
Trichoptera	Hydropsychidae				20	29.4	11	36.7
Trichoptera	Hydropsychidae		Ceratopsyche		4	5.9	2	6.7
Trichoptera	Hydropsychidae		Ceratopsyche	alhedra	5	7.4	4	13.3
Trichoptera	Hydropsychidae		Ceratopsyche	bronta	9	13.2	4	13.3
Trichoptera	Hydropsychidae		Ceratopsyche	bronta pupa	1	1.5	1	3.3
Trichoptera	Hydropsychidae		Ceratopsyche	morosa bifida form	2	2.9	1	3.3
Trichoptera	Hydropsychidae		Ceratopsyche	sparna	5	7.4	4	13.3
Trichoptera	Hydropsychidae		Cheumatopsyche		37	54.4	16	53.3
Trichoptera	Hydropsychidae		Cheumatopsyche	pupa	2	2.9	2	6.7
Trichoptera	Hydropsychidae		Cheumatopsyche	pettiti pupa	1	1.5	1	3.3
Trichoptera	Hydropsychidae		Hydropsyche		10	14.7	6	20.0
Trichoptera	Hydropsychidae		Hydropsyche	betteni	31	45.6	15	50.0
Trichoptera	Hydroptilidae				9	13.2	8	26.7
Trichoptera	Hydroptilidae			Pupa	2	2.9	2	6.7
Trichoptera	Hydroptilidae		Hydroptila		8	11.8	3	10.0
Trichoptera	Leptoceridae		Oecetis		2	2.9	2	6.7
Trichoptera	Philopotamidae		Chimarra	aterrima	1	1.5	1	3.3
Trichoptera	Philopotamidae		Chimarra	obscura	1	1.5	1	3.3
Trichoptera	Phryganeidae		Ptilostomis		1	1.5	1	3.3
Ostracoda								
					9	13.2	9	30.0
Mollusca								
Basommatophora					1	1.5	1	3.3
Basommatophora	Ancylidae				3	4.4	2	6.7
Basommatophora	Ancylidae		Ferrissia		3	4.4	2	6.7
Basommatophora	Ancylidae		Laevapex		2	2.9	2	6.7
Basommatophora	Physidae				1	1.5	1	3.3
Basommatophora	Physidae		Haitia	acuta	1	1.5	1	3.3
Basommatophora	Physidae		Physa		13	19.1	9	30.0
Basommatophora	Planorbidae				1	1.5	1	3.3

Table continued on next page.

Table L.2 (Continued)

Order	Family	Subfamily	Genus	Species	Number of Samples Detected	Percent of Samples Detected	Total Sites	Percent Sites
Mollusca (continued)								
Gastropoda					9	13.2	8	26.7
Neotaenioglossa	Hydrobiidae				3	4.4	2	6.7
Bivalvia[g]					8	11.8	8	26.7
Veneroida	Pisidiidae				4	5.9	3	10.0
Veneroida	Pisidiidae		Pisidium		5	7.4	5	16.7
Veneroida	Pisidiidae		Sphaerium		15	22.1	11	36.7
Nematoda								
					1	1.5	1	3.3
Mermithida					6	8.8	5	16.7
Nematomorpha								
					1	1.5	1	3.3
Turbellaria								
					6	8.8	5	16.7
Tricladida					15	22.1	9	30.0

Note: Rows without more detailed taxonomic identifications (i.e., Order to Species) indicate data for individuals that were only identified to the taxonomic grouping in the sub-header.

[a] *Subclass includes Acanthobdellidea and Euhirudinea—this includes Glossiphoniidae, Arhychobdellida, and Rhynchobdellida.*

[b] *Subclass that includes Haplotaxida and Lumbriculida.*

[c] *Subclass.*

[d] *Includes Hydracarina.*

[e] *Includes orders Calanoida, Cyclopoida, and Harpacticoida.*

[f] *Includes Cladocera.*

[g] *Class which includes order Veneroida.*

Source: University of Wisconsin-Parkside, US Geological Survey, Wisconsin Department of Natural Resources, and SEWRPC

APPENDIX M

WATER QUALITY SIMULATION MODEL AND POLLUTANT LOADS FROM THE RWQMPU

RELATIONSHIP OF THE OAK CREEK WATERSHED RESTORATION PLAN TO THE REGIONAL WATER QUALITY MANAGEMENT PLAN

As noted previously in this report, the Oak Creek watershed restoration plan builds on the framework established under the 2007 SEWRPC regional water quality management plan update (RWQMPU) for the greater Milwaukee watersheds.[1] Chapter 2 of this watershed restoration plan summarizes 1) the recommendations of the RWQMPU as they relate to the Oak Creek watershed and 2) the status of implementation of those recommendations within the watershed. This appendix summarizes the water quality modeling analyses conducted under the RWQMPU and describes how the modeling results for the Oak Creek component of the recommended RWQMPU can be applied directly to estimate water quality improvements that would be expected from implementing the recommended watershed restoration plan set forth in Chapter 6 of this report.

WATER QUALITY MODELING

Under the RWQMPU, a comprehensive, watershed-based, calibrated and validated U.S. Environmental Protection Agency (USEPA) HSPF continuous simulation model was developed to simulate pollutant loads and instream water quality conditions in the streams of the Oak Creek watershed.[2] This model has been used extensively across the country to develop water quality restoration plans through the Federal Clean Water Act Total Maximum Daily Load (TMDL) Program. The HSPF model is particularly suited to modeling water quality conditions in the Oak Creek watershed because it:

- Can be used on watersheds with both rural and urban land uses
- Can be used to simulate all of the constituents of interest for the RWQMPU

---

[1] *SEWRPC Planning Report No. 50,* A Regional Water Quality Management Plan Update for the Greater Milwaukee Watersheds, *December 2007 and* Amendment to the Regional Water Quality Management Plan for the Greater Milwaukee Watersheds, *May 2013.*

[2] *U.S. Environmental Protection Agency, Environmental Research Laboratory,* Hydrological Simulation Program-Fortran, User's Manual for Release 12, *Athens Georgia, March 2001.*

- Allows long-term continuous simulations to predict hydrologic and water quality variability
- Provides adequate temporal resolution to facilitate a direct comparison to water quality standards
- Simulates surface runoff and subsurface flows
- Simulates receiving stream water quality processes in addition to land surface loads

Under the RWQMPU, the HSPF model was applied to estimate pollutant loads and instream pollutant concentrations over a 10-year simulation period representing meteorological conditions from 1988 through 1997.[3] The HSPF model of the Oak Creek watershed was applied to represent then-existing year 2000 land use conditions and also planned year 2020 (baseline) land use conditions. Water quality conditions were simulated and evaluated at 10 assessment points along the Oak Creek mainstem and tributaries (see Map 5.1 in Chapter 5 of this report).

WATER QUALITY RESULTS OF THE RWQMPU MODELING ANALYSES

Under the RWQMPU, alternative plans were developed to represent different approaches to improving water quality under planned 2020 land use conditions through combinations of point source pollution controls and implementing agricultural and urban best management practices and green infrastructure.

Four of the five pollutants identified for abatement under this watershed restoration plan—total suspended solids, total phosphorus, total nitrogen, and fecal coliform bacteria—were modeled under the RWQMPU along with several other pollutants.[4] The pertinent water quality indicators used to compare the plans are set forth in Table L.1. The RWQMPU alternative plans were evaluated as to their ability to cost-effectively meet a set of planning objectives related primarily to water quality management, land use development, and outdoor recreation and open space preservation.

The recommended RWQMPU plan was synthesized from the most effective components of the alternatives, and it consists of a combination of point source controls and urban and rural nonpoint source controls. The USEPA HSPF water quality model developed to represent recommended plan conditions explicitly accounted for the following rural and urban nonpoint source pollution control measures:

- Reducing soil erosion from cropland to the tolerable soil loss rate as determined by the U.S. Natural Resources Conservation Service
- Establishing riparian buffers with a minimum width of 75 feet on each side of streams
- Converting 10 percent of existing cropland to wetland or prairie conditions
- Expanding oversight of private onsite wastewater treatment systems
- Implementing nonagricultural (urban) performance standards established by the State of Wisconsin in Chapter NR 151, "Runoff Management," of the *Wisconsin Administrative Code*
- Establishing coordinated programs to detect and eliminate illicit discharges to storm sewer systems and to control urban-sourced pathogens that are harmful to human health
- Infiltrating residential roof drain runoff in rain gardens, or similar green infrastructure practices at 30 percent of the homes in the study area

---

[3] *This simulation period was selected because it was determined to be representative of the long-term precipitation statistics as measured at the National Weather Service Milwaukee Mitchell International Airport weather station for the 63-year period from 1940 through 2002.*

[4] *The fifth pollutant considered under this planning effort is chloride. Chloride loads and concentrations were not computed by the RWQMPU water quality model.*

Table M.1
Water Quality Indicators Used to Compare Alternative Plans in the RWQMPU

Water Quality Parameter	Indicator
Fecal Coliform Bacteria over the Entire Year	Arithmetic mean concentration of fecal coliform bacteria Proportion of time fecal coliform bacteria concentration is equal to or below the single sample criterion Geometric mean concentration of fecal coliform bacteria Days per year geometric mean of fecal coliform bacteria concentration is equal to or below the geometric mean criterion
Fecal Coliform Bacteria from May to September[a]	Arithmetic mean concentration of fecal coliform bacteria Proportion of time fecal coliform bacteria concentration is equal to or below the single sample criterion Geometric mean concentration of fecal coliform bacteria Days per year geometric mean of fecal coliform bacteria concentration is equal to or below the geometric mean criterion
Total Phosphorus	Mean concentration of total phosphorus Median concentration of total phosphorus Proportion of time total phosphorus concentration is equal to or below the recommended planning standard
Total Suspended Solids	Mean concentration of total suspended solids Median concentration of total suspended solids

[a] *This time period represents the body contact recreation season when bacteria concentrations are of the greatest interest.*

Source: SEWRPC

These measures are also generally included in the recommended watershed restoration plan described in Chapter 6. Thus, the degree to which implementing the watershed restoration plan described in the chapter would be expected to improve instream water quality can be inferred from the comprehensive water quality modeling results set forth in the report documenting the regional water quality management plan for the greater Milwaukee watersheds[5] and briefly summarized in the next paragraph.

Implementing the recommended RWQMPU plan, and the recommended watershed restoration plan which is set forth in Chapter 6 of this report and which adds detail to the RWQMPU recommendations, would be expected to result in significant reductions in instream mean and median concentrations of total suspended solids,[6] total phosphorus,[7] and total nitrogen[8] and in mean and geometric mean concentrations of fecal coliform bacteria. Relative to then-existing year 2000 conditions, implementing the recommended plan would be expected to result in significant improvements in the levels of compliance with the geometric mean standard for fecal coliform bacteria, and generally more modest increases in the level of compliance with the single sample standard along the mainstem of Oak Creek and many tributaries.[9]

The load reductions required to achieve recommended RWQMPU conditions, and which have been adopted as reduction targets under this watershed restoration plan, are set forth in Tables 5.2, 5.4, 5.6, and 5.9 in Chapter 5 of this report.

ADJUSTMENT OF MODELED LOADS TO DEVELOP POLLUTANT LOAD REDUCTION TARGETS

Numerical targets for some of the pollutants selected for reductions by this watershed restoration plan can be derived from the results of the RWQMPU model. These targets and the reductions in mean and median

[5] *SEWRPC Planning Report No. 50,* op. cit. *and* Amendment to the Regional Water Quality Management Plan for the Greater Milwaukee Watersheds, *May 2013.*

[6] *See Table 5.5 in Chapter 5 of this report.*

[7] *See Table 5.3 in Chapter 5 of this report.*

[8] *See Table 5.10 in Chapter 5 of this report.*

[9] *See Tables 5.7 and 5.8 in Chapter 5 of this report.*

instream pollutant concentrations derived from the water quality simulation model used in the RWQMPU are presented and discussed in Chapter 5 of this report.

The RWQMPU made recommendations whose implementation would act to reduce contributions of phosphorus, TSS, fecal coliform bacteria, and total nitrogen. These recommendations were summarized, and the status of their implementation was reviewed in Chapter 2 of this report. The RWQMPU also included estimates of pollutant loads of these water quality constituents to the stream system that would occur under three sets of conditions.[10] These conditions include:

- Existing condition: Representing watershed conditions as of the year 2000

- Revised 2020 Baseline condition: The condition projected to occur in 2020 under planned 2020 land use conditions, assuming full implementation of the urban stormwater runoff performance standards set forth in Chapter NR 151, "Runoff Management," of the *Wisconsin Administrative Code,* but without implementation of the recommendations of the RWQMPU

- Recommended Plan condition: The condition projected to occur under planned 2020 land use conditions, assuming full implementation of both the urban stormwater runoff performance standards set forth in NR 151 and the recommendations of the RWQMPU[11]

These estimates were made using the calibrated and validated water quality simulation model described above.[12] The estimated pollutant loads associated with each of these three conditions are given in Tables L.2 through L.5. Maps L.1 though L.8 show comparisons of the estimated existing condition pollutant loads and per acre pollutant loads among the subwatersheds of the Oak Creek watershed.

It is important to note that for total phosphorus, TSS, fecal coliform bacteria, and total nitrogen the portion of the pollutant loads contributed by point sources is quite low under all three conditions described above.[13] On a whole watershed basis, point sources are estimated to have contributed less than 1 percent of the total phosphorus load, less than 0.1 percent of the TSS load, less than 1 percent of the fecal coliform bacteria load and less than 1 percent of the total nitrogen load under both the Existing (2000) condition and the Recommended Plan (2020) condition. Given that point sources are estimated to contribute these small percentages of the loads of these pollutants, the management objectives and targets for this watershed restoration plan should focus on nonpoint sources. The reductions in nonpoint source loads between the Existing (2000) condition and the Recommended Plan (2020) condition that are envisioned in the RWQMPU define targets to be met in order to improve water quality conditions in the Oak Creek watershed.

---

[10] *SEWRPC Planning Report No. 50,* op. cit. *and* Amendment to the Regional Water Quality Management Plan for the Greater Milwaukee Watersheds, *May 2013.*

[11] *The RWQMPU included pollutant load estimates for two additional conditions: A Revised 2020 Baseline condition with a five-year level of protection to control against sanitary sewer overflows (five-year LOP) and an Extreme Measures condition. In the Oak Creek watershed, the estimated pollutant loads under the Revised 2020 Baseline with a five-year LOP condition were identical to the estimated pollutant loads under the Revised 2020 Baseline condition. The Extreme Measures condition examined a level of nonpoint source controls in excess of the levels envisioned under the recommended plan and envisioned the virtual elimination of phosphorus from discharges of industrial noncontact cooling water. In the Oak Creek watershed at most locations, the degree of compliance with applicable water quality standards under the Extreme Measures condition, as estimated by the calibrated water quality simulation model, was similar to the degree of compliance under the Recommended Plan condition, although more significant improvements in compliance were indicated for fecal coliform bacteria.*

[12] *The calibrated and validated water quality model is described in more detail, and its results are presented and discussed in SEWRPC Planning Report No. 50, op. cit. The results presented here incorporate revisions made to Planning Report No. 50 in a May 2013 plan amendment that corrected errors in the calculation of mean and median concentrations of total phosphorus and total nitrogen at some water quality assessment locations.*

[13] *While municipal separate storm sewer systems (MS4s) are regulated under the Wisconsin Pollutant Discharge Elimination System as point sources, their discharges have much in common with nonpoint sources. These discharges and the associated pollutant loading are intermittent and usually occur as the result of runoff events driven by precipitation or snowmelt. Because of this, the RWQMPU model treated pollutant loads from MS4 discharges as nonpoint source pollution and these loads are included in the urban nonpoint totals in Tables L.2 through L.5.*

Table M.2
Average Annual Total Phosphorus Loads for the Oak Creek Watershed Taken from the RWQMPU

			Point Sources (pounds)			Nonpoint Sources (pounds)[a,b]			
Subwatershed	Assessment Areas	Condition	Industrial Point Sources	SSOs	Subtotal	Urban	Rural[c]	Subtotal	Total (pounds)
Upper Oak Creek	Oak Creek Headwaters, Upper Oak Creek	Existing (2000)	0	0	0	1,360	170	1,530	1,530
		Revised (2020) Baseline	0	0	0	1,270	120	1,390	1,390
		Recommended Plan (2020)	0	0	0	1,150	110	1,300	1,300
Middle Oak Creek	Middle Oak Creek, Oak Creek Drainage Ditches	Existing (2000)	0	0	0	1,310	980	2,290	2,290
		Revised (2020) Baseline	0	0	0	1,230	1,050	2,280	2,280
		Recommended Plan (2020)	0	0	0	1,160	970	2,130	2,130
Lower Oak Creek	Lower Oak Creek, Lower Oak Creek-Millpond, Grant Park Ravine	Existing (2000)	10	10	20	2,200	40	2,240	2,260
		Revised (2020) Baseline	10	10	20	1,830	20	1,850	1,870
		Recommended Plan (2020)	10	10	20	1,730	20	1,750	1,770
North Branch Oak Creek	Upper North Branch Oak Creek, Lower North Branch Oak Creek, College Avenue Tributary, Rawson Avenue Tributary, Drexel Avenue Tributary, Southland Creek	Existing (2000)	0	0	0	2,650	510	3,160	3,160
		Revised (2020) Baseline	0	0	0	2,370	520	2,890	2,890
		Recommended Plan (2020)	0	0	0	1,950	460	2,410	2,410
Mitchell Field Drainage Ditch	Lower Mitchell Field Drainage Ditch, Mitchell Field Drainage Ditch-Airport	Existing (2000)	<10	0	<10	980	410	1,390	1,390
		Revised (2020) Baseline	<10	0	<10	950	350	1,300	1,300
		Recommended Plan (2020)	<10	0	<10	730	260	990	990
	Watershed Total	Existing (2000)	10	10	20	8,500	2,110	10,610	10,630
		Revised (2020) Baseline	10	10	20	7,650	2,060	9,710	9,730
		Recommended Plan (2020)	10	10	20	6,760	1,820	8,580	8,600

[a] *Certain apparent anomalies in the relationship between urban and nonpoint source loads are due to the manner in which the loads were apportioned. In those cases, the loads in the nonpoint subtotal column generally exhibit the anticipated relationships between conditions.*

[b] *In certain limited cases, relatively minor anomalies in nonpoint source pollutant loads may occur among the three conditions for which the model results are presented in this table. Those anomalies might indicate a relatively slight increased load under the recommended plan condition relative to the revised 2020 baseline. In those cases, it may be assumed that no significant change in pollutant load occurs among those conditions. Since it was not always possible to explicitly represent certain components of the recommended plan condition in the water quality model, adjustments were made to model parameters that served as surrogates for the actual water pollution control measures being represented. In the sense that these modifications sometimes alter parameters established under the revised 2020 baseline model version, in limited cases, representation of a measure in the recommended plan model may have a side effect of introducing small, relatively insignificant anomalies in the comparative results.*

[c] *For reporting purposes, certain land uses such as forests and wetlands have been categorized as rural sources even though they may exist in a predominantly urban setting.*

Source: Brown and Caldwell, Tetra Tech, Inc., and SEWRPC

Table M.3
Average Annual Total Suspended Solids Loads for the Oak Creek Watershed Taken from the RWQMPU

Subwatershed	Assessment Areas	Condition	Point Sources (pounds) Industrial Point Sources	Point Sources (pounds) SSOs	Point Sources (pounds) Subtotal	Nonpoint Sources (pounds)[a,b] Urban	Nonpoint Sources (pounds)[a,b] Rural[c]	Nonpoint Sources (pounds)[a,b] Subtotal	Total (pounds)
Upper Oak Creek	Oak Creek Headwaters, Upper Oak Creek	Existing (2000)	0	0	0	663,060	156,240	819,300	819,300
		Revised (2020) Baseline	0	0	0	513,460	10,710	524,170	524,170
		Recommended Plan (2020)	0	0	0	532,840	10,360	543,200	543,200
Middle Oak Creek	Middle Oak Creek, Oak Creek Drainage Ditches	Existing (2000)	0	0	0	685,780	387,670	1,073,450	1,073,450
		Revised (2020) Baseline	0	0	0	528,200	102,730	630,930	630,930
		Recommended Plan (2020)	0	0	0	545,020	102,060	647,080	647,080
Lower Oak Creek	Lower Oak Creek, Lower Oak Creek-Millpond, Grant Park Ravine	Existing (2000)	1,930	500	2,430	974,250	23,560	997,810	1,000,240
		Revised (2020) Baseline	1,930	500	2,430	689,780	3,970	693,750	696,180
		Recommended Plan (2020)	1,930	500	2,430	692,760	3,970	696,730	699,160
North Branch Oak Creek	Upper North Branch Oak Creek, Lower North Branch Oak Creek, College Avenue Tributary, Rawson Avenue Tributary, Drexel Avenue Tributary, Southland Creek	Existing (2000)	0	0	0	1,558,560	212,030	1,770,590	1,770,590
		Revised (2020) Baseline	0	0	0	1,169,670	50,010	1,219,680	1,219,680
		Recommended Plan (2020)	0	0	0	1,012,020	47,270	1,059,290	1,059,290
Mitchell Field Drainage Ditch	Lower Mitchell Field Drainage Ditch, Mitchell Field Drainage Ditch-Airport	Existing (2000)	<10	0	<10	532,620	108,810	641,430	641,430
		Revised (2020) Baseline	<10	0	<10	438,880	29,820	468,700	468,700
		Recommended Plan (2020)	<10	0	<10	364,090	23,660	387,750	387,750
	Watershed Total	Existing (2000)	1,930	500	2,430	4,414,270	888,310	5,302,580	5,305,010
		Revised (2020) Baseline	1,930	500	2,430	3,339,990	197,240	3,537,230	3,539,660
		Recommended Plan (2020)	1,930	500	2,430	3,146,730	187,320	3,334,050	3,336,480

[a] *Certain apparent anomalies in the relationship between urban and nonpoint source loads are due to the manner in which the loads were apportioned. In those cases, the loads in the nonpoint subtotal column generally exhibit the anticipated relationships between conditions.*

[b] *In certain limited cases, relatively minor anomalies in nonpoint source pollutant loads may occur among the three conditions for which the model results are presented in this table. Those anomalies might indicate a relatively slight increased load under the recommended plan condition relative to the revised 2020 baseline. In those cases, it may be assumed that no significant change in pollutant load occurs among those conditions. Since it was not always possible to explicitly represent certain components of the recommended plan condition in the water quality model, adjustments were made to model parameters that served as surrogates for the actual water pollution control measures being represented. In the sense that these modifications sometimes alter parameters established under the revised 2020 baseline model version, in limited cases, representation of a measure in the recommended plan model may have a side effect of introducing small, relatively insignificant anomalies in the comparative results.*

[c] *For reporting purposes, certain land uses such as forests and wetlands have been categorized as rural sources even though they may exist in a predominantly urban setting.*

Source: Brown and Caldwell; Tetra Tech, Inc., and SEWRPC

Table M.4
Average Annual Fecal Coliform Bacteria Loads for the Oak Creek Watershed Taken from the RWQMPU

			Point Sources (trillion cells)			Nonpoint Sources (trillion cells)[a,b]			
Subwatershed	Assessment Areas	Condition	Industrial Point Sources	SSOs	Subtotal	Urban	Rural[c]	Subtotal	Total (trillion cells)
Upper Oak Creek	Oak Creek Headwaters, Upper Oak Creek	Existing (2000)	0.00	0.00	0.00	354.83	7.39	362.22	362.22
		Revised (2020) Baseline	0.00	0.00	0.00	310.06	6.17	316.23	316.23
		Recommended Plan (2020)	0.00	0.00	0.00	201.08	4.16	205.24	205.24
Middle Oak Creek	Middle Oak Creek, Oak Creek Drainage Ditches	Existing (2000)	0.00	0.00	0.00	394.77	96.09	490.86	490.86
		Revised (2020) Baseline	0.00	0.00	0.00	357.33	100.90	458.23	458.23
		Recommended Plan (2020)	0.00	0.00	0.00	227.44	66.76	294.20	294.20
Lower Oak Creek	Lower Oak Creek, Lower Oak Creek-Millpond, Grant Park Ravine	Existing (2000)	0.00	9.55	9.55	612.67	0.33	613.00	622.55
		Revised (2020) Baseline	0.00	9.55	9.55	493.55	0.10	493.65	503.20
		Recommended Plan (2020)	0.00	9.55	9.55	315.86	0.10	315.96	325.51
North Branch Oak Creek	Upper North Branch Oak Creek, Lower North Branch Oak Creek, College Avenue Tributary, Rawson Avenue Tributary, Drexel Avenue Tributary, Southland Creek	Existing (2000)	0.00	0.00	0.00	735.48	39.60	775.08	775.08
		Revised (2020) Baseline	0.00	0.00	0.00	646.58	47.39	693.97	693.97
		Recommended Plan (2020)	0.00	0.00	0.00	359.89	30.36	390.25	390.25
Mitchell Field Drainage Ditch	Lower Mitchell Field Drainage Ditch, Mitchell Field Drainage Ditch-Airport	Existing (2000)	0.00	0.00	0.00	505.12	36.28	541.40	541.40
		Revised (2020) Baseline	0.00	0.00	0.00	524.29	28.76	553.05	553.05
		Recommended Plan (2020)	0.00	0.00	0.00	269.75	15.19	284.94	284.94
		Existing (2000)	0.00	9.55	9.55	2,602.87	179.69	2,782.56	2,792.11
	Watershed Total	Revised (2020) Baseline	0.00	9.55	9.55	2,331.81	183.32	2,515.13	2,524.68
		Recommended Plan (2020)	0.00	9.55	9.55	1,374.02	116.57	1,490.59	1,500.14

[a] *Certain apparent anomalies in the relationship between urban and nonpoint source loads are due to the manner in which the loads were apportioned. In those cases, the loads in the nonpoint subtotal column generally exhibit the anticipated relationships between conditions.*

[b] *In certain limited cases, relatively minor anomalies in nonpoint source pollutant loads may occur among the three conditions for which the model results are presented in this table. Those anomalies might indicate a relatively slight increased load under the recommended plan condition relative to the revised 2020 baseline. In those cases, it may be assumed that no significant change in pollutant load occurs among those conditions. Since it was not always possible to explicitly represent certain components of the recommended plan condition in the water quality model, adjustments were made to model parameters that served as surrogates for the actual water pollution control measures being represented. In the sense that these modifications sometimes alter parameters established under the revised 2020 baseline model version, in limited cases, representation of a measure in the recommended plan model may have a side effect of introducing small, relatively insignificant anomalies in the comparative results.*

[c] *For reporting purposes, certain land uses such as forests and wetlands have been categorized as rural sources even though they may exist in a predominantly urban setting.*

Source: Brown and Caldwell; Tetra Tech, Inc., and SEWRPC

Table M.5
Average Annual Total Nitrogen Loads for the Oak Creek Watershed Taken from the RWQMPU

			Point Sources (pounds)			Nonpoint Sources (pounds)[a,b]			
Subwatershed	**Assessment Areas**	**Condition**	Industrial Point Sources	SSOs	Subtotal	Urban	Rural[c]	Subtotal	**Total (pounds)**
Upper Oak Creek	Oak Creek Headwaters, Upper Oak Creek	Existing (2000)	0	0	0	9,180	4,910	14,090	14,090
		Revised (2020) Baseline	0	0	0	9,000	1,140	10,140	10,140
		Recommended Plan (2020)	0	0	0	8,920	1,130	10,050	10,050
Middle Oak Creek	Middle Oak Creek, Oak Creek Drainage Ditches	Existing (2000)	0	0	0	9,240	13,810	23,050	23,050
		Revised (2020) Baseline	0	0	0	8,950	8,280	17,230	17,230
		Recommended Plan (2020)	0	0	0	8,920	8,290	17,210	17,210
Lower Oak Creek	Lower Oak Creek, Lower Oak Creek-Millpond, Grant Park Ravine	Existing (2000)	340	20	360	15,280	1,010	16,290	16,650
		Revised (2020) Baseline	340	20	360	13,320	380	13,700	14,060
		Recommended Plan (2020)	340	20	360	13,350	380	13,730	14,090
North Branch Oak Creek	Upper North Branch Oak Creek, Lower North Branch Oak Creek, College Avenue Tributary, Rawson Avenue Tributary, Drexel Avenue Tributary, Southland Creek	Existing (2000)	0	0	0	17,590	8,790	26,380	26,380
		Revised (2020) Baseline	0	0	0	16,500	4,490	20,990	20,990
		Recommended Plan (2020)	0	0	0	14,290	4,280	18,570	18,570
Mitchell Field Drainage Ditch	Lower Mitchell Field Drainage Ditch, Mitchell Field Drainage Ditch-Airport	Existing (2000)	<10	0	<10	9,360	7,580	16,940	16,940
		Revised (2020) Baseline	<10	0	<10	9,060	4,630	13,690	13,690
		Recommended Plan (2020)	<10	0	<10	7,340	3,740	11,080	11,080
	Watershed Total	Existing (2000)	340	20	360	60,650	36,100	96,750	97,110
		Revised (2020) Baseline	340	20	360	56,830	18,920	75,750	76,110
		Recommended Plan (2020)	340	20	360	52,820	17,820	70,640	71,000

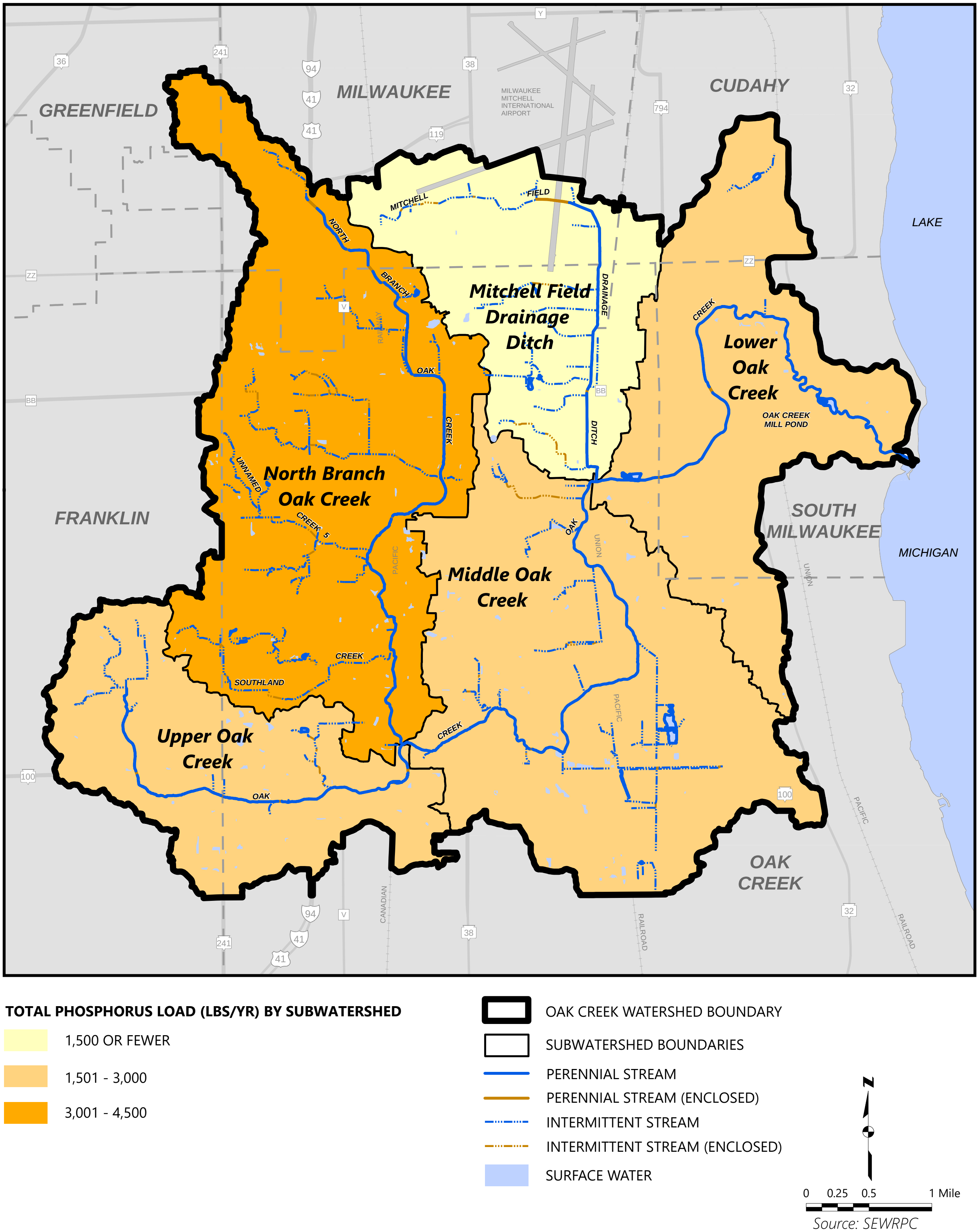
[a] *Certain apparent anomalies in the relationship between urban and nonpoint source loads are due to the manner in which the loads were apportioned. In those cases, the loads in the nonpoint subtotal column generally exhibit the anticipated relationships between conditions.*

[b] *In certain limited cases, relatively minor anomalies in nonpoint source pollutant loads may occur among the three conditions for which the model results are presented in this table. Those anomalies might indicate a relatively slight increased load under the recommended plan condition relative to the revised 2020 baseline. In those cases, it may be assumed that no significant change in pollutant load occurs among those conditions. Since it was not always possible to explicitly represent certain components of the recommended plan condition in the water quality model, adjustments were made to model parameters that served as surrogates for the actual water pollution control measures being represented. In the sense that these modifications sometimes alter parameters established under the revised 2020 baseline model version, in limited cases, representation of a measure in the recommended plan model may have a side effect of introducing small, relatively insignificant anomalies in the comparative results.*

[c] *For reporting purposes, certain land uses such as forests and wetlands have been categorized as rural sources even though they may exist in a predominantly urban setting.*

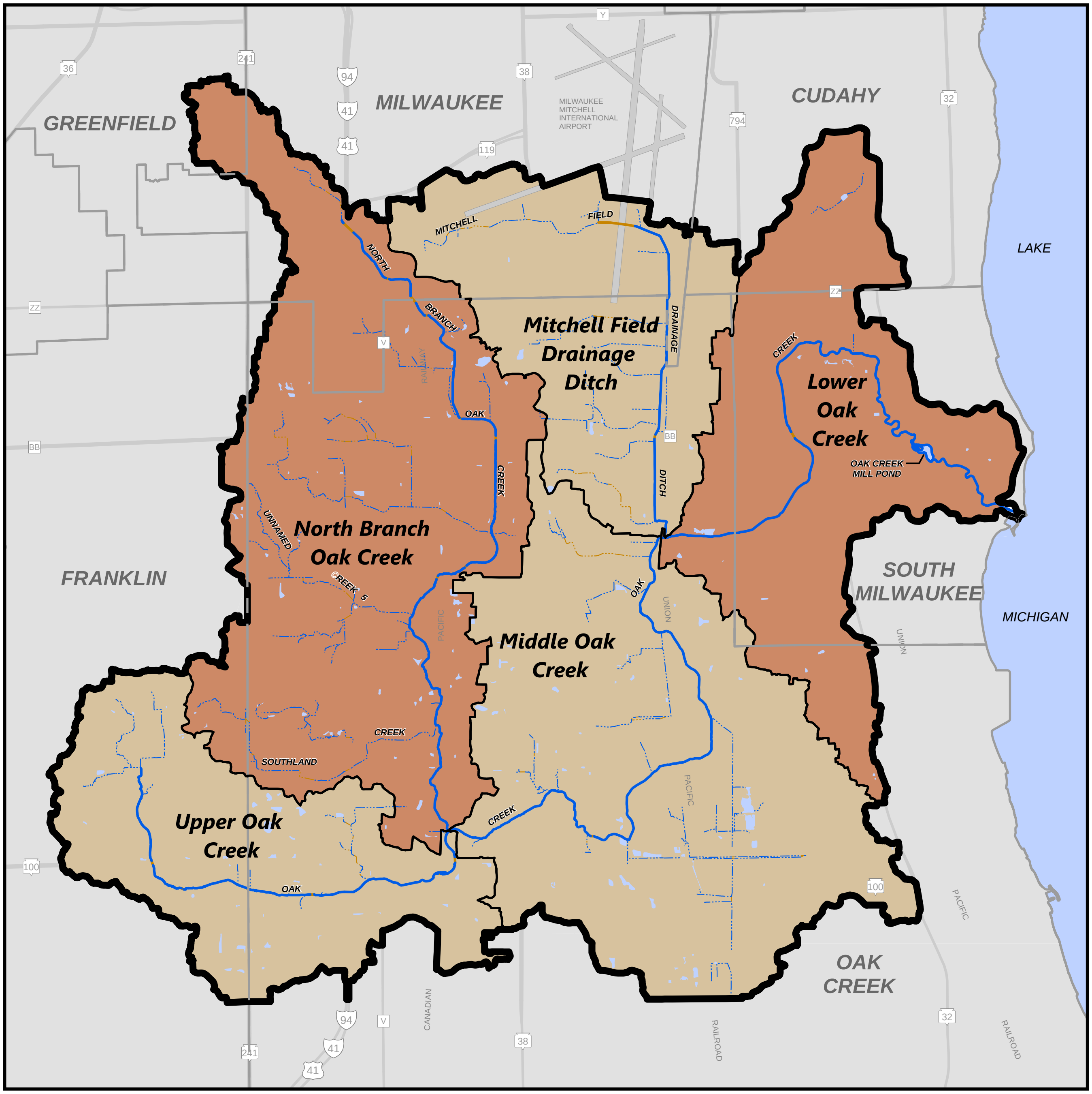
Source: Brown and Caldwell; Tetra Tech, Inc., and SEWRPC

Map M.1
Estimated Average Annual Nonpoint Source Pollution Loads of Total Phosphorus in the Oak Creek Watershed



Source: SEWRPC

Map M.2
Estimated Average Annual per Acre Nonpoint Source Pollution Loads of Total Phosphorus in the Oak Creek Watershed



TOTAL PHOSPHORUS UNIT AREA LOAD (LBS/ACRE/YR)

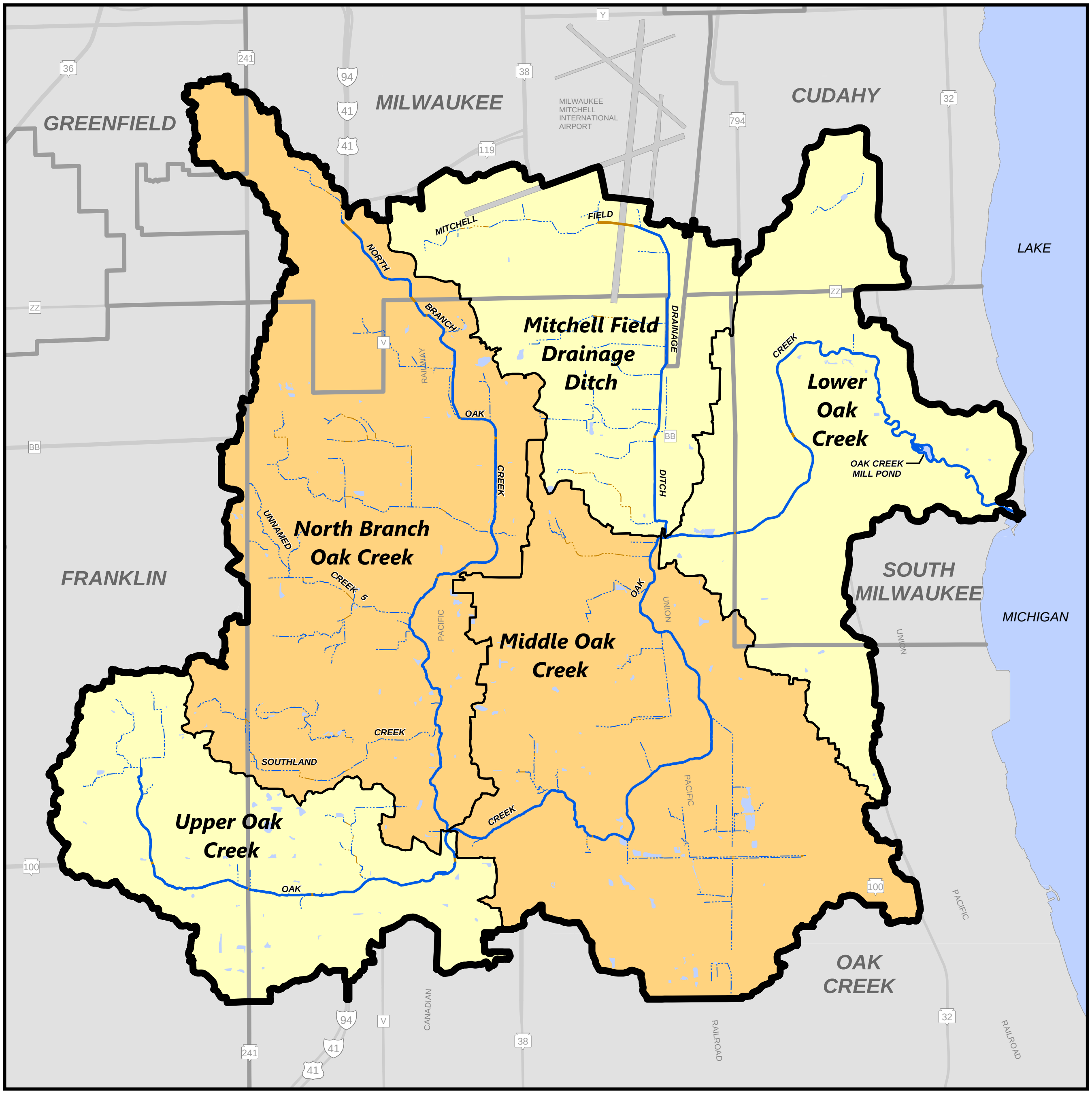
- 0.46 - 0.60
- 0.61 - 0.75

- OAK CREEK WATERSHED BOUNDARY
- SUBWATERSHED BOUNDARY
- PERENNIAL STREAM
- PERENNIAL STREAM (ENCLOSED)
- INTERMITTENT STREAM
- INTERMITTENT STREAM (ENCLOSED)
- SURFACE WATER

0 0.25 0.5 1 Mile

Source: SEWRPC

Map M.3
Estimated Average Annual Nonpoint Source Pollution Loads of Total Suspended Solids in the Oak Creek Watershed



TOTAL SUSPENDED SOLIDS LOAD (LBS/YR) BY SUBWATERSHED

1,000,000 OR FEWER

1,000,001- 2,000,000

OAK CREEK WATERSHED BOUNDARY

SUBWATERSHED BOUNDARY

PERENNIAL STREAM

PERENNIAL STREAM (ENCLOSED)

INTERMITTENT STREAM

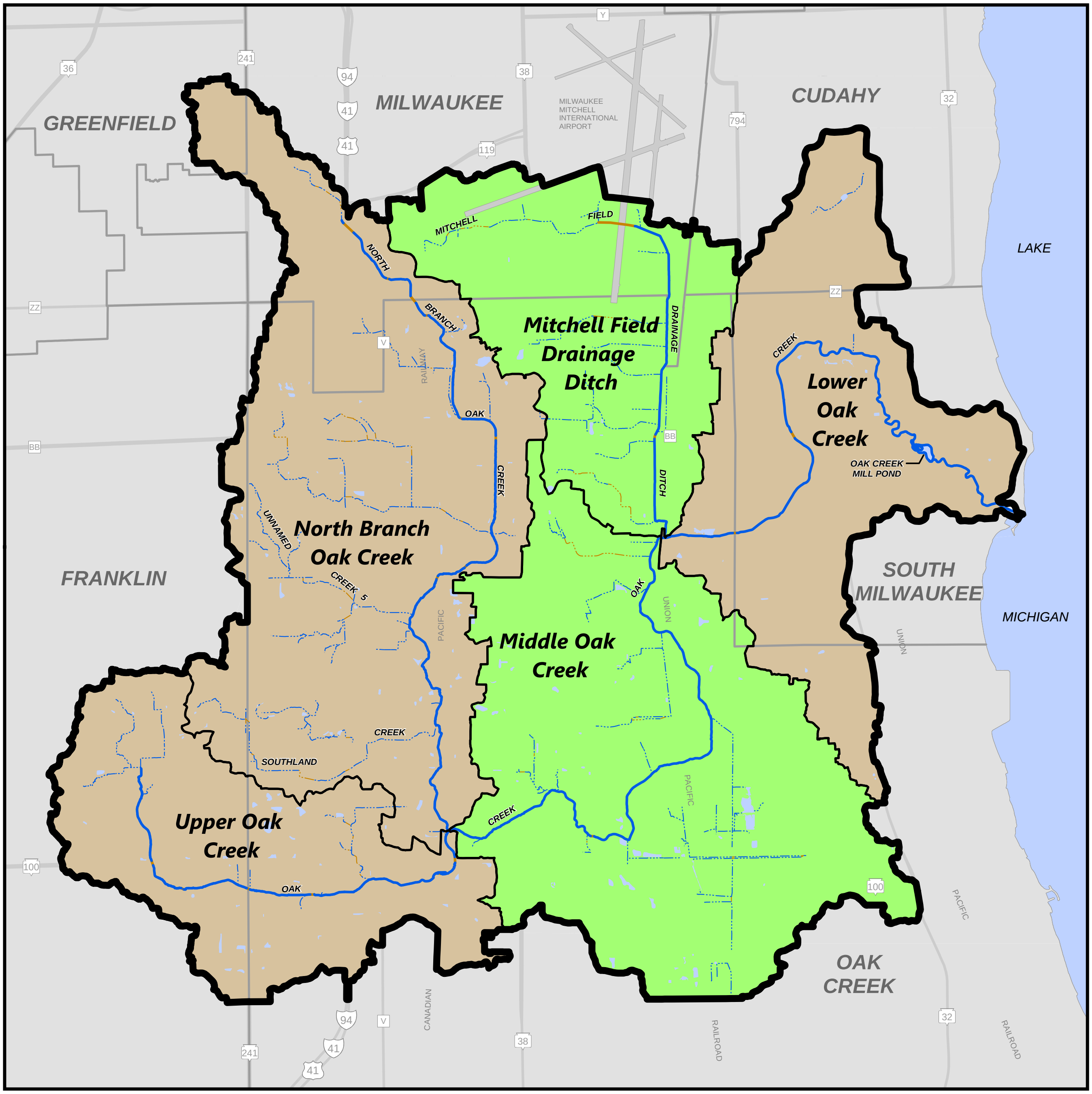
INTERMITTENT STREAM (ENCLOSED)

SURFACE WATER

0 0.25 0.5 1 Mile

Source: SEWRPC

Map M.4
Estimated Average Annual per Acre Nonpoint Source Pollution Loads of Total Suspended Solids in the Oak Creek Watershed



TOTAL SUSPENDED SOLIDS UNIT AREA LOAD (LBS/ACRE/YR)

201 - 300

301 - 400

OAK CREEK WATERSHED BOUNDARY

SUBWATERSHED BOUNDARY

PERENNIAL STREAM

PERENNIAL STREAM (ENCLOSED)

INTERMITTENT STREAM

INTERMITTENT STREAM (ENCLOSED)

SURFACE WATER

0 0.25 0.5 1 Mile

Source: SEWRPC

Map M.5
Estimated Average Annual Nonpoint Source Pollution Loads of Fecal Coliform Bacteria in the Oak Creek Watershed

FECAL COLIFORM BACTERIA LOAD (TRILLION CELLS/YR) BY SUBWATERSHED

1,000 OR FEWER

OAK CREEK WATERSHED BOUNDARY

SUBWATERSHED BOUNDARY

PERENNIAL STREAM

PERENNIAL STREAM (ENCLOSED)

INTERMITTENT STREAM

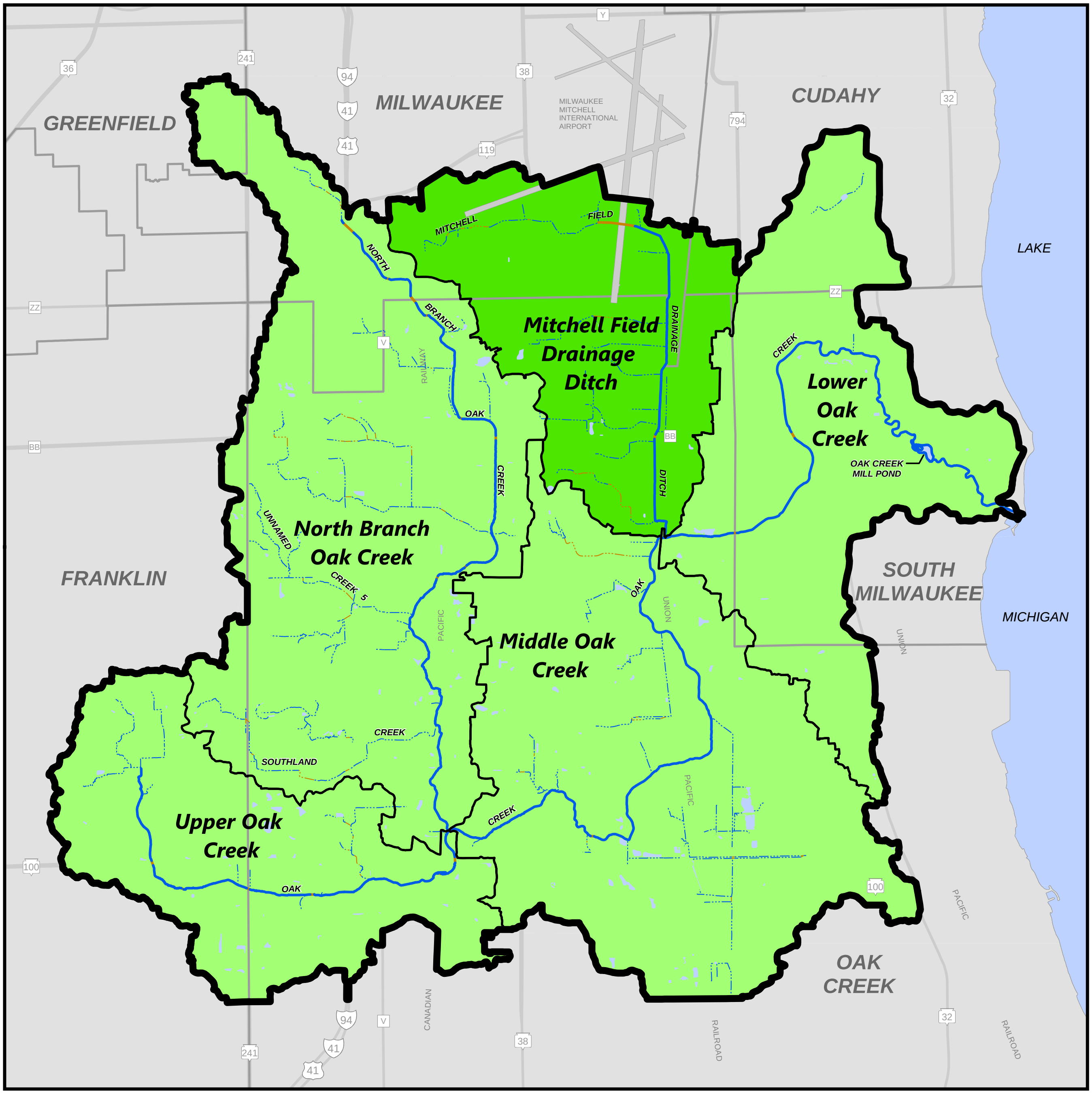
INTERMITTENT STREAM (ENCLOSED)

SURFACE WATER

0 0.25 0.5 1 Mile

Source: SEWRPC

Map M.6
Estimated Average Annual per Acre Nonpoint Source Pollution Loads of Fecal Coliform Bacteria in the Oak Creek Watershed



TOTAL FECAL COLIFORM BACTERIA UNIT AREA LOAD (TRILLION CELLS/ACRE/YR)

0.11 - 0.20

0.21 - 0.30

OAK CREEK WATERSHED BOUNDARY

SUBWATERSHED BOUNDARY

PERENNIAL STREAM

PERENNIAL STREAM (ENCLOSED)

INTERMITTENT STREAM

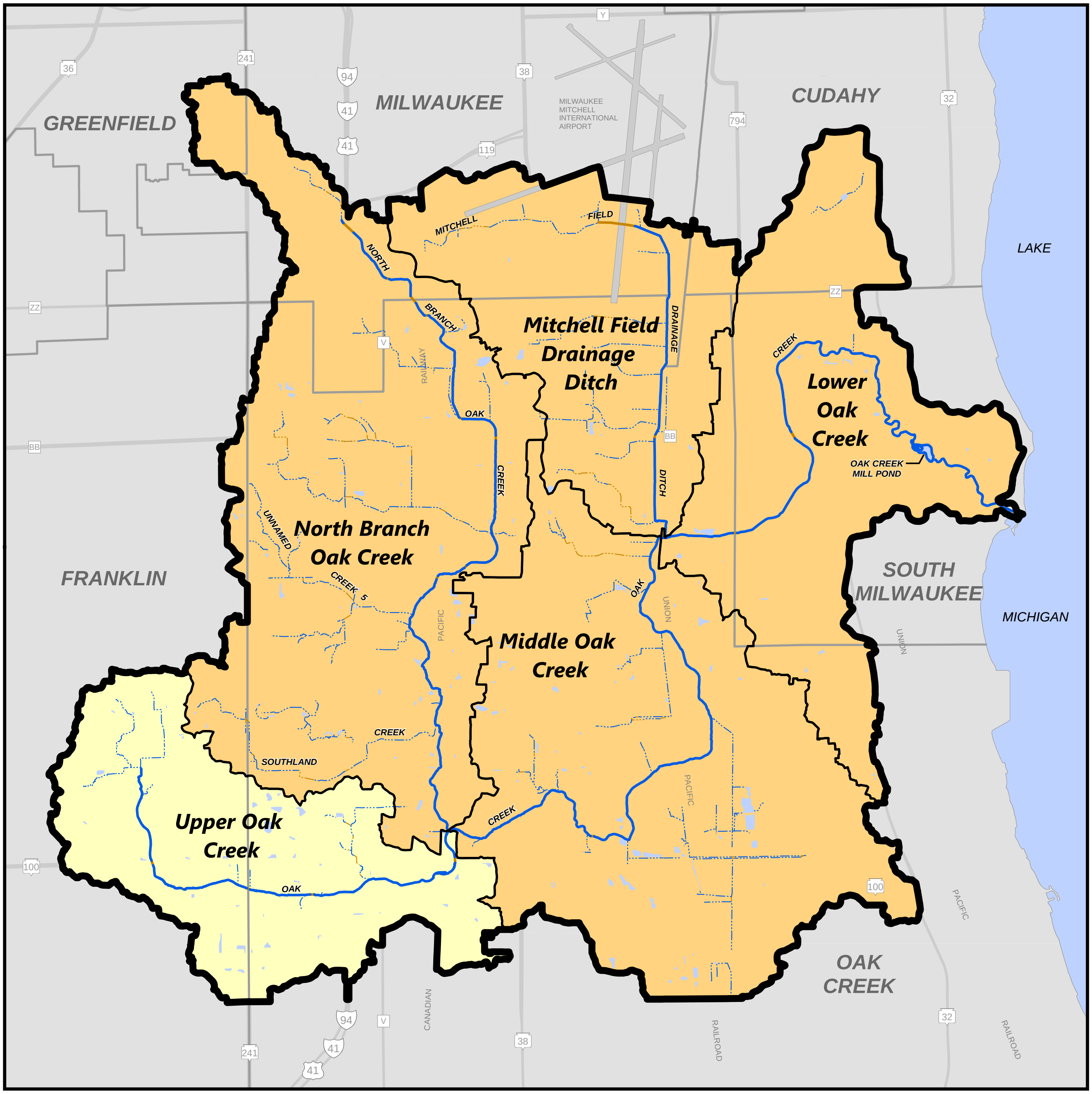
INTERMITTENT STREAM (ENCLOSED)

SURFACE WATER

0 0.25 0.5 1 Mile

Source: SEWRPC

Map M.7
Estimated Average Annual Nonpoint Source Pollution Loads of Total Nitrogen in the Oak Creek Watershed



NITROGEN LOAD (LBS/YR) BY SUBWATERSHED

15,000 OR FEWER

15,001 - 30,000

OAK CREEK WATERSHED BOUNDARY

SUBWATERSHED BOUNDARY

PERENNIAL STREAM

PERENNIAL STREAM (ENCLOSED)

INTERMITTENT STREAM

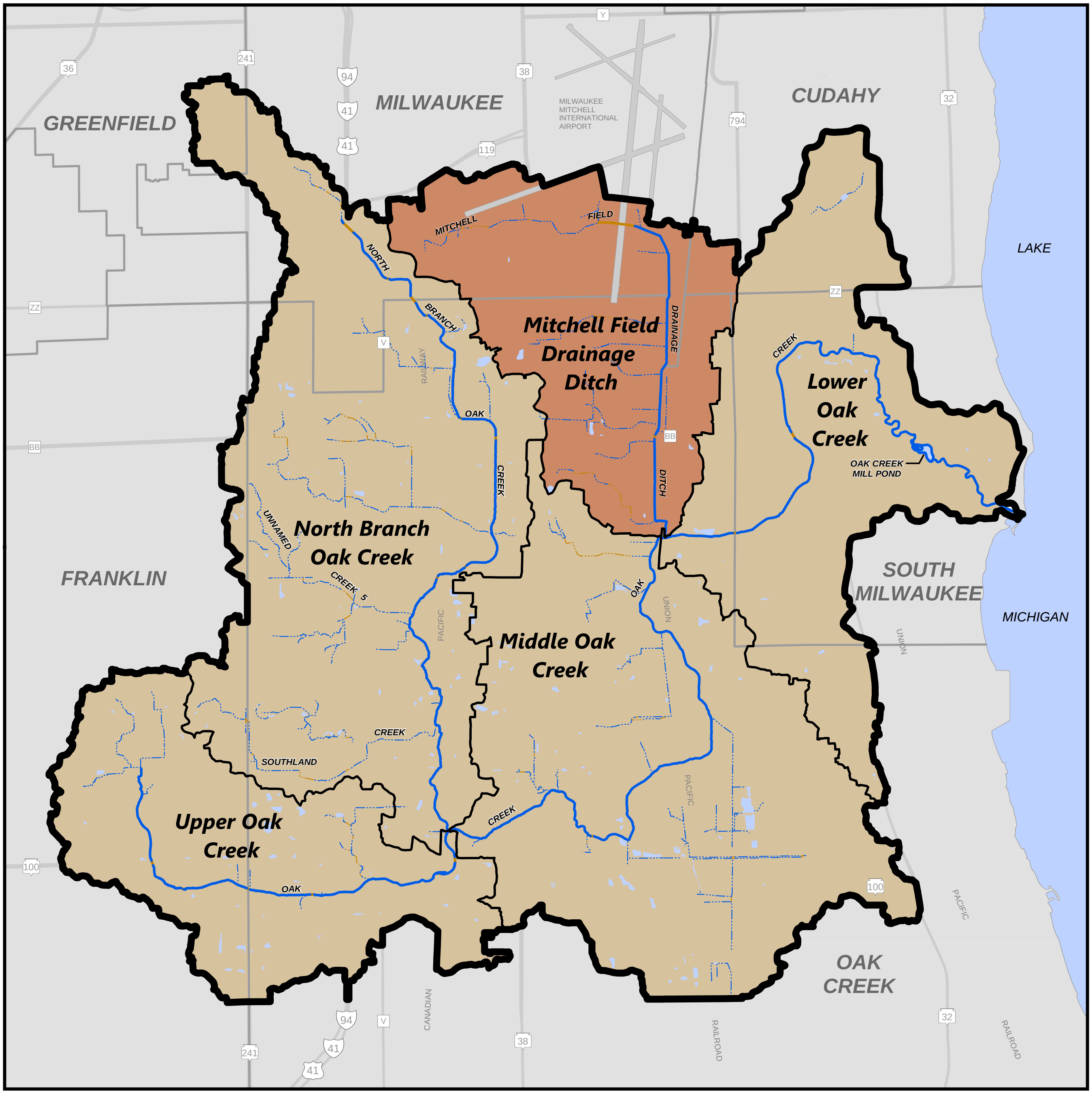
INTERMITTENT STREAM (ENCLOSED)

SURFACE WATER

0 0.25 0.5 1 Mile

Source: SEWRPC

Map M.8
Estimated Average Annual per Acre Nonpoint Source Pollution Loads of Total Nitrogen in the Oak Creek Watershed



TOTAL NITROGEN UNIT AREA LOAD (LBS/ACRE/YR)

4.51 - 6.00

6.01 - 7.50

OAK CREEK WATERSHED BOUNDARY

SUBWATERSHED BOUNDARY

PERENNIAL STREAM

PERENNIAL STREAM (ENCLOSED)

INTERMITTENT STREAM

INTERMITTENT STREAM (ENCLOSED)

SURFACE WATER

N

0 0.25 0.5 1 Mile

Source: SEWRPC

The RWQMPU targets were refined in two ways for the Oak Creek watershed restoration plan. First, the load estimates from the three conditions were used to estimate how much of the pollutant load reductions envisioned in the RWQMPU would result from implementing the NR 151 stormwater runoff performance standards and how much would result from other elements of the recommended plan. Second, the load reductions were adjusted to account for changes in the application of NR 151 that have been made since the RWQMPU was completed.

The developed urban area performance standard for municipalities set forth in Section NR 151.13 requires that municipalities with Wisconsin Pollutant Discharge Elimination System (WPDES) stormwater discharge permits reduce the amount of TSS in stormwater runoff from areas of existing development that were in place as of October 1, 2004, to the maximum extent practicable, by 20 percent by March 10, 2008 and by 40 percent by October 1, 2013. In addition, other sections of NR 151 require that all construction sites that have one acre or more of land disturbance must achieve an 80 percent reduction in the sediment load generated by the site. With certain limited exceptions, those sites required under NR 151 to have construction erosion control permits must also have post-development stormwater management practices to reduce the TSS load from the site by 80 percent for new development, 40 percent for redevelopment, and 40 percent for infill development occurring prior to October 1, 2012. After October 1, 2012, infill development will be required to achieve an 80 percent reduction. An action by the State Legislature has changed the application of these performance standards. As a result of 2011 Wisconsin Act 32, the WDNR is prohibited from enforcing the 40 percent reduction in TSS load from areas of existing development.[14]

The impact of this is that the load reductions from urban nonpoint sources as represented under the RWQMPU modeling need to be adjusted to account for the change in application of the developed urban area performance standard. This was done on a subwatershed basis using the existing 2000 land use and the planned land use (see Tables 3.8 through 3.11 in Chapter 3 of this report) to estimate the portions of urban lands within each subwatershed under the Recommended Plan (2020) condition that represent:

- Existing development that would have been subject to the 40 percent TSS reduction requirement

- New development that is subject to the 80 percent TSS reduction requirement, redevelopment that is subject to the 40 percent TSS reduction requirement, and infill development that is subject to a 40 percent TSS reduction requirement prior to October 1, 2012 and an 80 percent TSS reduction requirement after October 1, 2012

To adjust the urban nonpoint source load reductions for the changes in the application of NR 151, the portion of the NR 151-related load reductions that are attributable to existing development was estimated for each subwatershed. This portion of the pollutant load reduction was reduced by half. In order to maintain the recommended levels of water quality improvement envisioned under the RWQMPU, the amount of this reduction was added to the "other reductions" categories for urban nonpoint sources in the pollutant load reduction target tables given in Chapter 5 of this report.

[14] *2011 Wisconsin Act 32 also required that any reductions of TSS that had already been achieve in areas of existing development had to be retained.*

DESIGN CONSIDERATIONS FOR IRON-ENHANCED SAND FILTERS (IESF)[15]

Based on research projects and field installations of IESFs in Minnesota, staff at the University of Minnesota have made the following recommendations for the design and installation of IESFs:

- Clean, washed sand meeting ASTM C33 specifications shall be used for the IESF trench media.

- The iron-enhanced sand portion of the media shall be approximately 18 inches thick. While shallower depth filters are acceptable, they may not perform as well or last as long.

- The iron-enhanced sand media shall contain 5 to 8 percent iron shavings by weight mixed thoroughly throughout the entire media volume to make a mixture that is homogeneous vertically and horizontally. The iron shavings should have a similar size profile as the sand.

- The iron used for the IESF should be high purity and consist of at least 90 percent elemental iron. In addition, it should contain little to no toxic impurities, such as copper, cadmium, and lead. The iron should be reactive with phosphate. Iron, reactivity, and impurity content should be verified independently of the supplier to ensure purity and prevent leaching of contaminants into the filtered runoff. This should be done through laboratory analysis.

- The iron-enhanced sand media shall be covered by 2 to 5 inches of ASTM C33 sand. Non-routine maintenance shall include periodically removing 1 to 1.5 inches from the top of this layer, and replacing it with clean, washed ASTM C33 sand.

---

[15] *Adapted from A.J. Erickson, P.T. Weiss, and J.S. Gulliver,* Monitoring an Iron-Enhanced Sand Filter Trench for the Capture of Phosphorus in from Stormwater Runoff, *University of Minnesota Saint Anthony Falls Laboratory Project Report No. 575, September 2015; A.J. Erickson,* Capturing Stormwater Nitrate and Phosphate with Sorptive Filter Media, *Ph.D. Dissertation, University of Minnesota, Minneapolis, Minnesota, July 2017; A.J. Erickson,* Performance Enhancing Devices for Stormwater BMPs—Iron Amendments, *Report to the Center for Watershed Protection, December 2018.*

- The IESF shall have a layer of clean, washed ASTM C33 sand of at least 6 inches thick below the iron-enhanced sand media.

- The IESF media should be surrounded by an impermeable layer on all sides except the top.

- The design should limit the amount of organic material deposited on the IESF surface media.

- Stormwater should enter the IESF evenly and be distributed across the entire top surface to ensure widespread treatment and minimize the occurrence of small areas treating an unequal portion of the stormwater. Earthen berms and grading have been found to be imprecise, resulting in low areas that receive considerably more stormwater than the entire filter surface. A level spreader or manifold distribution system may be appropriate or necessary.

- The IESF should be sized so that it allows rainfall to drain quickly in order to allow a drying time of one to two days to occur prior to the next rainfall event.

- For maintenance considerations, a filtration rate of 10 centimeters per hour vertically down and through the IESF media can be used to estimate the IESF surface area needed to treat a known or estimated peak flow rate. The smaller the IESF surface area, the greater the frequency of required maintenance.

- For lifetime capacity considerations, a sorption capacity of 5 mg phosphorus per gram iron can be used to estimate the amount of iron needed to treat a known or estimated phosphorus load.

- The IESF must be allowed to drain. The outlet of the underdrain system below the IESF must be placed above the high-water elevation of the downstream conveyance system and/or waterbody to prevent inundation of the IESF.

- Underdrain size should be considered during design. All sites in the City of Prior Lake, Minnesota were designed and installed with 4-inch perforated underdrains. The flow rate for some of these sites appears to be limited by this pipe size, which results in longer drawdown times and the potential for anaerobic conditions to develop in the filter. Larger underdrain pipes could be used to avoid limiting the flow rate with the underdrain. If the flow rate is found to be too large such that performance is limited by contact time, a cap with an orifice smaller than the pipe could be added to the underdrain outlet.

- The design should provide access for maintenance of the filter surface, underdrains, and media. Equipment such as a bobcat, flatbed truck, or excavator may need access.

- The design should include clean-outs connected to the underdrain system that are accessible from the surface. They should use 45° bends rather than elbows to allow inspection using small cameras.

- The design should exclude vegetation from the IESF media. In filter systems, micropores formed by vegetation roots can short-circuit the media.

Design Considerations Specific to IESF Trenches Adjacent to Wet Ponds

- In order to prevent duckweed, algae, and other organics or solids from accumulating on the surface of the filter, the filter should be surrounded by an impermeable barrier or surface skimmer, or the design should incorporate a separate pretreatment cell containing only sand that discharges to the IESF trench. The top elevation of the barrier should be higher than the water level control weir crest in the catch basin so that flow will not overtop the barrier surrounding the filter during the design event. In order to allow pond water to flow onto the filter, a pipe should run from the pond, at a depth below the frost line, through the impermeable barrier to the surface of the IESF trench. A flow spreader or manifold system may be necessary to evenly distribute the water over the surface of the entire filter. The barrier, pipe, and elevations should be designed such that the treatment volume and routing are as intended, and structural integrity is protected.

Design Considerations Specific to IESF Ditch Check Dams[16]

Based on research projects and field installations of IESFs in Minnesota, staff at the University of Minnesota have made the following recommendations for the design of iron-enhanced ditch check dams.

- Sand coarser than ASTM C33 can be used.
- The IESF shall be rectangular in cross-section for ease of construction.
- The filter berm depth shall be 12 to 17 inches in the direction of flow.
- The filter berm length perpendicular to the direction of flow shall extend across the ditch width. The filter shall be sufficiently long such that runoff does not flow around the filter.
- The filter berm height shall be at least 18 inches; however, the sizing shall be determined based on the site conditions.
- The filter media shall be filled within a woven geotextile enclosure in the berm. It is recommended that the filter media be installed within a single geotextile enclosure as one filter log in the ditch check berm. The single filter log-design is recommended since it uses less geotextile material and reduces the overall construction time and effort. This design also reduces the possibility of water seeping between multiple filter logs.
    - If a single filter log-design is not feasible for the site conditions, multiple filter logs shall be stacked to build the IESF berm. Two rows of filter logs shall be placed in a staggered pattern to allow for good overlap between the logs. A geotextile sheet covering all sides of the filter logs should be installed. Gaps between the outer geotextile cover and the filter logs and gaps between individual filter logs should be filled with loose IESF media.
- The IESF berm must be trenched into the ground to prevent flow-bypass underneath the filter media. The filter log should be installed at least 6 inches below the normal ditch bottom. If multiple filter logs are used, the bottommost filter logs shall be trenched into the ground.
- An impermeable liner shall be placed directly underneath the filter log.
- A frame shall be constructed around the filter berm to hold the filter log(s) in place. The frame will ease installation of the IESF media and prevent dislocation of the media during high-flow conditions and other disturbances.
- The edge of the filter log shall be properly sealed against the ditch side. This can be done by trenching the filter log to the ditch side. Alternatively, any gap present between the filter log and ditch side shall be filled with loose filter media and the sides backfilled with topsoil or sealed with clay. This is important to ensure that water does not bypass the filter log.
- Class I riprap shall be placed at a 1:10 slope on both the upstream and downstream sides of the filter log to form the check dam.
- If exposed aggregate is undesirable, the riprap check dam shall be covered with topsoil and sod. The topsoil shall consist of 60 percent C33 sand, 30 percent topsoil, and 10 percent peat moss, by volume. Compost shall not be used in the topsoil mixture as it can leach additional phosphorus into the water and reduce the overall effectiveness of the iron-enhanced ditch check dam. Covering with topsoil and sod may be undesirable, as this may leach phosphorus and reduce performance.

[16] *Adapted from P. Natarajan and J.S. Gulliver,* Assessing Iron-Enhanced Swales for Pollution Prevention, *University of Minnesota Saint Anthony Falls Laboratory Project Report No. 576, September 2015; P. Natarajan, J.S. Gulliver, and P.T. Weiss,* Iron-Enhanced Swale Ditch-Checks for Phosphorus Retention: Final Report, *Minnesota Department of Transportation, July 2019.*

- If necessary, a porous drain tile shall be added on the downstream side of the ditch check dam to allow proper drainage of the water.

OPERATION AND MAINTENANCE

The following recommendations regarding operation and maintenance will enhance performance and increase the life of an IESF:

- The IESF should be inspected quarterly to annually, with inspections occurring more often when more water is filtered. The IESF should be inspected after any events with recurrence intervals of two or more years.
- Routine maintenance should be performed about four times a year.
- Routine maintenance involves removing trash and debris from the filter, removing vegetation growing on the surface of the filter, removing obstructions to underdrains and outlet structures, and raking the filter to break up the surface.
- Non-routine maintenance occurs as required by a change in performance. This may need to be done about once a year. This can often be detected through a reduction in the rate of infiltration into the filter.
- Non-routine maintenance may include:
    - Removing the top 1 to 1.5 inches of sand and accumulated solids and organics that have been filtered and replacing with clean, washed sand.
    - Breaking up any clumps of iron shaving conglomerates that have formed.
    - Performing testing to determine the filtration rate.
    - Removing retained sediment every five to ten years in stable watersheds and annually in unstable watersheds.
    - Mixing the filter media from top to bottom in IESFs installed in ditch check dams. This should be done every other year.
    - Replacement of filter media when its phosphorus sorption capacity is exhausted. This can be estimated by measuring the magnetic susceptibility of the medium.
- The filter must be allowed to dry between rainfall/runoff events. This will prevent the development of anaerobic conditions and will allow more phosphate adsorption sites to develop on the iron shavings. Iron clumping appears to be more prevalent when the filter remains submerged for more than two days.

APPENDIX O

DESKTOP ANALYSIS PROCEDURE DEVELOPED FOR ILLICIT DISCHARGE DETECTION AND ELIMINATION SCREENING

In accordance with the conditions of its watershed-based municipal stormwater discharge permit, the Menomonee River Watershed Permittees, in collaboration with Milwaukee Riverkeeper, the Wisconsin Department of Natural Resources, and Southeastern Wisconsin Regional Planning Commission (SEWRPC), developed a desktop analysis procedure to identify those stormwater outfalls most likely to be conveying water contaminated with sanitary wastewater and prioritized those outfalls for dry-weather field screening.[17] This procedure is intended to evaluate all outfalls, regardless of size.

Screening is conducted using the matrix shown in Table O.1. Each subbasin of the surface water system within a municipality's municipal separate storm sewer system (MS4) is screened for the likelihood that storm sewers are conveying water contaminated with sanitary wastewater. The subbasins are screened based upon the evaluation of a group of factors that give an indication of the likelihood of whether storm sewers within the subbasin are conveying contaminated water. For each factor, subbasins are given a rating of 1, 2, or 3, with 1 indicating a low potential for illicit discharge, 2 indicating a moderate potential for illicit discharge, and 3 indicating a high potential for illicit discharge. For a given factor, those subbasins where information is not available to assess the illicit discharge potential are given a rating or 2. The individual factor ratings are summed to yield a Human Illicit Discharge Potential (HDIP) raw score. This raw score is normalized by dividing it by the number of factors screened. The normalized HIDP scores can range between 1.0 and 3.0, with higher values indicating a greater potential for storm sewers in the subbasin to be conveying water contaminated with sanitary wastewater.

The procedure developed by the Menomonee River Watershed Permittees uses the following factors for screening. The details of scoring are given in Table O.1:

- The basin's history of complaints of discharges from outfalls in the subbasin and of outfalls with discharge occurring during dry-weather screening.

- The percentage of urban development within the subbasin that is greater than 50 years old. This factor is intended to identify

[17] *The Menomonee River Watershed Permittees consist of the Cities of Brookfield, Greenfield, Milwaukee, West Allis, and Wauwatosa; the Villages of Butler, Elm Grove, Germantown, Menomonee Falls, and West Milwaukee; and Milwaukee County.*

Table O.1
Matrix for Prioritizing Drainage Areas for Outfall Screening Using Screening Factors for Illicit Discharge Potential of Human Waste

SEWRPC Subbasin	Past Discharge Complaints or Flowing Outfalls During Dry Weather (Rating)[a]	Age of Development (Rating)[b]	Material/ Condition of Pipes (NASSCO Ratings)[c]	Proximity of Sanitary and Stormwater Pipes[d]		Subbasin Area (square miles)	Parcels per Square Mile[e]		Optional Indicator (Rating)[f]	HIDP Raw Score[g]	Normalized HIDP Score[h]	Comments	Final Rank[i]
				Density of Crossings	Rating		Density	Rating					

[a] If there have been complaints of discharges or past detections of dry-weather flow from outfalls in the subbasin, rate as 3. If there have not been complaints of discharges or past detections of dry-weather flow, rate as 1. If this is not known, rate as 2.

[b] Rate subbasins in which less than 30 percent of the area is 50 years old or older as 1. Rate subbasins in which in which 30 to 60 percent of the area is 50 years old or older as 2. Rate subbasins in which over 60 percent of the area is 50 years old or older as 3.

[c] Material/condition of pipes is based on NASSCO (National Association of Sewer Service Company) ratings for sanitary pipe inspection. Where average pipe condition in a subbasin receives a NASSCO rating of good or excellent, rate as 1. Where average pipe condition in a subbasin receives a NASSCO rating of poor or needs immediate attention, rank as 3. Where average pipe condition in a subbasin is not known, rate as 2.

[d] Rating is based on the density of crossings of sanitary and storm sewer pipes in the subbasin. Count all of the pipe crossings in the area. Where sanitary and sewer pipes are within four feet of each other (center to center), count each eight-foot section of pipe as a crossing. Rank all subbasins based on the number of crossings divided by the area of the subbasins. Subbasins in the lowest 25th percentile of crossing density are rated 1, subbasins in the 25th through 75th percentile of crossing density are rated 2, subbasins in the upper 25th percentile of crossing density are rated 3.

[e] Rating is based on parcel density which is calculated by dividing the number of parcels in the subbasin by the area of subbasin. Subbasins in the lowest 25th percentile of parcel density are rated 1, subbasins in the 25th through 75th percentile of parcel density are rated 2, subbasins in the upper 25th percentile of parcel density are rated 3.

[f] The optional factor is included to prioritize subbasins based upon available water quality data. This could be based upon data such as percent exceedance of water quality criteria for fecal indicator bacteria, TMDL reduction priorities, or other indicators. Subbasins in the lowest 25th percentile of the indicator are rated 1, subbasins in the 25th through 75th percentile of the indicator are rated 2, subbasins in the upper 25th percentile of the indicator are rated 3.

[g] HIDP (Human Illicit Discharge Potential) raw score is the sum of ratings for past discharge complaints, age of development, material/condition of pipes, proximity of sanitary and storm sewer pipes, parcels per square mile, and the optional indicator, if it is used.

[h] Normalize the raw HIDP scores by dividing the raw score by the number of screening factors assessed. This normalization produces scores that fall onto a standard scale of 1.0 to 3.0 for low to high illicit discharge potential, respectively. The suggested scale for prioritization for field screening is subbasins with normalized HIDP scores between 1.0 and 1.5 are low priority for screening, subbasins with normalized HIDP scores greater than 1.5 to 2.5 are medium priority for field screening, and subbasins with normalized HIDP greater than 2.5 are high priority for field screening.

[i] The final rank will take normalized HIDP score into account, but may also include other factors such as proximity to capital construction projects, available funding, and neighborhood concerns.

Source: Menomonee River Watershed Permittees, Milwaukee Riverkeeper, and SEWRPC basins with a high proportion of older infrastructure which may be degrading. It can be assessed using the SEWRPC historical urban growth mapping layer. An alternative means of assessing this would be to use the ages, if known, of sanitary and storm sewer pipes in the subbasin.

- The average condition of sanitary sewer pipes in the subbasin, based upon the National Association of Sewer Service Company's rating system for pipe inspection.

- The proximity of sanitary sewer and storm sewer pipes to one another. This would be assessed by the average density of crossings of sanitary and storm sewer pipes within the basin. In addition, each eight-foot section in which these pipes are adjacent to and within four feet of each other would be counted as a crossing. The number of crossings is divided by the area of the subbasin.

- The density of parcels in the subbasin. This serves as a surrogate for the number of sanitary sewer laterals within the subbasin. The number of parcels within the subbasin is divided by the area of the subbasin.

In addition to these factors, the matrix allows for the inclusion of an optional screening factor. This is intended to allow municipalities to take other factors for which data are available into account. Examples of factors that could potentially be used include the percent exceedances of recreational use water quality criteria in the locations in the surface water system where the subbasin discharges, presence of fecal indicator bacteria hot spots in the subbasin, or the level of fecal indicator bacteria load reductions assigned to a subbasin through a total maximum daily load (TMDL) study.

The normalized HIDP score is used to prioritize outfalls for field screening. The Menomonee River Watershed Permittees suggest that outfalls within subbasins having normalized HIDP scores greater than 2.5 be given high priority for field screening, while those in subbasins with normalized HIDP scores between 1.5 and 2.5 be given medium priority and those in subbasins with normalized HIDP scores less than 1.5 be given low priority for field screening. While they recommend that the final rank for field screening be based upon normalized HIDP scores, the ranking can also be adjusted to account for issues such as the proximity of outfalls to current or future capital construction projects, available funding, and neighborhood concerns. They also note that, if the necessary additional data are available, a second round of desktop screening could be conducted to prioritize storm sewersheds within subbasins for screening.

It should be emphasized that this analysis procedure is intended to be used to prioritize storm sewer outfalls for field screening. It is not intended as a substitute for field screening or other in-depth analyses.

APPENDIX P

BIBLIOGRAPHY OF REFERENCES RELATED TO MYCOREMEDIATION TO ADDRESS FECAL INDICATOR BACTERIA AND PATHOGENS

Akyuz, M., A.N. Onganer, P. Erecevit, and S. Kirbag, "Antimicrobial Activity of Some Edible Mushrooms in the Eastern and Southeast Anatolia Region of Turkey," *Gazi University Journal of Science*, (23): 125-130, 2010.

Alves, M.J., I.C.F.R. Ferreira, J. Dias, V. Teixeira, A. Martins, and M. Pintado, "A Review on Antimicrobial Activity of Mushroom (Basidiomycetes) Extracts and Isolated Compounds," *Planta Medica,* 78(16): 1707-1718, 2012.

Alves, M.J., I.C.F.R. Ferreira, H.J. Froufe, R. Abreu, A. Martins, and M. Pintado, "Antimicrobial Activity of Phenolic Compounds Identified in Wild Mushrooms, SAR Analysis, and Docking Studies," *Journal of Applied Microbiology,* 115(2): 346-357, 2013.

Barrech, D., I. Ali, and M. Tareen, "A Review on Mycoremediation--the Fungal Bioremediation," *Pure and Applied Biology,* 7(1): 343-348, 2018.

Barron, G., "Microcolonies of Bacteria as a Nutrient Source for Lignicolous and Other Fungi," *Canadian Journal of Botany,* 66(12): 2505-2510, 1988.

Barron, G.L., "Lignolytic and Cellulolytic Fungi as Predators and Parasites," In G.C. Carrol and D.T. Wicklow (editors), *The Fungal Community, Its Organization and Role in the Ecosystem,* 2nd edition, Marcel Dekker, Inc., New York, 1992.

Barron, G. L., "Predatory Fungi, Wood Decay, and the Carbon Cycle," *Biodiversity*, 4: 3-9, 2003.

Barron, G.L., and R.G. Thorn, "Destruction of Nematodes by Species of *Pleurotus*," *Canadian Journal of Botany,* 65: 774-778, 1987.

Barrech, D., I. Ali, and M. Tareen, "A Review on Mycoremediation—The Fungal Bioremediation," *Pure and Applied Biology,* 7(1): 343-348, 2018.

Chandrasena, G.I., M. Shirdashtzadeh, Y. Li, A. Deletic, J.M. Hathaway, and D.T. McCarthy, "Retention and Survival of *E. coli* in Stormwater Biofilters: Role of Vegetation, Rhizosphere Microorganisms and Antimicrobial Filter Media," *Ecological Engineering,* 102: 166-177, 2017.

Chirnside, A., J. Harris, and N. Gregory, "Degradation of Harmful Bacteria in Simulated Wastewater by the White Rot Fungus *Pleurotus ostreatus,*" In: *World Environmental and Water Resources Congress 2013,* pp. 1517-1525, 2013.

Das, N., "Heavy Metals Biosorption by Mushrooms," *Natural Product Radiance,* 4(6): 454-459, 2005.

Femor, T., and D. Wood, "Degradation of Bacteria by *Agaricus bisporus* and Other Fungi," *Journal of General Microbiology,* 126: 377-387, 1981.

Femor, T.R., D.A. Wood, S.P. Lincoln, and J.S. Fenlon, "Bacteriolysis by *Agaricus bisporus,*" *Journal of General Microbiology,* 137: 15-22, 1991.

Flatt, A.A., *Removal of* Escherichia coli *from Stormwater Using Mycofiltration,* Master's Thesis, Washington State University, Pullman, Washington, May 2013.

Gulis, V., and K. Suberkropp, "Interactions between Stream Fungi and Bacteria Associated with Decomposing Leaf Litter at Different Levels of Nutrient Availability," *Aquatic Microbial Ecology,* 30: 149-157, 2003.

Harris, J.P., *Degradation of Harmful Bacteria in Simulated Wastewater and Stormwater Runoff by the White Rot Fungus* Pleurotus Ostreatus*,* Undergraduate Thesis, University of Delaware, Newark, Spring 2012.

Haynes, B., *Assessment of spent mushroom waste from Pleurotus ostreatus cultivation for removal of* Escherichia coli *from wastewater*, Master's Thesis, State University of New York, 2015.

Hayward, S. and P. Stamets, *Water Quality Research Project Using Mushroom Mycelia for Mycofiltration of Fecal Bacteria,* No. 91-RG-0, Washington State Conservation Commission, 1998.

Hyslop, P.A., D.B. Hinshaw, I.U. Scraufstatter, C.G. Cochrane, S. Kunz, and K. Vosbeck, "Hydrogen Perioxide as a Potent Bacteriostatic Antibiotic: Implications for Host Defense," *Free Radical Biology and Medicine,* 19(1): 31-37, 1995.

Iwalokun, B.A., U.A. Usen, A.A. Otunba, and D.K. Olykoya, "Comparative Phytochemical Evaluation, Antimicrobial and Antioxidant Properties of *Pleurotus ostreatus,*" *African Journal of Biotechnology,* 6(15):1732-1739, 2007.

Janes, D., A. Umek, and S. Kreft, "Evaluation of Antibacterial Activity of Extracts of Five Species of Wood-colonizing Fungi," *Journal of Basic Microbiology,* 46(3): 203-207, 2006.

Kalyoncu, F., M. Oskay, H. Saglam, T. F. Ergodan, and A.U. Tamer, "Antimicrobial and Antioxidant Activities of Mycelia of 10 Wild Mushroom Species," *Journal of Medicinal Food,* 13: 415-429, 2010.

Kapahi, M., and S. Sachdeva, "Mycoremediation Potential of *Pleurotus* Species for Heavy Metals: A Review," *Bioresources and Bioprocessing,* 4: 32, doi: 10.1186/s40643-017-0162-8, 2017.

Kenny, S., *Staff Report of Oakland Bay Activities March 1, 2008 to June 30, 2008,* Macon County Public Health Department, Shelton, Washington, 2008.

Martinez, S.E., E. coli *Removal by* Pleurotus ostreatus *Mycofilter in Simulated Wet Environmental Pond,* Master's Thesis, University of New Mexico, Albuquerque, New Mexico, December 2016.

Mehta, A., R. Dubey, and S. Kumar, "Mycofiltration: A Step Towards Sustainable Environment," *International Journal of Current and Applied Sciences,* 6(6): 1524-1528, 2017.

Melville, A.D., *Assessment of a Mycorrhizal Fungi Application to Treat Stormwater in an Urban Bioswale,* Master's Thesis, Portland State University, Portland, Oregon, 2016.

Mille-Lindblom, C., and L. Tranvik, "Antagonism between Bacteria and Fungi on Decomposing Aquatic Plant Litter," *Microbial Ecology,* 45: 173-182, 2003.

Mille-Lindblom, C., *Interactions between Bacteria and Fungi on Aquatic Detritus – Causes and Consequences,* Doctoral Dissertation, Uppsala University, Uppsala, Sweden, May 2005.

Perez, F., *Noncompetetive Tribal Projects for the Restoration and Protection of Puget Sound: Installation of Mycofiltration Gardens to Treat Polluted Land-based Runoff,"* Report by the Stillaguamish Tribe Department of Natural Resources to the Puget Sound Partnership, December 2015.

Radulescu, C., C. Stihi, G. Busuioc, A.I. Gheboianu, and I.V. Popescu, "Studies Concerning Heavy Metals Bioaccumulation of Wild Edible Mushrooms from Industrial Area by Using Spectrometric Techniques," *Bulletin of Environmental Contamination and Toxicology,* 84: 641-646, 2010.

Rogers, T., *Experimental Evaluation of Mycoremediation of* Escherichia coli *Bacteria in Solution Using* Pleurotus ostreatus, Master's Thesis, Evergreen State College, Olympia, Washington, June 2012.

Sanglimsuwan, S., N. Yoshida, T. Morinaga, and Y. Murooka, "Resistance to and Uptake of Heavy Metals in Mushrooms," *Journal of Fermentation and Bioengineering,* 75(2): 112-114, 1993.

Stamets, L., *Best Mycorestoration Practices for Habitat Restoration of Small Land Parcels,* Master's Thesis, The Evergreen State College, Olympia, Washington, June 29, 2012.

Stamets, P., M. Beutel, A. Taylor, A. Flatt, M. Wolff, and K. Brownson, *Mycofiltration Biotechnology for Pathogen Management: SBIR Phase I Research Results for "Comprehensive Assessment of Mycofiltration Biotechnology to Remove Pathogens from Urban Stormwater,"* http://fungi.com/pdf/articles/Fungi_Perfecti_Phase_I_Report.pdf, May 2013.

Taylor, A.W., A. Flatt, M. Beutel, M. Wolff, K. Brownson, and P.E. Stamets, "Removal of *Escherichia coli* from Synthetic Stormwater Using Mycofiltration," *Ecological Engineering,* 78:79-86, 2015.

Taylor, A.W., and P.E. Stamets, "Implementing Fungal Cultivation in Biofiltration Systems--The Past, Present, and Future of Mycofiltration," *USDA Forest Service Proceedings,* RMRS-P-72.2014, 2014.

Taylor, A., J. Wetzel, E. Murdock, K. King, J. Cameron, J. Davis, and J. McIntyre, "Engineering Analysis of Plant and Fungal Contributions to Bioretention Performance," *Water,* 10: 1226, doi: 10.3390/w10091226, 2018.

Thomas, S.A., L.M. Aston, D.L. Woodruff, V.I. Cullinan, *Field Demonstration of Mycoremediation for Removal of Fecal Coliform Bacterial and Nutrients in the Dungeness Watershed, Washington,* Report prepared for the Jamestown S'Klallam Tribe, March 2009

Thorn, R., and G. Barron, "Carnivorous Mushrooms," *Science,* 224(4644): 76-78, 1984. (R-2)

Tlaska, V., *Structure and function of bacterial communities during succession on dead plant biomass*, Master's Thesis, Charles University in Prague, Prague, Czech Republic, 2015.

Tsuneda, A., and R. Thorn, "Interactions of Wood Decay Fungi with Other Microorganisms, with Emphasis on Degradation of the Cell Wall," *Canadian Journal of Botany,* 73(1):1325-1333, 1995.

Ulmstead, R.B. *Development of Fungal Bioreactors for Water Related Treatment and Disinfection Applications.* Master's Thesis, Virginia Poytechnic Institute and State University, Blacksburg, Virginia, June 27, 2016.

Wolfand, J.M., Bell, C.D., Boehm, A.B., Hogue, T.S., and Luthy, R.G., Multiple Pathways to Bacterial Load Reduction by Stormwater Best Management Practices: Trade-Offs in Performance, Volume, and Treated Area, *Environmental Science & Technology*, 52(11): 6,370-6,379, 2018.

Wolff, E.R.S., E. Wisbeck, M.L.L. Silveira, R.M.M Gern, M.S.L. Pinho, and S.A. Furlan, "Antimicrobial and Antineoplasic Activity of *Pleurotus ostreatus,*" *Applied Biochemistry and Biotechnology,* 151: 402-412, 2008.

Zhu, H., K. Sheng, E. Yan, J. Qiao, and F. Lv, "Extraction, Purification and Antibacterial Activities of a Polysaccharide from Spent Mushroom Substrate," *International Journal of Biological Macromolecules,* 50(3): 840-843, 2012.

BEST MANAGEMENT PRACTICES FOR CHLORIDE MANAGEMENT

APPENDIX Q

BEST MANAGEMENT PRACTICES FOR SALT AND DEICER STORAGE AND ONSITE MANAGEMENT

Improper storage and management of deicing material can lead to contamination of surface water and groundwater. Salt-based materials can dissolve in precipitation and stormwater and run off into surface water or infiltrate through the ground into groundwater. Storing deicing materials responsibly and following good housekeeping practices during the delivery, storage, loading, and management of deicing materials can reduce the amount of chlorides that needlessly enter the environment. Several best management practices are recommended for storage and onsite management of deicers.[18]

The following best management practices address locating storage facilities for deicing materials:

- Storage facilities should be located in areas that are not environmentally sensitive. Areas where there are wells, reservoirs, or stratified-drift aquifers should be avoided.

- Storage facilities should be located on flat sites away from surface waterbodies and wetlands.

- Site drainage should be designed to direct clean stormwater away from the operations and storage areas in order to keep the stockpiles as dry as possible.

- Drainage that is contaminated with salt should be directed to a sewage treatment plant (subject to municipal approval), collected for use in pre-wetting activities, or sent for proper disposal.

[18] *Transportation Association of Canada,* Syntheses of Best Practices: Road Salt Management, *2003; Transportation Association of Canada,* Salt SMART Learning Guide, *2005; Salt Institute,* The Salt Storage Handbook: A Practical Guide for Storing and Handling Deicing Salt, *2006; New Hampshire Department of Environmental Services,* Environmental Fact Sheet: Storage and Management of Deicing Materials, *WD-DWGB-22-30, 2019.*

The following best management practices address the design of deicer material storage structures:

- Ideally, deicing material storage facilities should be completely enclosed, with storage and working areas on impervious surfaces such as asphalt or coated concrete.

- Overhead cover should be installed to protect material from exposure to snow and rain and to minimize runoff and inventory loss. Because it is very difficult to keep storage piles completely covered with tarpaulins, fixed roofs are preferable to tarpaulins.

- Structures should have stormwater drainage controls to prevent runoff and snow melt from contacting or running through material storage and loading areas. Areas should be sloped away to prevent stormwater from entering the loading areas or structures. Building floors and storage pads should be sloped to prevent ponding and allow any water to drain away from the storage piles.

- Salt and salt-sand mixtures should be stored on pads of impermeable asphalt or concrete.

- Concrete pads and walls should be treated to prevent concrete deterioration.

The following best management practices address on-site management, delivery, handling, and loading of deicers:

- Solid deicers should be handled as little as possible to avoid breakdown of particles and loss of material. Spillage should be minimized.

- Deicers spilled in storage and loading areas should be collected and returned to the storage pile.

- All deicer materials temporarily out in the open should be covered to prevent deicer material from being washed or blown from the pile.

- Solid bagged materials should be stored securely, indoors if possible. Bags should be protected from rain and snow. All open bags should be resealed. Once empty, the bags should be disposed of properly.

- Frozen or clumped blocks of deicer should either be set aside to be dried and crushed or added to brine tanks.

- Liquid storage tanks should be protected from freezing. Know the freezing point of liquid deicers to determine whether they can be stored outdoors.

- Liquid storage tanks should be double-walled or have secondary containment.

- Liquid storage tanks should be designed so that a plumbing failure will not result in release of contents.

- Liquid storage tanks should be protected from impact from vehicles moving about the yard. They should be located such that spilled material can be contained and retrieved in the event of a tank or piping failure.

- Spreaders should not be overloaded such that material spills off the vehicle.

- Spreaders should only be washed at locations where wash water is properly managed.

BEST MANAGEMENT PRACTICES FOR APPLICATION OF DEICERS TO ROADS

Snow and ice control activities on roadways reduce the likelihood of accidents and protect drivers and passengers using these facilities, but runoff originating on or flowing over these surfaces can carry deicers into surface waters or groundwater. It is recommended that following snow and ice control best management practices be used to keep roadways safe and reduce environmental impacts:[19]

- A clear level of service as to the condition that a roadway will be maintained should be established, based on traffic volume or regulation. This level of service should be communicated to staff and the public.[20]
- Staff should be trained in proper spreading procedures, record-keeping, and the environmental impacts of deicing activities. Such training should include seasonal and contracted employees.
- Spreading equipment should be calibrated prior to and regularly during the winter deicing season. Equipment should be recalibrated if there is a change in the deicing material used.
- Spreaders should be equipped with instrumentation to monitor current conditions and deicer usage.
- Spreading rates should be based on the best available information, including current road conditions, precipitation type and rate, pavement temperature, level of service, deicing cycle time, and weather forecast.[21] Spreading equipment should be able to apply deicers at specified rates and should be capable of calibration.
- Spreader routes should be optimized to eliminate leftover salt and driving without spreading.
- The appropriate deicing compound should be used for the pavement temperature.
- Solid deicers should be prewetted to reduce the amount of deicer that leaves the roadway during application.
- Spreaders should be covered to prevent loss of deicer in wind and precipitation.
- Records should be kept of deicer usage by each truck and route. Actual usage should be compared to the prescribed spreading rates to identify over-use and inefficiencies.
- Under specified conditions, anti-icing materials should be applied to prevent ice formation on pavement and to prevent ice and snow from bonding to the pavement. The conditions under which anti-icing materials should be applied include all of the following:
    - Snow or frost is predicted to occur within the next three days.
    - Rain is not predicted to occur prior to the snow.
    - Pavement temperatures are 15°F or greater.
    - The dewpoint temperature is at least 3°F below the air temperature.

---

[19] *Salt Institute,* The Snowfighter's Handbook: A Practical Guide for Snow and Ice Control, *1999; Transportation Canada,* Salt SMART Learning Guide, *2005; Minnesota Department of Transportation,* Minnesota Snow and Ice Control: Field Handbook for Snowplow Operators, *Manual No. 2005-01, 2005; W. Nixon and R.M. DeVries,* Manual of Best Management Practices for Road Salt in Winter Maintenance, *Clear Roads, 2015*.

[20] *An example of level of service for highways under the jurisdiction of the State of Wisconsin can be seen at wisconsindot.gov/Documents/doing-bus/local-gov/hwy-mnt/winter-maintenance/snowplowbrochuer2014mapside.pdf.*

[21] *An example of variable application rates based on highway level of service, pavement temperature, and road conditions can be seen in Wisconsin Department of Transportation,* Highway Maintenance Manual, Chapter 06, Section 12, Subject 25, "Application Rates De-Icing, *November 2008*.

- The relative humidity level is 70 percent or less.
- The pavement is dry.
- Winds are less than 15 miles per hour when loose snow is present.
- When it has been confirmed that sufficient anti-icing material residue is no longer present on the pavement.

BEST MANAGEMENT PRACTICES FOR SNOW AND ICE CONTROL ON PARKING LOTS AND SIDEWALKS

Snow and ice control activities on parking lots and sidewalks protect the drivers and pedestrians using these facilities, but runoff originating on or flowing over these surfaces can carry deicers into surface waters or groundwater. It is recommended that following snow and ice control best management practices be used to keep parking lots and sidewalks safe and reduce environmental impacts:[22]

- Develop a maintenance policy or plan that guides winter operations. Conduct training sessions for supervisors, staff, and customers on the policy and best management practices.
- Conduct site assessments in parking lots and near building entrances to document drainage problems such as roofs that drip onto steps and downspouts that drain to sidewalks. Fix these during the summer.
- Inspect storm drains in the fall and remove obstructions such as leaves, sticks, and trash to prepare for the spring melt.
- Calibrate each piece of deicing equipment in the fall of the year. If the equipment has different settings, calibrate it for each setting.
- Equipment should be designed or modified to be able to deliver granular products at very low rates.
- For sidewalks, use drop spreaders instead of rotary spreaders. If using a rotary spreader, install shields to restrict the spread pattern, reduce the application rate, and protect vegetation.
- Look for opportunities to close extra building entrances during winter. High maintenance, non-essential entrances are good candidates.
- Use a pavement temperature sensor to measure pavement temperature and apply deicers at appropriate rates for the temperature.
- Always remove snow prior to applying deicers. Focus on aggressive mechanical removal of snow. The less snow present, the less deicer that will be required for a safer walking surface.
- Know the composition of the deicing product and its practical melting temperature range. Use it only at temperatures at which it will be effective and use the minimum amount needed for deicing.
- It may be possible to use a lower rate of deicer application in high traffic areas of parking lots as traffic tends to mix deicers into snow, helping snow and ice to melt.
- Handicap parking spots are often over-salted and over-sanded. They should get the same amount of deicers as other areas.
- Store snow piles in areas where solids can be recovered after the snow melts. Locate these areas down-slope from salt and sand storage to prevent snow melt from flowing through salt and sand storage areas.

[22] *Minnesota Pollution Control Agency,* Winter Parking Lot and Sidewalk Maintenance Manual, *Third Revision, June 2015.*

- Avoid pushing snow into lakes, ponds, wetlands, rivers, streams, or other natural areas.

BEST MANAGEMENT PRACTICES FOR WATER SOFTENING

Discharge of brine used to recharge water softeners releases chloride to the environment. While sanitary sewerage systems receive most of the brine from water softener recharge in the Oak Creek watershed, some is discharged into the remaining onsite sewage treatment systems that are present in the watershed. It is recommended that the following best management practices be used by water treatment professionals to reduce chloride contributions to wastewater:[23]

- Evaluate existing softening units during service calls. Verify that hardness settings are in line with actual tested hardness on site. Review the historical softened water use and family size and use those data to make any necessary adjustments to softener settings to use salt as efficiently as possible.

- Provide the consumer with educational material regarding the benefits of upgrading to a more efficient softening system.

- For residential softening, follow the Wisconsin plumbing code's alternative sizing criteria for residential installations.

- For residential softening, use a typical rate of 40 gallons of water consumed per person per day and the actual number of household residents or use the actual flow rates based on the history obtained from an existing softener.

- Use a minimum softening efficiency for new softening equipment of 4,000 grains of hardness per pound of salt.

- Use a maximum regeneration water usage of 2.5 gallons of water per 1,000 grains of hardness provided.

- Size a regeneration frequency of no less than three days at 4,000 grains of hardness per pound of salt.

- Replacement of existing or installation of new water softening systems should be consistent with the requirement in Section SPS 382.40(8)(j) of the *Wisconsin Administrative Code,* which states that "ion exchange water softeners used primarily for water hardness reduction that, during regeneration, discharge a brine solution shall be of a demand initiated regeneration type equipped with a water meter or sensor unless a wastewater treatment plant downstream of the water softener specifically documents the reduction of chlorides."

[23] *K. Lake, R. Erickson, and A.F. Cantor,* The Reduction of Influent Chloride to Wastewater Treatment Plants by the Optimization of Residential Water Softeners, *Report to the Madison Metropolitan Sewerage District, November 2015.*

MILWAUKEE COUNTY PARKS QUICK REFERENCE GUIDE: PHENOLOGY AND CONTROL OF COMMON INVASIVE PLANT SPECIES IN SOUTHEASTERN WISCONSIN

APPENDIX R

Quick Reference Guide

Phenology and Control of Common Invasive Plant Species in Southeastern Wisconsin

Sources:

Milwaukee County Parks field staff experience

Wisconsin Department of Natural Resources

University of Wisconsin Stevens Point Freckmann Herbarium

Czarapata, Elizabeth. Invasive Plants of the Upper Midwest: An illustrated Guide to Their Identification and Control

Renz Lab, University of Wisconsin Madison

Techline News Calibration Handout

Wisconsin State Natural Area Volunteer Handbook

Pennsylvania Department of Conservation and Natural Resources

The Nature Conservancy

National Park Service

Cornell University Cooperative Extension

Publication developed by:

Mary McQuiggin, Natural Areas Stewardship Assistant, Milwaukee County Parks

Stacy Greefkes, Natural Areas Stewardship Assistant, Milwaukee County Parks

Allison Hager, Natural Areas Intern, Milwaukee County Parks

Katlyn Pluer, Restoration Ecologist, Milwaukee County Parks

Brian Russart, Natural Areas Supervisor, Milwaukee County Parks

Table of Contents

Common Herbicide Application Methods

Invasive Trees, Shrubs, Vines of Southeastern Wisconsin

Invasive Forbs of Southeastern Wisconsin

Invasive Grasses of Southeastern Wisconsin

Calibration for Backpack Sprayers

Common Herbicide Application Methods

Cut-stump Treatment:

Applying herbicide to freshly cut stump's cambium layer. Triclopyr should be mixed with a penetrating bark oil (year round) and Glyphosate can be mixed with water (growing season only).

Foliar Treatment:

Apply to the green leaves of the plant with a sprayer or wick applicator. Leaves should be thoroughly covered without herbicide dripping off of them. Follow herbicide label instructions to determine if and which kind of surfactant is recommended. Recommended application times are early Spring and late Fall within high quality sites because most native plants are dormant. In degraded sites application can occur throughout the growing season.

*__Aquatic Foliar Treatment:__

Apply ONLY aquatic approved herbicides when treatment is ocurring in standing water or within 2 feet of standing water. Use extreme caution when using Imazapyr as it can cause tree mortality.

Basal bark Treatment:

Applying a mixture of Triclopyr and bark oil in a 6-15" band around the entire trunk of a tree or the stems at the base of a shrub.

Bloody Glove Treatment:

Soak a cloth glove in herbicide and wear it over chemical resistant rubber gloves. Wipe the glove along the blades of grass or other vegetation. This method is particularly useful in high quality site where broad foliar treatments would be ecologically damaging.

Girdling Treatment:

Cut and remove a band (1-2" wide on smaller trees, 6-8" on larger trees) of bark around the entire trunk of the tree to interrupt the flow of sap between the roots and the crown of the tree. Cuts should be treated with herbicide prior to sap flow. On larger trees, two cuts roughly 10" apart, are most effective if not using herbicide.

Invasive Trees, Shrubs & Vines of Southeastern Wisconsin

Blue cells indicate the need to assess the site for aquatic approved herbicides.

Amur Cork Tree (*Phellodendron amurense*)

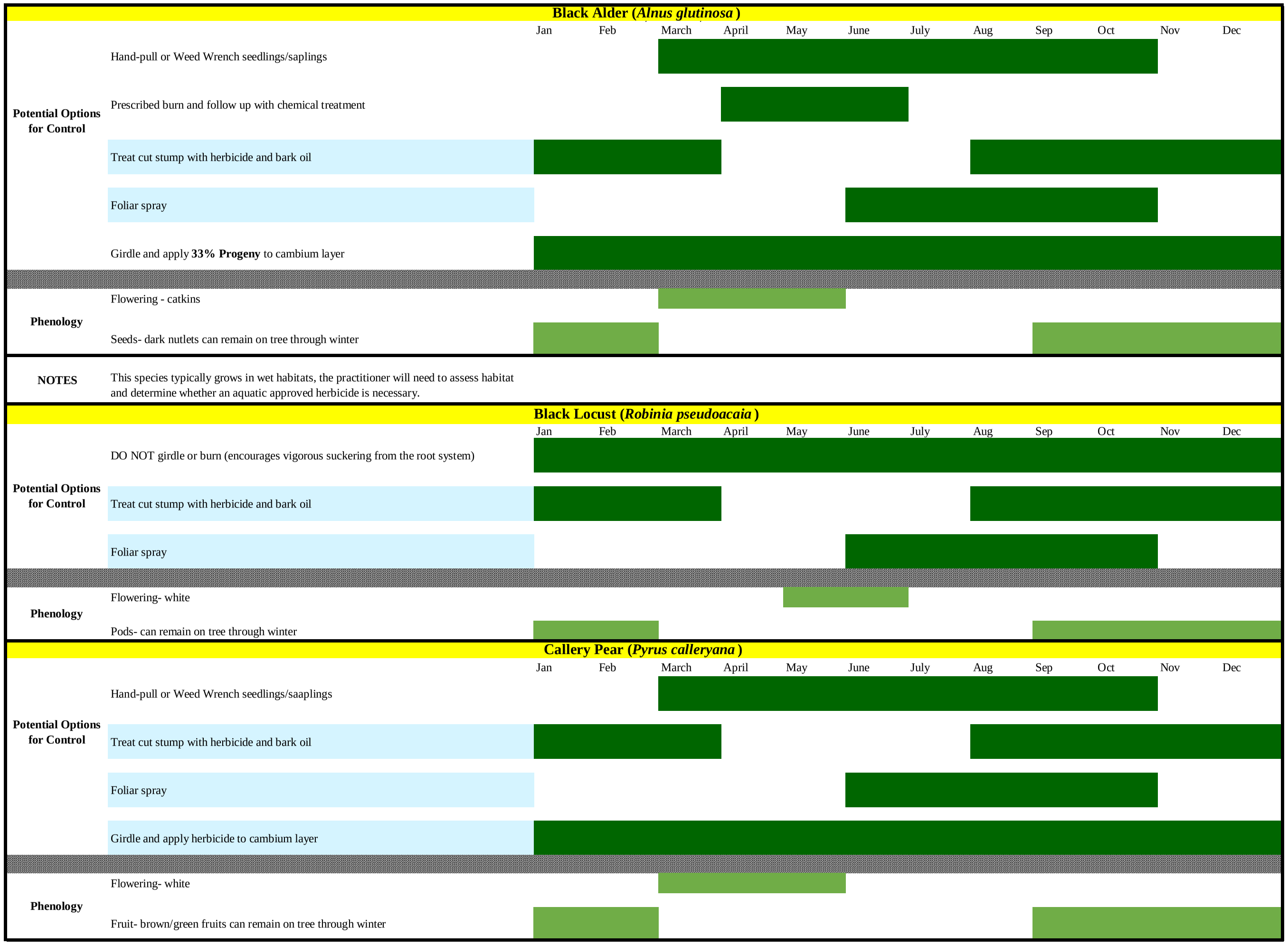
		Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec
Potential Options for Control	Hand-pull or weed wrench seedlings/saplings			X	X	X	X	X	X	X	X		
	Treat cut stump with herbicide and bark oil	X	X	X					X	X	X	X	X
	Foliar spray				X	X	X						
Phenology	Flowering- yellowish green						X						
	Fruit-light green to black						X	X	X	X	X	X	X
NOTES	This species typically grows in wet habitats, the practitioner will need to assess habitat and determine whether an aquatic approved herbicide is necessary.												

Amur Maple (*Acer ginnala*)

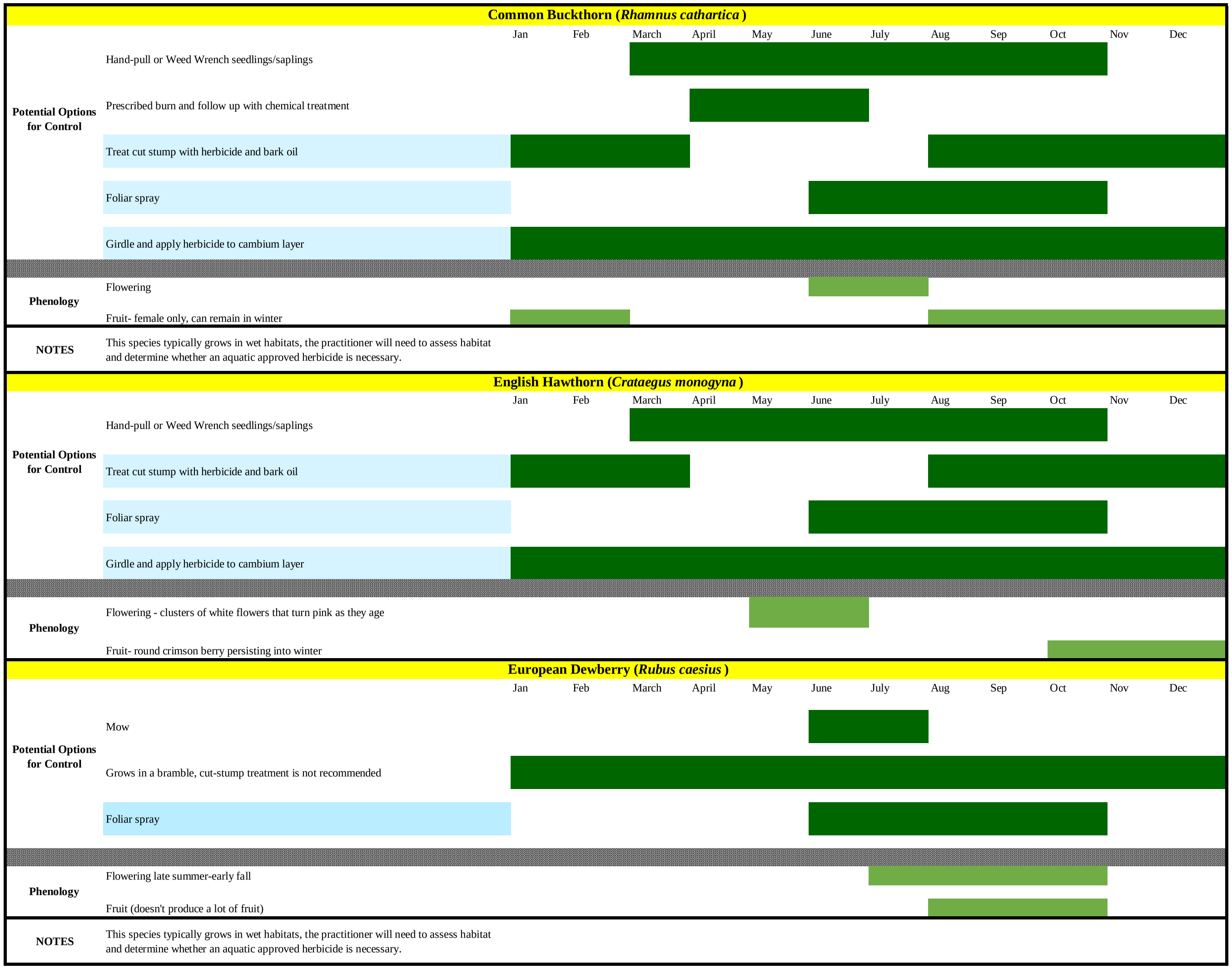
		Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec
Potential Options for Control	Hand-pull or Weed Wrench seedlings/saplings			X	X	X	X	X	X	X	X		
	Prescribed burn and follow up with chemical treatment				X	X	X						
	Treat cut stump with herbicide and bark oil	X	X	X					X	X	X	X	X
	Foliar spray						X	X	X	X	X		
Phenology	Flowering- clusters of white fragrant flowers					X	X						
	Fruit- paired samaras initially very red maturing to a light brown							X	X				

Autumn Olive (*Elaeagnus umbellata*)

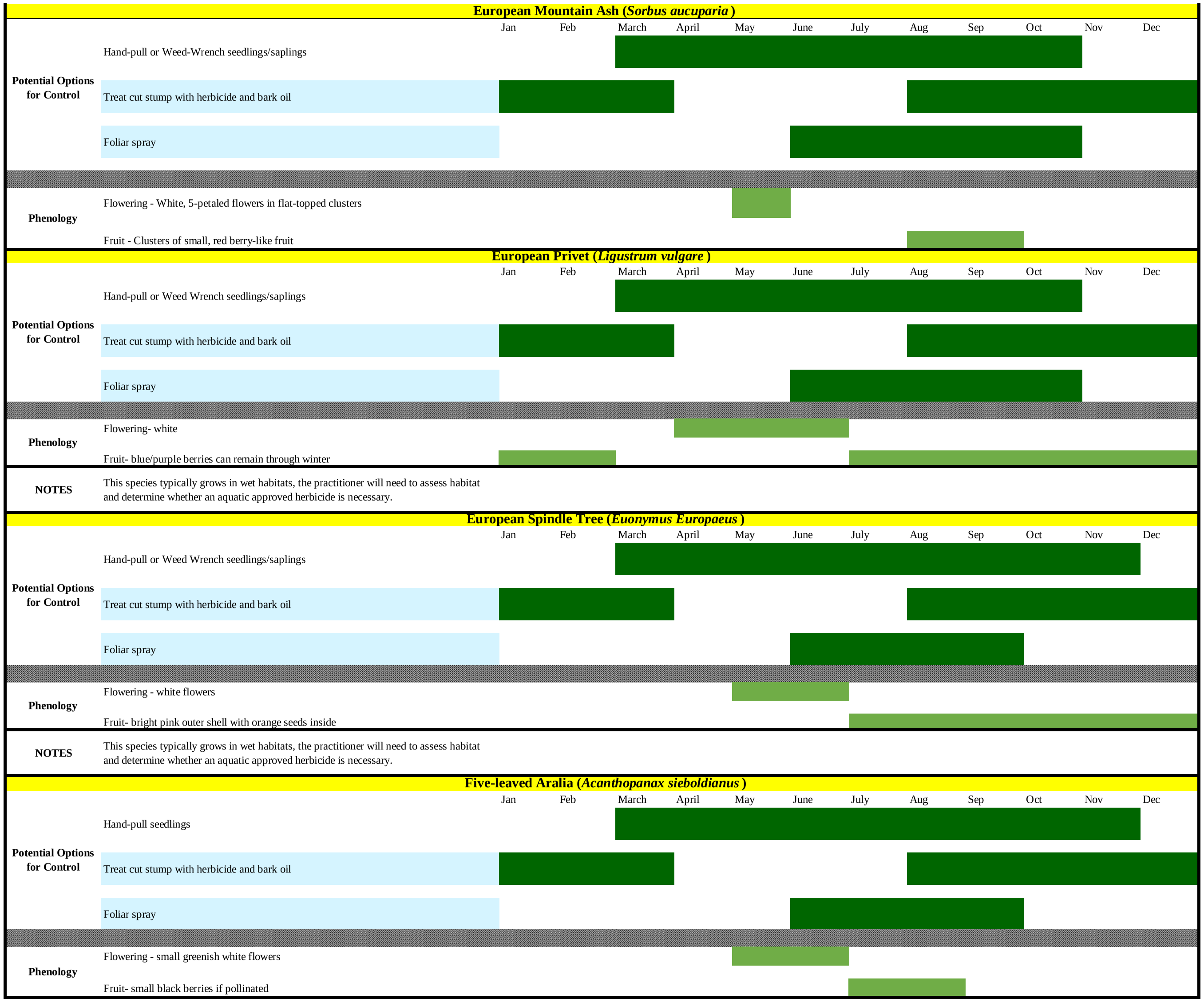
		Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec
Potential Options for Control	Hand-pull or Weed Wrench seedlings/saplings			X	X	X	X	X	X	X	X		
	Prescribed burn and follow up with chemical treatment				X	X	X						
	Treat cut stump with herbicide and bark oil	X	X	X					X	X	X	X	X
	Foliar spray						X	X	X	X	X		
Phenology	Flowering- pale yellow/white					X	X						
	Fruit- red berries with silvery spots leaves-green above and silvery below							X	X	X			

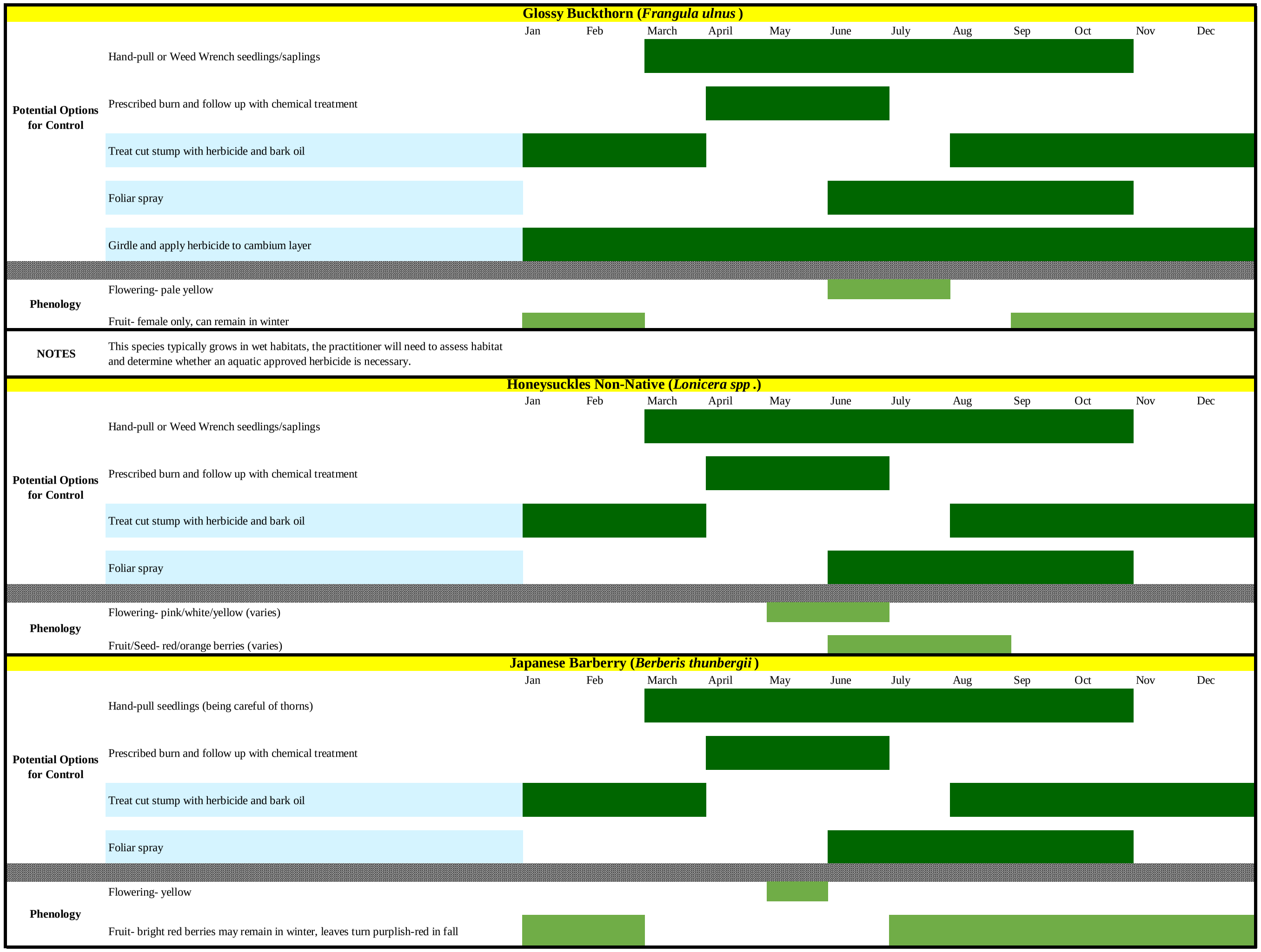


Black Alder (Alnus glutinosa)
Jan Feb March April May June July Aug Sep Oct Nov Dec
Potential Options for Control
Hand-pull or Weed Wrench seedlings/saplings
Prescribed burn and follow up with chemical treatment
Treat cut stump with herbicide and bark oil
Foliar spray
Girdle and apply 33% Progeny to cambium layer
Phenology
Flowering - catkins
Seeds- dark nutlets can remain on tree through winter
NOTES
This species typically grows in wet habitats, the practitioner will need to assess habitat and determine whether an aquatic approved herbicide is necessary.
Black Locust (Robinia pseudoacaia)
Jan Feb March April May June July Aug Sep Oct Nov Dec
Potential Options for Control
DO NOT girdle or burn (encourages vigorous suckering from the root system)
Treat cut stump with herbicide and bark oil
Foliar spray
Phenology
Flowering- white
Pods- can remain on tree through winter
Callery Pear (Pyrus calleryana)
Jan Feb March April May June July Aug Sep Oct Nov Dec
Potential Options for Control
Hand-pull or Weed Wrench seedlings/saaplings
Treat cut stump with herbicide and bark oil
Foliar spray
Girdle and apply herbicide to cambium layer
Phenology
Flowering- white
Fruit- brown/green fruits can remain on tree through winter



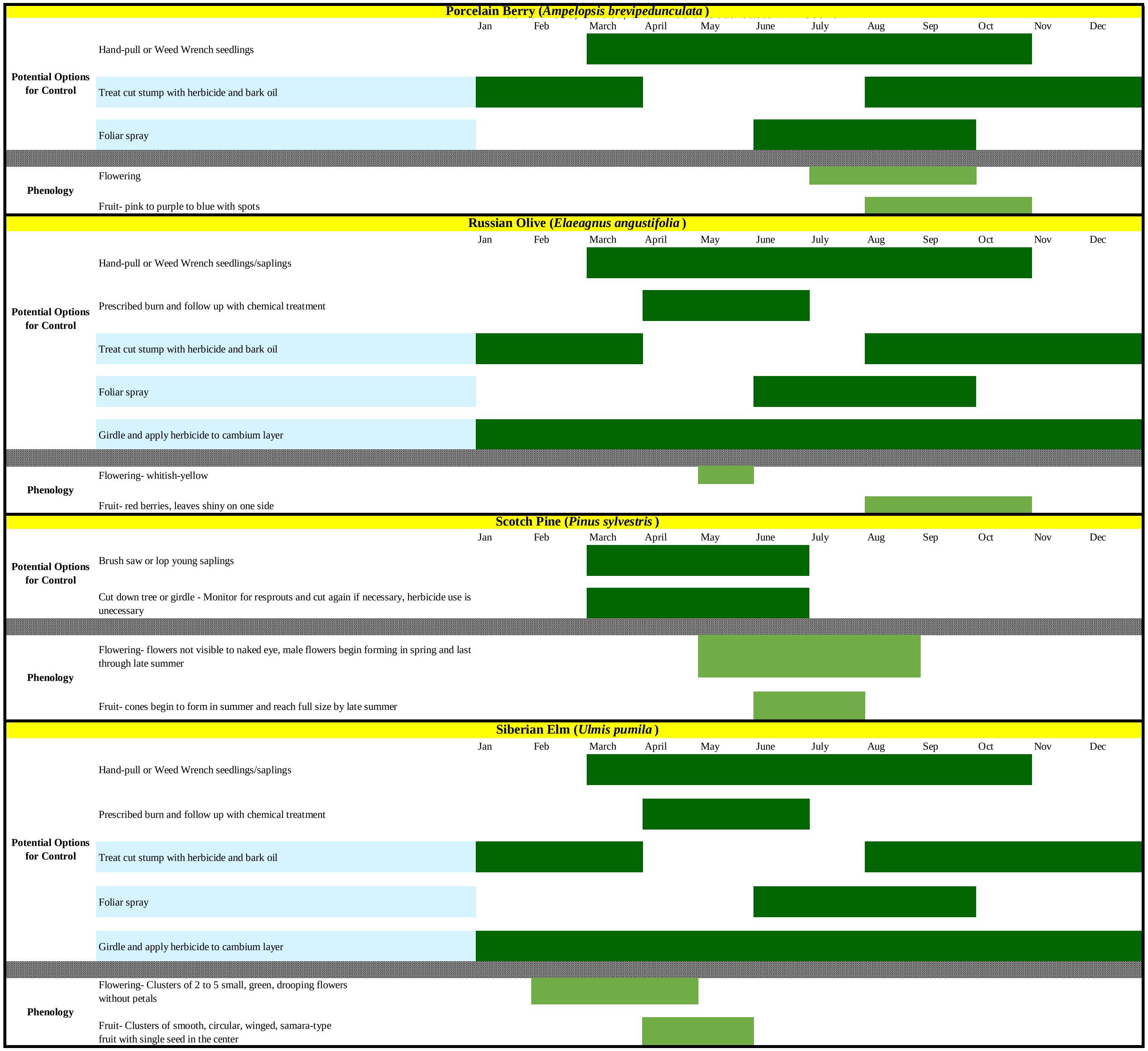
Common Buckthorn (*Rhamnus cathartica*)
Jan Feb March April May June July Aug Sep Oct Nov Dec
Potential Options for Control
Hand-pull or Weed Wrench seedlings/saplings
Prescribed burn and follow up with chemical treatment
Treat cut stump with herbicide and bark oil
Foliar spray
Girdle and apply herbicide to cambium layer
Phenology
Flowering
Fruit- female only, can remain in winter
NOTES
This species typically grows in wet habitats, the practitioner will need to assess habitat and determine whether an aquatic approved herbicide is necessary.
English Hawthorn (*Crataegus monogyna*)
Jan Feb March April May June July Aug Sep Oct Nov Dec
Potential Options for Control
Hand-pull or Weed Wrench seedlings/saplings
Treat cut stump with herbicide and bark oil
Foliar spray
Girdle and apply herbicide to cambium layer
Phenology
Flowering - clusters of white flowers that turn pink as they age
Fruit- round crimson berry persisting into winter
European Dewberry (*Rubus caesius*)
Jan Feb March April May June July Aug Sep Oct Nov Dec
Potential Options for Control
Mow
Grows in a bramble, cut-stump treatment is not recommended
Foliar spray
Phenology
Flowering late summer-early fall
Fruit (doesn't produce a lot of fruit)
NOTES
This species typically grows in wet habitats, the practitioner will need to assess habitat and determine whether an aquatic approved herbicide is necessary.


European Mountain Ash (*Sorbus aucuparia*)
Jan Feb March April May June July Aug Sep Oct Nov Dec
Potential Options for Control
Hand-pull or Weed-Wrench seedlings/saplings
Treat cut stump with herbicide and bark oil
Foliar spray
Phenology
Flowering - White, 5-petaled flowers in flat-topped clusters
Fruit - Clusters of small, red berry-like fruit
European Privet (*Ligustrum vulgare*)
Jan Feb March April May June July Aug Sep Oct Nov Dec
Potential Options for Control
Hand-pull or Weed Wrench seedlings/saplings
Treat cut stump with herbicide and bark oil
Foliar spray
Phenology
Flowering- white
Fruit- blue/purple berries can remain through winter
NOTES
This species typically grows in wet habitats, the practitioner will need to assess habitat and determine whether an aquatic approved herbicide is necessary.
European Spindle Tree (*Euonymus Europaeus*)
Jan Feb March April May June July Aug Sep Oct Nov Dec
Potential Options for Control
Hand-pull or Weed Wrench seedlings/saplings
Treat cut stump with herbicide and bark oil
Foliar spray
Phenology
Flowering - white flowers
Fruit- bright pink outer shell with orange seeds inside
NOTES
This species typically grows in wet habitats, the practitioner will need to assess habitat and determine whether an aquatic approved herbicide is necessary.
Five-leaved Aralia (*Acanthopanax sieboldianus*)
Jan Feb March April May June July Aug Sep Oct Nov Dec
Potential Options for Control
Hand-pull seedlings
Treat cut stump with herbicide and bark oil
Foliar spray
Phenology
Flowering - small greenish white flowers
Fruit- small black berries if pollinated



Glossy Buckthorn (*Frangula ulnus*)
Jan Feb March April May June July Aug Sep Oct Nov Dec
Potential Options for Control
Hand-pull or Weed Wrench seedlings/saplings
Prescribed burn and follow up with chemical treatment
Treat cut stump with herbicide and bark oil
Foliar spray
Girdle and apply herbicide to cambium layer
Phenology
Flowering- pale yellow
Fruit- female only, can remain in winter
NOTES
This species typically grows in wet habitats, the practitioner will need to assess habitat and determine whether an aquatic approved herbicide is necessary.
Honeysuckles Non-Native (*Lonicera spp* .)
Jan Feb March April May June July Aug Sep Oct Nov Dec
Potential Options for Control
Hand-pull or Weed Wrench seedlings/saplings
Prescribed burn and follow up with chemical treatment
Treat cut stump with herbicide and bark oil
Foliar spray
Phenology
Flowering- pink/white/yellow (varies)
Fruit/Seed- red/orange berries (varies)
Japanese Barberry (*Berberis thunbergii*)
Jan Feb March April May June July Aug Sep Oct Nov Dec
Potential Options for Control
Hand-pull seedlings (being careful of thorns)
Prescribed burn and follow up with chemical treatment
Treat cut stump with herbicide and bark oil
Foliar spray
Phenology
Flowering- yellow
Fruit- bright red berries may remain in winter, leaves turn purplish-red in fall

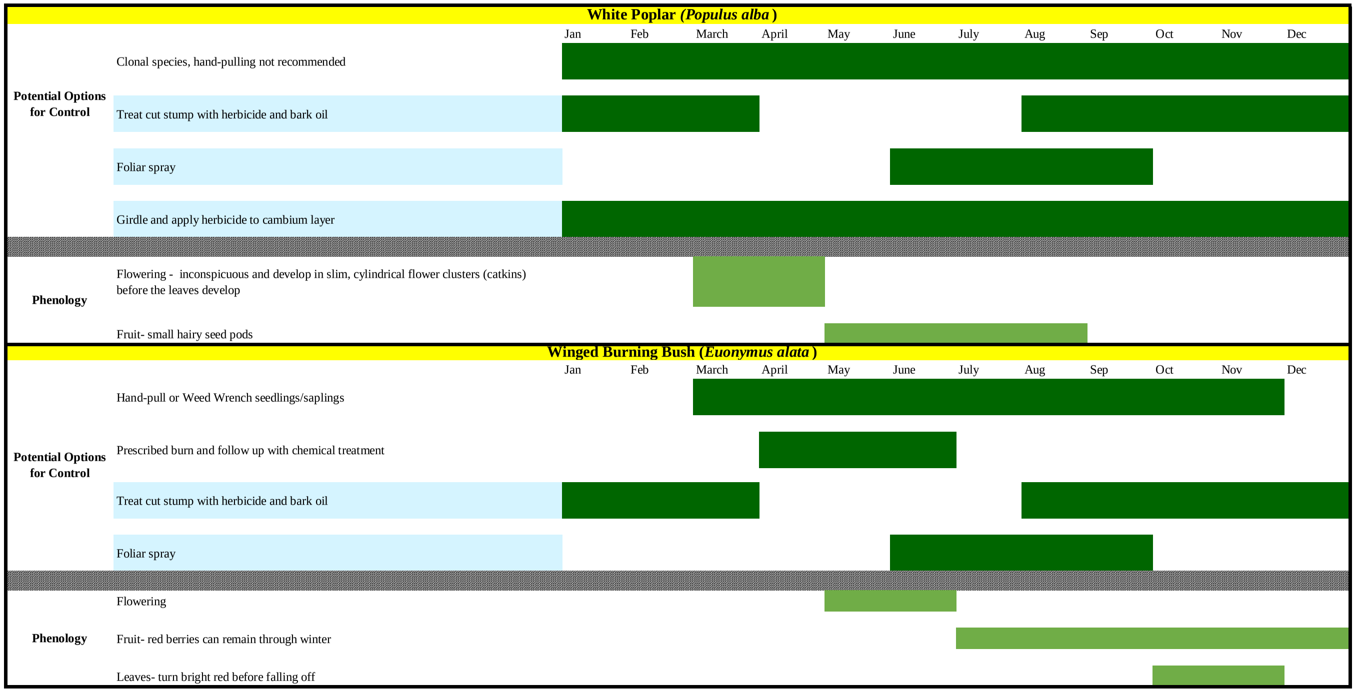

Japanese Tree Lilac (Syringia reticulata)
Jan Feb March April May June July Aug Sep Oct Nov Dec
Potential Options for Control
Hand-pull or Weed Wrench seedlings/saplings
Treat cut stump with herbicide and bark oil
Foliar spray
Girdle and apply herbicide to cambium layer
Phenology
Flowering-white
Fruit/Seed - clusters of green seeds
Little-leaved Linden (Tilia cordata)
Jan Feb March April May June July Aug Sep Oct Nov Dec
Potential Options for Control
Hand-pull or Weed Wrench seedlings/saplings
Treat cut stump with herbicide and bark oil
Foliar spray
Phenology
Flowering- fragrant yellow flowers
Fruit/Seed
Norway Maple (Acer platanoides)
Jan Feb March April May June July Aug Sep Oct Nov Dec
Potential Options for Control
Hand pull or Weed Wrench larger seedlings/saplings
Treat cut stump with herbicide and bark oil
Foliar spray
Girdle and apply herbicide to cambium layer
Phenology
Flowering
Seed (Samaras)- leaf petiole contains milky sap
Oriental Bittersweet (Celastrus orbiculatus)
Jan Feb March April May June July Aug Sep Oct Nov Dec
Potential Options for Control
Hand-pull or Weed Wrench seedlings
Treat cut stump with herbicide and bark oil
Foliar spray
Phenology
Flowering
Fruit- females only, yellow/orange berries along stem, can remain in winter


Porcelain Berry (Ampelopsis brevipedunculata)
Jan Feb March April May June July Aug Sep Oct Nov Dec
Potential Options for Control
Hand-pull or Weed Wrench seedlings
Treat cut stump with herbicide and bark oil
Foliar spray
Phenology
Flowering
Fruit- pink to purple to blue with spots
Russian Olive (Elaeagnus angustifolia)
Jan Feb March April May June July Aug Sep Oct Nov Dec
Potential Options for Control
Hand-pull or Weed Wrench seedlings/saplings
Prescribed burn and follow up with chemical treatment
Treat cut stump with herbicide and bark oil
Foliar spray
Girdle and apply herbicide to cambium layer
Phenology
Flowering- whitish-yellow
Fruit- red berries, leaves shiny on one side
Scotch Pine (Pinus sylvestris)
Jan Feb March April May June July Aug Sep Oct Nov Dec
Potential Options for Control
Brush saw or lop young saplings
Cut down tree or girdle - Monitor for resprouts and cut again if necessary, herbicide use is unecessary
Phenology
Flowering- flowers not visible to naked eye, male flowers begin forming in spring and last through late summer
Fruit- cones begin to form in summer and reach full size by late summer
Siberian Elm (Ulmis pumila)
Jan Feb March April May June July Aug Sep Oct Nov Dec
Potential Options for Control
Hand-pull or Weed Wrench seedlings/saplings
Prescribed burn and follow up with chemical treatment
Treat cut stump with herbicide and bark oil
Foliar spray
Girdle and apply herbicide to cambium layer
Phenology
Flowering- Clusters of 2 to 5 small, green, drooping flowers without petals
Fruit- Clusters of smooth, circular, winged, samara-type fruit with single seed in the center

Tree-of-Heaven (*Ailanthis altissima*)		Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec
Potential Options for Control	Hand-pull or Weed Wrench seedlings/saplings (wear gloves-some people have an allergic reaction)												
	Treat cut stump with herbicide and bark oil												
	Foliar spray												
	Girdle and apply herbicide to cambium layer												
Phenology	Large exaggerated leaf scars and burnt nut odor												
	Flowering- large terminal clusters of pale yellow to greenish flowers												
	Fruit- flat, twisted, winged fruits with one central seed Spreads by seed and vegetatively												

Wayfaring Tree (*Viburnum lantana*)		Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec
Potential Options for Control	Hand-pull or Weed Wrench seedlings/saplings												
	Treat cut stump with herbicide and bark oil												
	Foliar spray												
Phenology	Flowering- white												
	Fruit- red clusters of berries can remain on tree through winter												
NOTES	This species typically grows in wet habitats, the practitioner will need to assess habitat and determine whether an aquatic approved herbicide is necessary.												

White Mulberry (*Morus alba*)		Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec
Potential Options for Control	Hand-pull or Weed Wrench seedlings/saplings												
	Prescribed burn and follow up with chemical treatment												
	Treat cut stump with herbicide and bark oil												
	Foliar spray												
	Girdle and apply herbicide to cambium layer												
Phenology	Flowering												
	Fruit- drooping berries start out white and turn dark purple												
NOTES	Be sure of identification, looks very similar to native red mulberry												


White Poplar (Populus alba)
Jan
Feb
March
April
May
June
July
Aug
Sep
Oct
Nov
Dec
Potential Options for Control
Clonal species, hand-pulling not recommended
Treat cut stump with herbicide and bark oil
Foliar spray
Girdle and apply herbicide to cambium layer
Phenology
Flowering - inconspicuous and develop in slim, cylindrical flower clusters (catkins) before the leaves develop
Fruit- small hairy seed pods
Winged Burning Bush (Euonymus alata)
Jan
Feb
March
April
May
June
July
Aug
Sep
Oct
Nov
Dec
Potential Options for Control
Hand-pull or Weed Wrench seedlings/saplings
Prescribed burn and follow up with chemical treatment
Treat cut stump with herbicide and bark oil
Foliar spray
Phenology
Flowering
Fruit- red berries can remain through winter
Leaves- turn bright red before falling off

Invasive Trees, Shrubs & Vines of Southeastern Wisconsin

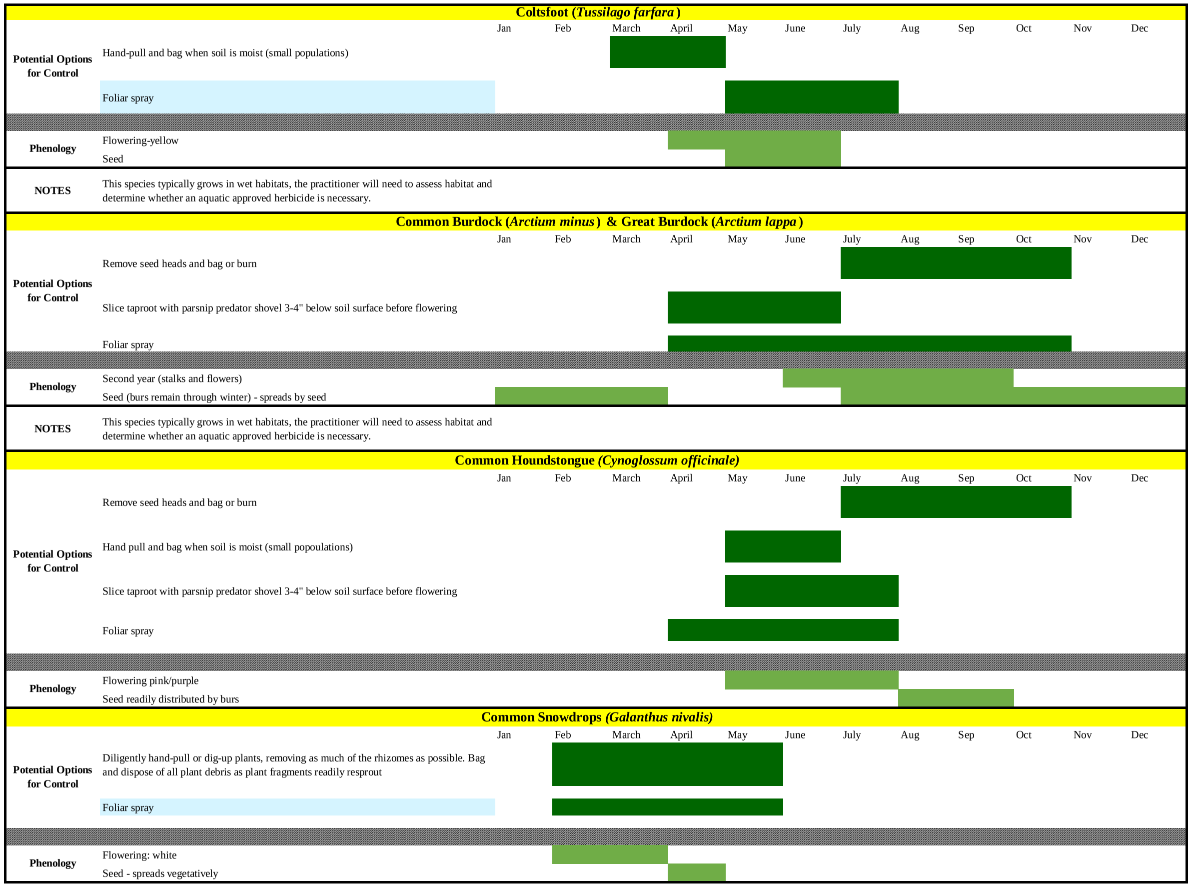
Blue cells indicate the need to assess the site for aquatic approved herbicides.

Bird's Foot Trefoil (*Lotus corniculata*)		Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec
Potential Options for Control	Prescribed burning NOT RECOMMENDED (increases seed germination for this plant)												
	Manually dig out all root fragments for small infestations												
	Mow at height of 2" or less for multiple years												
	Foliar spray (after re-greening from mowing)												
Phenology	Flowering: Small yellow legume flowers												
	Seed: Slender purplish-brown pod about 1 inch long. Spreads vegetatively and by seed												

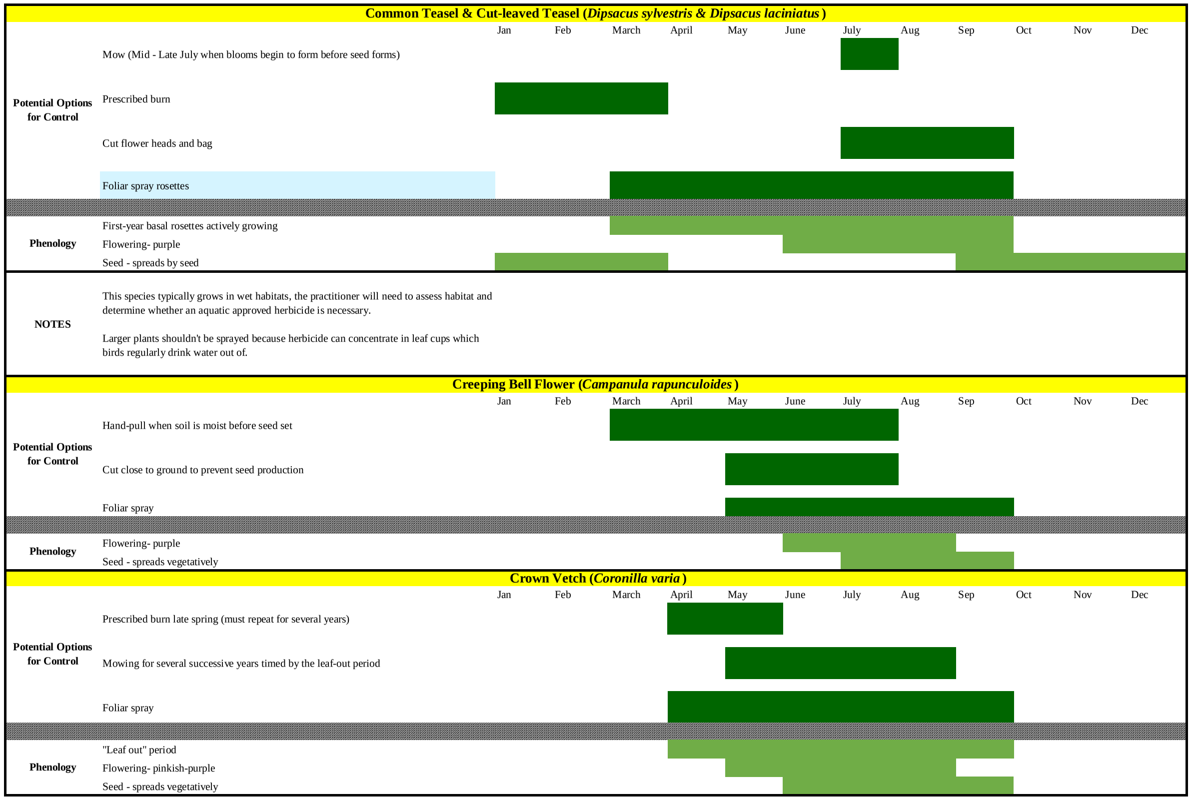
Bishop's Goutweed (*Aegopodium podagraria*)		Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec
Potential Options for Control	Diligently hand-pull or dig-up plants, removing as much of the rhizomes as possible. Bag and dispose of all plant debris as plant fragments readily resprout												
	Cutting and mowing may slow the plants from invading new areas												
	Foliar spray												
Phenology	Flowering: White umbels 2-4 inches across												
	Seed: (seeds typically not viable, short lived seed bank)												
NOTES	This species typically grows in wet habitats, the practitioner will need to assess habitat and determine whether an aquatic approved herbicide is necessary.												

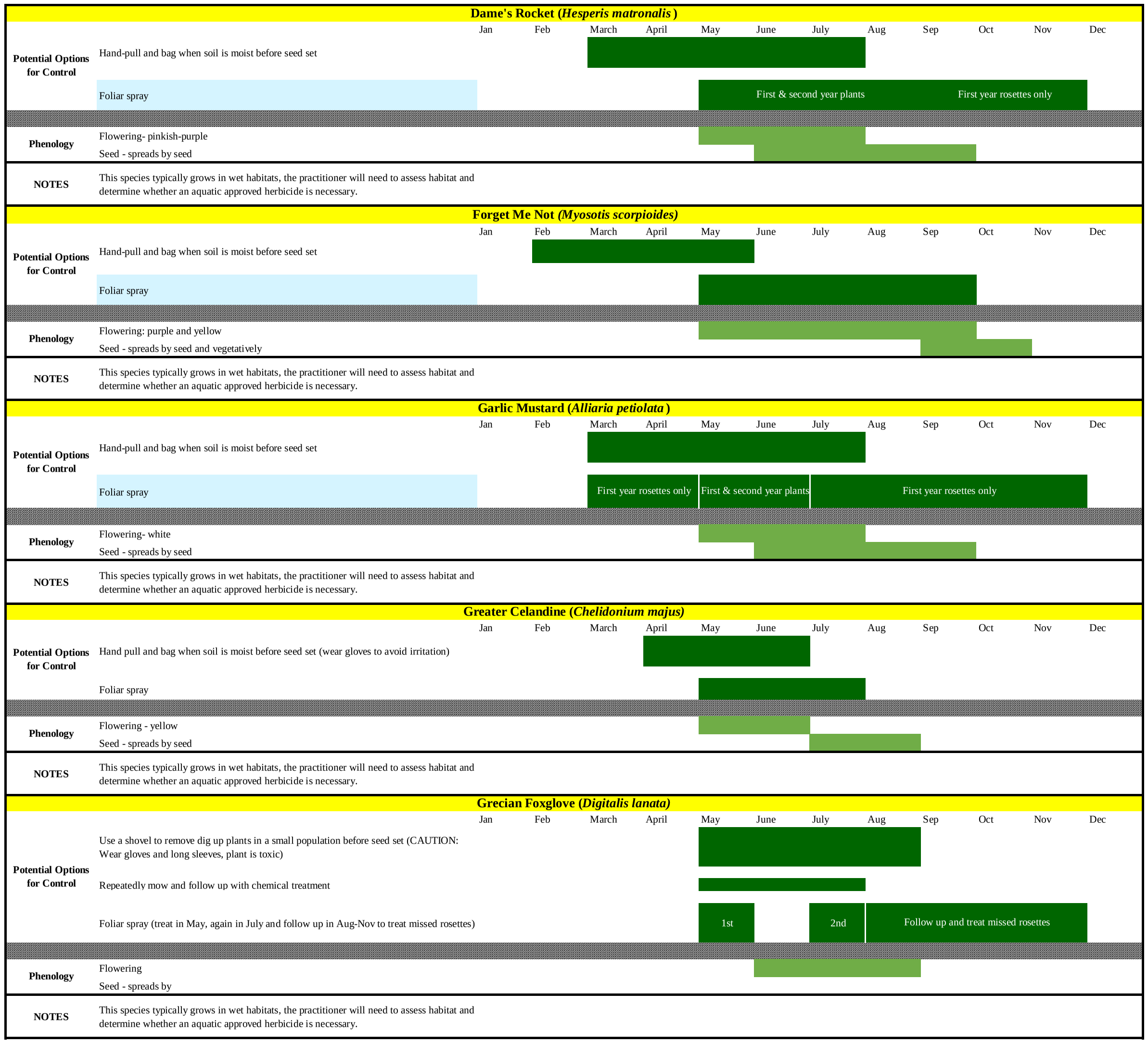
Bouncing Bet (*Saponaria officinalis*)		Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec
Potential Options for Control	Diligently hand-pull or dig-up plants, removing as much of the rhizomes as possible. Bag and dispose of all plant debris as plant fragments readily resprout												
	Foliar spray												
Phenology	Flowering: Dense groups of white/pink flowers with 5 slightly notched petals												
	Seed- spreads vegetatively												
NOTES	This species typically grows in wet habitats, the practitioner will need to assess habitat and determine whether an aquatic approved herbicide is necessary.												

Canada Thistle (*Cirsium arvense*)		Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec
Potential Options for Control	Prescribed burn												
	Cut flower heads just prior to inflorescences (i.e. before they turn purple)												
	Foliar spray												
Phenology	Flowering- purple												
	Seed- spreads vegetatively and by seed												



Coltsfoot (*Tussilago farfara*)
Jan Feb March April May June July Aug Sep Oct Nov Dec
Potential Options for Control
Hand-pull and bag when soil is moist (small populations)
Foliar spray
Phenology
Flowering-yellow
Seed
NOTES
This species typically grows in wet habitats, the practitioner will need to assess habitat and determine whether an aquatic approved herbicide is necessary.
Common Burdock (*Arctium minus*) & Great Burdock (*Arctium lappa*)
Jan Feb March April May June July Aug Sep Oct Nov Dec
Potential Options for Control
Remove seed heads and bag or burn
Slice taproot with parsnip predator shovel 3-4" below soil surface before flowering
Foliar spray
Phenology
Second year (stalks and flowers)
Seed (burs remain through winter) - spreads by seed
NOTES
This species typically grows in wet habitats, the practitioner will need to assess habitat and determine whether an aquatic approved herbicide is necessary.
Common Houndstongue (*Cynoglossum officinale)*
Jan Feb March April May June July Aug Sep Oct Nov Dec
Potential Options for Control
Remove seed heads and bag or burn
Hand pull and bag when soil is moist (small popoulations)
Slice taproot with parsnip predator shovel 3-4" below soil surface before flowering
Foliar spray
Phenology
Flowering pink/purple
Seed readily distributed by burs
Common Snowdrops (*Galanthus nivalis*)
Jan Feb March April May June July Aug Sep Oct Nov Dec
Potential Options for Control
Diligently hand-pull or dig-up plants, removing as much of the rhizomes as possible. Bag and dispose of all plant debris as plant fragments readily resprout
Foliar spray
Phenology
Flowering: white
Seed - spreads vegetatively


Common Teasel & Cut-leaved Teasel (Dipsacus sylvestris & Dipsacus laciniatus)
Jan Feb March April May June July Aug Sep Oct Nov Dec
Potential Options for Control
Mow (Mid - Late July when blooms begin to form before seed forms)
Prescribed burn
Cut flower heads and bag
Foliar spray rosettes
Phenology
First-year basal rosettes actively growing
Flowering- purple
Seed - spreads by seed
NOTES
This species typically grows in wet habitats, the practitioner will need to assess habitat and determine whether an aquatic approved herbicide is necessary.
Larger plants shouldn't be sprayed because herbicide can concentrate in leaf cups which birds regularly drink water out of.
Creeping Bell Flower (Campanula rapunculoides)
Jan Feb March April May June July Aug Sep Oct Nov Dec
Potential Options for Control
Hand-pull when soil is moist before seed set
Cut close to ground to prevent seed production
Foliar spray
Phenology
Flowering- purple
Seed - spreads vegetatively
Crown Vetch (Coronilla varia)
Jan Feb March April May June July Aug Sep Oct Nov Dec
Potential Options for Control
Prescribed burn late spring (must repeat for several years)
Mowing for several successive years timed by the leaf-out period
Foliar spray
Phenology
"Leaf out" period
Flowering- pinkish-purple
Seed - spreads vegetatively


Dame's Rocket (*Hesperis matronalis*)
Jan Feb March April May June July Aug Sep Oct Nov Dec
Potential Options for Control
Hand-pull and bag when soil is moist before seed set
Foliar spray
First & second year plants
First year rosettes only
Phenology
Flowering- pinkish-purple
Seed - spreads by seed
NOTES
This species typically grows in wet habitats, the practitioner will need to assess habitat and determine whether an aquatic approved herbicide is necessary.
Forget Me Not (*Myosotis scorpioides*)
Jan Feb March April May June July Aug Sep Oct Nov Dec
Potential Options for Control
Hand-pull and bag when soil is moist before seed set
Foliar spray
Phenology
Flowering: purple and yellow
Seed - spreads by seed and vegetatively
NOTES
This species typically grows in wet habitats, the practitioner will need to assess habitat and determine whether an aquatic approved herbicide is necessary.
Garlic Mustard (*Alliaria petiolata*)
Jan Feb March April May June July Aug Sep Oct Nov Dec
Potential Options for Control
Hand-pull and bag when soil is moist before seed set
Foliar spray
First year rosettes only
First & second year plants
First year rosettes only
Phenology
Flowering- white
Seed - spreads by seed
NOTES
This species typically grows in wet habitats, the practitioner will need to assess habitat and determine whether an aquatic approved herbicide is necessary.
Greater Celandine (*Chelidonium majus*)
Jan Feb March April May June July Aug Sep Oct Nov Dec
Potential Options for Control
Hand pull and bag when soil is moist before seed set (wear gloves to avoid irritation)
Foliar spray
Phenology
Flowering - yellow
Seed - spreads by seed
NOTES
This species typically grows in wet habitats, the practitioner will need to assess habitat and determine whether an aquatic approved herbicide is necessary.
Grecian Foxglove (*Digitalis lanata*)
Jan Feb March April May June July Aug Sep Oct Nov Dec
Potential Options for Control
Use a shovel to remove dig up plants in a small population before seed set (CAUTION: Wear gloves and long sleeves, plant is toxic)
Repeatedly mow and follow up with chemical treatment
Foliar spray (treat in May, again in July and follow up in Aug-Nov to treat missed rosettes)
1st
2nd
Follow up and treat missed rosettes
Phenology
Flowering
Seed - spreads by
NOTES
This species typically grows in wet habitats, the practitioner will need to assess habitat and determine whether an aquatic approved herbicide is necessary.

Hemp Nettle (*Galeopsis tetrahit*)		Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec
Potential Options for Control	Dig up or hand pull when in the flower bud stage												
	Foliar spray												
Phenology	Flowering: purple												
	Seed												
NOTES	This species typically grows in wet habitats, the practitioner will need to assess habitat and determine whether an aquatic approved herbicide is necessary.												

Hill Mustard (*Bunias orientalis*)		Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec
Potential Options for Control	Mow before seed production and when flowers re-grow before seed matures												
	Foliar spray												
Phenology	Flowering yellow												
	Seed tear drop shaped different from yellow rocket - spreads by seed												

Japanese Hedge Parsley (*Torilis japonica*)		Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec
Potential Options for Control	Hand pull and bag when soil is moist before seed set												
	Mow before seed production and when flowers re-grow before seed matures												
	Foliar spray												
Phenology	Flowering- white												
	Seed - spreads by seed												
NOTES	This species typically grows in wet habitats, the practitioner will need to assess habitat and determine whether an aquatic approved herbicide is necessary.												

Japanese Knotweed (*Fallopia japonica*)		Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec
Potential Options for Control	Cut in spring when it reaches 3' tall												
	Cut again when the re-growth has again reached over 3' tall and the plant is in flower.												
	Foliar spray (after 3 ft of re-growth)												
	Cut-stem between 1st and 2nd joint pour herbicide into stalk (small populations)												
Phenology	Flowering- white												
	Seed - spreads vegetatively												
NOTES	This species typically grows in wet habitats, the practitioner will need to assess habitat and determine whether an aquatic approved herbicide is necessary.												

Leafy Spurge & Cypress Spurge (*Euphorbia esula & Euphorbia cyparissias*)		Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec
Potential Options for Control	Prescribed burn late spring (must repeat for several years)												
	Mow every 2-4 weeks followed by a foliar treatment (3-5 weeks later)												
	Re-seed area with native grasses for 80% control												
	Foliar spray					Apply when seeds are forming				Apply to re-growth before frost			
Phenology	Flowering- yellow												
	Seed - spreads vegetatively												

Lesser Celandine (*Ranunculus ficaria*)		Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec
Potential Options for Control	Manual control requires the removal of all bulblets and tubers (digging)												
	Foliar spray												
Phenology	Flowering- yellow												
	Seed - spreads mostly by tubers and bulblets. Thoroughly clean shoes after walking in populations of *R.ficaria*												
NOTES	This species typically grows in wet habitats, the practitioner will need to assess habitat and determine whether an aquatic approved herbicide is necessary.												

Lily-of-the-valley (*Convallaria majalis*)

		Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec
Potential Options for Control	Manual control requires the removal of all tubers and roots (digging)												
	Foliar spray												
Phenology	Flowering - white												
	Seed -spreads vegetatively												
NOTES	This species typically grows in wet habitats, the practitioner will need to assess habitat and determine whether an aquatic approved herbicide is necessary.												

Orange Daylily (*Hemerocallis fulva*)

		Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec
Potential Options for Control	Manual control requires the removal of all tubers and roots (digging)												
	Foliar spray												
Phenology	Flowering - orange												
	Seed (most escaped cultivars are sterile, spreads mainly by tubers)												
NOTES	This species typically grows in wet habitats, the practitioner will need to assess habitat and determine whether an aquatic approved herbicide is necessary.												

Pachysandra (*Pachysandra terminalis*)

		Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec
Potential Options for Control	Manual control requires the removal of all roots and runners (digging)												
	Foliar spray												
Phenology	Flowering												
	Seed -Spreads mainly by undeground runners												
NOTES	This species typically grows in wet habitats, the practitioner will need to assess habitat and determine whether an aquatic approved herbicide is necessary.												

Invasive Pea spp. (*Lathyrus latifolius, L.sylvestris & L.tuberosus*)

		Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec
Potential Options for Control	Prescribed burn late spring (must repeat for several years)												
	Mowing for several successive years timed by the leaf-out period												
	Foliar spray												
Phenology	Flowering- pink												
	Seed												

Periwinkle (*Vinca major*)

		Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec
Potential Options for Control	Manual control requires the removal of all roots and runners over many years (digging)												
	Mowing is not recommended												
	Foliar spray												
	Foliar spray												
Phenology	Flowering - bluish purple												
	Seed -Most plants are sterile and spread mainly by undeground runners												
NOTES	This species typically grows in wet habitats, the practitioner will need to assess habitat and determine whether an aquatic approved herbicide is necessary.												

Poison Hemlock (Conium maculatum)
Jan Feb March April May June July Aug Sep Oct Nov Dec
Potential Options for Control
Mow (when seeds have just begun to form but not mature)
Late June-Mid July
Foliar spray
Phenology
Flowering - white umbels of 12-16 flowers
Seed - spreads by seed
NOTES
This species typically grows in wet habitats, the practitioner will need to assess habitat and determine whether an aquatic approved herbicide is necessary.
Purple Loosestrife (Lythrum salicaria)
Jan Feb March April May June July Aug Sep Oct Nov Dec
Potential Options for Control
Bio-control with beetles
Foliar spray
Spray at or beyond bloom phase but before first frost
Treat stems using the "bloody glove" technique (small populations)
Phenology
Flowering- purple
Seed
NOTES
This species typically grows in wet habitats, the practitioner will need to assess habitat and determine whether an aquatic approved herbicide is necessary.
Scarlet Pimpernel (Pimpinella saxifraga)
Jan Feb March April May June July Aug Sep Oct Nov Dec
Potential Options for Control
Hand pull and bag when soil is moist before seed set
Mow before seed set, monitor for resprouts
Foliar spray
Phenology
Flowering - umbels made up of 7 to 20 groups (umbellets) of 10 to 20 flowers each.
Seed
Siberian Squill (Scilla siberica)
Jan Feb March April May June July Aug Sep Oct Nov Dec
Potential Options for Control
Diligently hand-pull or dig-up plants, removing as much of the rhizomes as possible. Bag and dispose of all plant debris as plant fragments readily resprout. (small populations only)
Foliar spray
Phenology
Flowering
Seed - spreads by seed and vegetatively
Spotted Knapweed (Centurea maculosa)
Jan Feb March April May June July Aug Sep Oct Nov Dec
Potential Options for Control
Hand-pull small plots (wear gloves-some people have an allergic reaction)
Prescribed burn late spring (must repeat for atleast 3 years)
Slice taproot with parsnip predator shovel 3-4" below soil surface before flowering
Mow annually for 3 years, resprouts will not likely produce viable seed
Foliar spray
Phenology
Flowering- purple
Seed

Star of Bethlehem *(Ornithogalum umbellatum)*													
		Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec
Potential Options for Control	Manual control involves removing the plant including bulbs (digging)												
	Foliar spray												
Phenology	Flowering - white flower with green line on bottom of petal												
	Seed- spreads from bulbs undergound												
NOTES	This species typically grows in wet habitats, the practitioner will need to assess habitat and determine whether an aquatic approved herbicide is necessary.												

Tansy *(Tanacetum vulgare)*													
		Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec
Potential Options for Control	Hand pull and bag when soil is moist before seed set (wear gloves to avoid irritation)												
	Foliar spray												
Phenology	Flowering												
	Seed												

Wild Chervil (*Anthriscus sylvestris*)													
		Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec
Potential Options for Control	Hand pull and bag when soil is moist before seed set (small populations)												
	Mow 3 times annually before flowers form												
	Cut through root 1-2" below ground level with a parsnip predator shovel before flowering begins (small populations)												
	Foliar spray												
Phenology	Flowering- flowers from May-early July in its second year												
	Seed - spreads by seed												
NOTES	This species typically grows in wet habitats, the practitioner will need to assess habitat and determine whether an aquatic approved herbicide is necessary.												

Wild Parsnip (*Pastinaca sativa*)

		Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec
Potential Options for Control	Mow (when seeds have just begun to form but not mature)						Late June-Mid July						
	Cut through root 1-2" below ground level with a parsnip predator shovel before flowering begins												
	Foliar spray												
Phenology	Flowering												
	Seed - spreads by seed												
NOTES	This species typically grows in wet habitats, the practitioner will need to assess habitat and determine whether an aquatic approved herbicide is necessary.												

Wormwood (*Artemisia absinthium*)

		Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec
Potential Options for Control	Hand pull and bag when soil is moist roots because roots are woody and extensive (small populations)												
	Foliar spray					treat before plants reach							
Phenology	Flowering - yellow												
	Seed												
NOTES	This species typically grows in wet habitats, the practitioner will need to assess habitat and determine whether an aquatic approved herbicide is necessary.												

Yellow Iris (*Iris pseudacorus*)

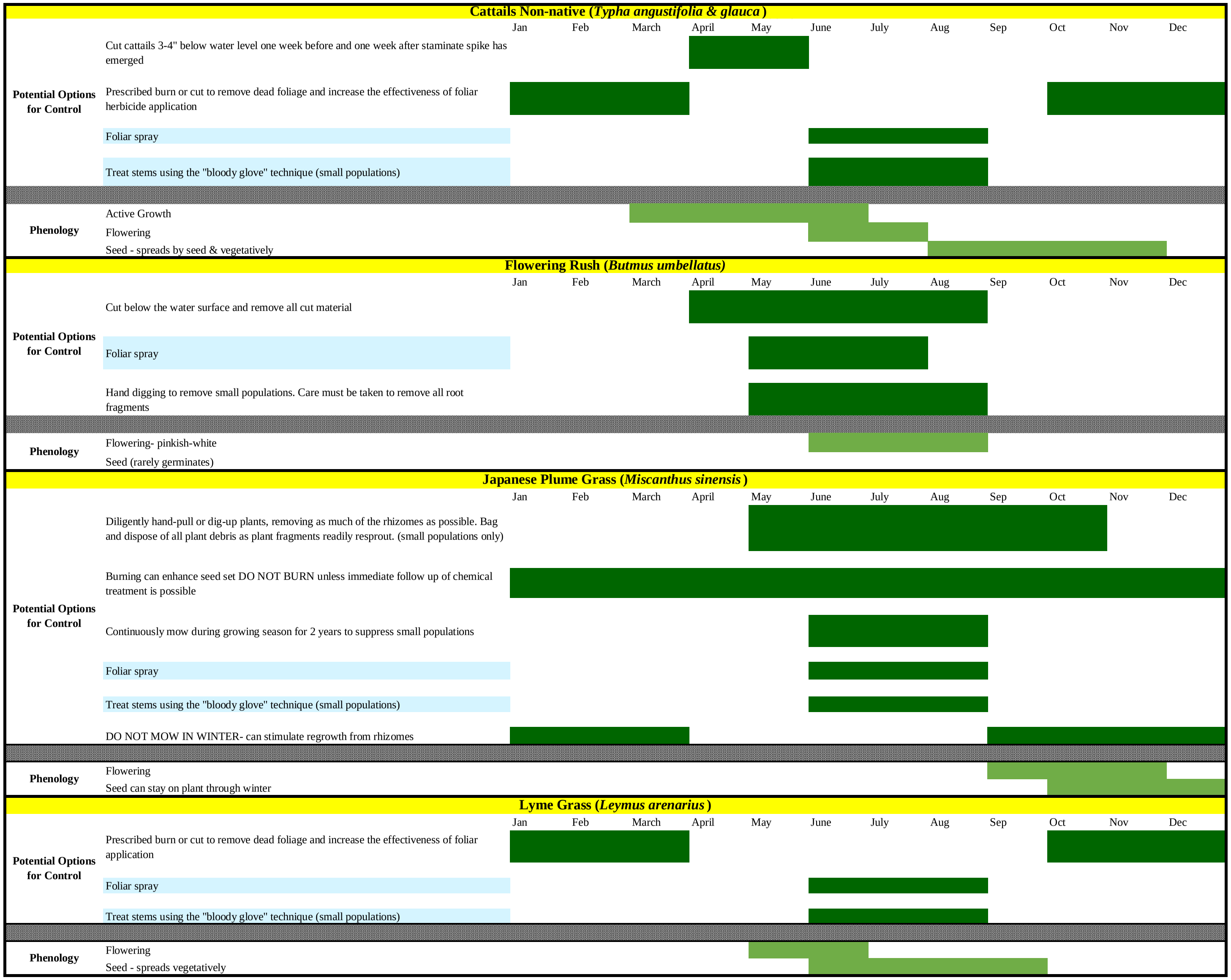
		Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec
Potential Options for Control	Dig out bulbs and tubers of small populations												
	Foliar spray												
	Cut flower stalks to 8", inject herbicide into stem center												
Phenology	Flowering- yellow												
	Seed												
NOTES	This species typically grows in wet habitats, the practitioner will need to assess habitat and determine whether an aquatic approved herbicide is necessary.												

Yellow Sweet Clover & White Sweet Clover (*Melilotus officinalis & Melilotus albus*)

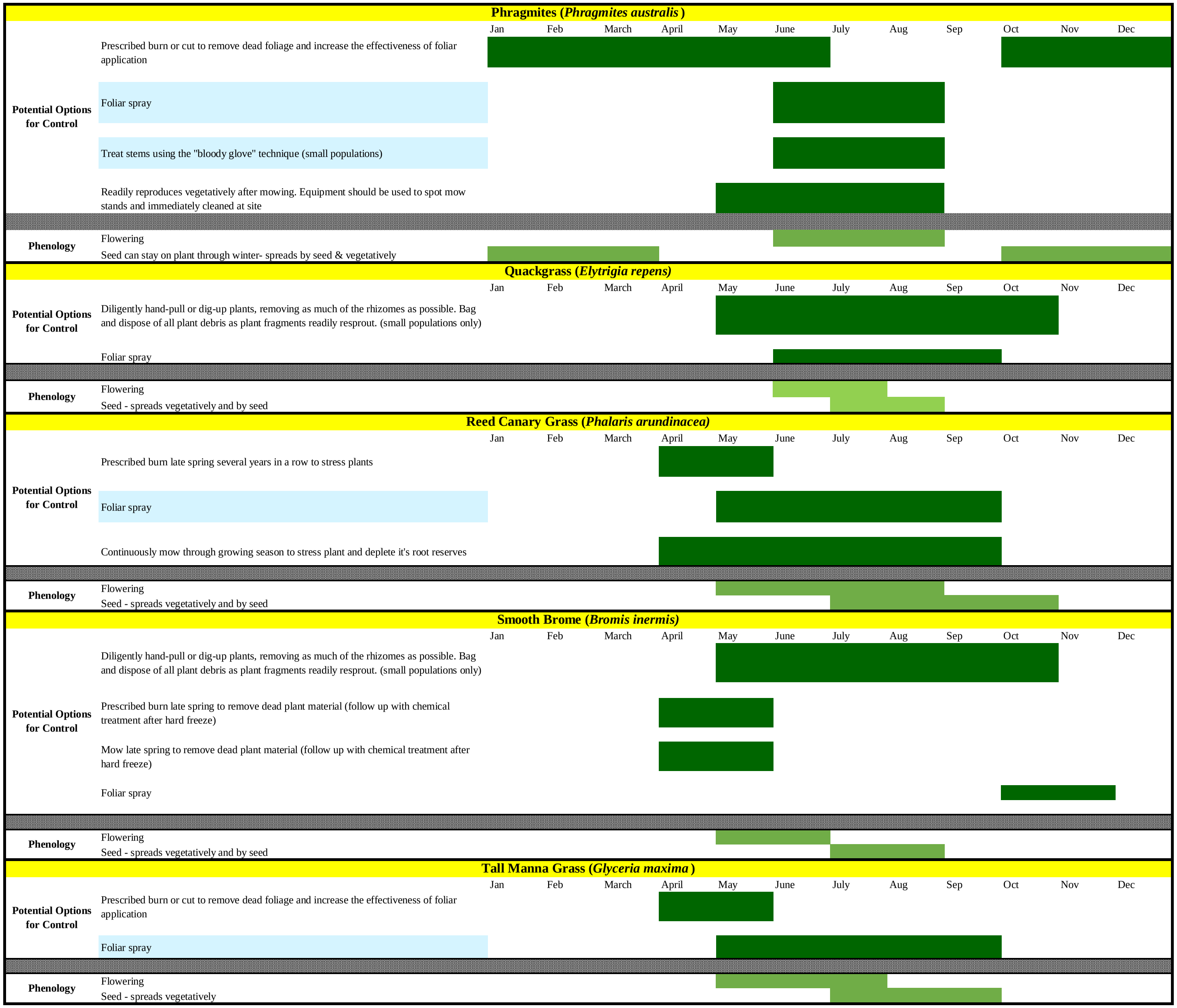
		Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec
Potential Options for Control	Mow just after flowering before seed matures												
	Cut through root 1-2" below ground level with a parsnip predator shovel before flowering begins												
	Hand-pull small populations before seed set												
	Spray foliage with **Milestone@ 7oz/ acre** and **MSO @ .4%** mixed with water					First & second year plants			First year rosettes only				
Phenology	Flowering												
	Seed - spreads by seed												

Invasive Grasses of Southeastern Wisconsin

Blue cells indicate the need to assess the site for aquatic approved herbicides.



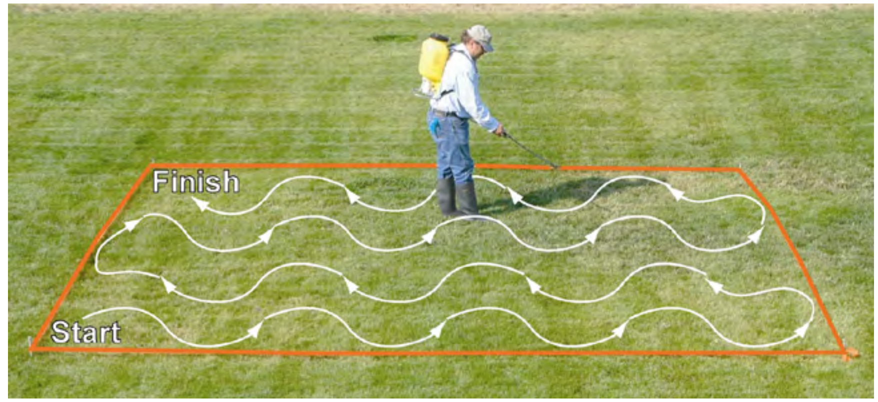
Cattails Non-native (*Typha angustifolia & glauca*)
Jan Feb March April May June July Aug Sep Oct Nov Dec
Potential Options for Control
Cut cattails 3-4" below water level one week before and one week after staminate spike has emerged
Prescribed burn or cut to remove dead foliage and increase the effectiveness of foliar herbicide application
Foliar spray
Treat stems using the "bloody glove" technique (small populations)
Phenology
Active Growth
Flowering
Seed - spreads by seed & vegetatively
Flowering Rush (*Butmus umbellatus*)
Jan Feb March April May June July Aug Sep Oct Nov Dec
Potential Options for Control
Cut below the water surface and remove all cut material
Foliar spray
Hand digging to remove small populations. Care must be taken to remove all root fragments
Phenology
Flowering- pinkish-white
Seed (rarely germinates)
Japanese Plume Grass (*Miscanthus sinensis*)
Jan Feb March April May June July Aug Sep Oct Nov Dec
Potential Options for Control
Diligently hand-pull or dig-up plants, removing as much of the rhizomes as possible. Bag and dispose of all plant debris as plant fragments readily resprout. (small populations only)
Burning can enhance seed set DO NOT BURN unless immediate follow up of chemical treatment is possible
Continuously mow during growing season for 2 years to suppress small populations
Foliar spray
Treat stems using the "bloody glove" technique (small populations)
DO NOT MOW IN WINTER- can stimulate regrowth from rhizomes
Phenology
Flowering
Seed can stay on plant through winter
Lyme Grass (*Leymus arenarius*)
Jan Feb March April May June July Aug Sep Oct Nov Dec
Potential Options for Control
Prescribed burn or cut to remove dead foliage and increase the effectiveness of foliar application
Foliar spray
Treat stems using the "bloody glove" technique (small populations)
Phenology
Flowering
Seed - spreads vegetatively



Phragmites (Phragmites australis)
Jan Feb March April May June July Aug Sep Oct Nov Dec
Potential Options for Control
Prescribed burn or cut to remove dead foliage and increase the effectiveness of foliar application
Foliar spray
Treat stems using the "bloody glove" technique (small populations)
Readily reproduces vegetatively after mowing. Equipment should be used to spot mow stands and immediately cleaned at site
Phenology
Flowering
Seed can stay on plant through winter- spreads by seed & vegetatively
Quackgrass (Elytrigia repens)
Jan Feb March April May June July Aug Sep Oct Nov Dec
Potential Options for Control
Diligently hand-pull or dig-up plants, removing as much of the rhizomes as possible. Bag and dispose of all plant debris as plant fragments readily resprout. (small populations only)
Foliar spray
Phenology
Flowering
Seed - spreads vegetatively and by seed
Reed Canary Grass (Phalaris arundinacea)
Jan Feb March April May June July Aug Sep Oct Nov Dec
Potential Options for Control
Prescribed burn late spring several years in a row to stress plants
Foliar spray
Continuously mow through growing season to stress plant and deplete it's root reserves
Phenology
Flowering
Seed - spreads vegetatively and by seed
Smooth Brome (Bromis inermis)
Jan Feb March April May June July Aug Sep Oct Nov Dec
Potential Options for Control
Diligently hand-pull or dig-up plants, removing as much of the rhizomes as possible. Bag and dispose of all plant debris as plant fragments readily resprout. (small populations only)
Prescribed burn late spring to remove dead plant material (follow up with chemical treatment after hard freeze)
Mow late spring to remove dead plant material (follow up with chemical treatment after hard freeze)
Foliar spray
Phenology
Flowering
Seed - spreads vegetatively and by seed
Tall Manna Grass (Glyceria maxima)
Jan Feb March April May June July Aug Sep Oct Nov Dec
Potential Options for Control
Prescribed burn or cut to remove dead foliage and increase the effectiveness of foliar application
Foliar spray
Phenology
Flowering
Seed - spreads vegetatively

Calibrating backpacks

One gallon = 128 fluid ounces and your calibration area to be sprayed is 1/128 of an acre, thus fluid ounces collected = gallons per acre.



1. Clean sprayer and nozzle thoroughly. Then, fill the spray tank with clean water. Spray with water only to check to see that the nozzle forms a uniform spray pattern. If the pattern is uneven, check to make sure the nozzle is clean and replace it if needed. Adjustable nozzles should be set and marked to permit repeated use of the selected spray pattern. If necessary, add a marker dye to the water to more easily see your spray pattern.
2. Measure an area 18.5 feet by 18.5 feet, which is equal to 1/128th of an acre.
3. Time the number of seconds it takes to spray the measured area uniformly with water using gentle side-to-side sweeping motion with the spray wand similar to spray painting a home or automobile. Record the number of seconds required to spray the area. During application be sure to maintain a constant sprayer pressure and cover the entire area uniformly one time. You should repeat step 3 at least twice and use the average of the two times.
4. Spray into a container for the average time calculated in step 3. Be sure to maintain constant sprayer pressure while you spray into the container.
5. Measure the number of fluid ounces of water in the container. The number of fluid ounces collected from the container is equal to the number of gallons of water per acre the sprayer is delivering. Volume sprayed in fluid ounces = gallons of water per acre (GPA).
6. Convert from gallons to liters if necessary. 1 gal = 3.79 L

Information adapted from Techline News Calibration Handout

** use cone tip nozzles when calibrating and average the time for all backpacks**

CONSIDERATIONS FOR DESIGN AND PLACEMENT OF STREAM CROSSINGS

APPENDIX S

TYPES OF CROSSINGS[24]

- The number of stream crossings should be minimized.

- If a crossing is necessary, structures that maintain to the extent possible the existing streambed and bank conditions are preferable; therefore, bridges spanning streams are preferable to other structures.

- If a culvert is necessary, open bottom structures are preferable to closed bottom structures.

- If a closed bottom culvert is necessary, box culverts, elliptical, or pipe arch culverts are preferable to round pipe culverts, because round pipes generally reduce stream width to a much larger degree than the aforementioned structures, causing long term upstream and downstream passage limitations (see physical considerations below).

- Offsetting Multiple Culverts—If multiple culverts are necessary, it is recommended that the culvert inverts be offset vertically and only one culvert be designed to provide passage during low flow conditions and the additional culverts be used to pass the higher flow events (see Figure S.1). Therefore, the low flow culvert will be the only culvert, in a series of two or more culverts, designed to provide fish passage during low flows and shall meet the physical requirements of passage above.

BIOLOGICAL CONSIDERATIONS[25]

- Contact the area WDNR fisheries manager prior to design and construction to minimize impacts[26]

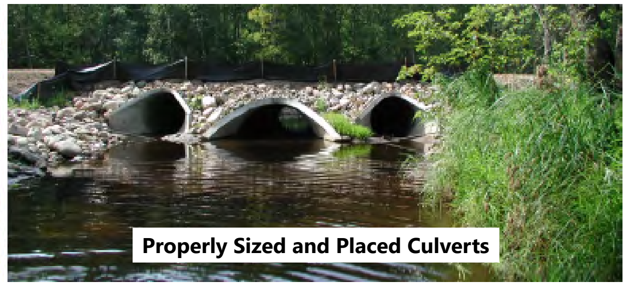
---

[24] *Department of Fish and Game, Division of Ecological Restoration,* Massachusetts Stream Crossings Handbook*, Editors: Amy Singler, Brian Graber, and Carrie Banks, Writing and design: biodrawversity (www.biodrawversitS.com), 2nd Edition, June 2012, www.mass.gov/eea/docs/dfg/der/pdf/stream-crossings-handbook.pdf.*

[25] *British Colombia Ministry of Forests,* Fish-stream crossing guidebook, *For. Prac. Br., Min. For., www.for.gov.bc.ca/tasb/legsregs/fpc/FPCGUIDE/Guidetoc.htm, Victoria, B.C. Forest Practices Code of British Columbia guidebook, 2002.*

[26] *UW-Extension and WDNR,* Fish Friendly Culverts*, 2002.*

Figure S.1
Considerations for Culvert Design and Placement



Source: Minnesota Department of Natural Resources

- Species of fish present (coldwater, warmwater, threatened, endangered, species of special concern)
- Life stages to potentially be impacted
- Migration timing of affected species/life stages (e.g., adult spawning times should be avoided)

PHYSICAL CONSIDERATIONS[27]

It is important to note that in order to achieve the minimum physical criteria outlined below, the culvert(s) will need to be oversized as part of the design to ensure adequate long-term fish passage as well as the ability to pass the design period rainfall event.

It is understood that it may not be possible to achieve some of the minimum passage criteria below based upon specific on-site conditions or constraints; however, the closer the designed and completed culvert can meet these criteria the better the long-term passage and overall sustainability of the fishery will be in this region.

Provide Adequate Depth

- Slope—Culvert should be installed with a slope that matches the riffle slope as measured in the thalweg[28] (see Minnesota DNR guidelines)[29]
- Water Depth and Velocity—Water depths and velocities should be comparable to those found in the natural channel at a variety of flows. Depths should maintain the determined thalweg depth at any point within the culvert during low flow periods (see Minnesota DNR guidelines).
- Installation Below Grade—The culvert should be installed so that the bottom of the structure is buried to a depth equal to 1/6th the bankfull width of the stream (up to two feet) below the natural grade line elevation of the stream bottom (see Minnesota DNR guidelines). The culvert should then be filled to stream grade with natural substrates. The substrates should consist of a variety of gravel ranging from one to four inches in diameter and either mixed with nonuniformly laid riprap or uniformly placed alternate riprap baffles, large enough to be stable during the culvert design discharge, which will ensure stability of substrates during high flow events.

[27] *Washington Department of Fish and Wildlife, Habitat and Lands Program, Environmental Engineering Division,* Fish Passage Design at Road Culverts: A Design Manual for Fish Passage at Road Crossings, *Washington, March 3, 1999.*

[28] *The thalweg is the lowest point of the streambed.*

[29] *Minnesota DNR,* Best Practices for Meeting DNR General Public Waters Work Permit GP *2004-0001, March 2006.*

Provide Adequate Width and Openness

- Crossing Span (see Massachusetts Stream Crossings Handbook):[30]
  - General—Spans channel width (a minimum of 1.2 times the bankfull with of the stream).
  - Optimum—Spans the streambed and banks (at least 1.3 times the bankfull width) with sufficient capacity to provide dry passage for wildlife (see Figure S.2). Culvert width shall match the bankfull width (minimum) of the existing channel.
- Openness (see Massachusetts Stream Crossings Handbook):[31]
  - General—Openness ratio (cross sectional area/crossing length) of at least 0.82 feet. The crossing should be wide and high relative to its length.
  - Optimum—Openness ratio of at least 1.64 feet and minimum height of six feet. If conditions significantly reduce wildlife passage near a crossing (e.g. steep embankments, high traffic volumes, or other physical barriers), maintain a minimum height of eight feet and openness ratio of 2.46 feet.

Provide Adequate Resting Areas

- Length—Culverts that exceed more than 75 feet in length need to provide additional resting areas (e.g., installation of baffles or weirs) within the culvert to facilitate passage.[32]

Inlet and Outlet Protection

- Align the culvert with the existing stream alignment (e.g., 90 degree bends at the inlet or outlet should be avoided, even though this will increase culvert length, see Minnesota DNR guidelines).[33]
- The low flow culvert should be centered on the thalweg of the channel to ensure adequate depths inside the culvert.
- Provide grade control where there is potential for head-cuts that could degrade the channel.
- It may be necessary to install riprap protection on the outside bank below the outlet to reduce bank erosion during high flow events.

[30] *Department of Fish and Game,* Massachusetts Stream Crossings Handbook*, June 2012.*

[31] *Ibid.*

[32] *Thomas Slawski and Timothy Ehlinger, "Habitat Improvement in Box Culverts: Management in the Dark?,"* North American Journal of Fisheries Management*, Volume 18:676-685, 1998.*

[33] *Minnesota DNR, March 2006 op.cit.*

Figure S.2
Key Features that Promote Fish and Wildlife Passage

Source: Department of Fish and Game, Massachusetts Stream Crossings Handbook, *June 2012*

DETAILED COST ESTIMATES FOR THE MILL POND AND DAM ALTERNATIVES

APPENDIX T

ALTERNATIVE 1

Description: Minimum work required per WDNR order, which is to rebuild the sluice gate to be able to dewater the pond for dam maintenance.

Item #	Item Description	Unit	Quantity	Unit Price	Total
CONSTRUCTION					
1	Mobilization - Sluice Gate Repairs	LS	1	$ 5,603	$ 5,603
2	Remove Existing 36" CMP Storm Sewer	LF	10	$ 19.83	$ 198
3	Cofferdam Construction, Maintenance, and Removal	LS	1	$ 11,206	$ 11,206
4	Pumping Water from Within Cofferdam - Sluice Gate Repairs	Day	1	$ 1,394	$ 1,394
5	Safety Fence	LF	150	$ 4.48	$ 672
6	Silt Fence	LF	100	$ 3.36	$ 336
7	Tracking Pad	EA	1	$ 1,681	$ 1,681
8	Common Excavation and Grading	LS	1	$ 5,603	$ 5,603
9	Stockpile Topsoil	LS	1	$ 1,681	$ 1,681
10	Dredging Material (Removal and Disposal)	CY	1,212	$ 100	$ 121,203
11	Dewatering Dredged Material	CY	1,212	$ 5.17	$ 6,264
12	30" Diameter RCP Storm Sewer	LF	10	$ 111	$ 1,107
13	36" Diameter RCP Storm Sewer, Stub Out with Bulkhead	LF	3	$ 145	$ 434
14	Sluice Gate Manhole Structure, 4'x6' Precast (Including Metal Decking)	LS	1	$ 56,031	$ 56,031
15	Vertical Lift Gate	LS	1	$ 28,016	$ 28,016
16	Turf Restoration (Topsoil, Seed, and Mulch)	SY	125	$ 5.60	$ 700
17	Replace Asphalt Pathway	SY	35	$ 44.82	$ 1,569
				Construction Sub-Total	**$ 243,700**
				35% Contingency	**$ 85,295**
				Construction Total	**$ 329,000**
CORE SAMPLING					
18	Sediment Core Sampling[1]	LS	1	$ 14,444	$ 14,444
ONGOING MAINTENANCE[2]					
19	Dam Inspection Every 10 Years	LS	1	$ 59,605	$ 59,605
20	Dredging Sluice Gate Cone Every 20 Years	LS	1	$ 138,833	$ 138,833
				Ongoing Maintenance Total	**$ 198,500**

[1] Core sampling to be done in winter with at least 11" to 16" of ice to safely support equipment.

[2] Costs as present worth - see Present Worth Worksheet

ALTERNATIVE 2A

Description: Southern lobe of pond restored to original 1930s design with all dredged material hauled offsite and no seeding of floodfringe area; repair sluice gate per Alternative 1.

Item #	Item Description	Unit	Quantity	Unit Price	Total
CONSTRUCTION					
Sluice Gate Repair Items Per Alternative 1					
1	Mobilization - Sluice Gate Repairs	LS	1	$ 5,603	$ 5,603
2	Remove Existing 36" CMP Storm Sewer	LF	10	$ 19.83	$ 198
3	Cofferdam Construction, Maintenance, and Removal	LS	1	$ 11,206	$ 11,206
4	Pumping Water Within Cofferdam - Sluice Gate Repairs	Day	1	$ 1,394	$ 1,394
5	Safety Fence	LF	150	$ 4.48	$ 672
6	Silt Fence	LF	100	$ 3.36	$ 336
7	Tracking Pad	EA	1	$ 1,681	$ 1,681
8	Common Excavation and Grading	LS	1	$ 5,603	$ 5,603
9	Stockpile Topsoil	LS	1	$ 1,681	$ 1,681
10	Dredging Material (Removal and Disposal) - Sluice Gate Repairs	CY	1,212	$ 100	$ 121,203
11	30" Diameter RCP Storm Sewer	LF	10	$ 111	$ 1,107
12	36" Diameter RCP Storm Sewer, Stub Out with Bulkhead	LF	3	$ 145	$ 434
13	Sluice Gate Manhole Structure, 4'x6' Precast (Including Metal Decking)	LS	1	$ 56,031	$ 56,031
14	Vertical Lift Gate	LS	1	$ 28,016	$ 28,016
15	Turf Restoration (Topsoil, Seed, and Mulch)	SY	125	$ 5.60	$ 700
16	Replace Asphalt Pathway	SY	35	$ 44.82	$ 1,569
Additional Construction Items					
17	Cofferdam Construction, Maintenance, and Removal - Upstream of Pond	LS	1	$ 11,206	$ 11,206
18	Dredging Material (Removal and Disposal) - Pond	CY	12,168	$ 100	$ 1,216,797
19	36" Diameter HDPE Bypass Piping	LF	1,400	$ 58.48	$ 81,874
20	Pumping For Bypass Piping	Day	60	$ 1,394	$ 83,660
				Construction Sub-Total	**$ 1,631,000**
				35% Contingency	**$ 570,850**
				Construction Total	**$ 2,201,900**
CORE SAMPLING					
21	Sediment Core Sampling[1]	LS	1	$ 24,240	$ 24,240
ONGOING MAINTENANCE[2]					
22	Dam Inspection Every 10 Years	LS	1	$ 59,605	$ 59,605
23	Dredging Pond Every 20 Years	LS	1	$ 3,065,244	$ 3,065,244
				Ongoing Maintenance Total	**$ 3,124,900**

[1] Core sampling to be done in winter with at least 11" to 16" of ice to safely support equipment.

[2] Costs as present worth - see Present Worth Worksheet

ALTERNATIVE 2B

Description: Southern lobe of pond restored to original 1930s design with some of the dredging spoils used as fill in the floodfringe with vegetative seeding; repair sluice gate per Alternative 1

Item #	Item Description	Unit	Quantity	Unit Price	Total
CONSTRUCTION					
Sluice Gate Repair Items Per Alternative 1					
1	Mobilization - Sluice Gate Repairs	LS	1	$ 5,603	$ 5,603
2	Remove Existing 36" CMP Storm Sewer	LF	10	$ 19.83	$ 198
3	Cofferdam Construction, Maintenance, and Removal	LS	1	$ 11,206	$ 11,206
4	Pumping Water Within Cofferdam - Sluice Gate Repairs	Day	1	$ 1,394	$ 1,394
5	Safety Fence	LF	150	$ 4.48	$ 672
6	Silt Fence	LF	100	$ 3.36	$ 336
7	Tracking Pad	EA	1	$ 1,681	$ 1,681
8	Common Excavation and Grading	LS	1	$ 5,603	$ 5,603
9	Stockpile Topsoil	LS	1	$ 1,681	$ 1,681
10	Dredging Material (Removal and Disposal) - Sluice Gate Repairs	CY	1,212	$ 100	$ 121,203
11	30" Diameter RCP Storm Sewer	LF	10	$ 111	$ 1,107
12	36" Diameter RCP Storm Sewer, Stub Out with Bulkhead	LF	3	$ 145	$ 434
13	Sluice Gate Manhole Structure, 4'x6' Precast (Including Metal Decking)	LS	1	$ 56,031	$ 56,031
14	Vertical Lift Gate	LS	1	$ 28,016	$ 28,016
15	Turf Restoration (Topsoil, Seed, and Mulch)	SY	125	$ 5.60	$ 700
16	Replace Asphalt Pathway	SY	35	$ 44.82	$ 1,569
Additional Construction Items					
17	Cofferdam Construction, Maintenance, and Removal - Upstream of Pond	LS	1	$ 11,206	$ 11,206
18	Dredging Material (Removal and Disposal) - Pond	CY	2,168	$ 100	$ 216,797
19	Dredging Material (Spread On Site in Floodfringe Area)	CY	10,000	$ 20.00	$ 200,000
20	36" Diameter HDPE Bypass Piping	LF	1,400	$ 58.48	$ 81,874
21	Pumping For Bypass Piping	Day	60	$ 1,394	$ 83,660
22	Seeding - Floodfringe Fill Area	SY	6,415	$ 2.87	$ 18,416
				Construction Sub-Total	**$ 849,400**
				35% Contingency	**$ 297,290**
				Construction Total	**$ 1,146,700**
CORE SAMPLING					
23	Sediment Core Sampling[1]	LS	1	$ 24,240	$ 24,240
ONGOING MAINTENANCE[2]					
24	Dam Inspection Every 10 Years	LS	1	$ 59,605	$ 59,605
25	Dredging Pond Every 20 Years	LS	1	$ 3,065,244	$ 3,065,244
26	Vegetation Maintenance	LS	1	$ 18,815	$ 18,815
				Ongoing Maintenance Total	**$ 3,143,700**

[1] Core sampling to be done in winter with at least 11" to 16" of ice to safely support equipment.

[2] Costs as present worth - see Present Worth Worksheet

ALTERNATIVE 3

Description: Pond restored to original 1930s design; repair sluice gate per Alternative 1

Item #	Item Description	Unit	Quantity	Unit Price	Total
CONSTRUCTION					
Sluice Gate Repair Items Per Alternative 1					
1	Mobilization - Sluice Gate Repairs	LS	1	$ 5,603	$ 5,603
2	Remove Existing 36" CMP Storm Sewer	LF	10	$ 19.83	$ 198
3	Cofferdam Construction, Maintenance, and Removal	LS	1	$ 11,206	$ 11,206
4	Pumping Water Within Cofferdam - Sluice Gate Repairs	Day	1	$ 1,394	$ 1,394
5	Safety Fence	LF	150	$ 4.48	$ 672
6	Silt Fence	LF	100	$ 3.36	$ 336
7	Tracking Pad	EA	1	$ 1,681	$ 1,681
8	Common Excavation and Grading	LS	1	$ 5,603	$ 5,603
9	Stockpile Topsoil	LS	1	$ 1,681	$ 1,681
10	Dredging Material (Removal and Disposal) - Sluice Gate Repairs	CY	1,212	$ 100	$ 121,203
11	30" Diameter RCP Storm Sewer	LF	10	$ 110.65	$ 1,107
12	36" Diameter RCP Storm Sewer, Stub Out with Bulkhead	LF	3	$ 145	$ 434
13	Sluice Gate Manhole Structure, 4'x6' Precast (Including Metal Decking)	LS	1	$ 56,031	$ 56,031
14	Vertical Lift Gate	LS	1	$ 28,016	$ 28,016
15	Turf Restoration (Topsoil, Seed, and Mulch)	SY	125	$ 5.60	$ 700
16	Replace Asphalt Pathway	SY	35	$ 44.82	$ 1,569
Additional Construction Items					
17	Cofferdam Construction, Maintenance, and Removal - Upstream of Pond	LS	1	$ 11,206	$ 11,206
18	Dredging Material (Removal and Disposal) - Pond	CY	45,968	$ 100	$ 4,596,797
19	36" Diameter HDPE Bypass Piping	LF	1,400	$ 58.48	$ 81,874
20	Pumping For Bypass Piping	Day	130	$ 1,394	$ 181,263
				Construction Sub-Total	**$ 5,108,600**
				35% Contingency	**$ 1,788,010**
				Construction Total	**$ 6,896,700**
CORE SAMPLING					
21	Sediment Core Sampling[1]	LS	1	$ 48,980	$ 48,980
ONGOING MAINTENANCE[2]					
22	Dam Inspection Every 10 Years	LS	1	$ 59,605	$ 59,605
23	Dredging Pond Every 20 Years	LS	1	$ 5,404,268	$ 5,404,268
				Ongoing Maintenance Total	**$ 5,463,900**

[1] Core sampling to be done in winter with at least 11" to 16" of ice to safely support equipment.

[2] Costs as present worth - see Present Worth Worksheet

ALTERNATIVE 4

Description: Bypass channel for sediment and then a smaller restored pond with the dam lowered by 2-ft; repair existing sluice gate per Alt 1

Item #	Item Description	Unit	Quantity	Unit Price	Total
CONSTRUCTION					
Sluice Gate Repair Items Per Alternative 1					
1	Mobilization - Sluice Gate Repairs	LS	1	$ 5,603	$ 5,603
2	Remove Existing 36" CMP Storm Sewer	LF	10	$ 19.83	$ 198
3	Cofferdam Construction, Maintenance, and Removal	LS	1	$ 11,206	$ 11,206
4	Pumping Water Within Cofferdam - Sluice Gate Repairs	Day	1	$ 1,394	$ 1,394
5	Safety Fence	LF	150	$ 4.48	$ 672
6	Silt Fence	LF	100	$ 3.36	$ 336
7	Tracking Pad	EA	1	$ 1,681	$ 1,681
8	Common Excavation and Grading	LS	1	$ 5,603	$ 5,603
9	Stockpile Topsoil	LS	1	$ 1,681	$ 1,681
10	Dredging Material (Removal and Disposal) - Sluice Gate Repairs	CY	1,212	$ 100	$ 121,203
11	30" Diameter RCP Storm Sewer	LF	10	$ 111	$ 1,107
12	36" Diameter RCP Storm Sewer, Stub Out with Bulkhead	LF	3	$ 145	$ 434
13	Sluice Gate Manhole Structure, 4'x6' Precast (Including Metal Decking)	LS	1	$ 56,031	$ 56,031
14	Vertical Lift Gate	LS	1	$ 28,016	$ 28,016
15	Turf Restoration (Topsoil, Seed, and Mulch) - Sluice Gate Repairs	SY	125	$ 5.60	$ 700
16	Replace Asphalt - Pathway	SY	35	$ 44.82	$ 1,569
Additional Construction Items					
17	Cofferdam Construction, Maintenance, and Removal - Upstream of Pond	LS	1	$ 11,206	$ 11,206
18	Dredging Material (Removal and Disposal) - Pond	CY	43,248	$ 100	$ 4,324,797
19	36" Diameter HDPE Bypass Piping	LF	1,400	$ 58.48	$ 81,874
20	Pumping For Bypass Piping	Day	130	$ 1,394	$ 181,263
21	Overflow Sharp-Crested Weir (Cast In Place Concrete)	CY	9.2	$ 414	$ 3,799
22	Inflow Notch Weir (Cast In Place Concrete)	CY	54	$ 414	$ 22,524
23	Drop Structure (Cast In Place Concrete)	CY	10	$ 414	$ 4,305
24	96" Diameter RCP Storm Sewer	LF	190	$ 673	$ 127,938
25	Mobilization - Crane to Place 96" Diameter RCP	LS	1	$ 2,000	$ 2,000
26	Rental - Crane to Place 96" Diameter RCP	Day	15	$ 2,003	$ 30,040
27	96" Apron End Wall	EA	1	$ 6,200	$ 6,200
28	Rock Rip-Rap at Culvert Outfall	CY	89	$ 80.00	$ 7,111
29	Rock Lining - Trapezoidal Channel	CY	1,674	$ 80.00	$ 133,888
30	Grate - Inlet Trash Guard	EA	1	$ 18,800	$ 18,800
31	Grate - Outlet	EA	1	$ 7,300	$ 7,300
32	Remove Asphalt - Mill Road	SY	68	$ 6.45	$ 439
33	Asphalt - Mill Road	SY	68	$ 22.64	$ 1,539
34	Aggregate Base Course - Mill Road	SY	68	$ 20.18	$ 1,372
35	Gravel Fill	CY	322	$ 38.04	$ 12,247
36	Excavation	CY	3,632	$ 100	$ 363,157
37	Lowering of Dam Weir	LS	1	$ 13,000	$ 13,000
38	Geotextile Filtration Fabric	SY	133	$ 3.11	$ 414
39	Clay Core - Berm	CY	1,633	$ 8.21	$ 13,417
40	Fill - Berm	CY	10,453	$ 2.58	$ 26,962
41	Topsoil (6") - Berm and Slopes	SY	6,043	$ 3.61	$ 21,820
42	Seeding - Berm and Slopes	SY	6,043	$ 2.87	$ 17,350
				Construction Sub-Total	**$ 5,672,200**
				35% Contingency	**$ 1,985,270**
				Construction Total	**$ 7,657,500**
CORE SAMPLING					
43	Sediment Core Sampling[1]	LS	1	$ 48,980	$ 48,980
ONGOING MAINTENANCE[2]					
44	Dam Inspection Every 10 Years	LS	1	$ 59,605	$ 59,605
45	Dredging Pond Every 20 Years	LS	1	$ 2,546,352	$ 2,546,352
46	Vegetation Maintenance	LS	1	$ 17,601	$ 17,601
				Ongoing Maintenance Total	**$ 2,623,600**

[1] Core sampling to be done in winter with at least 11" to 16" of ice to safely support equipment.

[2] Costs as present worth - see Present Worth Worksheet

ALTERNATIVE 5A

Description: Dam removed and channel restored through the pond area with riffle-pools; all dredged sediment hauled off site. Larger floodplain area.

Item #	Item Description	Unit	Quantity	Unit Price	Total
CONSTRUCTION					
1	Mobilization	LS	1	$ 5,603	$ 5,603
2	Remove Existing Dam	LS	1	$ 79,000	$ 79,000
3	Abandon Existing Sluice Gate	LS	1	$ 5,603	$ 5,603
4	36" Diameter HDPE Bypass Piping	LF	1,400	$ 58.48	$ 81,874
5	Pumping For Bypass Piping	Day	240	$ 1,394	$ 334,640
6	Cofferdam Construction, Maintenance, and Removal	LS	1	$ 11,206	$ 11,206
7	Excavation - Riffle Pool Rocks	CY	4,726	$ 100	$ 472,593
8	Fill - Main Channel	CY	273	$ 2.58	$ 704
9	Dredging Material (Removal and Disposal)	CY	71,510	$ 100	$ 7,151,000
10	Clay Cap over Fill Placed Onsite	CY	1,111	$ 8.21	$ 9,127
11	Rock Rip-Rap along Riffles and Slopes	CY	2,954	$ 80.00	$ 236,356
12	Rounded Stone in Channel Riffles	CY	1,890	$ 115	$ 217,393
13	Rock Dam Between Riffles - 3' Rocks	CF	13,200	$ 5.00	$ 66,000
14	Topsoil for Restoration, 6" Deep	CY	3,646	$ 5.00	$ 18,232
15	Seeding - Bench Area	SY	10,253	$ 2.87	$ 29,435
16	Seeding - Higher/Drier Areas	SY	11,626	$ 2.87	$ 33,375
				Construction Sub-Total	**$ 8,752,200**
				35% Contingency	**$ 3,063,270**
				Construction Total	**$ 11,815,500**
CORE SAMPLING					
17	Sediment Core Sampling[1]	LS	1	$ 48,980	$ 48,980
ONGOING MAINTENANCE					
18	Vegetation Maintenance	LS	1	$ 60,694	$ 60,694
				Ongoing Maintenance Total	**$ 60,694**

[1] Core sampling to be done in winter with at least 11" to 16" of ice to safely support equipment.

[2] Costs as present worth - see Present Worth Worksheet

ALTERNATIVE 5B

Description: Dam removed and channel restored through the pond area with riffle-pools; some existing pond sediment allowed down stream in streamflow during dam removal, some sediment spoiled on site, and some sediment hauled off site. Larger floodplain area.

Item #	Item Description	Unit	Quantity	Unit Price	Total
CONSTRUCTION					
1	Mobilization	LS	1	$ 5,603	$ 5,603
2	Dewatering by Sequential Notch Removal of Dam Portion	Hrs	63	$ 100	$ 6,300
3	Remove Existing Dam	LS	1	$ 23,000	$ 23,000
4	Abandon Existing Sluice Gate	LS	1	$ 5,603	$ 5,603
5	36" Diameter HDPE Bypass Piping	LF	1,400	$ 58.48	$ 81,874
6	Pumping For Bypass Piping	Day	240	$ 1,394	$ 334,640
7	Cofferdam Construction, Maintenance, and Removal	LS	1	$ 11,206	$ 11,206
8	Excavation - Riffle Pool Rocks	CY	4,726	$ 100	$ 472,593
9	Dredging Material (Removal and Disposal)	CY	40,860	$ 100	$ 4,086,000
10	Dredging Material (Spread On Site in Floodfringe Area)	CY	7,090	$ 20.00	$ 141,800
11	Finishing Grading	SY	21,879	$ 0.23	$ 5,054
12	Rock Rip-Rap along Riffles and Slopes	CY	2,954	$ 80.00	$ 236,356
13	Rounded Stone in Channel Riffles	CY	1,890	$ 115	$ 217,393
14	Rock Dam Between Riffles - 3' Rocks	CF	13,200	$ 5.00	$ 66,000
15	Topsoil for Restoration, 6" Deep	CY	3,646	$ 5.00	$ 18,232
16	Seeding - Bench Area	SY	10,253	$ 2.87	$ 29,435
17	Seeding - Higher/Drier Areas	SY	11,626	$ 2.87	$ 33,375
				Construction Sub-Total	**$ 5,774,500**
				35% Contingency	**$ 2,021,075**
				Construction Total	**$ 7,795,600**
CORE SAMPLING					
18	Sediment Core Sampling[1]	LS	1	$ 48,980	$ 48,980
ONGOING MAINTENANCE					
19	Vegetation Maintenance	LS	1	$ 60,694	$ 60,694
				Ongoing Maintenance Total	**$ 60,694**

[1] Core sampling to be done in winter with at least 11" to 16" of ice to safely support equipment.

[2] Costs as present worth - see Present Worth Worksheet

ALTERNATIVE 5C

Description: Dam removed and channel restored through the pond area with riffle-pools; some pond sediment discharged down stream, some relocated within the pond area, and some hauled off site. Smaller floodplain area.

Item #	Item Description	Unit	Quantity	Unit Price	Total
CONSTRUCTION					
1	Mobilization	LS	1	$ 5,603	$ 5,603
2	Dewatering by Sequential Notch Removal of Dam Portion	Hrs	63	$ 100	$ 6,300
3	Remove Existing Dam	LS	1	$ 23,000	$ 23,000
4	Abandon Existing Sluice Gate	LS	1	$ 5,603	$ 5,603
5	36" Diameter HDPE Bypass Piping	LF	1,400	$ 58.48	$ 81,874
6	Pumping For Bypass Piping	Day	240	$ 1,394	$ 334,640
7	Cofferdam Construction, Maintenance, and Removal	LS	1	$ 11,206	$ 11,206
8	Excavation - Riffle Pool Rocks	CY	4,726	$ 100	$ 472,593
9	Fill - Main Channel	CY	273	$ 2.58	$ 704
10	Dredging Material (Removal and Disposal)	CY	11,865	$ 100.00	$ 1,186,504
11	Dredging Material (Spread On Site in Floodfringe Area)	CY	36,080	$ 20.00	$ 721,591
12	Finishing Grading	SY	20,932	$ 0.23	$ 4,835
13	Rock Rip-Rap along Riffles and Slopes	CY	2,954	$ 80.00	$ 236,356
14	Rounded Stone in Channel Riffles	CY	1,890	$ 115	$ 217,393
15	Rock Dam Between Riffles - 3' Rocks	CF	13,200	$ 5.00	$ 66,000
16	Topsoil for Restoration, 6" Deep	CY	3,646	$ 5.00	$ 18,232
17	Seeding - Bench Area and Shallow Slope Areas	SY	17,321	$ 2.87	$ 49,726
18	Seeding - 3:1 Slope Areas	SY	3,610	$ 2.87	$ 10,365
				Construction Sub-Total	**$ 3,452,600**
				35% Contingency	**$ 1,208,410**
				Construction Total	**$ 4,661,100**
CORE SAMPLING					
19	Sediment Core Sampling[1]	LS	1	$ 48,980	$ 48,980
ONGOING MAINTENANCE					
20	Vegetation Maintenance	LS	1	$ 60,694	$ 60,694
				Ongoing Maintenance Total	**$ 60,694**

[1] Core sampling to be done in winter with at least 11" to 16" of ice to safely support equipment.

[2] Costs as present worth - see Present Worth Worksheet

OPTIONAL SPILLWAY & DAM ABUTMENTS

Description: Optional emergency overflow spillway and optional dam abutments to expand overflow capacity

Item #	Item Description	Unit	Quantity	Unit Price	Total
CONSTRUCTION - OPTIONAL EMERGENCY SPILLWAY ITEMS					
1	Sharp-Crested Weir (Cast In Place Concrete)	CY	28	$ 414	$ 11,512
2	Drop Structure (Cast In Place Concrete)	CY	29	$ 414	$ 11,972
3	Mobilization - Crane to Place 8'x12' Box Culvert	LS	1	$ 2,000	$ 2,000
4	Concrete Box Culvert (8'x12')	LF	200	$ 1,293	$ 258,549
5	Wing Walls - 8'x12' Box Culvert Outlet	EA	1	$ 5,000	$ 5,000
6	Straight Apron End Wall - 8'x12' Box Culvert Outlet	EA	1	$ 14,000	$ 14,000
7	Rock Rip-Rap at Culvert Outfall	CY	70	$ 80.00	$ 5,570
8	Grate - Inlet Trash Guard	EA	1	$ 10,500	$ 10,500
9	Grate - Outlet	EA	1	$ 14,000	$ 14,000
10	Remove Asphalt	SY	83	$ 6.45	$ 536
11	Gravel Fill	CY	445	$ 38.04	$ 16,914
12	Excavation	CY	1,890	$ 100	$ 189,000
13	Asphalt	SY	83	$ 22.64	$ 1,881
14	Aggregate Base Course	SY	83	$ 20.18	$ 1,677
15	Geotextile Filtration Fabric	SY	35	$ 3.11	$ 108
				Construction Subtotal (Optional Spillway)	**$ 543,300**
				35% Contingency (Optional Spillway)	**$ 190,155**
				Construction Total (Optional Spillway)	**$ 733,500**
CONSTRUCTION - OPTIONAL EXTENSION OF ABUTMENTS					
16	Cast in Place Concrete (Extension of Abutments)	LS	1.0	$ 1,850	$ 1,850
				Construction Subtotal (Optional Abutment Extension)	**$ 1,850**
				35% Contingency (Optional Abutment Extension)	**$ 648**
				Construction Total (Optional Abutment Extension)	**$ 2,500**
				Total Optional Emergency Spillway and Extension of Abutments	**$ 736,000**

Present Worth Worksheet

Engineering Economics Formulas

(P/F, *i* %, n) : $(1+i)^{-n}$

DAM INSPECTION EVERY 10 YEARS

PW Cost of Dam Inspections Every 10[1] Years for Next 50 Years = $59,605

Recurring cost =	$10,000	[2] 2019 Dollars
CCI 10-Yr Factor =	1.476	
i =	3.375%	

PW for Inspection at Year:		10
Inspection cost at yr 10 =	$14,761	
PW factor =	0.7175	
PW cost =	$10,592	

PW for Inspection at Year:		20
Inspection cost at yr 20 =	$21,789	
PW factor =	0.5149	
PW cost =	$11,218	

PW for Inspection at Year:		30
Inspection cost at yr 30 =	$32,162	
PW factor =	0.3694	
PW cost =	$11,882	

PW for Inspection at Year:		40
Inspection cost at yr 40 =	$47,475	
PW factor =	0.2651	
PW cost =	$12,585	

PW for Inspection at Year:		50
Inspection cost at yr 50 =	$70,078	
PW factor =	0.1902	
PW cost =	$13,329	

[1] Per WDNR, low hazard dams must be inspected every 10 years https://dnr.wisconsin.gov/topic/dams/inspections.html. Per AECOM report in Ch. 4 appendix, the dam is a low hazard dam.

[2] DNR FAQ document listed inspection costs can range from $2,000 to $10,000 every 10 years (for low hazard dams)

ONGOING MAINTENANCE COSTS

[ALTERNATIVE 1]

<u>DREDGING MAINTENANCE</u>

PW Cost of Dredging 1/2 Sluice Gate Cone Volume Every 20 Years for Next 50 Years = $138,833

Recurring cost =	$60,602	2019 Dollars
Dredging volume =	606	CY
CCI 20-Yr Factor =	2.125	
i =	3.375%	

	Dredging
PW for Year:	20
Dredging cost at yr 20 =	$128,772
PW factor =	0.5149
PW cost =	$66,300

PW for Year:	40
Dredging cost at yr 40 =	$273,627
PW factor =	0.2651
PW cost =	$72,534

Note: Exercising the sluice gate every year is assumed to flush sediment from the sluice gate cone, so it was assumed dredging would be done every 20 years and only half the original volume (and cost) would be dredged at those future times.

ONGOING MAINTENANCE COSTS

[ALTERNATIVE 2A & 2B]

DREDGING MAINTENANCE (Both 2A and 2B)

W Cost of Dredging Southern Lobe and Sluice Cone = $3,065,244

W Cost of Dredging Southern Lobe and Sluice Cone = $3,065,244

2A Recurring cost =	$1,338,000	2019 Dollars
2B Recurring cost =	$1,338,000	2019 Dollars
Dredging volume =	13,380	CY
CCI 20-Yr Factor =	2.125	
i =	3.375%	

VEGETATIVE MAINTENANCE (Only 2B)

PW Cost of Vegetation Maintenance = $18,815

Initial Seeding Cost =	$6,200	2019 Dollars
Half of Initial Seeding Cost =	$3,100	2019 Dollars
CCI 1-Yr Factor =	1.038	
i =	3.375%	

	Dredging - 2A	Dredging - 2B	Vegetation
PW for Year:	10	10	1
Cost at Yr 10 / Yr 1 =	NA	NA	$6,437
PW factor =	0.7175	0.7175	0.9674
PW cost =	$0.00	$0.00	$6,227
PW for Year:	20	20	2
Cost at Yr 20 / Yr 2 =	$2,843,110	$2,843,110	$3,341
PW factor =	0.5149	0.5149	0.9358
PW cost =	$1,463,805	$1,463,805	$3,127
PW for Year:	30	30	3
Cost at Yr 30 / Yr 3 =	NA	NA	$3,469
PW factor =	0.3694	0.3694	0.9052
PW cost =	$0.00	$0.00	$3,140
PW for Year:	40	40	4
Cost at Yr 40 / Yr 4 =	$6,041,312	$6,041,312	$3,602
PW factor =	0.2651	0.2651	0.8757
PW cost =	$1,601,439	$1,601,439	$3,154
PW for Year:	50	50	5
Cost at Yr 50 / Yr 5	NA	NA	$3,739
PW factor =	0.1902	0.1902	0.8471
PW cost =	$0.00	$0.00	$3,167

Note: It was assumed dredging would be done every 20 years for the entire original south lobe pond volume (and cost) at those future times. For vegetative maintenance, it was assumed approximately 1/3 of the initial seeding (and cost) would need to be replaced in the first year and half the cost of year 1 costs would occur for each year for years 2-5.

[ALTERNATIVE 3]

DREDGING MAINTENANCE

PW Cost of Dredging 1/2 Pond and Sluice Cone $5,404,268

Recurring cost =	$ 2,359,000	2019 Dollars
Dredging volume =	23,590	CY
CCI 20-Yr Factor =	2.125	
i =	3.375%	

	Dredging
PW for Year:	20
Dredging cost at yr 20 =	$ 5,012,628
PW factor =	0.5149
PW cost =	$ 2,580,804
PW for Year:	40
Dredging cost at yr 40 =	$ 10,651,311
PW factor =	0.2651
PW cost =	$ 2,823,463

Note: It was assumed dredging would be done every 20 years and only half the original volume (and cost) would be dredged at those future times.

ONGOING MAINTENANCE COSTS

[ALTERNATIVE 4]

DREDGING MAINTENANCE

PW Cost of Dredging 1/4 Pond and Sluice Cone **$2,546,352**

Recurring cost =	$ 1,111,500	2019 Dollars
Dredging volume =	11,115	CY
CCI 20-Yr Factor =	2.125	
i =	3.375%	

VEGETATIVE MAINENANCE

PW Cost of Vegetation Maintenance = **$17,601**

Initial Seeding Cost =	$5,800	2019 Dollars
Half of Initial Seeding Cost =	$2,900	2019 Dollars
CCI 1-Yr Factor =	1.038	
i =	3.375%	

	Dredging	**Vegetation**
PW for Year:	10	1
Cost at Yr 10 / Yr 1 =	NA	$6,022
PW factor =	0.7175	0.9674
PW cost =	$0.00	$5,825
PW for Year:	20	2
Cost at Yr 20 / Yr 2 =	$2,361,821	$3,126
PW factor =	0.5149	0.9358
PW cost =	$1,216,008	$2,925
PW for Year:	30	3
Cost at Yr 30 / Yr 3 =	NA	$3,245
PW factor =	0.3694	0.9052
PW cost =	$0.00	$2,938
PW for Year:	40	4
Cost at Yr 40 / Yr 4 =	$5,018,623	$3,369
PW factor =	0.2651	0.8757
PW cost =	$1,330,343	$2,950
PW for Year:	50	5
Cost at Yr 50 / Yr 5	NA	$3,498
PW factor =	0.1902	0.8471
PW cost =	$0.00	$2,963

Note: The bypass channel is designed to pass the majority of sediment around the pond, thus it was assumed dredging would be done every 20 years and only one quarter the original volume (and cost) would be dredged at those future times. For vegetative maintenance, it was assumed approximately 1/3 of the initial seeding (and cost) would need to be replaced in the first year and half the cost of year 1 costs would occur for each year for years 2-5.

[ALTERNATIVE 5]

VEGETATIVE MAINTENANCE

PW Cost of Vegetation Maintenance = **$60,694**

Initial Seeding Cost =	$20,000	2019 Dollars
Half of Initial Seeding Cost =	$10,000	2019 Dollars
CCI 1-Yr Factor =	1.038	
i =	3.375%	

PW for Year:	1
Vegetation Costs at Yr 1 =	$20,764
PW factor =	0.9674
PW cost =	$20,086
PW for Year:	2
Vegetation Costs at Yr 2 =	$10,779
PW factor =	0.9358
PW cost =	$10,087
PW for Year:	3
Vegetation Costs at Yr 3 =	$11,191
PW factor =	0.9052
PW cost =	$10,130
PW for Year:	4
Vegetation Costs at Yr 4 =	$11,618
PW factor =	0.8757
PW cost =	$10,174
PW for Year:	5
Vegetation Costs at Yr 5 =	$12,062
PW factor =	0.8471
PW cost =	$10,218

Note: Assumed approximately 1/3 of the initial seeding (and costs) would need to be replaced in the first year, then we assumed a cost of $10,000 (2019 dollars) for each year for years 2-5.

MODEL RESOLUTION FOR ADOPTION OF THE OAK CREEK WATERSHED RESTORATION PLAN

APPENDIX U

WHEREAS, the Southeastern Wisconsin Regional Planning Commission, which was duly created by the Governor of the State of Wisconsin in accordance with Section 66.0309(2) of the *Wisconsin Statutes* on the 8th day of August 1960, upon petition of the Counties of Kenosha, Milwaukee, Ozaukee, Racine, Walworth, Washington, and Waukesha, has the function and duty of making and adopting a master plan for the physical development of the Region; and

WHEREAS, the City of South Milwaukee, Milwaukee County, and the Milwaukee Metropolitan Sewerage District executed agreements with the Regional Planning Commission on _____ __, ____, and _____ __, ____; and _____ __, ____, respectively, for the development of a watershed restoration plan for the Oak Creek watershed leading to recommendations for the management of water resources in the watershed, including recommendation to address issues and problems related to water quality, recreational access and use, habitat conditions, problems related to flooding, and the status of the Oak Creek Mill Pond and Mill Pond dam in the Oak Creek watershed; and

WHEREAS, such plan has been completed and;

WHEREAS, such plan contains recommendations to address issues and problems related to water quality, recreational access and use, habitat conditions, problems related to flooding, and the status of the Oak Creek Mill Pond and Mill Pond dam in the Oak Creek watershed; and

WHEREAS, the aforementioned recommendations, including all studies, data, maps, figures, charts, and tables are set forth in a published report entitled SEWRPC Community Assistance Planning Report No. 330, *A Restoration Plan for the Oak Creek Watershed*, published in ____ ____; and

WHEREAS, the Commission has transmitted copies of the aforementioned SEWRPC Community Assistance Planning Report No. 330, to the local units of government; and

WHEREAS, the (Name of Local Governing Body) has supported and generally concurred in the watershed and other regional planning programs undertaken by the Southeastern Wisconsin Regional Planning Commission and believes that the watershed restoration plan for the Oak Creek watershed prepared by the Commission is a valuable guide to the development of not only the watershed, but the community, and that the adoption of such plan by the (Name of Local Governing Body) will assure a common understanding by the several governmental levels and agencies concerned and enable these levels and agencies of government to program the necessary areawide and local plan implementation work.

NOW, THEREFORE, BE IT RESOLVED that, pursuant to Section 66.0309(12) of the *Wisconsin Statutes*, the (Name of Local Governing Body) on the _____ day of ______, ____, hereby adopts the watershed restoration plan for the Oak Creek watershed as set forth in SEWRPC Community Assistance Planning Report No. 330 as a guide for watershed management.

BE IT FURTHER HEREBY RESOLVED that the _________ clerk transmit a certified copy of this resolution to the Southeastern Wisconsin Regional Planning Commission.

(President, Mayor, or Chairman
of the Local Governing Body)

ATTESTATION:

(Clerk of Local Governing Body)