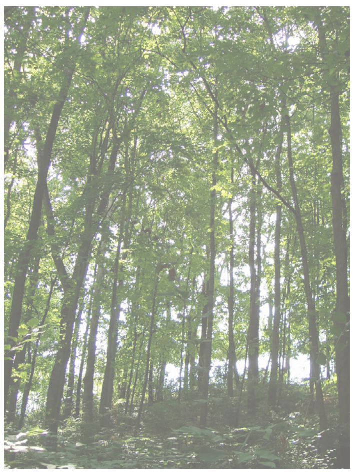
METROPOLITAN
SEWER DISTRICT
of greater
CINCINNATI



Integrated SUSTAINABLE Watershed Management MANUAL

October 2012

Foreword

An integrated approach to wet weather management that links natural systems-based solutions with capital planning was chosen by the Metropolitan Sewer District of Greater Cincinnati (MSDGC) to tackle the daunting task facing many aging wastewater systems across the country. By expanding our view beyond a specific project, and assessing an entire watershed, MSDGC has been able to identify sources of overflows and issues contributing to or exacerbating wet weather conditions, and to then develop a solution that addresses multiple needs and issues. This source control ideology was the beginning framework of MSDGC's Sustainable Watershed Evaluation Process (SWEP).

This manual is intended to provide insights into the SWEP process, and to serve as a resource to other communities seeking opportunities for wet weather management using a blend of both grey and green "sustainable" infrastructure. The SWEP manual is a dynamic guidance document to facilitate formulation of opportunities to integrate wet weather solutions into communities while achieving the goals MSDGC established — improving water quality, protecting the environment and public health, ensuring the viability of our utility, and responsibly serving our ratepayers and communities. MSDGC is confident this manual will assist planners, engineers, consultants, and communities working collaboratively to solve wet weather challenges.

MSDGC began the long journey of developing cost-effective ways to address local wet weather challenges in 2004 with development of a Capacity Assurance Program Plan (CAPP). The CAPP led to development of a Long-Term Control Plan and eventually to the Wet Weather Improvement Plan (WWIP). In August 2009, the Co-Defendants of the Consent Decree (the City of Cincinnati and Hamilton County) received formal approval of the WWIP and initiated a 3-year study of Lower Mill Creek (LMC Study).

The Regulators recognized in 2009, as did the Co-Defendants, that the default tunnel solution was a concept that required vetting with technical and engineering expertise, as well as cost. At the same time, Hamilton County led an effort to change State of Ohio law to clarify opportunities for cost-effective options for stormwater removal. Accordingly, the LMC Study was negotiated to provide MSDGC a 3-year window to develop a source control alternative approach having the same objectives as the default tunnel — to reduce combined sewer overflows throughout the Lower Mill Creek.

During the LMC Study, MSDGC advanced detailed planning and design for a source control approach conducive with integrated watershed planning. MSDGC began working with industry professionals to develop a holistic, integrated approach for addressing overflows at a watershed level.

MSDGC has focused on leading with source control and removal of stormwater from the combined sewer system cost effectively and strategically to advance combined sewer overflow (CSO) reduction and community goals. The WWIP already included partial separation projects at several CSOs — particularly the CSOs not in close proximity to the tunnel. Strategic sewer separation allows for more cost-effective solutions to offload stormwater and natural drainage, reducing the liability stormwater places on the combined sewer system. By strategically separating sewers, MSDGC can prioritize significant opportunities to remove stormwater from the combined sewer system. Using best management practices (BMPs), stormwater can be returned to the natural environment, peak flows and volumes can be managed, and water quality can be improved. Through additional policy changes, watershed solutions can be developed to anticipate and plan for development potential and improve stormwater management practices.

Foreword

MSDGC remains strongly committed to compliance with the Clean Water Act. This manual is a means of advancing cost-effective projects that consider the needs and priorities of the communities that MSDGC serves. The SWEP outlined in the manual applies innovative technologies to broad-based watershed solutions. As MSDGC moves forward with solving the liabilities created decades ago and reducing the volume of combined sewage entering local streams, creeks, and tributaries, ratepayers will benefit from optimizing use of capital dollars.

Compliance with the Consent Decree will be ongoing for several decades. As such, MSDGC is committed to minimizing the impact to ratepayers and maximizing the improvement to the environment. Thank you for your interest in sustainability and helping to build the communities of the future.

James A. "Tony" Parrott
Executive Director

Contents

Contents

Contents

Tables and Figures List on Next Page

Tables

Figures

Executive Summary

Background

The U.S. Environmental Protection Agency (USEPA) estimates that 772 communities across the United States have combined sewer systems (CSSs) which convey sanitary sewage and stormwater in the same pipes; when the capacity of these pipes is exceeded, overflows occur into rivers and streams and cause backups into residential basements (USEPA, 2008). Cincinnati, Ohio, ranks among the top five cities in the country in terms of the volume of its combined sewer overflows (CSOs) and control challenges it faces. In 2004, USEPA placed the City and Hamilton County under federal orders (issued Consent Decrees) to reduce their estimated 14 billion gallons per year of CSOs and eliminate all sanitary sewer overflows (SSOs).

In 2006, the Metropolitan Sewer District of Greater Cincinnati (MSDGC) developed the Wet Weather Improvement Program (WWIP) to address the 2004 Consent Decrees and demonstrate compliance with the Clean Water Act (CWA). The solution specified in the WWIP, also referred to as the "default" solution, includes four Phase I infrastructure projects to be completed by 2018 (**Figure ES-1**). Of these, one is the Lower Mill Creek Partial Remedy (LMCPR), which will provide 85 percent control of CSOs in the Lower Mill Creek basin by increasing the capacity of the existing CSS through construction of underground storage tunnels and consolidation sewers as well as separated conveyance systems. However, the WWIP was updated in 2009 (Final WWIP) and includes allowances to examine green infrastructure solutions and update the original LMCPR as appropriate.

Identifying the most cost-effective, sustainable, and beneficial combination of infrastructure types for a specific watershed is the underlying goal of the sustainable watershed evaluation and planning process (SWEPP), and the focus of this manual.

The inclusion of green infrastructure evaluations in the Final WWIP was based on a growing body of research and case studies on the use of green infrastructure to address wet weather discharges. In 2007, USEPA issued a memorandum (USEPA, 2007a) supporting the "development and use of green infrastructure in water program implementation." In 2010, Cincinnati's federal mandate was amended, allowing opportunities to utilize both green infrastructure solutions and traditional grey infrastructure solutions on a project-by-project basis. In response, MSDGC has developed a sustainable watershed evaluation and planning process (SWEPP) to identify the most cost-effective, sustainable, and beneficial combination of infrastructure types for a given watershed. This Integrated Sustainable Watershed Management Manual outlines the goals of the SWEPP and defines a repeatable, consistent methodology for meeting those goals.

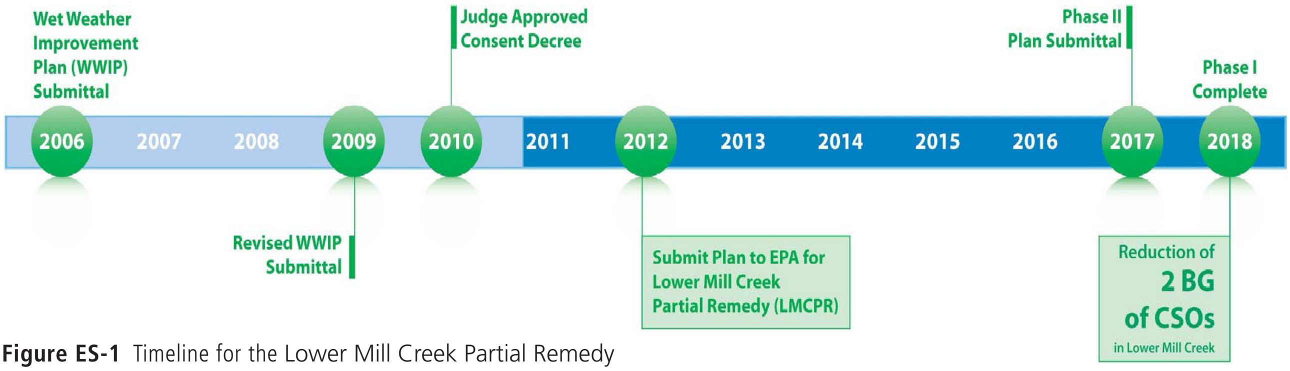


Figure ES-1 Timeline for the Lower Mill Creek Partial Remedy

Sustainable Watershed Planning

In recent years, USEPA (2012) has "increasingly embraced integrated planning approaches to municipal wastewater and stormwater management." In its Planning Approach Framework, USEPA indicates that integrated planning can "facilitate the use of sustainable and comprehensive solutions, including green infrastructure, that protect human health, improve water quality, manage stormwater as a resource, and support other economic benefits and quality of life attributes that enhance the vitality of communities." As such, MSDGC is following USEPA's lead and using this planning framework in its efforts to comply with federal mandates.

Green infrastructure practices, in conjunction with grey infrastructure practices, have been evaluated as being more cost-effective than grey infrastructure practices alone.

Traditionally, CSO improvement planning has followed an asset-centric approach, focusing on upgrades, changes, and maintenance of existing infrastructure, including sewer pipes and wastewater treatment plants (WWTPs). However, the increasing amount of imperviousness associated with transportation corridors, such as those in MSDGC's service area, has further complicated the options for watershed and stormwater management. To address these complex urban watershed conditions, MSDGC has adopted an approach to sustainable watershed planning that includes identifying and evaluating opportunities to reduce stormwater contributions to the CSS through a variety of integrated grey and green solutions. Green infrastructure practices, in conjunction with grey infrastructure practices, have been evaluated as being more cost-effective than grey infrastructure practices alone (Gunderson, 2011). MSDGC's SWEPP is intended to evaluate combinations of sustainable green infrastructure solutions and traditional grey infrastructure solutions to identify the most cost-effective combination of alternatives to meet the federal mandates. Using this approach, MSDGC hopes that alternatives to the "default" solution can be identified as being both affordable for its rate-payers and able to provide community benefits beyond CSO reduction and SSO elimination.

Project Groundwork is MSDGC's program for meeting the requirements of the Consent Decrees. One of the primary goals of Project Groundwork and its associated programs is to develop and implement sustainable watershed-based activities that address the Consent Decree requirements for CSO reduction and SSO elimination, improve overall water quality and biotic integrity conditions, and support community goals for improvement.

What is green infrastructure?

Green infrastructure is an approach to wet weather management that uses natural systems — or engineered systems that mimic natural processes — to enhance overall environmental quality and provide utility services. As a general principle, green infrastructure techniques use soils and vegetation to infiltrate, evapotranspire, and/or recycle stormwater runoff.

What is grey infrastructure?

In the context of stormwater management, grey infrastructure can be thought of as the hard, engineered systems to capture and convey runoff, such as gutters, storm sewers, tunnels, culverts, detention basins, and related systems.

Banking on Green: A Look at How Green Infrastructure Can Save Municipalities Money and Provide Economic Benefits Community-wide, A Joint Report by American Rivers, the Water Environment Federation, the American Society of Landscape Architects and ECONorthwest, April 2012

MSDGC's Wet Weather Strategy

MSDGC's approach to implementing the WWIP was developed through a comprehensive planning effort and is designed to be flexible, strategic, and affordable. The recommended WWIP strategy incorporates the overall concepts for sustainability outlined in the MSDGC 2010 Sustainability Report, which identified the specific sustainability goals for implementation of MSDGC's Strategic Plan. Implementation of the WWIP strategy involves:

1. The SWEPP (understanding current conditions within a community and a watershed, and identifying the most cost-effective, sustainable, and beneficial combination of water resource infrastructure types for a specific area)
2. Development of individual Watershed Master Plans, which are prioritized action plans for the watersheds, consisting of both green and grey infrastructure to meet a desired level of service (LOS)
3. Implementation of the Master Plan
4. Performance monitoring and lessons learned tracking

The strategic component of the WWIP (i.e., the wet weather strategy) consists of a three-pronged approach to meeting the federal mandates (**Figure ES-2**):

1. Source control

2. Conveyance and storage
3. Product control

By utilizing sustainable infrastructure for source control, MSDGC is able to incorporate, into its wet weather strategy, environmental and social community benefits that can be realized through integrated public/private planning and investment. Source control is the foundation of the wet weather strategy because it diverts stormwater, which is generally cleaner than sewage, and allows for the right-sizing of conveyance, storage, and treatment facilities, thereby decreasing life cycle costs. While the degree of pollutants in stormwater is site-specific, source control is targeted to redirect and remove relatively clean water from the CSS, much of which is delivered via stormwater runoff and direct inflow from ravines and streams into combined sewers. These solutions are intended to prevent (or reduce the volume of) stormwater entering the CSS by using green infrastructure that allows the stormwater to infiltrate the ground or evaporate. Source control solutions can include separation of stormwater pipes or natural drainage systems and use of bioretention features, as well as retention/detention structures. As a result, water quality and quantity issues can be addressed closer to the source of generation.

Conveyance and storage options to reduce CSOs and improve water quality are designed to manage or control the volume of sewage and stormwater that reach the sewer system. Typical conveyance and storage methods involve constructing larger sewers to transport wastewater to treatment plants or large underground storage tunnels to capture excess flow. Product control options for CSO reduction include grey infrastructure solutions intended to treat combined flows. These options include Real Time Control (RTC), upgrading WWTP capacity, or constructing Enhanced High Rate Treatment (EHRT) facilities to treat flows at the CSO outfall prior to discharge.

Communities of the Future

In 2009, MSDGC began investigating and applying source control techniques more extensively while also focusing efforts with other regional partners to leverage its wet weather strategy to support economic development and urban renewal. This strategy was branded as the Communities of the Future initiative to promote integrated sustainable solutions that take into consideration water, waste, and transportation, as well as economic, social, and environmental factors. In March 2010, MSDGC established the Communities of the Future Advisory Committee (CFAC), which has helped shape the approach outlined in this manual. The vision for Communities of the Future goes beyond the "end-of-pipe" focus of traditional approaches and solutions and recognizes the value of new partnerships and new ways to engage stakeholders and communities in the overall master planning process. MSDGC and its project planning partners seek to develop comprehensive, watershed-based solutions to the Consent Decrees that offer communities significant opportunities to make transformational improvements in how residents live, work, and play. The Communities of the Future is part of the guiding philosophy of Project Groundwork — that it will lead with sustainable and innovative investments and be evaluated with Triple Bottom Line (TBL) metrics, maximizing the social, economic, and environmental benefits to local communities.

Figure ES-2 MSDGC's Wet Weather Strategy

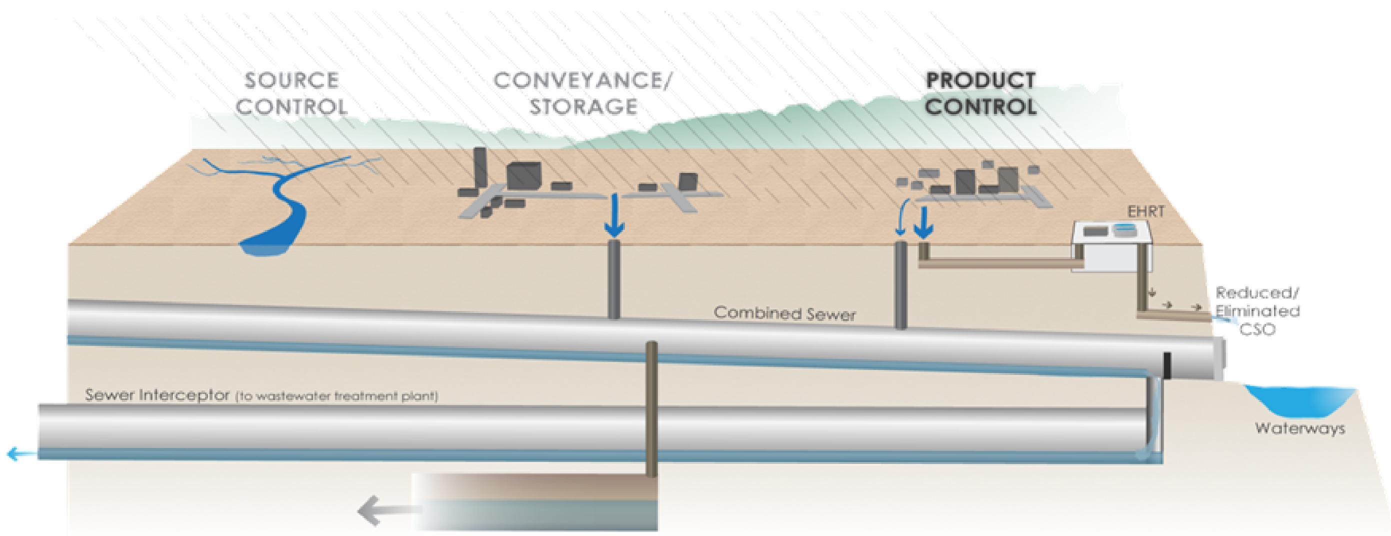


Figure ES-3 Steps for Sustainable Watershed Evaluation and Planning Process (SWEPP)

Step 1 Data Compilation and Inventory Analysis	Step 2 Identify Opportunities and Constraints	Step 3 Develop and Evaluate Alternatives	Step 4 Develop Master Plan	Step 5 Implement Master Plan	Step 6 Monitoring, Reporting, and Evaluation
• Define initial watershed goals and objectives • Collect existing data • Conduct coarse level modeling • Identify existing level of service • Coordinate with watershed partners and stakeholders	• Conduct detailed modeling • Develop watershed strategy (source control, conveyance/storage, and product control) • Identify opportunities, constraints, and desired level of service	• Identify watershed and subwatershed alternatives • Evaluate affordability and level of service • Develop Preliminary Watershed Master Plan with Direct Impact, Enabled Impact, and Inform & Influence Projects	• Conduct capital improvement planning and prioritization • Define enterprise-level project responsibilities • Develop Watershed Master Plan, a prioritized action plan for MSDGC investments in watershed	• Develop project-specific business case evaluations • Complete detailed engineering analysis • Determine monitoring plan and success criteria • Construct final alternative	• Conduct performance monitoring to evaluate success of projects • Perform adaptive management based on monitoring results • Identify lessons learned and incorporate into process

SWEPP and Master Planning Process

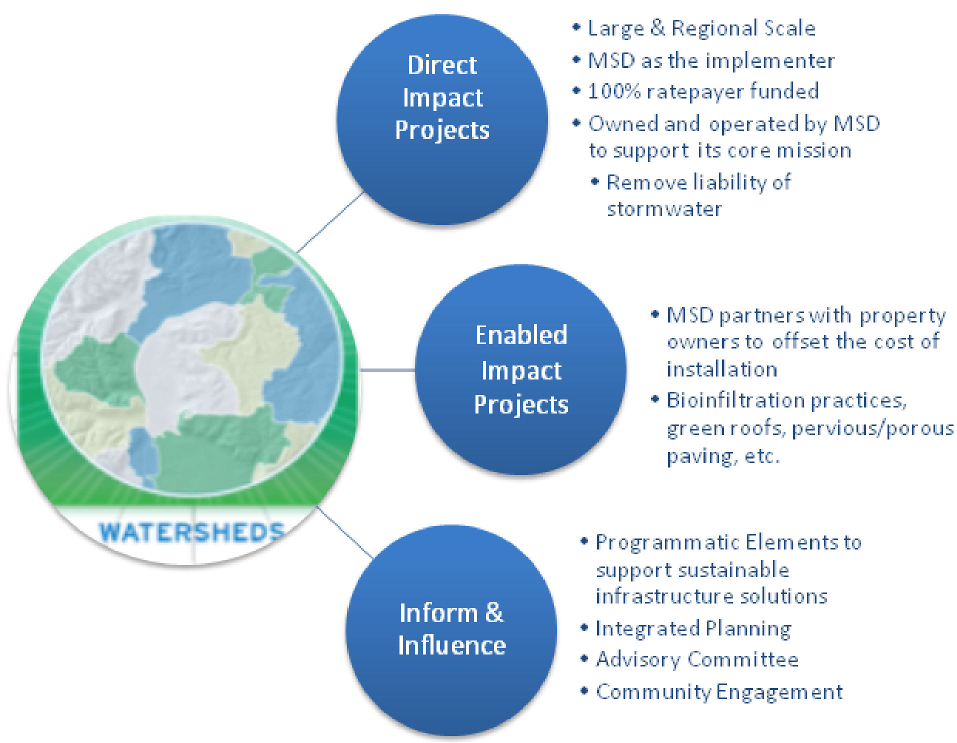
Figure ES-3 illustrates the objectives of MSDGC's SWEPP and Master Planning process, which involves six primary steps.

Steps 1 through 3 comprise the SWEPP (the outcome of which is a Preliminary Watershed Master Plan). Steps 4 through 6 use the Preliminary Watershed Master Plan to develop and implement a Watershed Master Plan, and then to monitor the success of the implemented plan, while continuously recognizing, documenting, and adapting to lessons learned.

MSDGC developed the SWEPP to prioritize watershed improvement projects so that they meet the federal mandates, address overall water quality improvement, and align with community priorities. The process includes the evaluation of traditional grey infrastructure (such as the recommendations in the WWIP) combined with green infrastructure alternatives to provide source control. MSDGC has illustrated the success of its SWEPP in the development of the partial remedy for Mill Creek, and plans to use this approach, along with lessons learned from implementation of the process, to address CSO and SSO issues in all of its watersheds. MSDGC plans to complete a SWEPP for each of the watersheds in its service area by 2017. The SWEPP will provide a consistent methodology for future watershed master planning efforts and assure the appropriate consideration of grey and green infrastructure as well as community goals.

The end result of the SWEPP is development of the Preliminary Watershed Master Plan, which will document all recommended projects in the watershed, including Direct Impact Projects (requiring direct investment by MSDGC), Enabled Impact Projects (involving a leveraged infrastructure investment or opportunities for cost-sharing and collaboration), and Inform & Influence Projects (engaging and educating watershed partners) (see **Figure ES-4**).

Figure ES-4 Types of Source Control Projects Identified Using SWEPP



MSDGC developed the sustainable watershed evaluation and planning process (SWEPP) to prioritize watershed improvement projects so that they meet the federal mandates, address overall water quality improvement, and align with community priorities.

From this plan, the Watershed Master Plan will be developed, and will essentially be a capital improvement plan for MSDGC's investments in the watershed. The Watershed Master Plan will detail all projects that are selected to advance into the detailed planning and design phase, including estimated LOS, implementation timeline, construction sequencing, cost allocation, risk management plan, monitoring plan, anticipated impacts on other watersheds, and responsibilities.

This manual is provided by MSDGC to aid staff, consultants, and agency partners in understanding the SWEPP and watershed master planning process. It should be used to provide consistency in the planning and project prioritization process, and to assure that the most sustainable and cost-effective strategies are developed to meet the requirements in the Consent Decrees and to support community goals.

Acronyms and Abbreviations

APA	American Planning Association
ASLA	American Society of Landscape Architects
BAT	best available technology
BCE	Business Case Evaluation
BMP	best management practice
BOCC	Board of County Commissioners
CAA	Clean Air Act
CAGIS	Cincinnati Area Geographic Information System
CAPEX	CAPital EXpenditure management
CCTV	closed-circuit television
CDOTE	Cincinnati Department of Transportation & Engineering
CEHRT	chemically enhanced high-rate treatment
CFAC	Communities of the Future Advisory Committee
CFCT	Cross Functional Core Team
CIP	Capital Improvement Plan
CLM	Coarse Level Modeling
CO_2	carbon dioxide
CPB	Cincinnati Park Board
CSO	combined sewer overflow
CSS	combined sewer system
CWA	Clean Water Act
DIW	Division of Industrial Waste
EHRT	enhanced high-rate treatment
EMC	event mean concentration
EPM	Environmental Program Management
EWH	Exceptional Warmwater Habitat
FEMA	Federal Emergency Management Agency
FWPC	Federal Water Pollution Control
GHG	greenhouse gas
GIS	geographic information system
H&H	hydrologic and hydraulic models
HEC-RAS	Hydrologic Engineering Centers River Analysis System
HSTS	household septic treatment system
HUD	Housing & Urban Development
I/I	inflow and infiltration
IPS	Integrated Prioritization System
KPI	key performance indicator
KWh	kiloWatt-hour
LID	low impact development
LMCPR	Lower Mill Creek Partial Remedy
LOS	level of service
LRW	Limited Resource Water
MBI	Midwest Biodiversity Institute
MG	million gallons
mgd	million gallons per day
MOU	Memorandum of Understanding
MPMP	Master Program Management Plan
MS4	municipal separate storm sewer system
MSDGC	Metropolitan Sewer District of Greater Cincinnati
MWH	Modified Warmwater Habitat
NLCD	National Land Cover Database
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
O&M	operation and maintenance
ODNR	Ohio Department of Natural Resources
OECA	Office of Enforcement and Compliance Assurance
OEPA	Ohio Environmental Protection Agency

OKI	Ohio-Kentucky-Indiana
OOD	Office of the Director
OPEX	Operations & Maintenance Expenditures
ORC	Ohio Revised Code
OW	Office of Water (USEPA)
PACP	Pipeline Assessment and Certification Program
PBD	Planning and Business Development
PD	Project Delivery
PI	Preformance Indicator
POC	Pollutant of Concern
PSO	pump station overflow
PUCO	Public Utilities Commission of Ohio
RCRA	Resource Conservation and Recovery Act
RDI/I	rainfall-derived inflow and infiltration
RTC	Real Time Control
SMU	Stormwater Management Utility
SSO	sanitary sewer overflow
SWEPP	Sustainable Watershed Evaluation and Planning Process
SWM	System-wide Model
SWMM	Storm Water Management Model
TBL	triple bottom line
TMDL	total maximum daily load
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VE	Value Engineering
WAP	Watershed Action Plan
WEF	Water Environment Federation
WIB	water in basement
WQA	Water Quality Act
WQS	water quality standards
WWC	Wastewater Collection
WWH	Warmwater Habitat
WWIP	Wet Weather Improvement Program
WWT	Wastewater Treatment
WWTP	wastewater treatment plant

Definitions

CAPEX (CAPital EXpenditure management) – MSDGC's initiative to improve investment management capabilities, with a focus on outlining roles and responsibilities. Facilitates agreement of the master plans, ensures ownership of the master plans developed, and ensures active implementation of the plans.

CFCT (Cross Functional Core Team) – A team created by MSDGC OOD, comprised of 8 members, including MSDGC staff from DIW, PD, WWT, EPM, OOD, WWC, and PBD, and charged with establishing a formal, collaborative process for developing measurable CIP strategic goals and a creating a defensible project prioritization and review process that aligns to the CIP strategic goals. The CFCT will establish the projected CAPEX and Operations and Maintenance Expenditures (OPEX) timeline for the watershed, determine the enterprise-level responsibilities for each of the watershed projects.

Communities of the Future A MSDGC initiative that applies systems thinking to develop watershed-specific solutions to water quality improvement and management, while also addressing community needs and promoting sustainable co-benefits to the environment, society, infrastructure, the economy, and the transportation system, ultimately leverageing MSDGCinvestments to maximize the triple bottom line (TBL) benefits of its CSO reductions

Direct Impact Projects Strategies that require direct investment by MSDGC for planning, design, and construction and long-term maintenance. These projects can include source control, conveyance/storage projects, and product control

Enabled Impact Projects Strategies that represent a leveraged infrastructure investment, or are opportunities for cost sharing and collaboration among MSDGC and key watershed stakeholders, such as reforestation, porous pavement, bioswales, living walls, bioretention facilities, or downspout disconnection. Enabled Impact Projects include partnerships with MSDGC and public or private entities to implement source control solutions to reduce the volume of stormwater entering the combined system. Projects in this category can provide additional value and benefits to Direct Impact Projects, which in turn can lead to a better community understanding of sustainable infrastructure-

Green Although often interchanged with sustainable, green refers to natural, ecosystem-based services. It does not imply sustainability, which considers the triple bottom line and extends beyond the environmental purview to include economical and community based perspective.

Inform Influence Projects Programmatic elements that engage and educate watershed partners and the broader public in making sustainable decisions that provide water quantity and quality benefits. Examples include forming partnerships with educational institutions or community thought leaders to create highly visible projects within the community, and foster long-lasting, inter-agency relationships.

Innovative Valley Conveyance System Refers to the hybrid system of open channel and underground box conduit to convey peak flows up to the 100-year event, but as part of a larger solution to leave behind community amenities as part of the system such as walking paths and recreational space, as well as opportunities for re/development.

Integrated Watershed Bioassessment Program Monitoring program that evaluates biological, chemical, and physical conditions of the waterways on a rotational basis.

Lick Run Master Plan A Watershed Master Plan for Lick Run Creek, developed in 2012, which identifies a sustainable solution to CSO problems, with consideration to the watershed's unique physical characteristics. The Plan specifically identifies a watershed based transect that is consistent with the Form Based Code effort. The Lick Run Master Plan serves as an example for an integrated watershed and infrastructure approach as well as the comprehensive community engagement and stakeholder involvement process that MSDGC can utilize other watersheds, as outlined in this manual.

LMC Watershed Action Plan (Lower Mill Creek Watershed Action Plan) is a comprehensive action plan to improve water quality throughout the Lower Mill Creek, including both direct and enabled impact projects and has assistance from other watershed partners. Watershed Action Plans (WAPs) are collaborative plans developed with stakeholders that identify numerous actions to improve water quality. WAPs are completed following at least one updated bioassessment and once the master plan.

Preliminary Watershed Master Plan The prelimnary watershed master plans is an out come of the SWEPP process and will serve as the basis for the development and implementation of the watershed master planning. The preliminary watershed master plan includes all recommended projects in the watershed including Direct Impact Projects (require direct investment by MSDGC), Enabled Impact Projects (involves a leveraged infrastructure investment, or are opportunities for cost sharing and collaboration), and Inform & Influence Projects (elements that engage and educate watershed partners).

Project Development and Alternatives Development Guidelines Primary tool , in conjunction with Risk Tool, to evaluate and prioritize the watershed alternatives. The guidelines will be used to evaluate the cost-benefit ratio of the watershed strategies.

Project Groundwork MSDGC initiative, branded in 2009 (formerly WWIP), referring to the multi-year construction program to meet the required CSO and SSO reductions.. The 4 key components of Project Groundwork are: 1. Asset Management Program (to rebuild the sewer system); 2.Assessment Sewers Program (to expand sewer service in Hamilton County); 3.Trenchless Technology Program (to update the sewer system and reduce inflow and infiltration); 4.WWIP to improve water quality.

Sustainable Infrastructure Sustainable water infrastructure is infrastructure that provides the public with clean and safe water and to helps ensure the social, environmental, and economic sustainability of the communities that water utilities serve (USEPA, 2012).

Transect A narrow section across the earth's surface, along which observations are made. A transect of a watershed may include zones of opportunity based on characteristics, such as forested hillsides (opportunity to capture natural streamflow), highly developed communities (opportunities for near source controls such as downspout disconnection or rain gardens), and open space corridors (opportunity to enhance existing community and recreational uses)

Triple Bottom Line In practical terms, the Triple Bottom Line means expanding the traditional financial accounting framework to include factors such as ecological and social performance. The Triple Bottom Line provides a way for MSDGC to evaluate the interest of the community in addition to the ratepayers.

Urban An area where the majority of land use is marked by a high density of created structures and developments. It is also marked by a high population density. A high population density consists of core census block groups or blocks that have a population density of at least 1,000 people per square mile and surrounding census blocks that have an overall density of at least 500 people per square mile (https://ask.census.gov).

Urban Watershed A waterbody that is part of a larger urban watershed having impairments or degradations of which the root causes are related to the effects of urbanization of the surrounding areas. Waterbody impairments may include hydrological changes of the waterbody (i.e., increased peak flows and flooding or loss of base flow), channelization, or loss of aquatic species, and may include pollutant loadings (i.e., adverse impacts from stormwater, discharges, or combined sewer overflows) (Beach 2003; Ladson et al 2004).

Watershed Master Plan An itemization of the problems, priorities, and activities the local watershed group would like to address. It serves as a guide for the watershed group by mapping a strategy for improving or protecting the watershed. The plan is all encompassing. It includes all infrastructure. It combines technical and financial management techniques over the life cycle of the asset to determine the most cost-effective manner by which to provide a specified level of service.

Wet Weather Strategy A strategy that address untreated discharges from storm-generated flows of water (CSOs, SSOs). MSDGC's wet weather strategy focuses on source control, conveyance & storage, and product control. The strategy includes setting watershed-specific goals for LOS, regulatory compliance, public health and safety, and environmental protection.

WWIP Wet Weather Improvement Program – A MSDGC initiative developed in 2006, later branded Project Groundwork, that was focused on meeting the requirements in the Consent Decree for CSO control and SSO elimination.

SECTION 1
Introduction and Background

Many communities in the United States have utility infrastructure systems that were installed over 100 years ago. Since this time, significant changes have occurred in both urban conditions and in design standards used for wastewater and stormwater infrastructure. Because many U.S. communities were established prior to 1940, their infrastructure continues to be comprised primarily of combined stormwater and sanitary sewer systems that cannot meet the demands of growing populations and that therefore contribute pollutants to local streams and rivers. The U.S. Environmental Protection Agency (USEPA) estimates that 772 communities across the United States have combined sewer systems (CSSs) which convey sanitary sewage and stormwater in the same pipe; when the capacity of the pipe is exceeded, overflows occur in rivers and streams and back up into basements (USEPA, 2008). To resolve this problem, USEPA has placed many communities under federal orders (i.e., issued Consent Decrees) to address the aging infrastructure and reduce combined sewer overflows (CSOs) and eliminate sanitary sewer overflows (SSOs).

Cincinnati, Ohio ranks among the top five cities in the country in terms of the amount of overflow volume and CSO control challenges it faces. In 2004, USEPA issued two Consent Decrees (the "CSO Decree" and the "SSO Decree") to the City and Hamilton County. One objective of the Consent Decrees was "full compliance with…USEPA's 1994 Combined Sewer Overflow Policy," which includes the elimination or control of no less than 85 percent by volume of the combined sewage collected in the combined sewer system during precipitation events on a system-wide annual average basis. Based on this policy and other objectives of the Decrees, the federal orders required the City and County to reduce their estimated 14 billion gallons per year of CSOs (based on the typical year storm) and to eliminate SSOs.

In 2006, the Metropolitan Sewer District of Greater Cincinnati (MSDGC) developed the Wet Weather Improvement Program (WWIP) to implement the Consent Decrees and comply with the Clean Water Act (CWA). The solution specified in the WWIP, also referred to as the "default" solution, includes four Phase I projects to be completed by 2018 (**Figure 1-1**). Of these, one is the Lower Mill Creek Partial Remedy (LMCPR), which requires 85 percent control of CSOs in the Lower Mill Creek Basin by increasing the capacity of the CSS through construction of underground storage tunnels and consolidation sewers as well as separated conveyance systems. However, the WWIP was updated in 2009 (Final WWIP) and includes allowances to examine green infrastructure and update the original LMCPR as appropriate.

Figure 1-1 Timeline for the Lower Mill Creek Partial Remedy

Timeline of Regulatory Change and Cincinnati's Infrastructure Development

1788: Cincinnati founded.

1850s: Population 150,000. Centralized sewer system established to take sewage via sewer lines to nearby water bodies.

1940: Many streams and waterways in underground pipes shared with sewage and stormwater. All flow directed to Ohio River. CSS serves all Cincinnati residents.

1948: Federal Water Pollution Control (FWPC) Act.

1950s: Population peaks at 500,000. City improves waste- and stormwater management with first treatment plant and overflow pipes.

1965: Water Quality Act (WQA) of 1965 (FWPC Amendment).

1972: FWPC Amendments of 1972; Ohio Water Pollution Control Act.

1977: CWA (FWPC Amendment); National Pollutant Discharge Elimination System (NPDES) program.

1985: Cincinnati establishes Stormwater Management Utility (SMU).

1987: Water Quality Act of 1987 (WQA) (CWA Amendment); NPDES Phase I (cities over 100,000).

1990: USEPA establishes NPDES Storm Water Program.

1994: USEPA issues Combined Sewer Overflow Policy.

1999: WQA NPDES Phase II (cities under 100,000).

2003: Hamilton County Stormwater District established.

2004: USEPA issues two Consent Decrees to the City and Hamilton County for SSO and CSO compliance.

2007: USEPA approves green infrastructure strategy.

2008: Ohio Senate Bill 221 (Energy Water Nexus).

The inclusion of green infrastructure evaluation was based on a growing body of research and case studies on green infrastructure to address wet weather discharges. In 2007, USEPA issued a memorandum (USEPA, 2007a) supporting the "development and use of green infrastructure in water program implementation." In 2010, Cincinnati's federal mandate was amended, providing opportunities to substitute green infrastructure solutions for grey infrastructure, on a project-by-project basis. The WWIP was branded in 2008 as Project Groundwork, referring to the multi-year construction program to meet the required CSO reductions and SSO elimination. Identifying the most cost-effective, sustainable, and beneficial combination of infrastructure types for a specific watershed is the underlying goal of the sustainable watershed evaluation and planning process (SWEPP), and the focus of this Integrated Sustainable Watershed Management Manual.

Brief History — Yesterday's Decisions, Today's Liability

Evolution of Wastewater and Stormwater Infrastructure of Greater Cincinnati

The Greater Cincinnati metropolitan area is centered around Cincinnati and encompasses four major tributaries of the Ohio River: Mill Creek, the Little Miami River, Muddy Creek, and the Great Miami River.

The natural history of Greater Cincinnati largely shaped its history of human development. Present-day Cincinnati was settled in 1788, at the confluence of three major tributaries to the Ohio River, and quickly became one of the fastest growing inland cities in the United States. By the 1850s, there were more than 150,000 residents of Cincinnati, mainly inhabiting areas near the Ohio River due to the complexity of settling the steep surrounding hills. The densely populated area and lack of a centralized sanitary sewer system began to pose significant health risks to the City's residents. To address groundwater contamination and increasing water-borne illnesses, a centralized sewer system was established in the mid-1800s to transport raw sewage through sewer pipes to the nearest ditch or water body, and eventually to the Ohio River. As the area became urbanized, many streams and waterways were directed into underground pipe networks. As residential areas and businesses grew in the same areas, both sanitary sewage and stormwater were directed into the same pipes. The combined sewer lines transported all raw sewage and stormwater to the Ohio River and by 1940, Cincinnati had expanded the combined sewer system to provide wastewater service to all its residents (MSDGC, 2009).

In the 1950s, with its population peaking at 500,000 and, with a growing awareness of the health risks associated with CSSs, Cincinnati retained its CSS but made major changes to more effectively manage its wastewater and stormwater. The first wastewater treatment plant (WWTP) began operation in the 1950s and, at the same time, the combined sewer system was equipped with overflow pipes so that sewage and stormwater could overflow to waterways if the system reached capacity. While these changes improved wastewater treatment overall and helped prevent sewer system back-ups, overflows during wet weather still contributed to public health concerns.

Regulatory requirements changed significantly between 1950 and 1970. Details of these changes are presented later in this section.

Since 1970, the population in MSDGC's service area has declined significantly: population losses in the City of Cincinnati and Hamilton County overall have amounted to 34 percent and 25 percent, respectively. Population losses, coupled with a reduction in water usage per account and increases in the expenditures required to meet the federal mandates, could have a cumulative effect on the rate base of MSDGC's service area and the region. Numerous studies have been done suggesting the need to take strategic actions to mitigate Hamilton County's continuing population loss over the next several years. Specifically, over the last 10 years efforts such as the Hamilton County Community Compass and the Regional Chamber's Agenda 360 have called attention to the need for strategic actions to mitigate population loss, and more recent studies and reports suggest the same.

Throughout the service area, there are large amounts of vacant and abandoned properties or brownfields that sit idle, adding to the list of improvements needed in multiple communities.

The community and region are at a critical fork in the road. Community leaders made decisions over 100 years ago — these decisions laid the groundwork for how wastewater and stormwater infrastructure is still used today. It was installed under a different scenario — one that is not sustainable and has left a liability for the current generation.

This manual provides an approach for how MSDGC, Cincinnati, and Hamilton County are working together within the Communities of the Future framework (see Section 4) to plan and implement solutions that meet MSDGC's Consent Decree requirements, improve overall water quality, and improve local communities. Using this systematic approach, as MSDGC has begun in the Lower Mill Creek Watershed, the partnership can grow beyond fixing sewers and in the process leverage investments to rebuild communities.

Evolution of Water Pollution Control Rules and Regulations

The following discussion has been included to provide context on the changes in the regulatory environment and how these changes have affected the approach for water quality management in the metropolitan area. In the early 1900s, there was an increase in

Cincinnati's Natural Conditions

Greater Cincinnati's geology includes deep underground aquifers, abundant surface waters, rich soils, and deep deposits of sand, gravel, clay, limestone, sandstone, oil, and gas. Cincinnati is considered to be the city of seven hills, with areas of steep slopes and infiltration rate-reducing clays. Greater Cincinnati is abutted by the Ohio River, which affects the terrain and humid continental climate, as well as the beech, oak, sugar maple, and swamp forests which characterize the portion of Greater Cincinnati north of the Ohio River.

(Ohio Historical Society, 2002, and Ohio History Central, 2005)

water supply and wastewater management programs throughout the United States. Advances in water quality control regulations date from 1949 and have evolved significantly since then. With the onset of stricter federal regulations in the 1970s, state and local policies addressing water pollution also increased.

Federal Laws

The FWPC Act of 1948 was the first major U.S. law to address water pollution. The Act authorized the Public Health Service to develop a comprehensive set of water quality programs to address pollution in interstate waters and authorized the Federal Works Administrator to provide states, municipalities, and interstate agencies with assistance in constructing WWTPs. Amendments to the FWPC Act of 1948 (WQA of 1965) required that states, or the newly created Federal Water Pollution Control Administration in their absence, establish water quality standards for interstate water bodies. However, the new water quality standards were ineffective because of a lack of permit authority and limitations in scientific understanding at the time. A growing public awareness and concern for managing water pollution led to significant expansion of the FWPC Act in 1972 (FWPC Amendments of 1972) and further amendments in 1977 (CWA) (USEPA, 2011).

The CWA is the primary water pollution control law in the United States. The CWA established the NPDES, a program to regulate point source discharges to waters of the United States. The CWA authorized USEPA to issue and enforce NPDES wastewater permits for all point source discharges to U.S. waters or to delegate this authority to the appropriate state agency or tribe. It is important to note that NPDES stormwater requirements are federally unfunded mandates, meaning each community is required to fund its own efforts to meet these requirements. The CWA maintained the

USEPA's Evolving Support for Green Infrastructure

In March 2007, USEPA issued a memorandum to promote green infrastructure as a viable option for addressing stormwater non-point source water quality issues (USEPA, 2007a).

In August 2007, USEPA issued another memorandum encouraging the incorporation of green infrastructure into NPDES stormwater permits and CSO long-term control plans (USEPA, 2007b). Additionally, the memo states that green infrastructure can and will be used in future USEPA enforcement activities.

In April 2011, USEPA's Office of Water (OW) and Office of Enforcement and Compliance Assurance (OECA) jointly issued a memo supporting the use of green infrastructure, highlighting Cincinnati MSDGC's approach for watershed-based planning in Lick Run. The memo reaffirms the commitment of both offices to work with interested communities to incorporate green infrastructure into stormwater permits and remedies for non-compliance with the CWA.

In October 2011, USEPA's OW and OCEA issued a joint memo encouraging USEPA Regions to assist their state and local partners in pursuing an integrated planning approach to CWA wastewater and stormwater obligations. The memo identifies green infrastructure as one example of a comprehensive solution that can improve water quality while supporting other quality of life attributes to enhance the vitality of communities.

existing surface water quality standards, but also authorized USEPA to develop and enforce technology-based and industry-specific standards for point source discharges. The surface water quality standards require states to define the goals for a waterbody by designating its uses, setting criteria to protect those uses, and establishing provisions such as anti-degradation policies to protect waterbodies from pollutants. Based on a growing body of research on the effects of stormwater runoff on water quality, the CWA recognized the need to address non-point source pollution but did not establish specific standards at that time.

In an effort to expand water pollution control beyond point sources, the CWA was amended further in 1987 (WQA of 1987). The Act required that industrial stormwater dischargers and municipal separate storm sewer systems (MS4s) obtain NPDES permits and meet requirements for non-point source control. USEPA established the NPDES Storm Water Program in 1990, requiring medium and large MS4s (serving populations of over 100,000 people) to obtain an NPDES permit, and to develop a program for managing stormwater by monitoring and reducing pollutants from industrial, wastewater, and municipal processes into creeks, streams, lakes and rivers. The City of Cincinnati was exempted from this phase because less than 100,000 people are serviced by a separate storm sewer system. In 1999, Phase II of the NPDES was enacted. This phase required MS4s in "urbanized areas" serving under 100,000 people to meet the same mandates. This is the point where the City of Cincinnati and the remainder of Hamilton County were required to join the NPDES program.

Stormwater management requirements have continued to evolve under the MS4 program. As part of these changes, USEPA requires that communities develop programs that include the following minimum controls:

- Public Education and Outreach
- Public Participation/Involvement
- Illicit Discharge Detection and Elimination
- Construction Site Runoff Control
- Post-Construction Runoff Control
- Pollution Prevention/Good Housekeeping

USEPA continues to promote the use of low impact development (LID) and green infrastructure practices for post-development stormwater controls. These best management practices (BMPs) help to mimic natural hydrologic conditions, thereby reducing offsite hydrologic impacts (including stormwater volumes and flooding, erosion, and habitat degradation) and non-point source pollutant loadings. As a result, LID BMPs and associated green infrastructure provide direct and indirect benefits for CSO volume reductions, overall pollutant load reductions, and potential for stream habitat and aquatic life improvements. In promoting and incorporating these techniques into its planning approaches over the last several years, MSDGC has learned that a more integrated watershed approach is needed for green infrastructure to be successful at a large scale.

State Laws

The federal CWA and the state of Ohio water pollution laws provide the basis for managing surface water quality in Ohio. The Ohio Water Pollution Control Act, found in Chapter 6111 of the Ohio Revised Code (ORC), was passed in 1972. The Ohio Environmental Protection Agency (OEPA) and Ohio Department of Natural

What is green infrastructure?

Green infrastructure is an approach to wet weather management that use natural systems — or engineered systems that mimic natural processes — to enhance overall environmental quality and provide utility services. As a general principle, green infrastructure techniques use soils and vegetation to infiltrate, evapotranspire, and/or recycle stormwater runoff.

What is grey infrastructure?

In the context of stormwater management, grey infrastructure can be thought of as the hard, engineered systems to capture and convey runoff, such as gutters, storm sewers, tunnels, culverts, detention basins, and related systems.

Banking on Green: A Look at How Green Infrastructure Can Save Municipalities Money and Provide Economic Benefits Community-wide, A Joint Report by American Rivers, the Water Environment Federation, the American Society of Landscape Architects and ECONorthwest, April 2012

Resources (ODNR) are responsible for many point and non-point source pollution programs. Under the federal CWA, Ohio has been granted authority, by USEPA, to implement programs involving actions such as the issuance of NPDES permits, including general stormwater permits.

The Ohio Water Pollution Control Act provides for the development of water quality standards (WQS; ORC 6111.041), which states "...the director of environmental protection shall adopt standards of water quality to be applicable to the waters of the state. Such standards shall be adopted pursuant to a schedule established, and from time to time amended, by the director, to apply to the various waters of the state, in accordance with Chapter 119 of the Revised Code. Such standards shall be adopted in accordance with Section 303 of the 'Federal Water Pollution Control Act' and shall be designed to improve and maintain the quality of such waters for the purpose of protecting the public health and welfare, and to enable the present and planned use of such waters for public water supplies, industrial and agricultural needs, propagation of fish, aquatic life, and wildlife, and recreational purposes. Such standards may be amended from time to time as determined by the director. Prior to establishing, amending, or repealing standards of water quality the director shall, after due notice, conduct public hearings thereon in Chapter 3745 of the Ohio Administrative Code" (http://codes.ohio.gov/oac/3745-1/).

In Ohio, WQS are specific to the goals of a designated use (e.g., aquatic life, water supply, recreation, human health, and wildlife) and may include quantitative and/or qualitative chemical, physical, and biological criteria that provide for the protection of the use. Ohio WQS for aquatic life are among the most scientifically advanced in the U.S. and are based on a tiered system that provides different levels of protection, with consideration to both ideal and realistic conditions. Using the tiered approach, the aquatic life designated use contains multiple subcategories (with different qualitative and quantitative criteria), one of which is assigned to a waterbody based on its potential to support the subcategory.

The tiered aquatic life use subcategories include Warmwater Habitat (WWH), Exceptional Warmwater Habitat (EWH), Modified Warmwater Habitat (MWH), and Limited Resource Water (LRW). Assigning these subcategories provides an incentive for improving degraded aquatic ecosystems, since meeting the use is realistic and helps with the development of regulatory or management actions, such as total maximum daily loads (TMDLs) or NPDES permits.

Local Regulations

Local stormwater programs in the Cincinnati/Hamilton County area are administered in numerous ways. In 2003, the Hamilton County Engineer's Office coordinated a county-wide response to the Federal NPDES Phase II stormwater regulations with the Board of County Commissioners establishing the Hamilton County Stormwater District. The Stormwater District makes up approximately 40 jurisdictions that include townships, cities, and villages, including the City of Cincinnati as the largest member of the District. As a Phase II MS4 permittee, the City and Hamilton County have developed a series of ordinances, rules, and regulations to facilitate implementation of stormwater management and regulatory requirements. **Table 1-1** summarizes the primary ordinances for the county. The City — through the creation of the Cincinnati Stormwater Management Utility (SMU) in 1985 — has established regulations as listed in **Table 1-2**. Note that earthwork (erosion and sediment control) requirements for the City of Cincinnati are enforced through Chapter 1113 of the City's municipal code. This section of the code is administered by the Building & Zoning Department. Also, the City has not yet enacted the required Stream Corridor Protection Rules. This section is also anticipated to be enacted through the City's Building & Zoning Department.

These ordinances and associated rules and regulations are designed to support the implementation of stormwater practices that reduce or mitigate potential impacts of stormwater runoff generated by new or redevelopment activities. For example, MSDGC has a policy that all requests for industrial discharges must include an evaluation of the potential impacts of the proposed industrial

Table 1-1 Hamilton County Stormwater Ordinances and Associated Rules and Regulations

Article	Description
Article I	Definitions
Article II	Illicit Discharge Detection and Elimination Rules and Regulations
Article III	Earthwork (Erosion and Sediment Control Rules and Regulations)
Article IV	Stream Corridor Protection Rules and Regulations
Article V	Post-Construction Rules and Regulations Adopting Resolution, Board of County Commissioners (BOCC)/Townships Adopting Resolution, Cities and Villages

Table 1-2 Cincinnati Stormwater Ordinances and Associated Rules and Regulations

Document	Description
Stormwater Management Code	Chapter 720 of the Cincinnati Municipal Code.
SMU Rules and Regulations	Contains the general rules pertaining to the SMU.
Post-construction Stormwater Regulations	Intended to promote and maintain the health, safety, and welfare of the residents of the City of Cincinnati by establishing standards for stormwater BMPs.

development (or redevelopment) on stormwater runoff to the combined sewers. Potential permittees must implement stormwater BMPs to meet specific stormwater detention requirements and implement pollution prevention to monitor impacts associated with downstream CSOs.

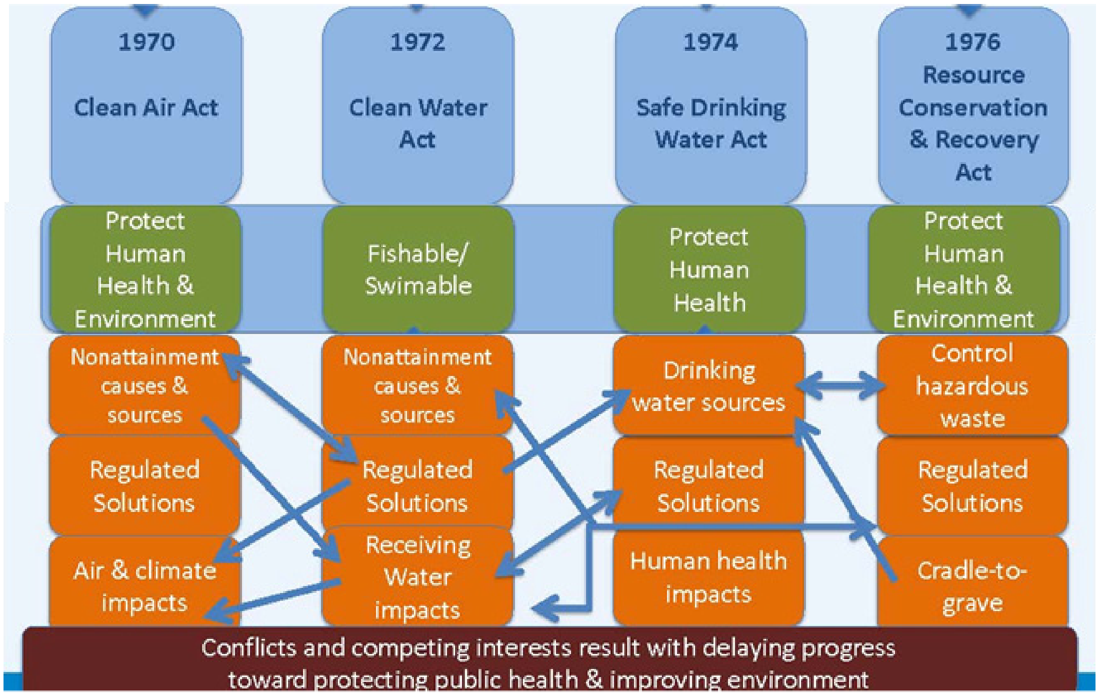
Many of these practices support the overall goals of the CSO program, including stormwater volume and quality control. MSDGC is currently collaborating with the County and City departments involved in stormwater management and development reviews to examine existing rules and regulations. A sustainable infrastructure Gap Analysis (http://projectgroundwork.org/downloads/cfac/Sustainable_Infrastructure_Policy_GAP_analysis_2012.01.09.pdf) has been performed, and a work plan is underway to streamline and enhance policy, rules, and regulations to help support successful implementation of LID BMPs and green infrastructure. MSDGC is currently working with Hamilton County to finalize the design and maintenance standards for stormwater BMPs. MSDGC is also working with the City and the County on finalizing and approving the policy, rules, and regulations that will facilitate the implementation of LID and green infrastructure practices.

Public Policy Challenges and Opportunities

The CWA has brought extraordinary gains to environmental and public health protection in communities all over the nation, and locally throughout Hamilton County and the City of Cincinnati. Over the last two decades, aquatic life in Mill Creek and the Little Miami River has improved dramatically, with more diverse species of fish observed with fewer stresses (Midwest Biodiversity Institute, 2011). However, solutions to many of the water quality challenges have increased operational costs for conveyance and treatment facilities and resulted in the need for additional capital investments. While some of those improvements are necessary, others may have resulted in limited environmental returns. Therefore, some changes in policies or actions may be necessary to provide the most environmental benefits for the public's investment. It is becoming increasingly apparent that current "end-of-pipe" limits and treatment paradigms, as dictated by the "best available technology" (BAT) requirement of the CWA, present significant financial and operational challenges for urban publicly owned utilities. More importantly, the decision framework for CWA implementation and enforcement needs review and re-evaluation in light of the ambiguous rates of environmental return for some mandated solutions.

From a policy perspective, integrated planning considers both the community and watershed scale. However, given the current planning framework, local governments are challenged to initiate and align the fragmented planning platform; the inability to align community planning efforts results in more costly, less desirable outcomes. **Figure 1-2** demonstrates the often-competing interests among primary environmental acts (Clean Air Act [CAA], CWA, Safe Drinking Water Act, and Resource Conservation and Recovery Act [RCRA]) and their associated goals (respectively: protection of human health and the environment, protection of fishable and swimmable designated uses, protection of human health, and protection of human health and the environment). For example, the primary goal of the CWA is to improve rivers and streams to meet fishable and swimmable designations. As a result, when each regulatory driver of the CWA is separately evaluated for specific compliance, the resulting recommendations may have the highest capital cost and may not achieve the desired environmental improvement. Cincinnati and Hamilton County were successful in developing a proposal for an integrated CSO/Stormwater/Community watershed solution, which is in alignment with the federal framework for integrated planning. Without an integrated platform for water resource planning that incorporates community priorities, the results will be outcomes that are less desirable. What is needed is an integrated approach to water resource management

Figure 1-2 Competition Among Environmental Regulations



Linkages Between Energy Needs, CSO Alternatives, and Air Quality

If 85 percent control of the 14 billion gallons of CSO, during a typical year, is in place without any source control or strategic separation considerations, annual operation will require over 4 billion megawatts of power to pump and treat the wastewater, resulting in the emission of over 2.4 billion metric tons of carbon dioxide. Considering this scenario, the environmental and social impacts of tunnel-based wet weather solutions are not well integrated into the regulatory programs and enforcement decision framework.

Ohio Senate Bill 221 (SB 221) enacted in 2008 encourages Ohio businesses and utilities to adopt renewable and advanced energy technologies that may help address the issues associated with the "energy water nexus." The bill includes new energy-efficiency and peak demand standards that utilities must meet through energy-efficiency programs. The Public Utilities Commission of Ohio (PUCO) has proposed new energy efficiency rules that have yet to take effect but the intent of the new rules is to establish clear and distinguishable requirements relating to the reporting, verification, and design of cost-effective energy-efficiency and peak demand programs.

In the Lick Run watershed, for example, MSDGC evaluated the energy impacts of the traditional grey (storage tunnel and treatment) vs. green solutions (LID and green infrastructure BMPs for stormwater management) for CSO volume controls. In this case, the default "grey" solution would require the additional energy output for pumping and treating 838 million gallons (MG) of CSO annually based on the typical year storm. Most of this stormwater would enter a new enhanced high rate treatment (EHRT) facility that would be constructed near the Mill Creek Water Treatment Plant. The typical year runoff is based on 1970, when the annual rainfall was approximately 40 inches. The difference in energy usage between the green and grey (tunnel) alternatives is estimated to be 26,974,730 kWh per year. Using the EPA's Greenhouse Gas Equivalencies Calculator (www.epa.gov/cleanenergy/energy-resources/calculator.html) this would generate 18,601 metric tons of CO_2 per year. This demonstrates the enhanced benefits of green stormwater management solutions for greenhouse gas (GHG) reductions. Consequently, MSDGC's approach considers issues beyond the traditional regulatory drivers and recognizes the "energy water nexus" between the CWA and CAA and that solutions must consider issues that span environmental media and full life cycle costs.

that is adaptable and makes it more affordable to rate-payers while addressing community needs using a prioritized, risk-based approach for overall environmental improvement.

Additionally, as residential populations and businesses decline in Hamilton County, the financial and social burden on rate-payers will be even greater — particularly when there is a possibility that for some, sanitary sewer bills could exceed the annual property tax. In 2012, there have been proposals introduced such as the Clean Water Affordability Act, legislation that would help Ohio communities meet federal mandates related to outdated sewer systems, while also lowering the existing relatively high water and sewer rates.

The Clean Water Affordability Act, if passed, would provide a cost-sharing program to help local communities improve aging sewer infrastructure.

The Act as proposed focuses on updating USEPA's clean water affordability policy to allow communities to re-evaluate federal mandates to consider the community's economic condition and the use of sustainable infrastructure to address CSO and SSO reduction requirements. The Clean Water Affordability Act authorizes $1.8 billion, over 5 years, to implement a cost sharing program to help Ohio communities update aging sewer infrastructure. The legislation has been endorsed by the National Association of Clean Water Agencies and is an example of the types of policy changes on the national scale needed to address the challenges.

Sustainable Watershed Planning

MSDGC has developed this integrated watershed-based approach to wet weather planning to appropriately factor risk, affordability, and environmental priorities into decision making. In March 2010, MSDGC established the Communities of the Future Advisory Committee (CFAC), which has helped shape the approach outlined in this manual.

The MSDGC integrated watershed-based approach has evolved during the development of an alternative to the default tunnel solution for the Lower Mill Creek basin. The watershed-based framework is presented in Section 3. MSDGC further developed an integrated approach under the Communities of the Future initiative — an initiative to leverage MSDGC investments to maximize the triple bottom line (TBL) benefits of its CSO reduction and SSO elimination program. As allowed in the approved Final WWIP, MSDGC will complete a 3-year study by December 31, 2012, to examine green infrastructure options and appropriately refine the LMCPR default solution. MSDGC will conduct the SWEPP on all remaining watersheds by 2017, to feed into the development of future planning and design projects for Phase 2 and future phases. Through SWEPP, MSDGC can identify and prioritize MSDGC and community needs as well as linkages with other public or private opportunities. SWEPP allows MSDGC to meet both water quality and water quantity goals for a watershed and identify the most cost-effective combination of green and grey infrastructure improvements.

The SWEPP is a comprehensive TBL (environmental, economic, and social) approach to understanding current conditions within a community and a watershed, and identifying the most cost-effective, sustainable, and beneficial combination of water resource infrastructure types for a specific area (**Figure 1-3**). This overall approach to planning was outlined in the *2010 Stainability Report* (MSDGC, 2010).

The "Triple Bottom Line" concept for sustainable utility planning integrates the social, economic, and environmental needs of the community.

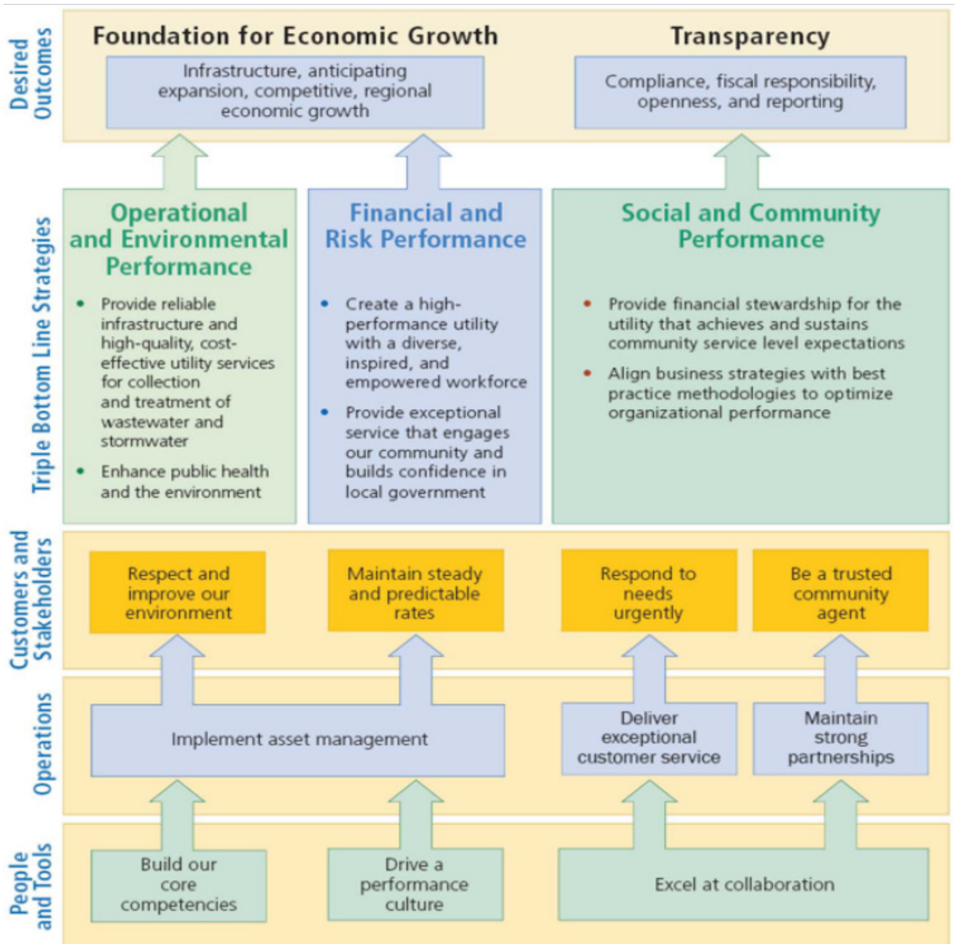
A key aspect of this process is to also incorporate the implementation, performance monitoring, and lessons learned into the Preliminary Watershed Master Plan. The components of the Preliminary Watershed Master Plan are further refined, budgeted, prioritized, and developed into a Watershed Master Plan (Section 3). The primary goal of this manual is to outline a consistent process for developing a Watershed Master Plan for water resource improvement.

The MSDGC service area is comprised of urban, suburban, and undeveloped land uses. The SWEPP Manual is intended to be used for the entire MSDGC service area; however, opportunities for improvement will be focused on suburban and urban areas, where sewer infrastructure is concentrated.

Metropolitan Sewer District of Greater Cincinnati — A Partnership Between City and County

In 1968, the Cincinnati City Council and Hamilton County Board of County Commissioners entered into a partnership, forming MSDGC, to manage wastewater collection and treatment in Hamilton County. MSDGC is also responsible for ensuring that the City meets federal, state, and local water pollution control laws

Figure 1-3 MSDGC's Organizational Framework Focusing on Triple Bottom Line



(MSDGC, 2009). In 1985, the SMU was established as a division of the Cincinnati Department of Public Works (now known as Public Services). In 1995, SMU was transferred from the Department of Public Works to the Department of Sewers. MSDGC is a separate division within the Department of Sewers and SMU is a fully separate enterprise-funded agency. SMU pays MSDGC for all services rendered on behalf of SMU and is solely responsible for overseeing the operation and maintenance (O&M) of the public storm sewer system inside the City of Cincinnati. Outside the City, each political jurisdiction is responsible for operating and maintaining its own public storm sewer systems. Per the original 1968 agreement between the City and the County, MSDGC was not permitted to own, operate, or maintain public storm sewer structures. The agreement was amended on March 17, 2010 to allow MSDGC to "acquire, develop, own or maintain, and to expend MSDGC funds for, any storm sewers."

The role of the sustainable watershed evaluation and planning process is to help MSDGC meet the Consent Decree requirements, identify and evaluate green alternatives, and, simultaneously, identify opportunities to collaborate with local communities in the watershed.

Currently, MSDGC serves nearly 230,000 residential, commercial, and industrial accounts spread over 43 different political jurisdictions in Hamilton County, and portions of adjoining Butler, Clermont, and Warren Counties. MSDGC treats an average of approximately 185 million gallons per day (mgd) of sewage collected through over 3,000 miles of sewer pipe. MSDGC operates 7 major WWTPs (Mill Creek, Little Miami, Muddy Creek, Indian Creek, Taylor Creek, Sycamore Creek, and Polk Run), 3 smaller WWTPs, 10 large pump stations, and 113 smaller pump stations.

About 45 percent of MSDGC's collection system consists of combined sewers; a large percentage of the CSS is located within the City of Cincinnati. Together, the City, Hamilton County, and MSDGC are working together to meet the USEPA mandated federal Consent Decrees, which requires reducing CSOs and eliminating SSOs.

MSDGC's biggest challenges are increased capital investments and O&M costs for facilities that will require increased revenues for the next 30 years or more. MSDGC rate-payers will be the primary source of these revenues, so it is critical that MSDGC carefully evaluate all the solutions for long-term sustainability based on life cycle costs/affordability, risk, and environmental priorities.

MSDGC Organizational Framework

Figure 1-4 provides an overview of the organizational structure of MSDGC. The MSDGC Executive Director manages the eight divisions shown, including the Office of the Director (OOD). The OOD is also responsible for SMU and Environmental Program Management (EPM) (not shown in figure).

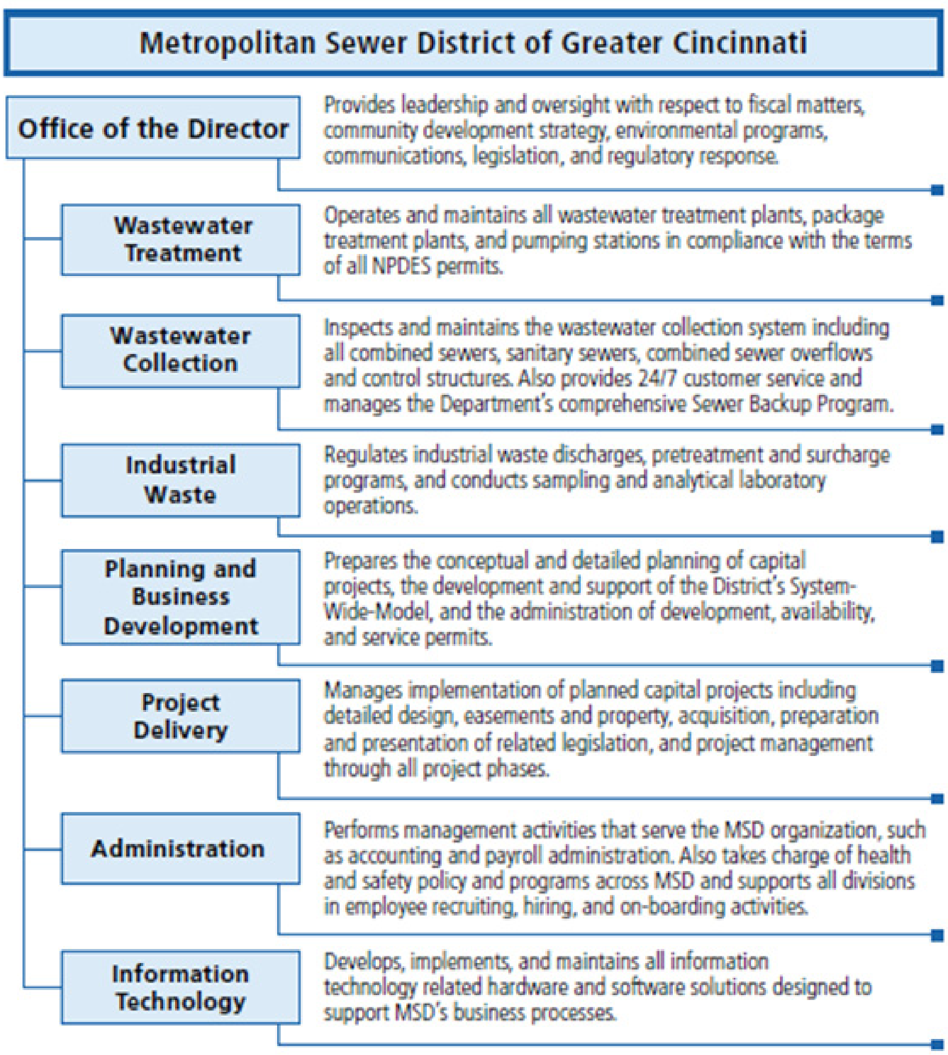
To achieve operational and environmental performance, MSDGC's strategic plan goals are to provide reliable infrastructure and high-quality, cost-effective utility services for collection and treatment of wastewater and to enhance public health and the environment (MSDGC, 2011). To achieve social and community performance, MSDGC's strategic plan goals emphasize relationships with customers, community stakeholders, and workforce to provide exceptional service that engages the community and builds confidence in the local government while creating a high-performance utility with a diverse, inspired, and empowered workforce. Finally, to achieve financial and risk management performance, MSDGC's strategic plan goal is to provide financial stewardship for the utility that achieves and sustains community service level expectations and aligns business strategies with best practice methodologies to optimize organizational performance.

The CSO problem arose primarily because of issues with the affordability of the improvements to the outdated collection system. Addidtional problems and costs were related to complying with end-of-pipe solutions, and containing and treating large volumes of stormwater and stream flows while not being able to ensure that the selected level of control would be sustainable. The goal is to develop solutions that a rate-payer is willing and able to support, and have discernible environmental benefits to the community. In order for MSDGC's wet weather program to be successful long term, it is of critical importance that wet weather reduction efforts provide tangible benefits to the community at large.

MSDGC Mission

MSDGC's mission is "to protect public health and the environment through water reclamation and watershed management." This mission extends to wastewater collection, water reclamation, biosolids handling, stormwater, and watershed management.

Figure 1-4 MSDGC's Organizational Structure (from projectgroundwork.org)



Contents of This Document

This manual is provided by MSDGC to aid staff, consultants, and agency partners in understanding the SWEPP and watershed master planning process. It should be used to provide consistency in the planning and project prioritization process and to assure that the most sustainable and cost-effective strategies are developed to meet the requirements in the Consent Decrees and support local community goals. The following sections include:

- **Section 2: Overview of Urban Watersheds and Integrated Watershed Planning**
- **Section 3: MSDGC's Wet Weather Strategy**
- **Section 4: Planning for Communities of the Future**
- **Section 5: Sustainable Watershed Evaluation and Planning Process and Master Plan Implementation**
- **Section 6: References**
- **Appendices:**

  A. Background on Urban Watersheds

  B. Sustainable LENS Tool Application

  C. MSDGC Asset Hierarchy Diagrams

  D. Example Preliminary Watershed Master Plan Outline

SECTION 2

Overview of Urban Watersheds and Integrated Watershed Planning

Background Understanding for Sustainable Watershed Planning

As a result of development, cities today face a loss of streams and wetlands, tree canopy, and greenspace. Understanding these land use changes and the effects on a city's natural systems is critical in planning, designing, and constructing sustainable infrastructure for the future. Specific to this manual, examining the historical and current topography, hydrology, soils, geology, and vegetation of Greater Cincinnati provides insights into watershed-specific opportunities and constraints related to CSO reduction, SSO elimination, and overall water quality improvement. For the purposes of this manual, essentially all MSDGC watersheds are considered urban watersheds, as they have been affected by some level of urbanization.

The following section summarizes the role of watersheds in the master planning process. A more detailed discussion of urban watershed conditions and key issues for consideration in the planning process is included in Appendix B. Management measures that can be used to mitigate the impacts of urbanization on natural systems are discussed in Section 3. Sources of data that should be used to model and evaluate natural systems for watershed management and CSO reduction are discussed in Section 5.

What is an urban watershed?

An urban watershed is a watershed having impairments or degradation with root causes related to the effects of urbanization of the surrounding areas. Watershed impairments may include hydrological changes of the stream and tributaries (i.e., increased peak flows and flooding or loss of base flow), channelization, or loss of aquatic species, and may include pollutant loadings (i.e., adverse impacts from stormwater, discharges, or combined sewer overflows).

(Beach, 2003; Ladson et al., 2004).

Urban watersheds generally have a high density of impervious land cover.

Role of Watershed and Integrated Infrastructure in Planning

Traditionally, CSO improvement planning has followed an asset-centric approach, focusing on upgrades, changes, and maintenance of existing infrastructure (including sewer pipes and treatment plants). The amount of imperviousness associated with transportation corridors has further complicated the options for watershed and stormwater management. For example, historical changes in land use and the traditional approach to conveyance of drainage in Cincinnati have led to highly impervious watersheds with enclosed, piped streams in many areas. In addition, pipe capacities are often exceeded, leading to backups and overflows. Large amounts of impervious land use, including parking lots, roads and highways, and building roofs contribute large volumes of runoff in urban watersheds.

Benefits of Green Infrastructure

A 2012 American Society of Landscape Architects (ASLA), American Rivers, and Water Environment Federation (WEF) report titled *"Banking on Green: How Green Infrastructure Saves Municipalities Money and Provides Economic Benefits Community-wide"* cites additional benefits to communities considering an integrated approach (Odefey et al., 2012). Both green and grey infrastructure options are able to reduce the potential for flooding, among other benefits. However, the report offers the following key findings in support of green infrastructure:

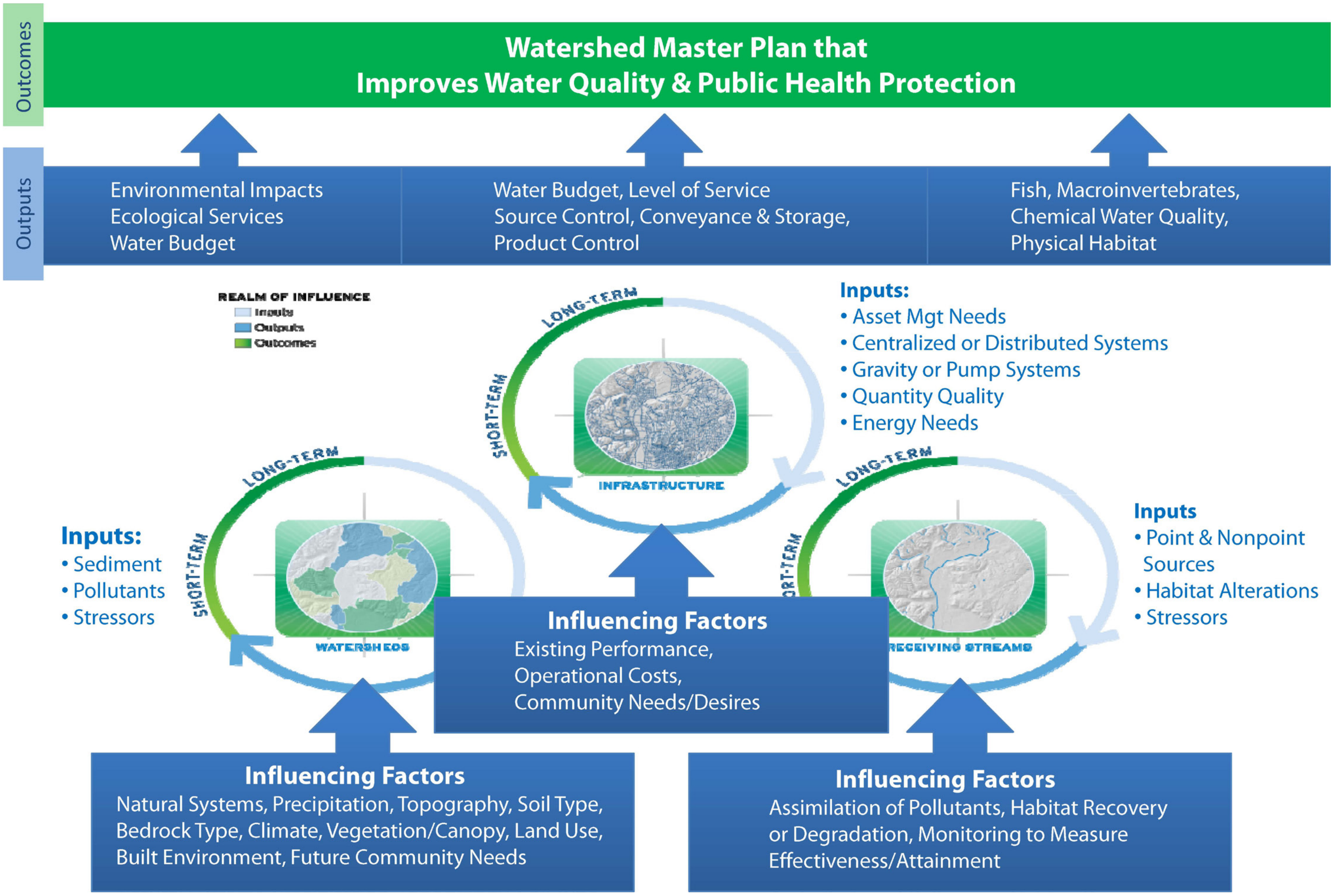
- In addition to costing less than traditional infrastructure practices, green infrastructure practices may further reduce costs of treating large amounts of polluted runoff.
- Green infrastructure can help municipalities reduce energy expenses.
- Green infrastructure can reduce flooding and related damage.
- Green infrastructure improves public health by reducing pollution (e.g., bacteria) in rivers and streams, which prevents gastrointestinal illnesses among primary contact users such as swimmers and boaters.

To address these complex urban watershed conditions, MSDGC has adopted an integrated approach to sustainable watershed planning that includes evaluating opportunities to reduce stormwater contributions to the CSS through a variety of integrated grey and green solutions. Green infrastructure practices (in conjunction with grey infrastructure practices) have been evaluated as being more cost-effective than grey infrastructure practices alone (Gunderson, 2011). In this approach, it is necessary first to understand the historical and current conditions and use this information to develop green with grey solutions to maximize water quality and quantity benefits and to meet community needs.

The primary goals of Project Groundwork and its associated programs are to ultimately develop and implement sustainable watershed-based activities that address the Consent Decree requirements for CSO reduction and SSO elimination and improve overall water quality, habitat, and biotic integrity conditions. These goals incorporate a natural systems-based approach to watershed planning and management (see **Figure 2-1**). The conditions in a specific watershed, such as precipitation, land use, and pollutant loadings (including sediment and nutrients), help to define the water budget, ecological services, environmental impacts, and existing level of service (LOS) for a watershed. Factors that influence the conditions of a watershed include natural features (e.g., topography, hydrology, climate, geology, soils, physical habitat, and biological communities) and built systems (e.g., impervious surfaces, infrastructure, and pollutant sources). The evaluation of existing watershed conditions, based on these influencing factors, is used to understand, for each watershed, the existing water quality, environmental impacts, ecological services, and water budget, and to define an aspirational target watershed-specific LOS. Potential opportunities for wet weather management (**Figure 2-1**) are defined primarily by a watershed's sewer infrastructure (e.g., centralized or distributed systems, gravity or pump systems), as well as watershed conditions (defined above) and associated outputs. The extent and condition of existing infrastructure, and the watershed's existing LOS or performance, are the basis for identifying potential alternatives for strategic separation (or various combinations of infrastructure solutions for wet weather management). These include opportunities for retrofits in existing developed areas, streams, transportation corridors, and other publicly owned properties and infrastructure projects. Opportunities should be evaluated based on the overarching TBL framework for sustainability (operational and environmental, social and community, and economic performance). MSDGC is in the process of identifying and defining its LOS, which will serve as the basis for the SWEPP process for future watersheds.

The Lick Run Master Plan provides a good example of the benefits of an integrated watershed and infrastructure approach. MSDGC used this approach to analyze an actual watershed to create a repeatable process for the service area and beyond. **Figure 2-2** demonstrates the integrated solution that was the final recommendation from the Lick Run Master Plan. Stream daylighting and innovative valley conveyance systems, combined with a series of natural stormwater retention facilities, were identified as the most cost-effective and sustainable way to reduce stormwater contributions to the CSS. An "innovative valley conveyance system" is a hybrid system of open channel and underground

Figure 2-1 Natural Systems-Based Approach to Watershed Planning

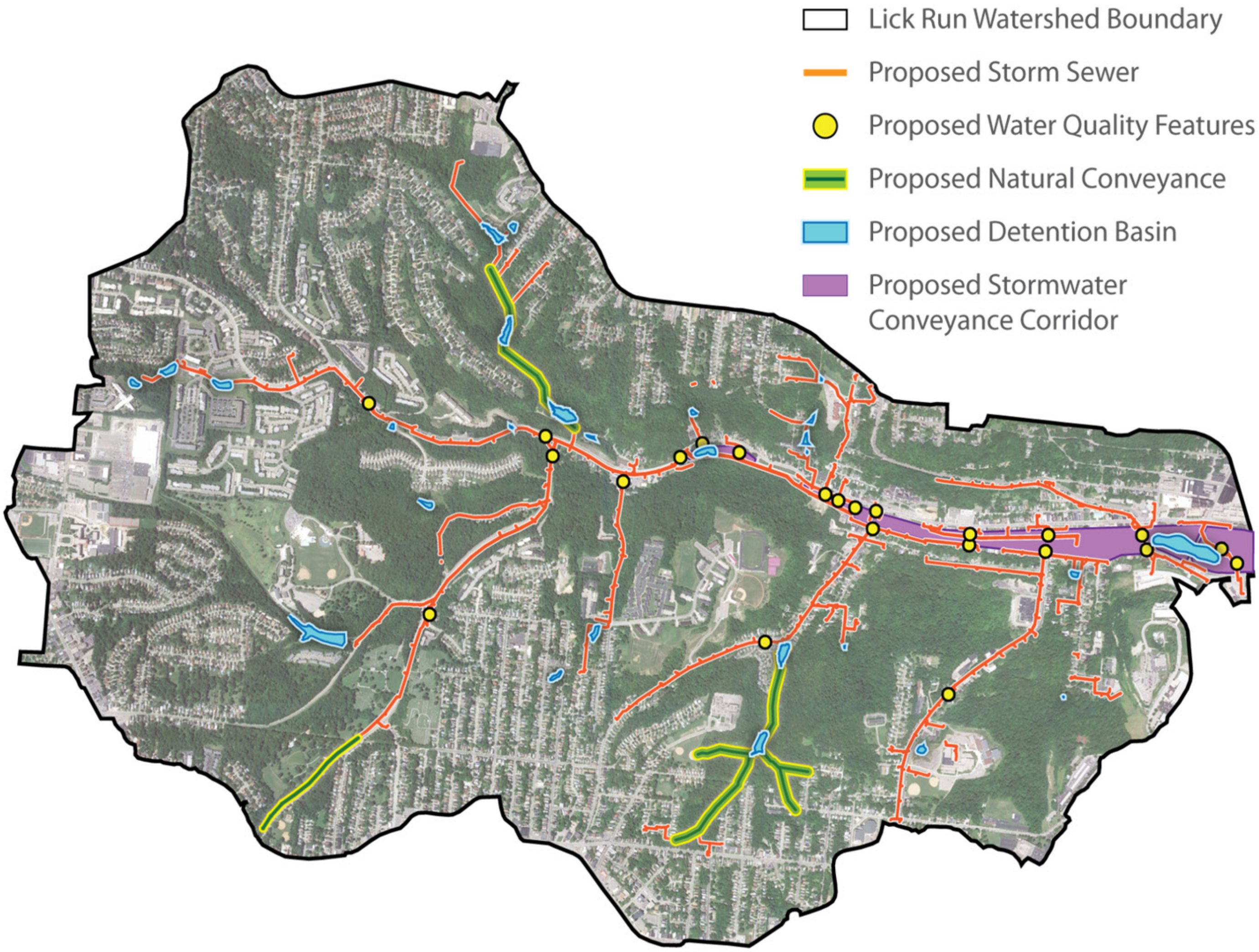


box conduit used to convey peak flows up to the 100-year event, but as part of a larger solution to incorporate community amenities as part of the system (walking paths and recreational space, for example), as well as opportunities for redevelopment. Valley conveyance systems provide an opportunity for additional urban restoration and revitalization. Improvements in the transportation system through the valley were also included, and the green street features are an integral component of the overall strategy. By integrating quantity and quality issues and needs associated with CSO and stormwater with transportation infrastructure elements in the Master Plan, MSDGC and its planning partners were able to develop a sustainable infrastructure alternative that was comparable in costs to the traditional storage and treatment alternative (tunnel) while providing significant benefits to the community.

As the Master Plan for Lick Run shows, there are significant opportunities to create better solutions through integrated watershed management with the tools that help support decision-making processes. The role of integrated planning is to promote better decisions and prioritization of community needs to be addressed while making improvements in water quality.

The SWEPP process is intended to consider numerous conditions and opportunities (as well as constraints) associated with water quality and quantity. Initial MSDGC efforts are following the "plan, do, check, act" process, which forms the basis for the SWEPP. Data being collected wil serve as background/baseline water quality data for watersheds and receiving streams so that potential infrastructure-related investments and priorities can be developed. The tools developed to date will continue to evolve and be enhanced to create more viable communities of the future (MSDGC, 2012).

Figure 2-2 Lick Run Watershed Integrated Solution



SECTION 3
MSDGC's Wet Weather Strategy

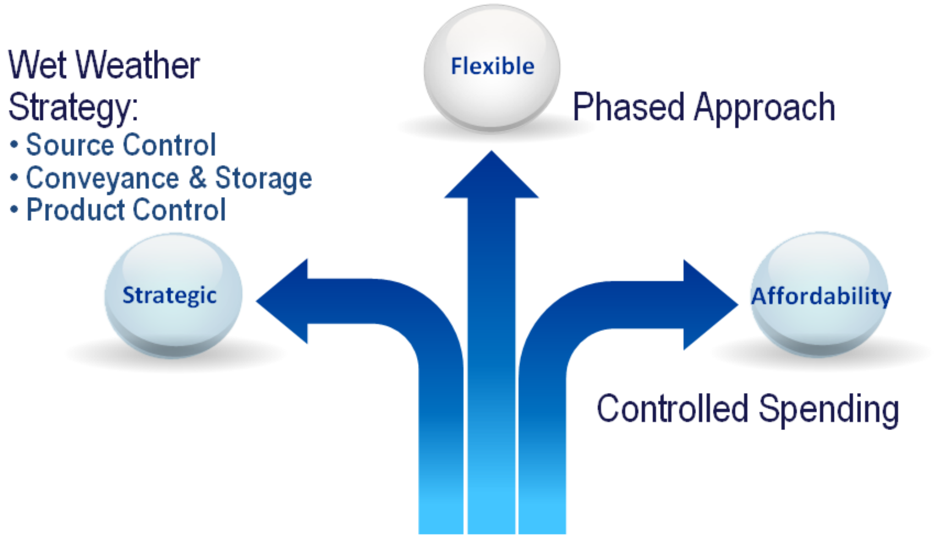
Project Groundwork is MSDGC's program for meeting the requirements of the federally mandated Consent Decrees. Through Project Groundwork, MSDGC is taking a holistic approach to improve public health and water quality while addressing its federal mandates, focusing on strategic, sustainable, cost-effective solutions to wet weather discharges. MSDGC's primary challenges are to achieve the required CSO reduction and SSO elimination, while also implementing solutions that improve the water quality of receiving streams and consider future energy needs of capital improvements, as well as other social, economic, and environmental outcomes of projects.

To meet the challenges outlined above, as well as the requirements of the Consent Decrees, Project Groundwork has four key components:

1. Asset Management Program — to build, operate, maintain, and rebuild existing sewer system assets
2. Assessment Sewers Program — to expand sewer service in Hamilton County
3. Trenchless Technology Program — to update the sewer system and reduce inflow and infiltration (I/I)
4. WWIP — to improve water quality and quantity issues, by implementing cost-effective combinations of product control, conveyance/storage, and source control opportunities

MSDGC's approach to WWIP was developed through a comprehensive planning effort and designed to be flexible and strategic while considering affordability, as illustrated in **Figure 3-1**.

Figure 3-1 MSDGC's Wet Weather Improvement Program Approach



Strategic Plan Goals

- Provide reliable infrastructure and high-quality cost-effective utility services for collection and treatment of wastewater and stormwater
- Enhance public health and the environment

Sustainability Goals

- Deploy energy and material resources efficiently
- Minimize waste
- Protect air quality and minimize odors
- Reduce GHG emissions
- Protect and enhance water quality
- Comply with environmental regulations

Key Performance Indicators for Sustainability

- MSDGC Products
  - Water quality regulatory compliance
- MSDGC Inputs
  - Wastewater
  - Energy consumption
  - Chemical consumption
- MSDGC By-products
  - Sludge dewatering
  - Incinerator air emissions
  - GHG emissions
  - Odor control
  - Waste disposal
  - Recycling

The recommended WWIP strategy incorporates the overall concepts for sustainability outlined in the MSDGC 2010 Sustainability Report which identified the specific sustainability goals for implementation of MSDGC's Strategic Plan. Implementation of the WWIP strategy involves:

1. The SWEPP (understanding current conditions within a community and a watershed, and identifying the most cost-effective, sustainable, and beneficial combination of water resource infrastructure types for a specific area),
2. Development of a prioritized Watershed Master Plan, a prioritized action plan for the watershed, consisting of both green and grey infrastructure to meet a desired LOS,
3. Implementation of the Master Plan, and
4. Performance monitoring and lessons learned tracking.

The following section outlines the foundation of MSDGC's Project Groundwork and sets the stage for Communities of the Future (Section 4) and the SWEPP and Master Plan implementation (Section 5).

Wet Weather Strategy

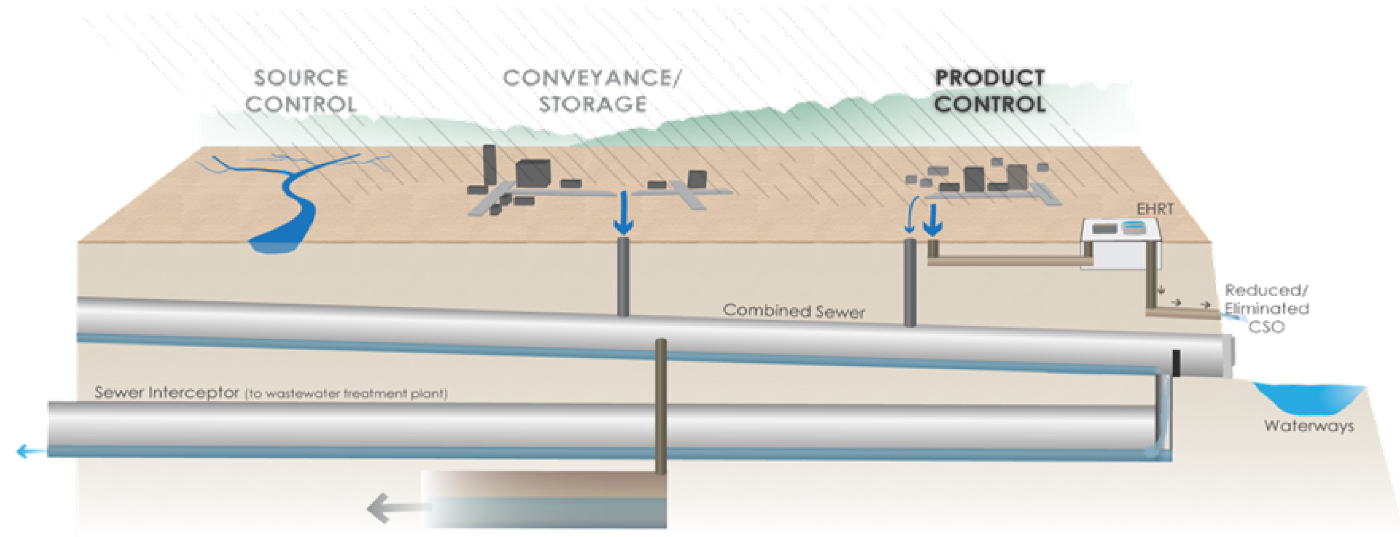
MSDGC's WWIP strategy consists of a three-pronged approach to meeting the federal mandates, including: (1) source control, (2) conveyance and storage, and (3) product control (**Figure 3-2**). By using a sustainable infrastructure strategy for source control, MSDGC is able to incorporate, into its WWIP approach, environmental and social community benefits that can be realized through integrated public/private planning and investment.

Source Control

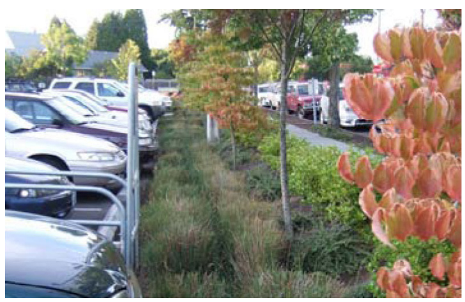
In 2009, MSDGC began investigating and applying source control techniques more extensively while also focusing efforts with other regional partners to leverage its wet weather strategy for economic development and urban renewal. This strategy was branded as Communities of the Future and has since become a multi-agency partnership to complement Project Groundwork efforts to reduce CSOs and eliminate SSOs.

Source Control is the foundation of the WWIP because it removes non-sanitary flow, which is generally cleaner than sanitary flow, and allows for the right-sizing of conveyance, storage, and treatment facilities, thereby decreasing life cycle costs. While the degree of pollutants in stormwater is site-specific, source control is targeted to redirect and remove relatively clean water from the CSS, much of which is delivered via stormwater runoff and direct inflow from ravines and streams that flow into combined sewers. These solutions are intended to prevent stormwater from reaching the CSS (or at least reduce the volume) by using green infrastructure that allows flow to infiltrate into the ground or evaporate. Source control solutions can include separation of stormwater pipes or natural drainage systems and use of bioretention features, as well as retention/ detention structures. As a result, water quality and quantity issues can be addressed closer to the source of generation. These solutions can also include green roofs, rainwater harvesting systems, bioswales, and pervious pavement, as well as larger systems of regional stormwater quality/quantity that could include a valley conveyance system, daylighting of streams, conveyance, reforestation, bioretention basins, and controlling/redirecting hillside runoff.

Figure 3-2 MSDGC's Wet Weather Strategy



Bioswales are designed to capture stormwater, filter out pollutants, and reduce flooding.



Green roofs not only detain stormwater — they also insulate buildings and provide aesthetic improvements.

Pervious pavers help rainwater seep into the ground, thereby helping to reduce stormwater runoff.

Rain barrels collect stormwater from roofs, making it available for garden irrigation.

MSDGC recognizes that some land uses generate more non-point source pollutants than others and, therefore, when evaluating areas for strategic separation, takes into consideration the existing land uses and stormwater pollutant loadings. For example, information collected as part of MSDGC's Division of Industrial Waste's pretreatment program, which follows procedures outlined in it SSO/CSO Discharge Management and Minimization Plan, helps guide the prioritization of sewer separation alternatives.

USEPA has recognized that "green infrastructure can be both a cost-effective and an environmentally preferable approach to reduce stormwater and other excess flows entering combined or separate sewer systems in combination with, or in lieu of, centralized hard infrastructure solutions" (http://water.epa.gov/infrastructure/greeninfrastructure/index.cfm). According to USEPA, green source control solutions provide a number of advantages over grey infrastructure used in product control or conveyance and storage.

In 2011, USEPA devised a strategic framework around development of an Urban Waters Program featuring goals that align with MSDGC's Communities of the Future. Specifically, the program seeks to develop outcomes such as:

- **Connection to Urban Waters:** Greater access to urban waterfront and greater public participation in waterfront activities, such as recreation, volunteer monitoring, clean-ups, education, and leisure.
- **Understanding of Urban Waters and Their Potential:** Greater public involvement and awareness of urban waters and their potential for improving public health, economic development, and quality of life.

Advantages of Green Source Control Solutions

- **Cost Savings** — Integrated grey and green infrastructure may save capital costs associated with reducing or right-sizing conveyance, tunnels, or storage facilities as well as treatment facilities. It can also reduce O&M expenses for treatment plants, pipes, and other hard infrastructure through lower energy, treatment, and pumping costs.
- **Community Benefits** — Trees and plants (associated with green infrastructure solutions) improve urban aesthetics and community livability by providing recreational and wildlife areas and can raise property values (Gunderson, 2011).
- **Cleaner Water** — Vegetation and greenspace reduce the amount of stormwater runoff and, in combined systems, the volume of CSOs.
- **Enhanced Water Supplies** — In many areas, most green infiltration approaches result in stormwater percolation through the soil to recharge the groundwater and the base flow for streams.
- **Cleaner Air** — Trees and other vegetation improve air quality by filtering many air-borne pollutants and can help reduce the amount of respiratory illness.
- **Reduced Urban Temperatures** — Summer city temperatures can average 10°F higher than nearby suburban temperatures. High temperatures are linked to higher ground-level ozone concentrations. Vegetation creates shade, reduces the amount of heat-absorbing materials, and emits water vapor — all of which cool the air.
- **Increased Energy-Efficiency** — Greenspace helps lower ambient temperatures and helps shade and insulate buildings, decreasing energy needed for heating and cooling.

(USEPA, 2007)

- **Sense of Public Ownership of Urban Waters:** Greater public benefit from improvement efforts, especially in underserved communities, and increased priority given to the improvement of urban waters.
- **Protection and Restoration of Urban Waters:** Acceleration of measurable improvements to urban water quality.
- **Community Revitalization:** Promotion of equitable community improvements that capitalize on the social and economic benefits derived from improved urban waters and adjacent lands.

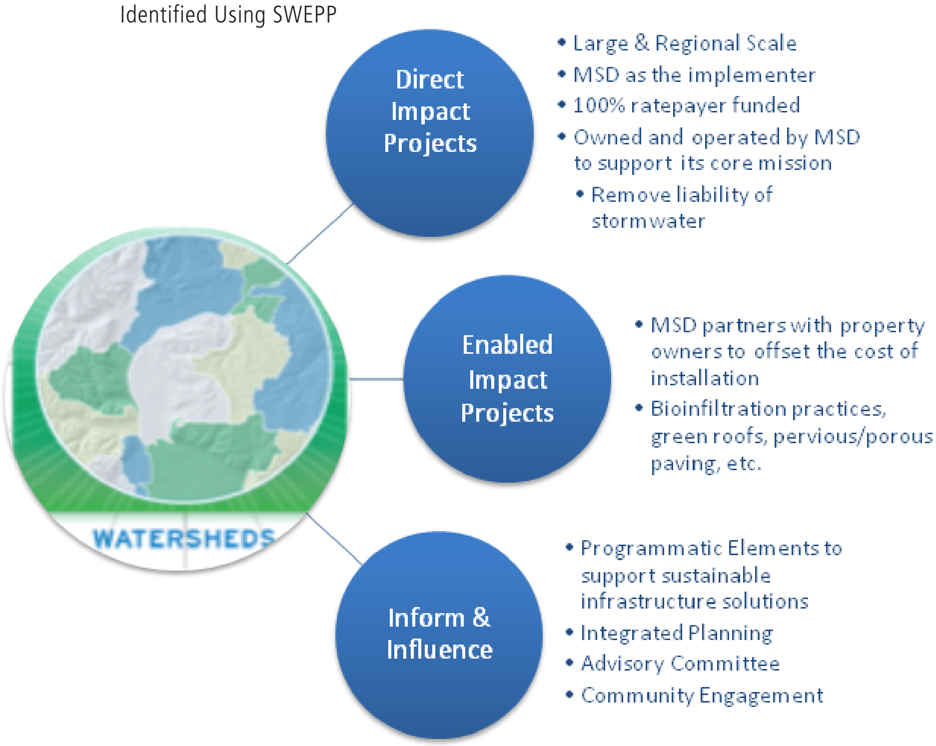
Source control opportunities identified by MSDGC can be categorized as Direct Impact Projects, Enabled Impact Projects, or Inform & Influence Projects (**Figure 3-3**).

Direct Impact Projects are strategies that require direct investment by MSDGC for planning, design, construction, and long-term maintenance. Depending on the project types, Direct Impact Projects may be completed under various Project Groundwork programs (Asset Management, Assessment Sewers, Trenchless Technology, or WWIP); however, a majority of the source control Direct Impact Projects are completed under the WWIP, using green infrastructure techniques.

Enabled Impact Projects are strategies that represent a leveraged infrastructure investment, or are opportunities for cost sharing and collaboration among MSDGC and key watershed stakeholders, such as reforestation, porous pavement, bioswales, living walls, bioretention facilities, or downspout disconnection. Enabled Impact Projects include partnerships with MSDGC and public or private entities to implement source control solutions to reduce the volume of stormwater entering the combined system. Projects in this category can provide additional value and benefits to Direct Impact Projects, which in turn can lead to a better community understanding of sustainable infrastructure. MSDGC's Enabled Impact Program was developed to assess the extent to which green infrastructure, either alone or integrated with more traditional stormwater management approaches, can have a meaningful impact on the reduction of CSOs in the MSDGC service area. It is estimated that 75 MG of stormwater have been removed from the CSS as a result of nearly 40 integrated Enabled Impact Projects (see Interim EIP Report, December 2011).

Inform & Influence Projects are programmatic elements that engage and educate watershed partners and the broader public in making sustainable decisions that provide water quantity and quality benefits. The Inform & Influence program was developed by MSDGC to engage and educate the public on the benefits of sustainable solutions for watershed management. Examples include forming partnerships with educational institutions or community leaders to create highly visible projects within the community, and foster long-lasting, inter-agency relationships. These projects can also include influencing changes to local and/or state policies, such as land development codes, watershed zoning, or

Figure 3-3 Types of Source Control Projects Identified Using SWEPP



tiered watershed zones. Others are projects such as transfer of development rights or establishment of conservation easements. The focus of these projects should be on large land owners within the watershed, with MSDGC's goal to inform and influence water quality and quantity decisions on these lands and the broader service area.

Conveyance and Storage Options

Conveyance and storage options to reduce CSOs and improve water quality are designed to manage or control the volume of sewage and stormwater that reach the sewer system. Typical conveyance and storage methods involve constructing larger sewers to transport wastewater to treatment plants or large underground storage tunnels to capture excess flow. A sustainable infrastructure approach integrates both types of systems for conveyance. Green and grey infrastructure options utilize natural systems to store stormwater runoff and treat stormwater; examples include filtering through natural systems, infiltration, evaporation, and evapotranspiration. Natural systems integrated with built systems minimize the need for larger sewers and additional treatment plants while optimizing the environmental, social, and economic benefits.

Existing grey infrastructure methods for conveyance and storage systems are products of urbanization and development. While built systems are essential to the quality of life in urban areas, they have influenced the natural conditions of Cincinnati's landscapes and watersheds and are experiencing increasing failure with age. Wet weather solutions involving built systems include grey infrastructure options, designed to control the volume of sanitary sewage and stormwater in the sewer system. Examples include constructing larger sewers to transport wastewater to treatment plants or large underground storage tunnels or interceptors to capture excess flow. Another component of conveyance and storage involves Real Time Control (RTC), which allows existing infrastructure capacity to be used for storage. With a combined source control and strategic separation approach, MSDGC has been able to create new capacity within the system and install RTC for added CSO reduction at very low cost.

In addition to WWIP, MSDGC's Asset Management Program involves rebuilding the aging sewer system. MSDGC has priorities based on criteria such as condition of the sewer (or other equipment) and operating efficiency. Projects in the Assessment Sewers Program involve expansion of conveyance and storage infrastructure to provide service to unsewered areas of Hamilton County. The Trenchless Technology Program implements upgrades/repairs of deteriorated sewers and manholes to reduce I/I.

Product Control

Product control options for CSO reduction include grey infrastructure solutions intended to treat combined flows. These options include RTC, upgrading WWTP capacity, or constructing EHRT facilities to treat flows at the CSO outfall prior to discharge.

RTC, as described in the previous section, provides for enhanced capture and treatment of wet weather flow by storing and releasing flow stored in the system as capacity becomes available at the WWTP.

Upgrading WWTP Capacity is a viable option where opportunities exist to either optimize existing WWTP unit processes or add additional facilities to effectively treat more flow. In accordance with accepted CSO Policy directives, primary equivalent treatment and disinfection is a viable option. Typically this could include chemically enhanced primary treatment (CEPT) to increase capacity through the primary sedimentation process with a bypass around the biological portion of the plant. Ultimately the acceptability of these options will require detailed understanding of the current NPDES discharge permit requirements, as well as an understanding of potential future performance criteria.

EHRT relates to the construction of new facilities specifically designed to process wet weather flow either remotely in the system or at the WWTP site. These facilities are defined in a very prescriptive manner in Attachment 5 of the Final Wet Weather Improvement Program. This attachment defines both Numeric Performance Criteria for the recreation season (suspended solids removal and disinfection treatment) as well as Design Criteria for screening, sedimentation, and disinfection. In addition to construction of storage tunnels, the default solution for Cincinnati includes an EHRT to treat combined flow. MSDGC has the opportunity to evaluate alternatives to the default solution, including the use of green infrastructure to control stormwater at the source.

Applying Systems Thinking

MSDGC applies systems thinking to develop watershed-specific solutions to water quality improvement and management, while also addressing community needs and promoting sustainable co-benefits to the environment, society, infrastructure, the economy, and the transportation system. The key elements of the systems thinking approach include defining LOS, performance monitoring, and evaluation and management of risk.

Defining Level of Service

The performance of a collection system can be measured based on four key elements: regulatory compliance, public health and safety, environmental protection, and LOS (USEPA, 2009). Regulatory compliance is related to requirements in the approved Consent Decrees, as well as compliance with federal, state, and local stormwater management regulations (see Section 1). The degree of public health and safety and environmental protection provided by wet weather management is guided by existing environmental ordinances (see Section 1), as well as existing areas of risk. These are discussed in relation to the SWEPP (Section 5), and the following section summarizes MSDGC's progress toward defining an LOS for its service area watersheds.

Historically, stormwater managers have considered "level of service" in terms of flooding and drainage requirements. For example, a typical LOS (in the context of drainage) is focused on the period of time that stormwater is allowed to pond on the surface during a specified storm event (i.e. 10-, 25-, or 100-year storm event). With the evolution of municipal stormwater permitting and the increased emphasis on water quality, the concepts for LOS have changed significantly to include environmental factors, such as water quality and biotic integrity, in addition to the standard hydrologic (quantity) factors. As such, the 2010 amendment to Cincinnati's federal mandate provides for opportunities to apply green infrastructure solutions, or measures that are focused on preventing stormwater from entering the sewer system.

"Level of service" has evolved from flooding and drainage requirements to include environmental factors that affect water quality and biotic integrity.

MSDGC is in the development phase of defining LOS for the organization. The following LOS components have been identified:

- CSS
- Sanitary sewer system
  - Dry weather hydraulic capacity
  - Wet weather hydraulic capacity
  - Number of overflow events
  - Number of sewer backups
- Stormwater system
- Facilities (pump stations and treatment plants)
- Water quality
- Factors defining social, economic, and environmental benefits for communities served

The LOS attributes relate primarily to portions of the service area where measuring and understanding performance have an important impact on ultimate service to the customer. LOS should ensure the reliability, maintenance, and efficiency of the infrastructure.

Initially identified LOS attributes for MSDGC include:

- Hydraulic capacity (dry weather and wet weather)
- Number of overflow events (SSO, CSO, and pump station overflow [PSO])
- Overflow volume
- Number of sewer backups
- Number of sewage surfacing incidents

- Number of properties impacted by sewage surfacing
- Number of water ponding incidents impeding public facilities/ right-of-way (ROW)
- WWTP effluent (per NPDES requirements)
- Air quality (per Title V Air Requirements)
- TMDL and/or use designation for receiving stream

The existing LOS is dependent on the existing watershed conditions, infrastructure conditions (specifically those that would affect the hydraulic capacity of the system, such as corrosion, I/I, sediment accumulation, pipe deflections, and cross-connections), existing CSO and SSO occurrences, system work orders and maintenance activities, extent of development, and projected extent of future development based on ordinances and development codes. To quantify the LOS for a watershed, MSDGC developed a System-Wide Model (SWM) based on USEPA's Storm Water Management Model (SWMM) 4.0 (further discussed in Section 5). Based on SWM outputs, MSDGC is able to identify areas of the watershed that would be addressed by the Asset Management, Assessment Sewers, Trenchless Technology, and Wet Weather Improvement Programs. This manual defines the process used to identify projects under each of these programs, through the SWEPP and Master Planning Process.

MSDGC is setting aspirational goals for a proposed level of service through the integrated watershed evaluation process, rather than setting arbitrary targets for the entire service area.

The MSDGC approach is to set aspirational goals for a proposed LOS through the integrated watershed evaluation process, rather than setting arbitrary targets for the entire service area. An understanding of watershed characteristics and diversity within the service area is key in defining LOS at the watershed level and managing performance levels to meet future goals.

As the watershed characterization phase of the SWEPP process is initiated, the existing LOS or performance of the system can be measured based on available data. Through analysis of opportunities and constraints within the watershed for source control (quantity — source of CSO/volumetric issues and quality — source of pollutants/water quality impairment), aspirational goals for future LOS within the watershed are developed by evaluating (achieving a balance of) cost, risk, and performance/service levels.

MSDGC recognizes that LOS goals will vary from watershed to watershed, as well as even within a given watershed. This flexible approach allows for a thorough and conscientious yet adaptive process for establishing priorities including capital decisions, and managing risk and uncertainty (e.g. changing water quality regulations), affordability and customer expectations. It is important to MSDGC that defining current, proposed, and/or aspirational LOS be a transparent process, and that decisions be data-driven.

Measuring System Performance — Monitoring and Assessment Strategies

MSDGC has developed a comprehensive approach for evaluating current conditions and assessing changes over time. Three efforts are being used to conduct this evaluation:

- Integrated watershed bioassessment program
- Pre/post-construction monitoring
- Routine water quality in-stream sampling per permit requirements

The integrated watershed bioassessment program evaluates biological, chemical, and physical conditions of the waterways on a rotational basis. To implement this program, MSDGC has worked with the Midwest Biodiversity Institute to develop and implement a rotational watershed monitoring and assessment program. The primary goals of the program are to:

- Determine the aquatic life and recreational status of the service area rivers and streams in quantitative terms, i.e., not only if the waterbody is impaired, but the spatial extent and severity of the impairments and their respective departures from established criteria.
- Evaluate the appropriateness of existing aquatic life and recreational use designations and make recommendations for any changes to those designations.
- Determine the most relevant stressors that correspond to observed impairments for the purpose of targeting appropriate management actions for those stressors.
- Develop an Integrated Prioritization System (IPS) for capital planning and environmental program opportunities for maximum benefit to align with the water quality needs.

The proposed assessment program has been designed to address the five key factors that determine the integrity of aquatic resources: habitat structure, energy source, biotic

Figure 3-4 Indicators for Evaluating the Effectiveness of Water Quality Management (adapted from Karr and Yoder, 2004)

factors, chemical variables, and flow regime (Karr et al., 1986). An indicators hierarchy (USEPA, 1995) provides the overall framework for the occurrence of environmental indicators (**Figure 3-4**) and offers a structured approach to evaluate management programs and make adjustments based on sound environmental data. As shown in **Figure 3-4**, these indicators are divided into three categories: administrative activities (includes Levels 1 and 2), which would theoretically cause changes to stressors (Level 3) and exposures (Levels 4 and 5), which are then followed by a response (Level 6) that can be used to measure the results/success of the administrative activities. Examples of these indicators (Yoder, 2011) include:

Level 1 — actions taken by regulatory agencies (e.g., permitting, enforcement, grants)

Level 2 — responses by the regulated community (e.g., construction of treatment works, pollution prevention)

Level 3 — changes in discharged quantities (e.g., pollutant loadings)

Level 4 — changes in ambient conditions (e.g., water quality, habitat)

Level 5 — changes in uptake and/or assimilation (e.g., tissue contamination, biomarkers, assimilative capacity)

Level 6 — changes in health, ecology, or other effects (e.g., ecological condition, pathogenicity)

The proposed comprehensive ambient monitoring program will provide data on indicators representative of the five key factors (noted above) that are essential for determining the integrity of a waterbody (Yoder, 2011). A systematic monitoring and assessment program was initiated in 2011 that includes water quality monitoring, biological monitoring (fish and benthic macroinvertebrates), and habitat assessments. The initial monitoring will be completed on a watershed basis over a 4-year time-frame.

Stormwater management and control technologies should be evaluated and selected based on water quality conditions downstream of the watershed and the types of pollutants in the watershed.

There are many technologies that can be used to manage and control stormwater runoff. These technologies should be evaluated and selected based on water quality conditions downstream of the watershed and the types of pollutants in the watershed. The water quality in the waterbodies might be regulated through a TMDL or a use attainment designation.

As part of this process, it is necessary to conduct a comprehensive system evaluation of the watershed and waterbody, to implement a robust management plan that utilizes sustainable technologies to improve water quality.

The work conducted by MBI complements the required routine water quality in-stream sampling conducted by MSDGC at its WWTPs and CSO outfalls at locations designated by OEPA. This work establishes the water quality of the waterbody downstream of a watershed. The assessment identifies and documents the point and non-point pollution sources in the watershed and types of pollutants. This interaction between the waterbody and watershed in terms of water quality drives stormwater management within the system. If any negative water quality issues are identified through this assessment, these pollution sources and pollutants will need to be included in watershed management activities.

The MSDGC Division of Industrial Waste (DIW) follows procedures outlined in it SSO/CSO Discharge Management and Minimization Plan to monitor the water quality of all wet weather/clean water discharges for reuse, detainment, or curtailment. DIW collects surface water, treatment plant, and sludge samples (in addition to other sampling and surveillance activities), to minimize the impact of the discharges from industrial/commercial users during overflow conditions; to provide additional collection and treatment capacity in the system; and to monitor the effectiveness of the procedures implemented.

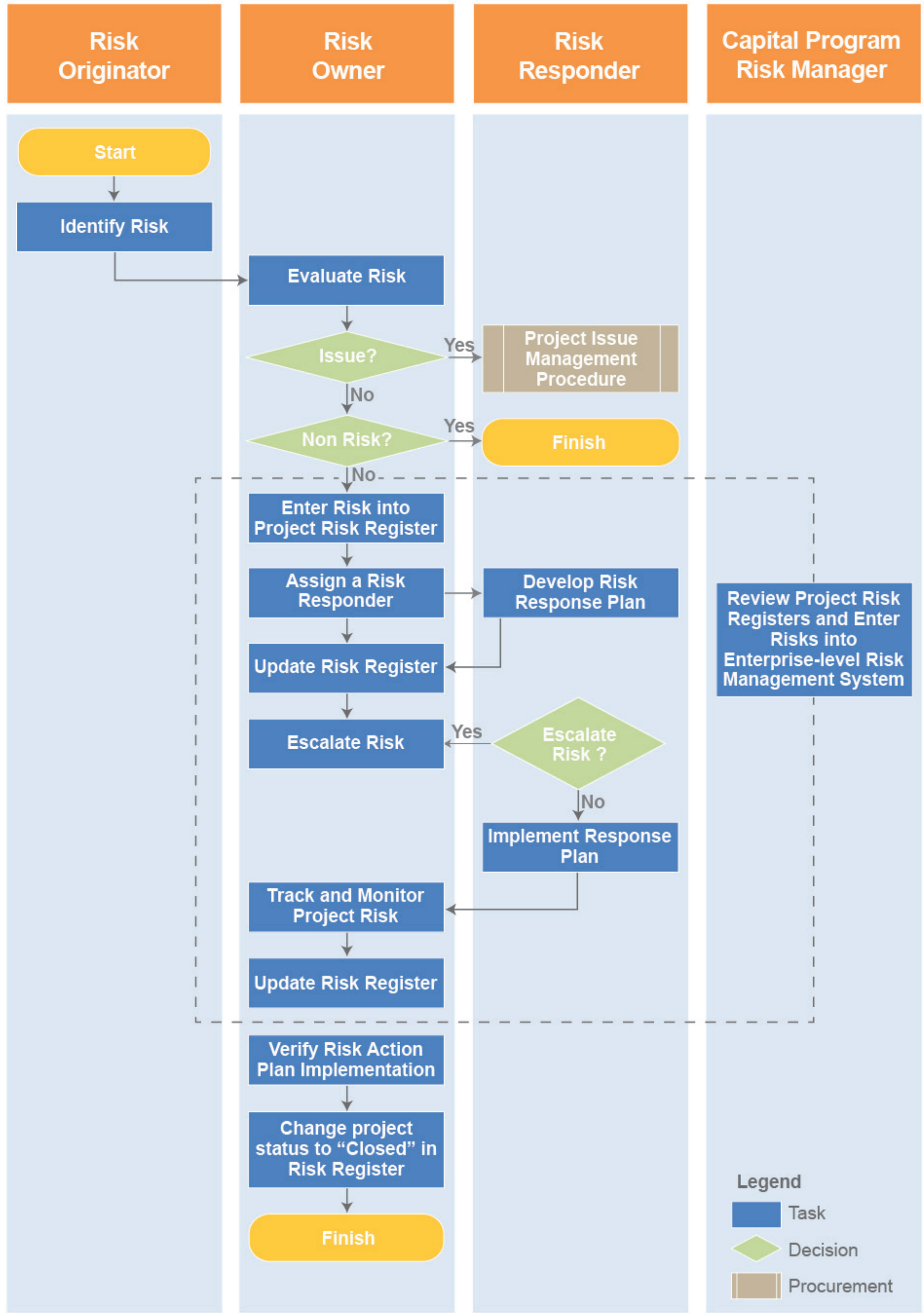
Additionally, as part of implementing robust and sustainable systems, pre- and post-conditions in terms of flow and water quality need to be evaluated. This evaluation is conducted through **pre- and**

post-construction monitoring. For water quality, procedures outlined above are followed, and additional project-specific water quality sampling locations can be identified. For flow, meters are placed in the combined and separate sewer pipes, at the lowest point in the watershed, to measure the effectiveness of sewer separation post-construction, e.g., flow volumes in the CSS should be reduced. Details of monitoring procedures for direct and enabled impact projects (and the differences in how they are managed/ monitored) are discussed in Section 5. The monitoring program should measure the effectiveness of the installed technologies to reduce runoff and improve water quality. For each project, this program should be designed during the planning and design phase. The program, including proposed monitoring locations and success criteria, may be updated during the construction and implementation phase of the planning process. However, this is project-specific, and the program, including proposed monitoring locations and success criteria, may be updated during the construction and implementation phase.

Risk Evaluation of Wet Weather Management

As part of its wet weather strategy, for every potential solution, MSDGC identifies and manages risks before they become problematic. In implementing watershed improvement projects, MSDGC encounters project-level and utility-level risk (the following discussion focuses on the project-level risk aspects specific to implementing the WWIP). Potential risks may include insufficient data to understand watershed characteristics and infrastructure performance, misalignment of customer expectations with the LOS, and changes in future water quality regulations. The risk-based approach is to identify, assess,

Figure 3-5 Project-Level Risk Management Procedure



and manage risk at the project and program level and involves developing a risk register, assessing the consequence and likelihood of occurrence, and estimating the maximum foreseeable loss. Based on the results, MSDGC develops possible management strategies and recommends a risk response plan. Management strategies may include avoiding the risk, mitigating the risk, reducing the probability of occurrence and/or the impact of occurrence, transferring the impact of an occurrence, sharing the risk, accepting the risk, or developing a contingency plan.

A few examples of these strategies include:

- Performing model sensitivity runs over a range of possible solutions (could mitigate for inadequate data, conservative assumptions, etc.)
- Conducting early stakeholder meeting(s) to define concerns or requirements (to mitigate for unidentified watershed concerns)
- Holding weekly project status calls (to mitigate for potentially not meeting project milestone deadlines)

Risk management is an iterative process and requires constant monitoring and control. MSDGC's Risk Management Guidelines explain this process in detail, and the Project-Level Risk Management Procedure and the Risk Register template are used in conjunction with the guidelines (http://mymsd/PD/MPMPv2/Documents/Project%20Level%20Risk%20Management%20Process.pdf). The Risk Assessment Matrix was developed by MSDGC to assist with its overall approach to risk management, which is structured around four key stages:

1. Identification
2. Assessment
3. Response
4. Reporting

Volume II of MSDGC's Master Program Management Plan (http://mymsd/PD/MPMPv2/Pages/VolumeII.aspx) includes instructions on the Project-Level Risk Management Procedure (**Figure 3-5**). MSDGC will use the Risk Assessment Tool (which includes the Risk Management Project Checklist (http://mymsd/PD/MPMPv2/Pages/default.aspx, Section 5, Volume III, PD-QA-05-006) and the Project Risk Register template (http://mymsd/PD/MPMPv2/Pages/default.aspx, Section 5, Volume III, PD-QA-05-020) to prepare a risk register for the selection of alternatives. The risk register outlines the risk description, risk rank, enterprise risk, impact description, and proposed response to the risk (e.g., prevent, accept, avoid) and provides a means of tracking actions taken or planned associated with each risk.

SECTION 4

Planning for Communities of the Future

In 2009, MSDGC created its Communities of the Future initiative to promote integrated sustainable solutions that take into consideration water, waste, transportation, and GHG emissions, as well as economic, social, and environmental factors (see MSDGC 2010 Sustainablity Report). Sustainable source control alternatives for CSO management include a variety of green stormwater management practices such as bioswales, vegetated areas, landscaping, and water features that can also provide community amenities. By involving the community in the process, MSDGC can ensure that investments in stormwater and sewer system improvements enhance community well being through economic development and urban revitalization. Through this approach, MSDGC can leverage its federal mandates and help its communities identify solutions for CSOs that can simultaneously address community issues such as brownfields, urban blight, vacancy, and property abandonment.

Opportunities for green stormwater management

The scope and scale of the required CSO improvements offer a unique platform for MSDGC and its partners in the community to leverage additional investments in brownfield development, urban revitalization, and the creation of livable communities.

Communities of the Future

The vision for Communities of the Future (**Figure 4-1**) is a broad one; it goes beyond the "end-of-pipe" focus of traditional approaches and solutions and recognizes the value of new partnerships and new ways to engage stakeholders and communities in the overall master planning process.

MSDGC and its project planning partners seek to develop comprehensive, watershed-based solutions to these challenging issues that offer communities significant opportunities to make transformational improvements in how residents live, work, and play. The Communities of the Future is part of the guiding philosophy of Project Groundwork — that it will lead with sustainable and innovative investments and be evaluated with TBL metrics, maximizing the social, economic, and environmental benefits to local communities.

Factor Conditions

"Factor Conditions" can be adverse conditions that force development of new methods, and this innovation often leads to a comparative advantage. *(Porter, 1998)*

MSDGC's Communities of the Future model is based on existing conditions and potential leveraged benefits or opportunities that are complemented by MSDGC base infrastructure investments. For Cincinnati and Hamilton County communities over the last several decades, many changes have resulted from population losses, property abandonment, and brownfield contamination. Working with its planning partners, MSDGC has developed this model and the SWEPP to consider how the CSO reduction and SSO elimination mandates could serve as a catalyst for creating "factor conditions" that could influence additional public and private investments around a base MSDGC investment. **Figure 4-1** shows the Communities of the Future model MSDGC has used to develop integrated community-based CSO investments.

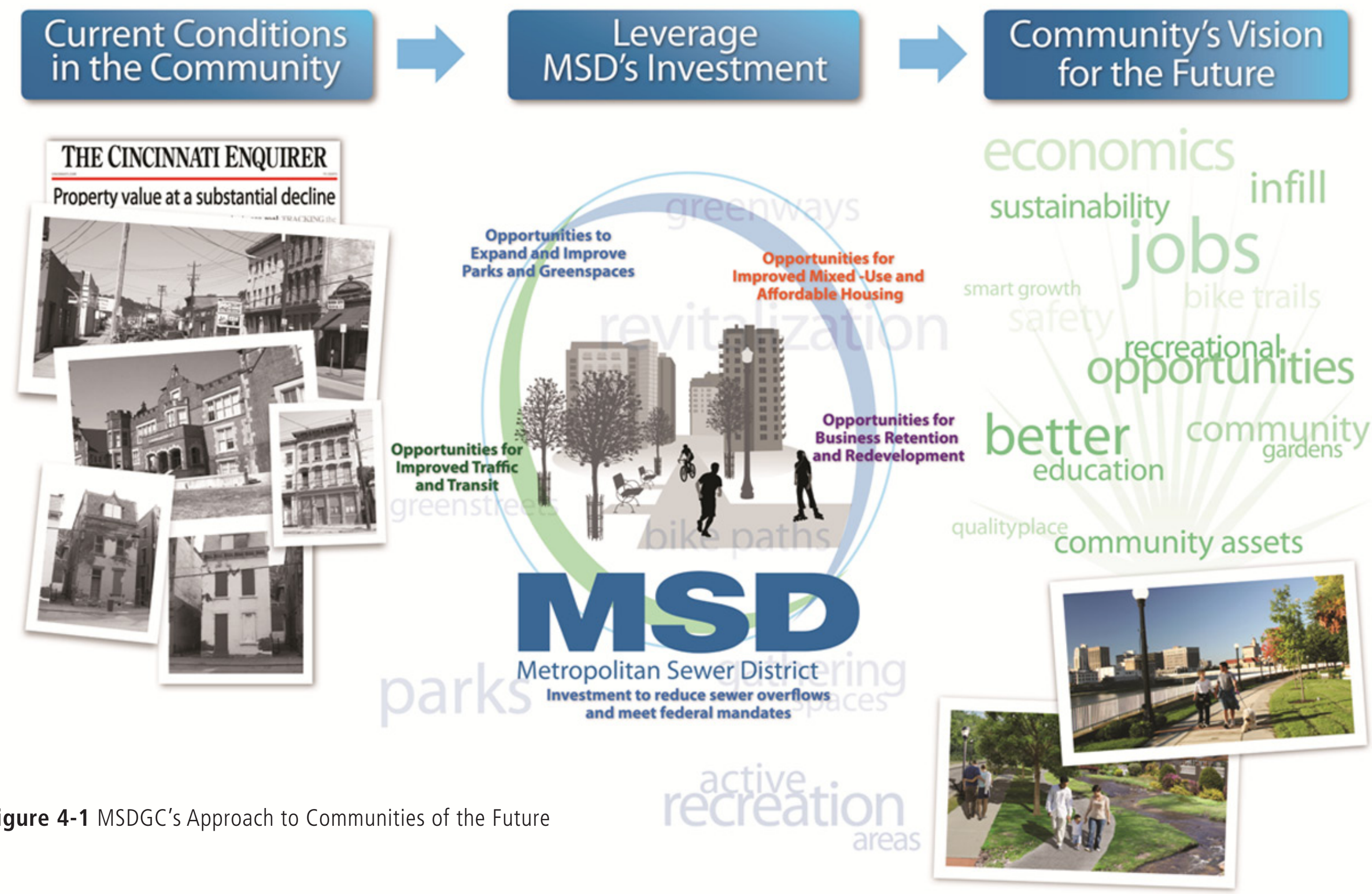


Figure 4-1 MSDGC's Approach to Communities of the Future

The Communities of the Future framework offers a fairly consistent "value proposition" in terms of benefits to residents, the environment, and economic prosperity. This initiative involves a comprehensive community engagement process, which MSDGC will use to gather public feedback throughout the Master Planning process. The initiative allows MSDGC to engage the public throughout the entire planning and implementation process, so that community priorities can be realized while also meeting the mandates in the Consent Decrees. The Lick Run Master Planning process provides an example of the comprehensive community engagement and stakeholder involvement process that MSDGC could utilize for other watersheds, as outlined in this manual. The following activities were conducted for the Lick Run community and provide examples of community outreach activities that could be used for future watershed evaluations:

- Community Open House (January 2011)
- Community Design Workshops (August 2011, October 2011, and February 2012)
- Multiple watershed tours
- Meetings with South Fairmount Community Council
- Meetings with South Fairmount Business Association
- Meetings with key stakeholder groups
- Meetings with individual business and property owners
- Meetings with the Communities of the Future Advisory Committee (CFAC)
- Meetings with key public agency partners
- Meetings with key regulators

Lick Run Master Plan Outreach

The outreach associated with the Lick Run Master Plan was an outcome of a Community Challenge Grant offered by the federal Department of Housing and Urban Development (HUD) and the City of Cincinnati Land Development Demonstration Project to present questions, conditions, and opportunities to shape an integrated vision for the future. It is also one that provides a model for how to replicate this experience and develop other watershed-based solutions to defining communities of the future.

Involving local communities and stakeholders in the planning, design, and construction of sustainable infrastructure is critical. This infrastructure supports, sustains, and connects communities. Designing and planning these infrastructure systems together is essential in the development and redevelopment of urban and suburban places to attract people to live, work, visit, and invest in the community. These efforts must proceed while devoting adequate attention to natural and cultural resources and cultivating and encouraging economic development. Additionally, there are other community needs related to energy usage and demands, mass transit, building practices, land development, and solid waste management — all of which require innovation and integration to maximize public investments and benefits. MSDGC and its partners have considered CSO alternative solutions using the Communities of the Future model as an integrated platform to address multiple issues and obtain input and support from public and private organizations, residents, and other watershed stakeholders.

Integrated Platform for Planning and Decision Making

An integrated planning platform features an approach that combines community planning needs, as outlined above, with implementation schedules for coordination to save time, save money, and minimize disruption. Using this type of planning, the City of Cincinnati and Hamilton County leverage various tools that include floodplain management, transformational land uses, brownfield revitalization, leveraged funding, green streets, transportation improvements, economic development, and watershed stewardship. The integrated planning platform allows watershed planning to address Consent Decree mandates and regulations, as well as to improve the economic, social, and environmental conditions of communities. The integrated platform for planning and decision making is largely focused on watersheds and wet weather needs or sanitary sewer needs and is inherent in MSDGC's SWEPP, discussed in Section 5. This approach is also adaptable to other needs and can incorporate other public or private investment activities.

Planning Principles for Watershed Management

A key basis for selecting specific alternatives is the need to manage water resources by different zones and tiers within the watershed. **Figure 4-2** provides an example of a watershed transect and types of projects that would be included in each section of the transect. Zones of opportunity are identified based on watershed characteristics, such as forested hillsides (opportunities to capture natural streamflow), highly developed communities (opportunities for near source controls such as downspout disconnection or rain gardens), and open space corridors (opportunities to enhance existing community and recreational uses).

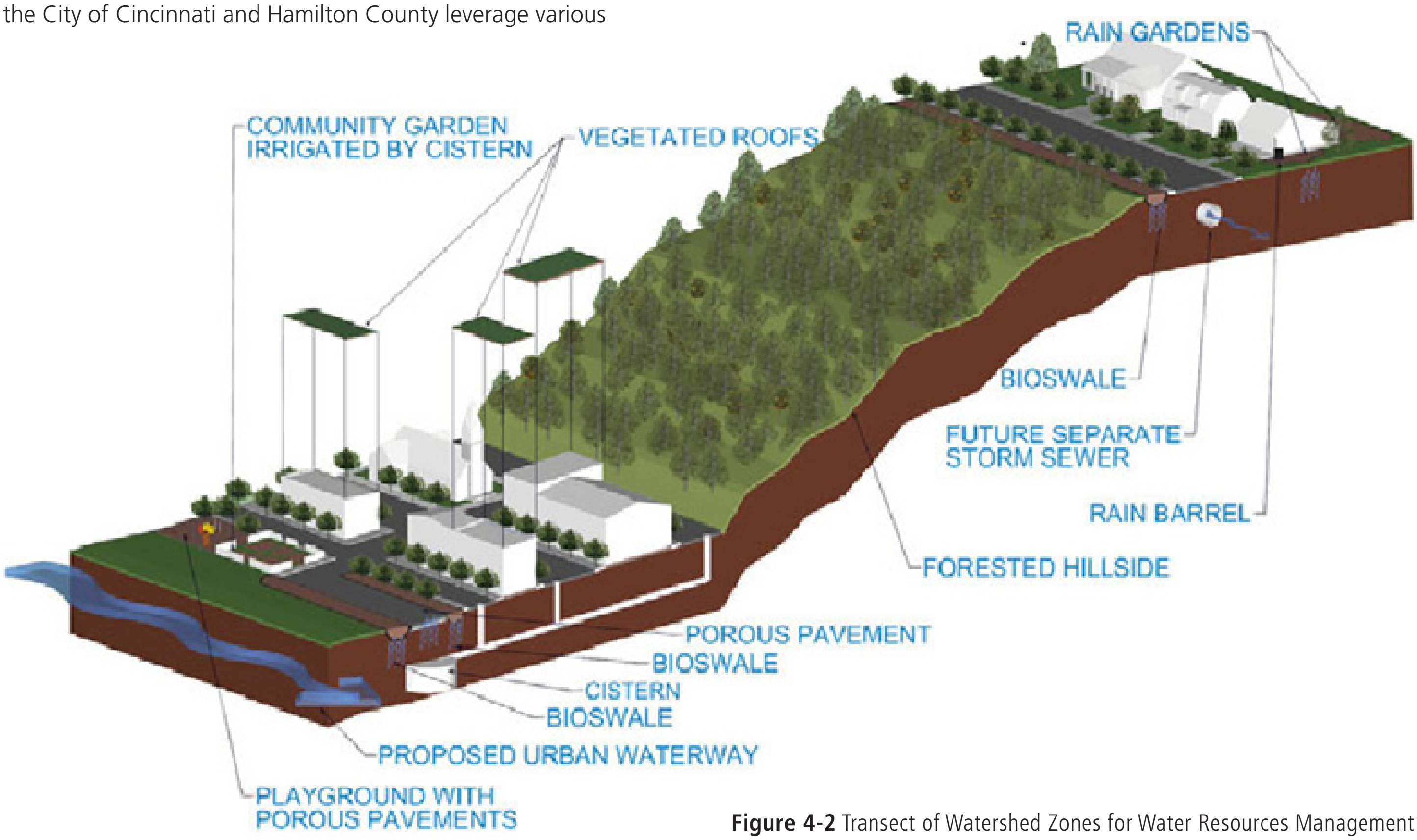


Figure 4-2 Transect of Watershed Zones for Water Resources Management

CFAC Roles

The roles of the CFAC members include:

- Providing and facilitating a forum for dialogue, discourse, and counsel, including community workshops with work groups
- Focusing watershed plans to align with local initiatives (e.g., Hamilton County's Community Compass, Agenda 360, and the City of Cincinnati's Comprehensive Plan Update)
- Facilitating the process of realizing policy recommendations and ordinances from local and regional governmental bodies' long-range community plans
- Providing unique perspectives and sharing ideas to help MSDGC engage with citizens and stakeholders within the watersheds in MSDGC's service area
- Reviewing information from MSDGC and, in return, providing counsel from their organizations' unique perspectives, in order to guide the integrated watershed management approach
- Providing professional guidance to MSDGC, communities, and stakeholders in each watershed
- Being a resource for Communities of the Future work groups within the individual watersheds
- Working with MSDGC to identify potential funding strategies to maximize the social, economic, and environmental benefits of Project Groundwork
- Engaging the community at all levels in order to identify opportunities to maximize the benefits from Project Groundwork and build the Communities of the Future approach

The Lick Run Master Plan is an example of the planning principles for watershed management that will be followed by MSDGC during the Master Planning process. A key component of the plan is cooperative development of planning principles specific to each community. For the Lick Run Master Plan, the sustainability planning principles included:

- Coordinate policies and leverage investment.
- Promote an integrated network of green infrastructure.
- Revitalize the economy through creation of jobs and growth opportunities for local businesses.
- Support existing communities.
- Benefit the watershed communities through environmentally, socially, and economically sustainable solutions.
- Provide more transportation choices.
- Promote a balanced mixed-use neighborhood.
- Use quality design to create an attractive public/private realm.

Using these principles, and a watershed transect framework, the Lick Run Master Plan identifies a sustainable solution to CSO problems, with consideration to the watershed's unique physical characteristics. This framework uses a methodology similar to the one in the Comprehensive Plan by designating Rural-To-Urban Transect Zones as the organizing principle that further defines how the intensity and character of the built environment influence decisions related to sustainable infrastructure design (Cincinnati Planning Department, 2012).

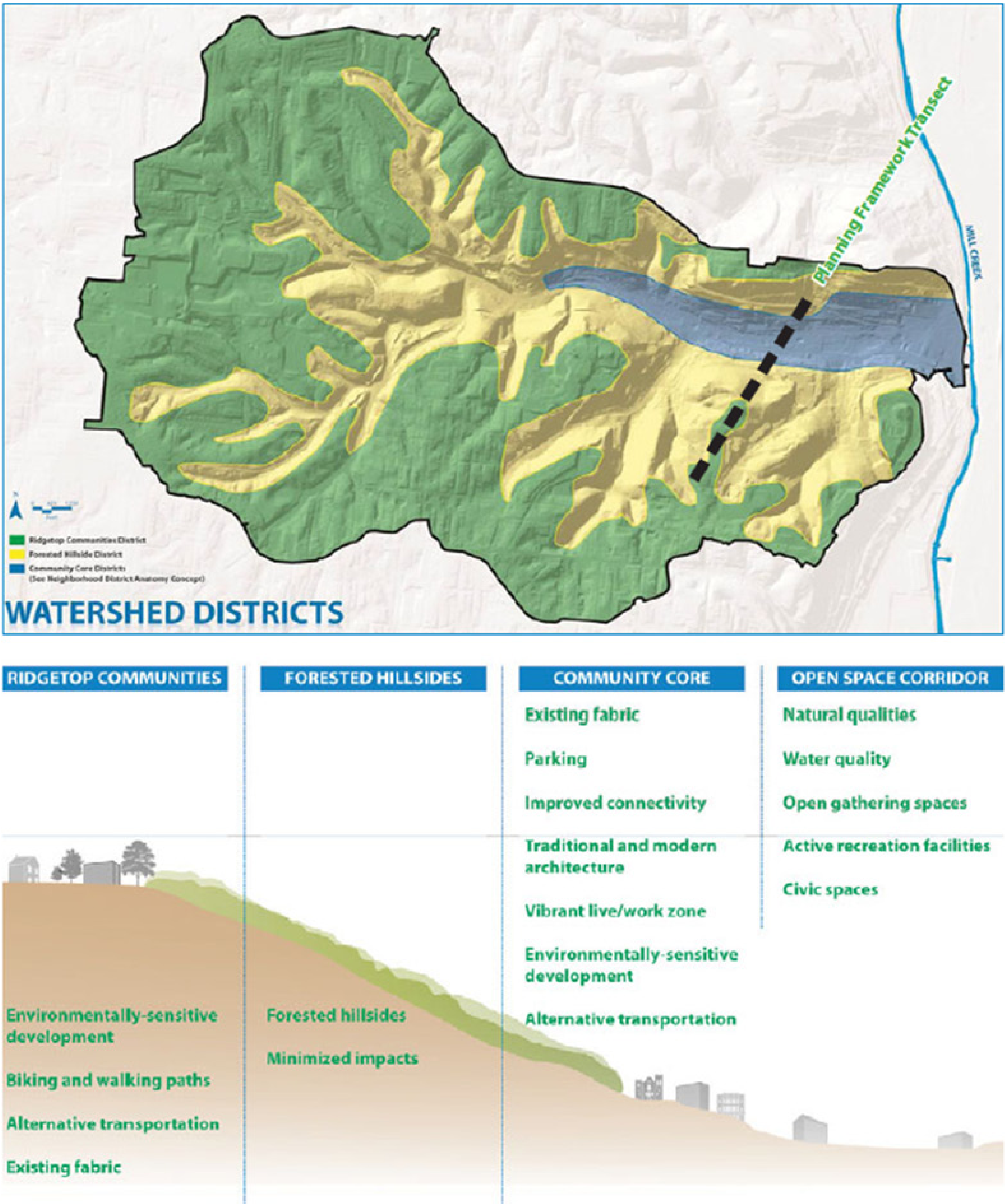
The Lick Run Master Plan illustrates an integrated solution to stormwater management, which includes watershed transect zones from ridgetops to the urban waterway, with defined neighborhood districts.

The Lick Run Master Plan illustrates an integrated solution to stormwater management, which includes watershed transect zones from ridgetops to the urban waterway, with defined neighborhood districts. The Lick Run watershed was divided into ridgetop communities, forested hillsides, community core, and open space corridors (**Figure 4-3**).

Sustainable Communities of the Future Framework

The framework for MSDGC's Communities of the Future approach includes the CFAC and a work group for each individual watershed within the area. The CFAC, which was created in February 2010 to assist MSDGC with the Communities of the Future vision, is comprised of representatives from a variety of public and private organizations, as well as private citizens. MSDGC continues to build the CFAC by seeking the expertise and counsel of stakeholders in the community whose missions incorporate social equity, economic development, and environmental conservation. CFAC members meet quarterly to review and provide feedback on MSDGC's planning

Figure 4-3 Lick Run Watershed Transect



process and recommend solutions for Project Groundwork. During the planning process for a community watershed, the CFAC assists with open houses/meetings with the local watershed's work group. The work groups consist of citizens and other stakeholders within the watershed. MSDGC rate-payers are making this investment, so the community should participate to provide meaningful input. While the final results are governed by the federal Clean Water Act (CWA) and other regulations, the community should be intimately involved in determining the path to achieving the required results.

Through a series of community workshops, CFAC engages watershed work groups in determining desired environmental, economic, and social community benefits, gauging interest in opportunities and conceptual alternatives, and eliciting feedback on the Preliminary Watershed Master Plan (described in Section 5). Initial workshops are held to establish the community's priorities, ideas, and concerns related to the specific watershed, and workshops are then held as the planning process continues. The CFAC and project design team continue to keep the community informed of technical challenges and opportunities and uses feedback to incorporate strengths into the final wet weather management strategy.

Attributes for Sustainable Communities

Form of a Community

Communities and their associated land use patterns have a major influence on the amount, timing, and quality of stormwater runoff. Transportation corridors, parking lots, retail development, and other impervious surfaces increase runoff volumes and carry pollutants to waterways, particularly when developed in traditional ways. The increased runoff impacts water quality, which in turn can affect public health. For example, stormwater runoff often includes heavy metals from roads and industrial areas and fecal bacteria from human and animal sources that can impact water supplies or pose risks to recreational users. These potential water quality impacts can affect the communities' confidence in their local environment and their "sense of place."

In 2012, the City of Cincinnati completed a Comprehensive Plan (Cincinnati Planning Department, 2012) update, the primary theme of which was "Thriving Re-Urbanization." As this process evolved, it became apparent that a conventional land-use-based approach to the Plan would not enable the City to achieve its objectives and focus on reinforcing the extensive framework of walkable urban neighborhoods in Cincinnati.

With the 2011 HUD Community Planning Challenge Grant, the City of Cincinnati initiated the development of a Land Development Code, which is to include implementation tools such as Form Based Codes, Transfer of Development Rights, land banks, etc. This effort is an example at the local level of what three federal agencies (USEPA, the Federal Highway Administration, and HUD) have been developing as part of the Sustainable Communities Partnership. The intent is to link federal programs and services to communities in efforts to achieve the following:

- Provide more transportation choices.
- Promote equitable and affordable housing.
- Enhance economic development.
- Support existing communities (including rural landscapes).
- Coordinate policies and leverage investment.
- Value communities and neighborhoods.

The Land Development Code also includes pilot demonstration projects, such as two MSDGC-related efforts: the Lick Run Master Plan, discussed above, and the Lower Mill Creek Watershed Action Plan (MSDGC, 2012). The Lick Run Master Plan specifically identifies a watershed-based transect that is consistent with the Form Based Code. The Lower Mill Creek Watershed Action Plan is a comprehensive plan to improve water quality throughout Lower Mill Creek, including both direct impact (MSDGC investments) and enabled impact (with assistance from other watershed partners) projects. Results of these plans will be used in revising the existing Land Development Code to support and advance sustainable infrastructure and watershed management.

Communities of the Future

Communities of the Future share the following characteristics:

- Clearly defined goals, objectives, and key performance indicators (KPIs) that drive the planning and design process
- Goals and objectives defined using a multi-stakeholder and multi-disciplinary approach involving CFAC and Project Groundwork
- Goals and objectives that represent a tailored approach to sustainable development and are aligned with community values
- Goals and objectives that are developed by integrating engineering and urban planning, allowing for feedback and refining the design to meet project goals and objectives
- Utilization of standard planning and assessment tools to clearly define defensible performance goals

MSDGC is working with partners to develop incentives for urban settings to more proactively manage stormwater onsite, in watershed transect zones. These management techniques offer benefits to MSDGC's wet weather strategies by minimizing the potential negative effects of urbanization on watersheds and water quality.

Form Based Code Development

To help secure desired outcomes of community development, the City is developing Form Based Codes as a tool within its Land Development Code (Cincinnati Municipal Code Titles XI, XIV,XVI). According to the Form Based Code Institute, a form based code is a tool that fosters predictable built results and a high quality public realm by using physical form (rather than separation of uses) as the organizing principle. Examples in other urban areas (in Florida, Tennessee, and Virginia) have demonstrated that form based codes can reduce urban sprawl, protect historic neighborhoods, and support "walkable" communities. Where adopted, form based codes are regulations, not mere guidelines adopted into city or county regulations. City planners and communities that have adopted form based codes suggest that they are a powerful alternative to traditional zoning (www.formbasedcodes.org/).

To help secure desired outcomes of community development, the City is developing Form Based Codes as a tool within its Land Development Code.

As part of Cincinnati's draft Form Based Code, the Cincinnati Transect was defined and refined using community design discussion sessions after the concept was highlighted in the updated Comprehensive Plan. Cincinnati is developing an "urban form" with various transect zones to extract the Cincinnati-specific "DNA" of the urban form. In parallel, the MSDGC and its planning partners, using community design workshops, have developed a watershed or stormwater transect that featured a watershed-driven approach to designing and planning for watershed-based CSO reduction and stormwater management.

The City of Cincinnati has updated its Comprehensive Plan and now focuses on updating the Land Development Code to help streamline and improve development opportunities. As a result, the City is well-positioned to couple (1) sustainable infrastructure solutions for reduction of CSO overflows with urban redevelopment with (2) new smart development techniques. Considering the form of a community and integrating effective water resources management for the future community will be a critical success factor for realizing the Communities of the Future vision.

Lick Run Corridor Master Plan

The Lick Run Corridor Master Plan set the stage for a form based code for the corridor. Through the Master Plan and associated urban design, the CSO reduction and stormwater management program is designed to consider the relationships between urban waterway amenities, remaining or new building facades and the public realm, the form and mass of the buildings in relation to a waterway and the transportation systems, in terms of scale and types of streets and blocks, and integrating stormwater management BMPs into the urban design plan.

Re-purposing Land Considering Opportunities

Land use changes and re-purposing of underutilized lands offer tremendous opportunities for integrated water resources management. Numerous opportunities are available throughout the region and in MSDGC priority areas, varying by sub-watershed and community. Planning for future land use conditions can be difficult, but is critical when evaluating alternatives for stormwater and CSO reduction and management. Because of the historical challenges resulting from isolated planning and the lack of a common planning platform, communities have struggled with numerous priorities and segmented efforts, focusing on traditional tools, then adapting those tools to help visualize the future.

In the City of Cincinnati and Hamilton County, planning staff have developed a robust geographic information system (GIS) database to assist in assessing existing community and watershed conditions and identifying opportunities for sustainable watershed management. Socio-economic, demographic, and market trends and forecasts are also critical information sources in determining long-term trends and needs and helping to create a vision for future community growth and revitalization opportunities (www.hamiltoncountyohio.gov/pubworks/hcpw_gis.asp). In specific areas, where land use changes have led to significant declines over time, community planners have been using more rigorous analysis and tools for Lick Run to conduct an Urban Audit of targeted areas (see the discussion on Urban Audits in Section 5). These data, when combined with community feedback on anticipated solutions and strategies, provide some of the most useful information for creating a vision and predicting future land use within the urban area. When redevelopment of vacant lands and brownfields can be combined with stormwater BMPs, planners are able to support community goals for redevelopment while addressing wet weather improvement requirements.

Sustainability LENS Tool

In 2011-2012, MSDGC was involved in developing the Sustainability LENS Tool, a web-based technology that provides the structure needed to effectively screen and evaluate key aspects of sustainability aligned with project goals and objectives (Appendix B). The Sustainability LENS Tool was designed with sufficient flexibility to assess, analyze, and report on a number of sustainability-related indicators that are developed consistent with each community's goals and objectives. The primary objectives of the tool are:

- To evaluate green and grey infrastructure alternatives on a watershed level, with respect to TBL goals
- To evaluate infrastructure alternatives during development and redevelopment activities to demonstrate the benefits of green infrastructure
- To develop, measure, project, and track KPIs and PIs (performance indicators) for the Watershed Master Planning process

The current version of the Sustainability LENS Tool (detailed in Appendix B) consists of:

- A user interface for inputting data
- A database function for storing data in an organized format for easy retrieval and archiving
- A dashboards interface to help users understand what the results are showing
- A reporting section to print the results shown on dashboards

The next version of the tool is currently under development and will include additional capabilities, such as community benchmarking and inclusion of multiple watersheds, as well as considering site plan evaluations and proposals for grey and green stormwater management. The Sustainability LENS Tool plays a key role in the SWEPP and Watershed Master Planning processes, and serves as a planning and facilitation tool for the Communities of the Future approach (see Section 5 for specifics on application of the tool during the SWEPP).

The interface for data entry and generating reports in the Sustainability LENS Tool software was designed for ease of use.

SECTION 5

Sustainable Watershed Evaluation and Planning Process and Master Plan Implementation

MSDGC has developed the following SWEPP to prioritize watershed improvement projects so that they meet the federal mandates, address overall water quality improvement, and align with community priorities. The process includes the evaluation of traditional grey infrastructure (such as the recommendations in the WWIP) combined with green infrastructure alternatives to provide source control.

MSDGC has illustrated the success of its SWEPP in the development of the partial remedy for Mill Creek and plans to use this approach, along with lessons learned from implementation of the process, to address CSO and SSO issues in all of its watersheds. **Figure 5-1** indicates the watersheds that have already been evaluated using the SWEPP. MSDGC plans to complete a SWEPP for each of the watersheds in its service area by 2017. The SWEPP will provide a consistent methodology for future watershed master planning efforts and assure the appropriate consideration of grey and green infrastructure as well as community goals.

MSDGC has developed the following the sustainable watershed evaluation and planning process to prioritize watershed improvement projects so that they meet the federal mandates, address overall water quality improvement, and align with community priorities.

For each watershed, a Preliminary Watershed Master Plan will be prepared to document all recommended projects in the watershed, including Direct Impact Projects (require direct investment by MSDGC), Enabled Impact Projects (involve a leveraged infrastructure investment, or are opportunities for cost sharing and collaboration), and Inform & Influence Projects (elements that engage and educate watershed partners). The end result of the SWEPP is development of the Watershed Master Plan, which is based on the Preliminary Watershed Master Plan and is essentially a capital improvement plan (CIP) for MSDGC's investments in the watershed. It will detail all projects that are selected to advance into the detailed planning and design phase, including estimated LOS, implementation timeline, construction sequencing, cost allocation, risk management plan, monitoring plan, anticipated impacts on other watersheds, and responsibilities (i.e., MSDGC department responsible for managing each project).

In order for a Watershed Master Plan to be developed and implemented, an internal process must be followed to ensure quality assurance and control. For this process, MSDGC has elected to form a CAPital EXpenditure management (CAPEX), which facilitates agreement concerning all watershed Master Plans, ensures ownership of master plans developed, and ensures active implementation of the plans. CAPEX is MSDGC's initiative to improve investment management capabilities, with a focus on outlining roles and responsibilities for CAPEX management. The Cross Functional Core Team (CFCT) was created by the MSDGC OOD. The CFCT is comprised of eight members, including MSDGC staff from the DIW, Project Delivery (PD), Wastewater Treatment (WWT), EPM, OOD, Wastewater Collection (WWC), Planning and Business Development (PBD), and the Office of the Director (), and is charged with establishing a formal, collaborative process for developing measurable CIP strategic goals and creating a defensible project prioritization and review process that aligns to the CIP strategic goals.

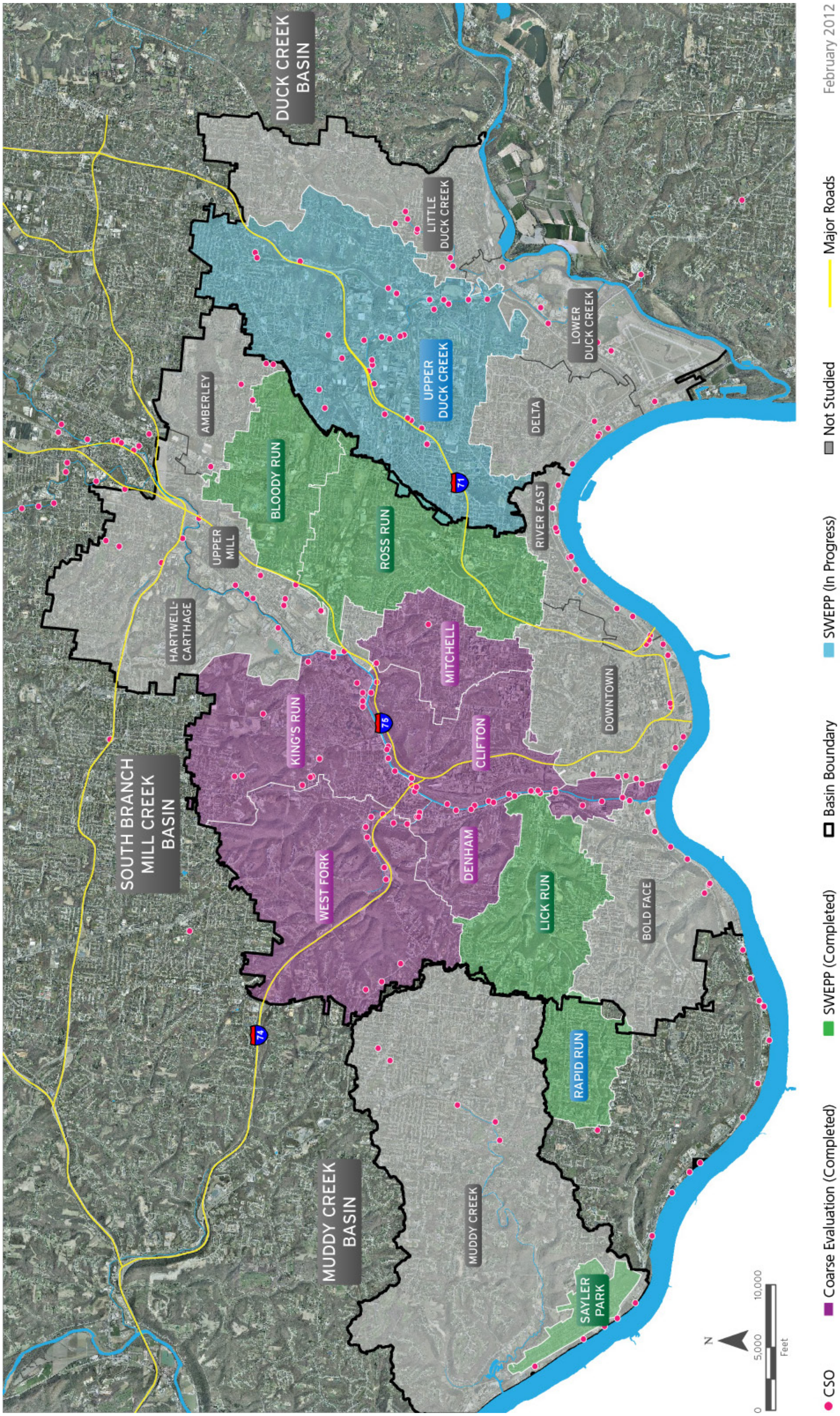


Figure 5-1 Status of Sustainable Watershed Evaluation and Planning Processes (SWEPPs) in the MSDGC Service Area

One of the key benefits of the SWEPP is to support the goal of leveraging MSDGC's investments in its communities toward community enhancement and development. Implementation of SWEPP is also intended to provide the following benefits:

- **Numerous internal and external benefits** that encompass many jurisdictional areas and complement MSDGC's Strategic Plan and long-term mission, vision, and goals.
- **Optimization of MSDGC funds to maximize water quality benefits.** The water quality benefits are in line with the policies/regulations/standards that are in place. The TMDL standards developed to achieve use attainment need to be considered to design sustainable, compliant alternatives.
- **Increased understanding by stakeholders** that water issues are not bound by political jurisdictions and there are many watershed conditions that influence MSDGC's desired outcomes.
- **Long-Term Asset Planning**
  - Plan for and align assets with a well developed O&M strategy.
  - Minimize life cycle costs.
  - Prioritize CIPs based on watershed factors, such as risks, opportunities, and funding.
  - Evaluate asset condition data, including Pipeline Assessment and Certification Program (PACP) reports and closed-circuit television (CCTV) footage, where available.
- **Levels of Service**
  - Different watershed conditions will define needs and costs to achieve the desired goals.
  - A clear water quality and quantity goal at an expected price will be established, based on stakeholder needs/desires.
- **Organization and Culture of MSDGC**
  - Alignment of current and future capital planning with O&M strategies.
  - Clearly defined divisional roles and responsibilities .
  - Standards and practices aligned with LOS.
- **Stakeholder Coordination and Alignment**
  - Understand what watershed stakeholders desire and how MSDGC coordinates with them.
  - Promote stakeholder involvement in the watershed evaluation and planning process.
  - Address watershed-related issues on a coordinated, regional basis.

MSDGC's Master Planning process involves six primary steps:

1. Data Compilation and Inventory and Analysis
2. Identify Opportunities and Constraints
3. Develop and Evaluate Alternatives
4. Develop Master Plan
5. Implement Master Plan
6. Monitoring, Reporting, and Evaluation

Steps 1 through 3 comprise the SWEPP and the resulting Preliminary Watershed Master Plan. Steps 4 through 6 use the Preliminary Watershed Master Plan to develop and implement a Watershed Master Plan.

Steps 1 through 3 comprise the SWEPP (the outcome of which is a Preliminary Watershed Master Plan). Steps 4 through 6 use the Preliminary Watershed Master Plan to develop and implement a Watershed Master Plan, and then to monitor the success of the implemented plan, while continuously recognizing, documenting, and adapting to lessons learned. **Figure 5-2**, **Figure 5-3a**, and **Figure 5-3-b** illustrate the objectives, sub-steps, tools, and outputs associated with each of these steps. The steps are described in detail in the remainder of this section. **Table 5-1** summarizes the six primary steps in terms of objectives, data inputs, tools, and primary responsibilities.

Roles and Responsibilities for Sustainable Watershed Management

MSDGC has been coordinating the Project Groundwork program with a variety of additional local programs to maximize the potential opportunities for water quality, economic, and community improvement. These additional programs, combined with the specific evaluation of grey and green infrastructure alternatives, provide opportunities for:

- Further reductions in stormwater runoff and contributions to the CSOs
- Overall water quality improvement
- Community improvement

Table 5-1 Watershed Master Planning Objectives, Data Inputs, and Tools

Step	Objectives	Data Inputs	Tools
Step 1: Data Compilation and Inventory Analysis	Define initial watershed goals and objectives, evaluate LOS, collect existing data, identify initial issues	Topography, hydrology, climate, geology, soils, land cover/use, water quality, biological communities, physical habitat, MSDGC capital improvement projects, non-MSDGC capital improvement projects, MSDGC sustainable infrastructure, MSDGC collection and treatment assets, MSDGC stormwater assets, cultural and historical assets, water infrastructure, MSDGC O&M data, non-MSDGC sewer, stormwater, and sustainable infrastructure, wastewater discharges, stormwater discharges, water supply resources, potential pollutant sources, impervious surfaces, transportation, neighborhoods and parcels, historic development, demographics, economic climate, floodplains, building conditions, foreclosure status, zoning, ordinances, urban development codes, stormwater codes, transportation plans, housing developments, comprehensive plans, business plans, community plans, Water In Basement (WIB) Info, records search, site reconnaissance	GIS, USEPA's Storm Water Management Model (SWMM), Regional Planning Documents and Coordination with Partners, Site Visits, Risk Assessment Tool
Step 2: Identify Opportunities and Constraints	Conduct initial watershed analysis, identify source control, product control, and conveyance/storage opportunities, identify project constraints	Results of Step 1, model input parameters, feedback from CFAC, watershed partners, and stakeholders	Sustainability LENS Tool, Urban Audit Tool, water quality model(s), MSDGC collection system models, process models, hydraulic models
Step 3: Develop and Evaluate Alternatives	Identify alternatives, conduct watershed-scale and subwatershed-scale analyses, prioritize alternatives, develop Preliminary Watershed Master Plan with all project types	Results of Steps 1 and 2, life cycle cost estimate data, current LOS, proposed LOS, as-needed field survey results, feedback from watershed partners, stakeholders, and public open house, Environmental Assessment	Financial Analysis Manual/MSDGC cost estimating standards, water quality model(s), MSDGC collection system models, process models, hydraulic models, Sustainability LENS Tool, Project Development and Alternatives Development Guidelines, Risk Assessment Tool
Step 4: Develop Master Plan	Define enterprise-level project responsibilities, develop Watershed Master Plan (i.e., prioritized action plan for all project types)	Results of Steps 1- 3, CAPEX feedback, preliminary engineering plans, feedback from CFAC, watershed partners, stakeholders, and public open house	Risk Assessment Tool, Project Development and Alternatives Development Guidelines, Business Case Evaluation (BCE) template, Sustainability LENS Tool
Step 5: Implement Master Plan	Develop project-specific implementation plans, develop final construction plans	Results of Steps 1- 4, topography survey results, utility survey results, geotechnical survey results, historical and archaeological survey results, alternatives funding review	Design tools, Value Engineering (VE) tools, capital improvement planning tools, Master Program Management Plan (MPMP), Risk Assessment Tool
Step 6: Monitoring, Reporting, and Evaluation	Conduct performance monitoring and O&M, use results to conduct adaptive management, conduct CIP tracking and project benchmarking, document lessons learned, and continue to adapt SWEPP	Results of Steps 1-5, biological monitoring data, water quality monitoring data, physical habitat assessments, peak flow monitoring, conveyance monitoring	Monitoring/sampling tools, Sustainability LENS Tool

Figure 5-2 Objectives, Steps, and Tools for Sustainable Watershed Evaluation and Planning Process

Objectives	**Data Compilation and Inventory Analysis**	**Identify Opportunities and Constraints**	**Develop and Evaluate Alternatives**	**Develop Master Plan**	**Implement Master Plan**	**Monitoring, Reporting, and Evaluation**
	• Define initial watershed goals and objectives • Collect existing data • Conduct coarse level modeling • Identify existing level of service • Coordinate with watershed partners and stakeholders	• Conduct detailed modeling • Develop watershed strategy (source control, conveyance/storage, and product control) • Identify opportunities, constraints, and desired level of service	• Identify watershed and subwatershed alternatives • Evaluate affordability and level of service • Develop Preliminary Watershed Master Plan with Direct Impact, Enabled Impact, and Inform & Influence Projects	• Conduct capital improvement planning and prioritization • Define enterprise-level project responsibilities • Develop Watershed Master Plan, a prioritized action plan for MSDGC investments in watershed	• Develop project-specific business case evaluations • Complete detailed engineering analysis • Determine monitoring plan and success criteria • Construct final alternative	• Conduct performance monitoring to evaluate success of projects • Perform adaptive management based on monitoring results • Identify lessons learned and incorporate into process
Steps	**Step 1**	**Step 2**	**Step 3**	**Step 4**	**Step 5**	**Step 6**
	Develop Watershed Goals and Objectives and Associated KPIs Compile Natural and Built Systems Data, MSDGC Asset and O&M Data Define Project Boundary Compile Policy Issues and Planned Watershed Projects Conduct Coarse Level Modeling Inventory Analysis Report Identify and Coordinate with Watershed Partners Current Watershed Level of Service Report	Conduct Existing Conditions Modeling Identify Opportunities for Integrated Watershed Strategies Identify Watershed Constraints Develop a Watershed Strategy (source control, conveyance/storage, product control) Opportunities and Constraints Report Conduct Urban Audit CFAC Engagement Coordinate with Watershed Partners and Revisit Watershed Goals and Objectives Proposed Watershed Level of Service Report	Identify Watershed Alternatives Conduct Detailed Modeling and Develop Levels of Service for Alternatives Class V Cost Estimates and Affordability Analysis Alternatives Decision Matrix Community Engagement Conduct Modeling and Field Work, Develop Levels of Service Class V Cost Estimates and Conduct Affordability Analysis Preliminary Watershed Master Plan Present Preliminary Watershed Master Plan to CAPEX	Capital Improvement Planning and Prioritization CFAC Engagement Community Engagement: Open House Watershed Master Plan	Detailed Field Surveys Project-Specific Business Case Evaluation 30%, 60%, and 90% Design Plans, Value Engineering Study Final Construction Plans Project Monitoring Plan Construction	Performance Monitoring Operations and Maintenance Project Monitoring Report Adaptive Management Updated Project Monitoring Plan CIP Tracking Benchmarking Lessons Learned
Tools	• Geographic Information System • Water quality and quantity models • Regional planning documents and coordination with partners • Risk Assessment Tool • Site visits	• Water quality and quantity models • Urban Audit Tool • Sustainability LENS Tool • Risk Assessment Tool	• Water quality and quantity models • Sustainability LENS Tool • Cost Estimating Standards • Project Development and Alternatives Evaluation Guidelines • Risk Assessment Tool	• Project Development and Alternatives Evaluation Guidelines • Risk Assessment Tool • Business Case Evaluation Template • Sustainability LENS Tool	• Design Tools • Capital Improvement Planning Book • VE Tools • Master Program Management Plan • Risk Assessment Tool	• Conduct performance monitoring to evaluate success of projects • Perform adaptive management based on monitoring results • Identify lessons learned and incorporate into process

Figure 5-3a Sustainable Watershed Evaluation and Planning Process (Steps 1-3)

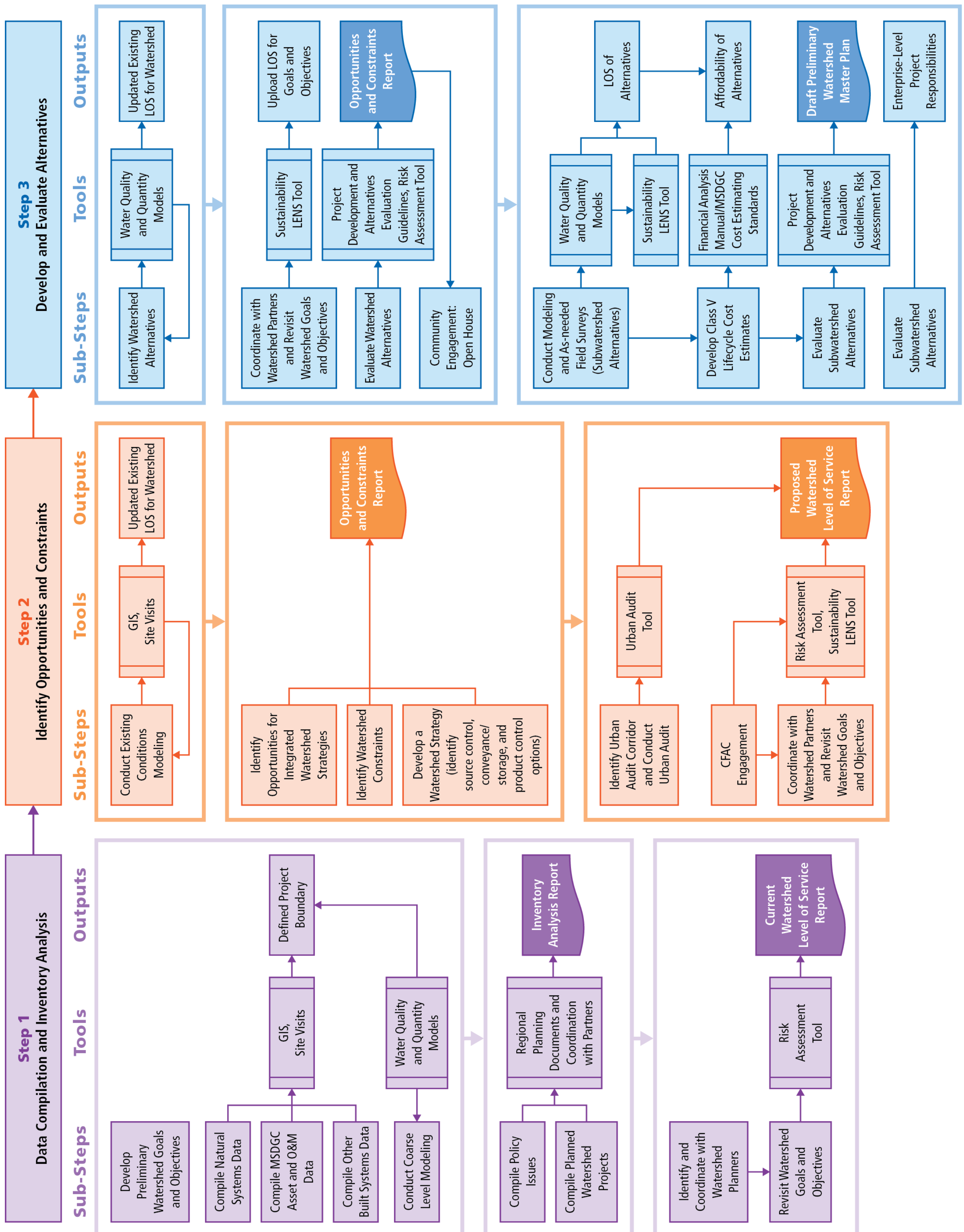
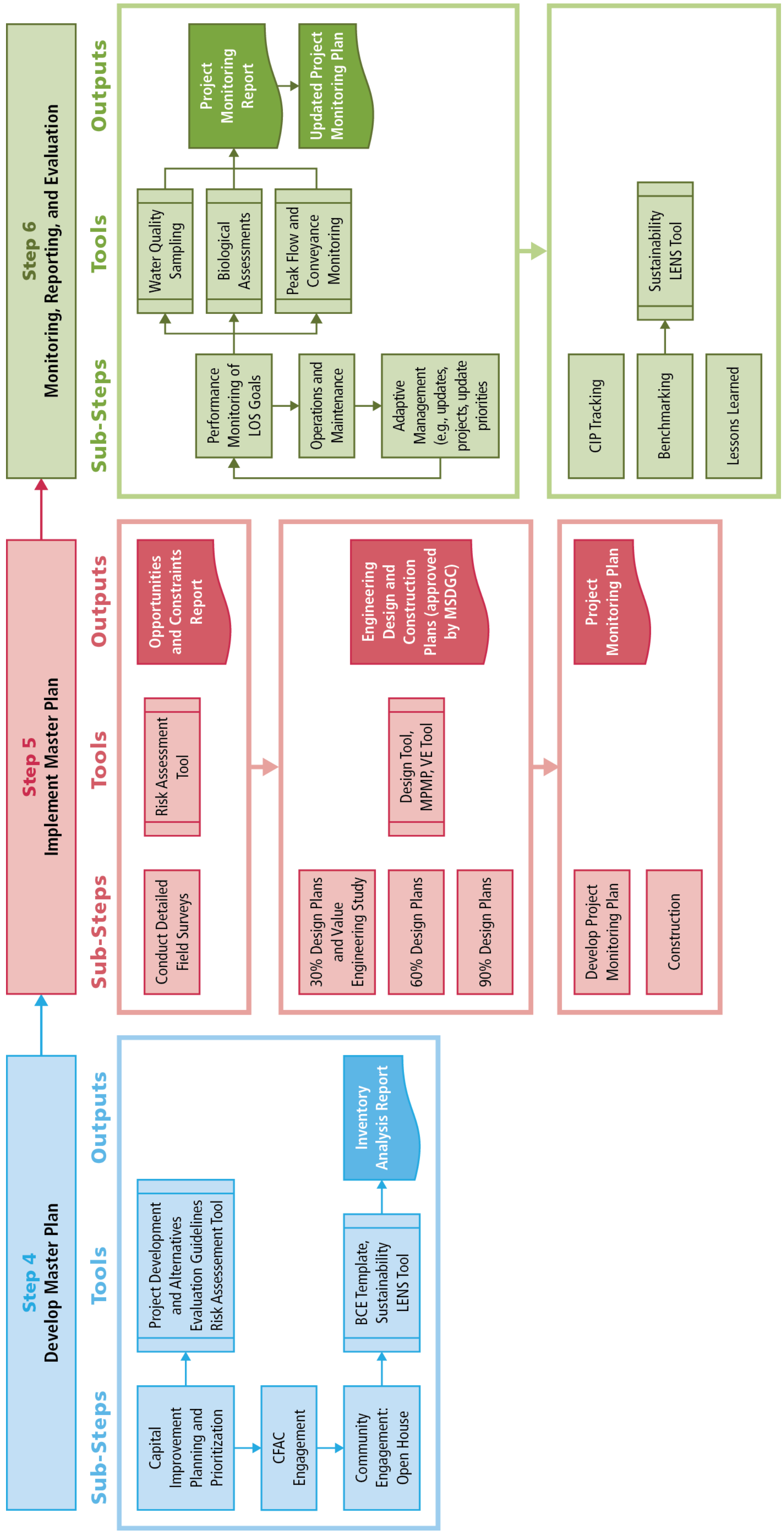


Figure 5-3b Sustainable Watershed Evaluation and Planning Process (Steps 4-6)



MSDGC's EPM is responsible for developing and implementing tools for Communities of the Future (Section 4), as well as the SWEPP (Section 5). The EPM is focused on source control components of the wet weather strategy and provides an opportunity for MSDGC to evaluate sustainable or green infrastructure solutions, as allowed by its revised federal mandates. Elements of watershed management that MSDGC departments are responsible for are summarized in **Table 5-2**, as well as the associated accountable, consulted, and informed MSDGC departments. Discussions associated with roles and responsibilities for watershed management are ongoing at MSDGC, and the roles and responsibilities outlined in **Table 5-2** will be revised in the near future.

Step 1: Data Compilation and Inventory and Analysis

Step 1 of the SWEPP — Data Compilation and Inventory Analysis — involves compiling and analyzing the data necessary to understand existing conditions in the watershed, including the environmental, political, and socioeconomic conditions. The data inventory included in this step is based on watershed-specific goals and objectives and associated KPIs, which will all be used to develop the Inventory Analysis Report and Current Watershed Level of Service Report. These reports become the foundation for identifying opportunities for watershed management and constraining factors in Step 2. Watershed stakeholder input is a key component of this initial step and includes community councils/groups, private individuals or organizations, Hamilton County Regional Planning, City Planning, and other public agencies. Understanding the stakeholder needs as well as the watershed characteristics is an important outcome of this first step.

STEP 1: DATA COMPILATION AND INVENTORY AND ANALYSIS

Inputs, Outputs, and Tools

Inputs

1. Preliminary goals and objectives
2. Various watershed databases, including natural systems data and built system data
3. Issues of watershed partners and stakeholders

Outputs

1. Inventory Analysis Report — presents the data compiled and identifies data gaps. Data gaps are evaluated to assess the risks of omitting the data and the cost-effectiveness of obtaining the data, if possible.
2. Current Watershed Level of Service Report — defines the existing LOS that is being provided in the watershed

Tools

1. Risk Assessment Tool (which includes the Risk Management Project Checklist (http://mymsd/PD/MPMPv2/Pages/default.aspx, Section 5, Volume III, PD-QA-05-006) and the Project Risk Register template (http://mymsd/PD/MPMPv2/Pages/default.aspx, Section 5, Volume III, PD-QA-05-020) — outlines the risk description, risk rank, enterprise risk, impact description, and proposed response to the risk (e.g., prevent, accept, avoid) and provides a means of tracking actions taken or planned associated with each risk.
2. GIS — used to organize and analyze the data gathered from various locations and sources.
3. Regional Planning Documents and Coordination with Partners — Collaboration with Hamilton County Regional Planning, City Planning, other City agencies, and neighborhood groups; interviews and coordination with all applicable stakeholders; review of planning and policy documents.
4. MSDGC collection system models for each of the seven WWTP Basins (USEPA SWMM 5)
5. MSDGC process models for each of the seven WWTP basins (based on the GPS-X modeling software)
6. MSDGC hydraulic models for each of the seven WWTP basins (Microsoft Excel-based HAZENPRO models)
7. Water quality model (dependent on the water quality improvement targets in the watershed)
8. Site Visits — field reconnaissance visits conducted to verify aerial photography and data compilation, and to gain an understanding of the current watershed conditions

Develop Watershed Goals and Objectives and Associated Key Performance Indicators

The foundation for any sustainable watershed plan is a concise, specific set of goals and objectives. It is critical to begin with a strong basis for initiating a sustainable watershed plan, so while these goals and objectives may be formulated from a fundamental knowledge of the watershed and community, they will be revisited, refined, and updated during each step of the planning process. MSDGC will collaboratively establish an initial statement of quantitative and/or qualitative goals and objectives. These should address the required CSO reduction and SSO elimination, any known stormwater and wastewater issues, and the appropriate level of economic, environmental, and social community benefits. When coarse level modeling is completed (later in Step 1), and the watershed LOS is identified, these goals and objectives will be further refined. Additionally, goals and objectives will be refined as MSDGC reaches out to watershed partners and stakeholders.

MSDGC is following the lead of USEPA's Integrated Municipal Stormwater and Wastewater Planning Approach Framework (USEPA, 2012) and focusing its efforts on meeting the objectives of the CWA and meeting requirements of its federal mandates using this integrated planning framework. Based on these overarching goals, examples of watershed-specific goals and objectives include: eliminating all SSO events, reducing the volume of CSOs, addressing local flooding issues, and providing community benefits. The goals and objectives will be entered into the Sustainability LENS Tool at a later stage and will be used to direct the development of performance indicator (PI) targets, for KPIs, which will be used to evaluate achievement. These KPIs will, in turn, provide a focus for the data compilation and inventory analysis. Examples of KPIs may include:

- Compliance with Consent Decrees
- Progress toward CWA standards

Table 5-2 Roles and Responsibilities for Sustainable Watershed Management

Task	Subtask	Responsible Department	Accountable Department(s)	Consulted Department(s)[a]	Informed Department(s)
Develop and Evaluate Alternatives	Coordinate with Watershed Partners and Revisit Watershed Goals	OOD EPM	OOD EPM, City/Co. Planning	PBD, WWC, WWT, SMU, DIW	PD
	Evaluate Alternatives and Refine to Sub-watershed Level	OOD EPM	OOD EPM, PBD	PBD, WWC, WWT, SMU, DIW	PD
	Conduct Modeling and Field Work, Develop LOS	OOD EPM	OOD EPM, PBD Modeling Group	PBD, WWC, WWT, SMU, DIW	PD
	Class V Cost Estimates and Affordability Analysis (sub-watershed level)	OOD EPM	OOD EPM, PBD	PBD, WWC, WWT, SMU, DIW	PD
	Preliminary Watershed Master Plan	OOD EPM	OOD EPM, PBD, City/ Co. Planning	PBD, WWC, WWT, SMU, DIW, City/Co. Planning	PD
	Present Preliminary Watershed Master Plan to CAPEX	OOD EPM	PBD Cost Estimating	PBD, WWC, WWT, SMU, PD (for projects being turned over)	PD
Develop Master Plan	CIP Planning and Prioritization	CAPEX, EPM	PBD, OOD EPM	PBD, WWC, WWT, SMU, PD, CAPEX	City/Co. Planning
	CFAC Engagement	OOD EPM	OOD EPM, PBD, City/ Co. Planning		WWC, WWT, SMU, DIW
	Community Engagement Open House	OOD EPM	OOD EPM	PBD, WWC, WWT, SMU, City/Co. Planning	PD
	Watershed Master Plan	CAPEX	OOD EPM , PBD	PBD, WWC, WWT, SM, City/Co. Planning	DIW, PD
Implement Master Plan	Develop Field Surveys	PBD	PBD, PD	OOD EPM, WWC, WWT, SMU	City/Co. Planning
	Project Specific BCE	PBD	PBD, OOD EPM	OOD EPM, WWC, WWT, SMU	City/Co. Planning, DIW
	30, 60, and 90% Designs	PD	PBD, PD	OOD EPM, WWC, WWT, SMU	City/Co. Planning, DIW
	Final Construction Plans	PD	PBD, PD	OOD EPM, WWC, WWT, SMU	City/Co. Planning, DIW
	Project Monitoring Plan	OOD EPM	PBD, OOD EPM		
	Construction	PD	PD, PBD	OOD EPM, WWC, WWT, SMU	City/Co. Planning, DIW
Monitoring, Reporting, and Evaluation	Performance Monitoring	EPM, Modeling Group	OOD EPM, PBD	WWC, WWT, SMU	
	O&M	WWC, WWT, SMU	WWC. WWT, SMU	OOD EPM, DIW	PD
	Project Monitoring Report	EPM, Modeling Group	OOD EPM, PBD	WWC, WWT, SMU	City/Co. Planning, DIW
	Adaptive Management	CAPEX	OOD EPM, PBD	WWC, WWT, SMU	City/Co. Planning, DIW

continued on next page

Table 5-2 Roles and Responsibilities for Sustainable Watershed Management

Task	Subtask	Responsible Department	Accountable Department(s)	Consulted Department(s)[a]	Informed Department(s)
Data Compilation and Inventory Analysis	Develop Watershed Goals and Objectives and Associated KPIs	OOD EPM	OOD EPM, City/Co. Planning	PBD, WWC, WWT, SMU, DIW	
	Compile Natural and Built Systems Data and MSDGC Asset Condition	OOD EPM	OOD EPM, PBD, City/ Co. Planning	PBD, WWC, WWT, SMU, DIW	
	Define Project Boundary	OOD EPM	OOD EPM, PBD	PBD	PBD, WWC, WWT, SMU, DIW
	Compile Policy Issues and Planned Watershed Projects	OOD EPM	OOD EPM, City/Co. Planning	PBD, WWC, WWT, SMU, DIW	
	Conduct Coarse Level Modeling	OOD EPM	OOD EPM, PBD Modeling Group	PBD, WWC, WWT, SMU, DIW	
	Inventory Analysis Report	OOD EPM	OOD EPM	PBD, WWC, WWT, SMU, DIW, City/Co. Planning	PD
	Identify and Coordinate with watershed partners	OOD EPM	OOD EPM, City/ Co. Planning	PBD, WWC, WWT, SMU, DIW	
	Current Watershed LOS Report	OOD EPM	OOD EPM, PBD, City/ Co. Planning	PBD, WWC, WWT, SMU, DIW	PD
Identify Opportunities and Constraints	Conduct Existing Conditions Modeling	OOD EPM	PBD Modeling Group	PBD, WWC, WWT, SMU, DIW	
	Identify Opportunities for Goals and Objectives	OOD EPM	OOD EPM, City/ Co. Planning, PBD	PBD, WWC, WWT, SMU, DIW	
	Identify Watershed Constraints	OOD EPM	OOD EPM, City/ County Planning, PBD	PBD, WWC, WWT, SMU, DIW	
	Develop Watershed Strategy	OOD EPM	OOD EPM, City/ County Planning, PBD	PBD, WWC, WWT, SMU,	
	Opportunities and Constraints Report	OOD EPM	OOD EPM	PBD, WWC, WWT, SMU, DIW	
	Conduct Urban Audit	OOD EPM	OOD EPM, City/ County Planning		PBD, WWC, WWT, SMU, DIW
	CFAC Engagement	OOD EPM	OOD EPM, City/ County Planning	CFAC	PBD, WWC, WWT, SMU, DIW
	Coordinate with Watershed Partners and Revisit Watershed Goals	OOD EPM	OOD EPM, City/Co. Planning	PBD, WWC, WWT, SMU, DIW	
	Proposed Watershed LOS Report	OOD EPM	OOD EPM, PBD, City/ Co. Planning	PBD, WWC, WWT, SMU, DIW	
Develop and Evaluate Alternatives	Identify Watershed Alternatives	OOD EPM	OOD EPM, PBD	PBD, WWC, WWT, SMU, DIW	PBD, PD (for projects being turned over)
	Conduct Modeling and Develop LOS for Alternatives	OOD EPM	PBD, Modeling Group	PBD, WWC, WWT, SMU, City/Co. Planning	DIW

continued on next page

Table 5-2 Roles and Responsibilities for Sustainable Watershed Management

Task	Subtask	Responsible Department	Accountable Department(s)	Consulted Department(s)[a]	Informed Department(s)
Monitoring, Reporting, and Evaluation	Updated Monitoring Plan	EPM, Modeling Group	OOD EPM, PBD	WWC, WWT, SMU	City/Co. Planning, DIW
	CIP Tracking	EM	PD, PBD	OOD EPM, WWC, WWT, SMU, DIW	City/Co. Planning
	Benchmarking	CAPEX	OOD EPM, PBD	WWC, WWT, SMU	City/Co. Planning, DIW
	Lessons Learned Report	CAPEX	OOD EPM, PBD	WWC, WWT, SMU	City/Co. Planning, DIW

OOD EPM – Office of the Director – Environmental Programs Management; CAPEX - CAPital EXpenditure management ; PBD - Planning and Business Development; PD – Project Delivery; SMU – Stormwater Management Utility; WWC – Wastewater Collection; WWT – Wastewater Treatment

[a] This list includes MSDGC entities only; however, other affected stormwater utilities will be consulted throughout the process to evaluate areas outside of the City of Cincinnati

- Improvement of workforce skills
- Construction coordination
- Financial stability
- Linkage of transportation options, pedestrian usability, and safety measures
- Increase in viable housing options
- Enhancement of community amenities and characteristics
- Preservation or mitigation of historic assets
- Support of community revitalization goals
- Promotion of community engagement in MSDGC projects
- Increase or maintenance of open spaces
- Protection of open and wild spaces
- Increase of carbon offsets through tree canopy cover or greenspace
- Reduction of MSDGC GHG emissions
- Minimization of landfill waste products

Compile Natural Systems Data

The importance of understanding natural systems as part of the SWEPP is discussed in Appendix A. These data will be used in the Inventory Analysis Report and later to model existing conditions in Step 2 of the SWEPP. Natural systems data should be acquired as or transferred to a GIS database, which provides a suite of analytical tools for spatially-referenced data. Sources and specific datasets to be compiled are summarized in **Table 5-3**. GIS datasets should be in a compatible format, scale, and resolution. Datasets should be certified, and MSDGC should have legal rights to use the data.

Compile MSDGC Asset and Operations and Maintenance Data

The SWEPP will include an evaluation of all MSDGC assets (see **Table 5-4**), asset condition information, and O&M data. Asset data will include infrastructure (such as that identified in the WWIP), sanitary sewer updates, to be funded by the Asset Management Program, as well as source control opportunities, to be funded by the Sustainable Allowance. Additionally, customer issues such as spills, overflows, and odors will be included in the inventory analysis, for use in identifying opportunities and constraints. Data compilation will involve obtaining works orders, complaint records, and maintenance records from WWC, WWT, and SMU to complete this task. The WWC rating system allows MSDGC to inventory the location and condition of all assets, assess the physical condition and functionality of the system, and estimate remaining service life and asset value. The hierarchy of the WWC, WWT, and SMU assets is provided in Appendix C.

For the MSDGC asset inventory, in addition to the spatial location of each asset, data collected for the GIS inventory should include the location, age, remaining useful life, and condition of each asset (PACP/asset rating; established by the asset owner) and the O&M cost of the asset (based on historical data, cost estimations, or CIP funding). O&M costs should be considered since the O&M and capital strategies must be connected in a Watershed Plan and they are significant costs to the MSDGC rate-payers. These data will be used in the Inventory Analysis Report and later to model existing conditions in the watershed.

Table 5-3 Summary of Natural Systems Data and Data Sources

Natural Systems Data Category	Dataset(s) to Compile	Source(s) of Data
Soils	– Soil type – Infiltration rate – Soil texture – Erosion potential – Landslide-susceptibility – Land slope – Drainage potential – Hydrologic soil groups – Runoff curve number – Saturation condition – Time of concentration – Watershed storage	– Cincinnati Area GIS (CAGIS) – Cincinnati Department of Transportation & Engineering's Division of Engineering, Structures & Geotechnical Services Section – Hamilton County Engineer's Office (soil borings) – Ohio Department of Transportation (soil borings) – Hamilton County Soil Survey – US Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) – ODNR Division of Lands and Soil – Ohio Agricultural Research and Development Center
Land Cover	– Vegetation/tree canopy – Open space – Water – Historical land use	– Cincinnati Park Board (CPB) – Hamilton County Parks Board – ODNR – National Land Cover Database (NLCD) – CAGIS aerial photography
Receiving Streams	– Scenic rivers – Regionally significant streams – Stream dimensions and changes over time – Stream channelization – Water quality data – TMDLs – Numeric criteria/state water quality standards – Designated use and use attainment – Anti-degradation policies/procedures – Sensitive areas – Estimate of existing pollutant loads – Future/build-out pollutant load estimates – Water quality data – Flow data (quantity, floods/floodplain, channelization, contaminated sediment) – Historical contact advisories	– CAGIS – MSDGC EPM – Historical maps – Previous studies – OEPA – USEPA – Ohio-Kentucky-Indiana (OKI) Regional Council of Governments – MSDGC EPM, OEPA, USEPA (existing and future pollutant loads) – Cincinnati Health District, Hamilton County Health District (existing pollutant loads) – U.S. Army Corps of Engineers (USACE) – National Stormwater Quality Database
Physical Habitat and Biological Communities	– Physical habitat assessment scores – Fish community indices of biotic integrity – Benthic macroinvertebrate assessment scores – Wildlife – Endangered species	– OEPA – MSDGC EPM – Midwest Biodiversity Institute – ODNR – U.S. Fish and Wildlife Service (USFWS)

Compile Non-MSDGC Built Systems Data

Non-MSDGC built systems data to be compiled include: land use, impervious surfaces, non-MSDGC-owned storm sewer infrastructure, ROWs, transportation, potential pollutant sources, neighborhood boundaries, and parcel information. As with natural systems data, the built systems data should be acquired as or transferred to a GIS database. Sources and specific datasets to be compiled are summarized in **Table 5-5**.

Define the Project Boundary

A key step in watershed planning is defining the problem and establishing the project boundary. Only after the project boundary is defined can strategies and tactical alternatives be developed to address a given problem. Based on GIS data, MSDGC has developed boundaries of sewersheds throughout its service area. However, the project boundary may or may not coincide with the hydrologic boundary of the watershed. The problem area (or study area) may also be defined by the sewershed delineations, or other inputs/outputs to the watershed. Using the built system data and

Table 5-4 Summary of MSDGC Asset Inventory Data and Data Sources

Built Systems Data Category	Dataset(s) to Compile		Source(s) of Data
Capital Improvement Projects	– Ongoing and potential future MSDGC capital improvements		– MSDGC Capital Improvement Plans
Non-Captial Improvement Projects	– Rain gardens – Bioswales – Infiltration basins – Permeable pavement	– For each: – Year built and by whom – Dimensions, composition, etc. – Owner/responsible party – Level of protection – Changes made since original construction – Maintenance frequency and annual costs	– CAGIS – Cincinnati Area Professional Green Infrastructure Network – MSDGC EPM – MSDGC PBD
MSDGC Collection and Treatment Assets and Asset Information	– Gravity sewers (WWC) – Tunnels (WWC) – Manholes (WWC) – Sewer valves (WWC) – Pressure sewers (WWC) – Grit pits (WWC and WWT) – Service locations (WWC) – Diversion chambers (WWC) – CSO (WWC) – Facilities (WWT) – Access roads (WWC, WWT) – WWTPs and facility plans (WWT) – High rate treatment facilities (WWT) – Pump stations (WWT) – Storage facilities (WWC) – Customer service requests/ complaints (e.g., odors) (WWC, WWT) – Sewage backups (formerly WIB) (WWC)	– Illegal discharges (SSOs, PSOs) (WWC) – Asset risk – Pipeline Assessment and Certification Program (PACP) reports and CCTV footage – O&M plan and cost – SSO/CSO monitoring – Sewer backup – Baseline condition assessments – Lining candidates, manhole rehab – WWTP facility plans – O&M plan – WWT Operations data – Maintenance data – System capacity and model – Flow monitoring data – Industrial users permits and inspections – Overflow records (telog) – Rainfall-derived I/I (RDI/I) program	– MSDGC WWC and WWT – CAGIS – Field site visits – Past studies, records, archives (MSDGC)
MSDGC Stormwater Assets and Asset Information	– Pump stations – Storm sewers – Sluice gates – Manholes – Collection appurtenances – Surface conveyance features	– Storage – Detention and retention basins – Outfalls – Flooding complaints – Flood control features – Barrier dams	– MSDGC, SMU – CAGIS
Capital Improvement Projects	– Ongoing and potential future MSDGC capital improvements		– MSDGC Capital Improvement Plans

natural system data, the problem area will be defined. If needed, field surveys will be conducted to confirm or adjust the boundaries included in MSDGC's hydrologic delineation. Site visits will be conducted and field data will be collected during the planning phase and during the design phase, as needed, for areas where a detailed data set does not currently exist.

Conduct Coarse Level Modeling

To provide a coarse level analysis of existing water quality and water quantity conditions in the watershed, a coarse level modeling (CLM) approach will be used to first model hydrologic and hydraulic (H&H) conditions, and then estimate pollutant loadings from sources within the basin. The CLM will be focused on establishing the background and baseline information to support successive

Table 5-5 Summary of Non-MSDGC Built Systems Data and Data Sources

Built Systems Data Category	Dataset(s) to Compile	Source(s) of Data
Land Use[a]	– Existing distribution, location, and characteristics of land use (e.g., urban, industrial, residential) – Projected future distribution, location, and characteristics of land use	– CAGIS – Hamilton County Auditor – Cincinnati Department of City Planning and Buildings – Hamilton County Department of Planning and Development – Site visits – Aerial photography – Previous studies
Cultural and Historical Assets	– Cultural and historical assets in the watershed	– National Register of Historic Places[b] – "The Mill Creek - An Unnatural History of an Urban Stream" by Stanley Hedeen[c]
Water Infrastructure	– Water distribution pipes	– Greater Cincinnati Water Works – Hamilton County Department of Planning and Development

Sustainable Infrastructure (non-MSDGC)	– Rain gardens
	– Bioswales
	– Infiltration basins
	– Permeable pavement
	– For each:
	  – Year built and by whom
	  – Dimensions, composition, etc.
	  – Owner/responsible party
	  – Level of protection
	  – Changes made since original construction
	  – Maintenance frequency and annual cost
		– Cincinnati Health District
		– Hamilton County Health District
		– Ohio River Sanitation Commission
		– Hamilton County Department of Planning and Development Division of Stormwater & Infrastructure (12 townships)
		– Stormwater utilities for 21 cities and 17 villages within Hamilton County
		– Ohio Department of Transportation (within state ROWs)
		– USACE (flood control structures)
		– ODNR (dams)

Permitted Wastewater Discharges	– Industrial wastewater facilities and outfall locations – Municipal wastewater facilities and outfall locations – Private wastewater facilities and outfall locations – Land application syste	– USEPA – OEPA
Water Supply Resources	– Groundwater wells – Water withdrawal locations, owners, and number supplied – Wellhead protection programs	– ODNR (groundwater) – Water supply utilities in Hamilton County – ODNR (wellhead protection)
Potential Pollutant Sources (other than those above)	– Landfills (active or inactive) – Hazardous waste sites and facilities – Surface mines (active or inactive) – Underground Storage Tanks and Leaking Underground Storage Tanks – Agriculture and animal production/husbandry facilities – Health department priority areas – Un-sewered Areas/household septic treatment systems (HSTSs) – Section 401/404 Permits – Comprehensive Environmental Response, Compensation, and Liability Act Sites – RCRA Sites – Brownfields	– USEPA – OEPA – City of Cincinnati's Office of Environmental Quality – The Hamilton County Soil & Water Conservation District – Local health departments – Cincinnati Health Department, Hamilton County Health District – MSDGC – Hamilton County Department of Environmental Services

continued on next page

Table 5-5 Summary of Non-MSDGC Built Systems Data and Data Sources

Built Systems Data Category	Dataset(s) to Compile	Source(s) of Data
Stormwater Discharges	– Municipal stormwater permits – Industrial stormwater permits – Notices of Intent for construction – Construction stormwater permits	– USEPA – OEPA – Hamilton County Department of Planning and Development – CAGIS – Aerial photography – Hamilton County Soil & Water Conservation District – SMU
Impervious Surfaces	– Parking lots – Pavements – Sidewalks – Rooftops – Driveways, roadways	– CAGIS – Aerial photography
Transportation	– ROWs – Highways, arterial and local streets, railways – Bridges – Pedestrian circulation, sidewalk connectivity, and bikeways	– Cincinnati Department of Transportation & Engineering – Hamilton County Engineer's Office – Ohio Department of Transportation – CAGIS
Other Utilities	– Utility lines – Utility ROWs	– Ohio Utilities Protection – Gas, electric, telephone, cable, and communication companies
Neighborhoods and Parcels	– Neighborhood boundaries – Neighborhood demographics, socioeconomic status, and level of public involvement – Parcel boundaries – Land ownership information	– Hamilton County Auditor – CAGIS

[a] Should follow standards established by the American Planning Association (APA), specifically the Land-based Classification Standards
[b] National Register of Historic Places Database; http://nrhp.focus.nps.gov/natreghome.do?searchtype=natreghome)
[c] Heeden, S. 1995. "The Mill Creek - An Unnatural History of an Urban Stream." Rivers Unlimited Mill Creek.

steps, including the evaluation of specific alternatives and eventual monitoring and project evaluation processes.

Sewershed modeling will use the latest version of the SWMM (Existing Conditions Model), as provided by the PBD Modeling Group. PBD will determine the extent of the modeling that is appropriate for the particular study. Collection system modeling will be done according to the MSDGC Modeling Guidelines and Standards (http://mymsd/PBD/ModelingMonitoring/Shared%20 Documents/Forms/AllItems.aspx). The coarse level water quality analysis will use the latest version of the SWMM for the combined sewer areas and CSO discharges and the Simple Method (the Simple Method calculates stormwater pollutant loads based on annual runoff volumes and pollutant concentrations by land use). Additional modeling based on the Simple Method will be used to quantify loading from areas with separated sewer and stormwater collection systems.

The selected watershed will be evaluated in terms of the following parameters:

- **Combined Sewer Overflow** is defined as the volume of wet weather overflow from the combined sewer system in a typical year analysis. The typical year is defined as the 1970 rainfall. This rainfall is available on an hourly basis and is considered to occur over the entire basin. The 1970 typical year rainfall is not a spatially varied rainfall. The performance metric for CSO is the percent capture calculation as given in the Original Lower Mill Creek Partial Remedy Phase 1 Tunnel Technical Memorandum 21 (MSDGC).

- **Sanitary Sewer Overflow** is defined as the volume of wet weather overflow from the sanitary sewer system during a design storm analysis. The proposed design storm for the sanitary and combined level of service is the 10-year return interval.

- **Asset Level of Service** is currently being defined by MSDGC as part of its Asset Management Program.
- **Water Quality** is defined for this analysis as loadings of bacteria, total nitrogen, total phosphorus, and total suspended sediment.
- **Percent effectiveness** is a measure of the ability to improve the pervious area of a site or subbasin and is related to existing land use and current percent imperviousness. Percent effective impervious area recognizes that some impervious areas are completely surrounded by pervious areas and therefore have less of an impact on aquatic ecosystems. "Effective impervious area" is the impervious cover that provides stormwater flows fairly directly and quickly to streams.

Hydrologic and Hydraulic Modeling Approach

The coarse level H&H evaluation will be performed using the latest version of the SWMM provided by the MSDGC Modeling Group. The first task is to review the Existing Conditions Model and confirm whether this model is sufficient to conduct SWEPP. Since SWMM was not designed to examine stormwater-only systems, other modeling resources will likely be needed to perform this work. The model will be reviewed, verified, and refined to include any updates identified during the verification process. This process will be coordinated with the MSDGC Modeling Group and any refinements coordinated with this group. The detailed model will be run for storm conditions evaluated during the SWEPP and appropriate boundary conditions will be extracted and loaded into the project model.

The stormwater paths will be evaluated in a desktop analysis using the CAGIS data. This level of modeling does not include field survey data. The coarse modeling level of detail will include determining the path of stormwater flow from the following areas:

- Roof areas from the CAGIS buildings layer
- Street pavement areas from the CAGIS pavement layer
- Storm sewers
- Single family residential
- Open space/transportation areas
- Commercial/Industrial/Multifamily subcatchments
- Right-of-way areas
- Grounds (pervious land uses)

Flow data collected at permanent flow meters throughout the watershed, if any, will be evaluated in the model. The rainfall data will be collected for the chosen monitoring period and loaded to the model. The dry weather flow, simulated versus observed, will be compared. If the dry weather flow is not verified, the condition will be documented and a flow monitoring program and calibration will be performed in subsequent phases. Additionally, the wet weather flow, simulated versus observed, will be evaluated at the permanently monitored sites throughout the watershed. Three storms will be evaluated and documented. If the wet weather flow is not verified, the condition will be documented and a flow monitoring program and calibration will be performed in subsequent phases. Three storms, to be selected based on flow and rainfall data, will be used for verification so that a range of storms and their responses can be evaluated. Intensive flow monitoring and recalibration of the H&H model is not included as part of the CLM and will be addressed in later steps of SWEPP in collaboration and with appropriate direction from the PBD Modeling and Monitoring Branch.

The coarse level evaluation of the hydrologic and hydraulic model will be performed using the latest version of the Storm Water Management Model provided by the MSDGC Modeling Group.

Coarse Level Water Quality Approach

The coarse level water quality modeling has two components: combined/sanitary flow and stormwater flow. The combined/sanitary flow component focuses on the discharge and pollutant loading from the CSOs and SSOs in the watershed and is studied and analyzed utilizing a sewershed hydraulic model. Discharges and loadings from the collection system will be calculated using the current version of the SWMM. Annual runoff and non-point source loading will be estimated using a runoff-based calculation using land use, imperviousness, and event mean concentration (EMC) data.

The first step in the process is to determine stormwater paths and delineate catchments if these steps have not been previously preformed. The stormwater paths and catchments will be determined in a desktop analysis using the CAGIS data, including sewershed, topographic, and hydrologic information. Field surveys of the stormwater paths and catchment delineations are not expected as part of the CLM assessment. Catchments will be used as the basis for calculating flow and pollutant loadings.

Rainfall not infiltrated or trapped in surface depressions will flow over the surface and then into the nearest waterway or into a stormwater interceptor to be conveyed into the combined sewer system. Non-point source loading for the separate sewer areas will be quantified using a rainfall-runoff relationship based model such as HEC-HMS or the Simple Method developed by the Center for Watershed Protection (www.stormwatercenter.net/monitoring%20and%20assessment/simple%20meth/simple.htm). EMCs are estimates of concentrations of pollutants in runoff or effluent. Calculated non-point source runoff is multiplied by EMCs to estimate loads for pollutants of interest. These methods provide a scoping level estimate of stormwater runoff and pollutant loading based on land use, EMCs, and specified rainfall amounts.

SWMM can be used to calculate surface runoff from combined areas, available capacity under different conditions, surcharging in the collection system, and SSO and CSO events. Once CSO and SSO volume estimates have been determined, loading estimates are calculated based on EMCs approved by MSDGC. Flow and pollutant contributions from separate sewer areas can come from SSOs and stormwater non-point runoff.

The coarse level water quality modeling has two components: combined/sanitary flow and stormwater flow.

Point source contributions will be identified through the NPDES database and quantified using historical discharge monitoring records. The potential for contributions from septic systems will be qualitatively evaluated, if GIS data for these systems are available. Contributions from watersheds draining to the study watershed will be quantified to the extent practical based on reports for adjacent watersheds.

Annual discharge, runoff volumes and pollutant loading results will be provided as event totals on a catchment scale. The combination of sewershed and stormwater loading estimates will allow for rapid identification of areas with the largest total and per acre loadings. The CLM can provide the basis for more detailed modeling in future phases of analysis.

Results of Coarse Level Modeling

The results of the CLM will provide baseline documentation on the existing H&H and water quality conditions in the watershed. This information will be used in the initial evaluation of opportunities and constraints for improvement in the watershed and help to establish the current LOS in the area. In addition, the CLM will facilitate future, more detailed modeling, which will be required to finalize the recommended alternatives for management in the watershed.

Compile Policy Issues

At this phase in the planning process, all potential policies should be compiled that could impact the watershed strategy development (e.g. obstacles or opportunities for a Communities of the Future project, including those related to zoning, stormwater management codes, local ordinances, and the Urban Development Code). This will involve communication with the Hamilton County Storm Water District; Interim Development Control Districts; the Hamilton County Regional Planning Commission, Park District, Department of Planning and Development, Department of Community Planning, Department of Zoning; and the Cincinnati Recreation Commission, Department of City Planning and Buildings, Department of Community Development, Department of Economic Development, Office of Environmental Quality, Parks Department, and Department of Transportation and Engineering (CDOTE), the Ohio Department of Transportation, and the OKI Regional Council of Governments. In addition, 21 cities within Hamilton County are not subject to decisions of the Hamilton County Regional Planning Commission, and there are 17 villages in the County, some of which have independent planning efforts. Discussions of policy issues would be coordinated with any of the cities or villages that are located partially or entirely in the watershed to provide a comprehensive review of existing plans.

Compile Planned Watershed Projects

A thorough analysis of the watershed should include identification of all public and private projects that are planned within and around the project area. These plans may represent opportunities to integrate sustainable technologies or to engage additional stakeholders in the planning and implementation processes. Understanding why previous plans were or were not successful, as well as what kind of public support they garnered, can help guide infrastructure alternatives and may help in establishing watershed goals and objectives. Furthermore, identifying watershed projects may determine how these plans may negatively or positively affect the infrastructure planning process.

Examples of watershed projects or plans include: transportation improvement projects, utility projects (e.g., sewer, water, and electricity), housing developments, commercial/business developments, comprehensive plans, business plans, community plans, strategic plans, and neighborhood-specific zoning changes or amendments. MSDGC should coordinate with all applicable organizations and local governments to identify any such plans.

This would include communications with the Hamilton County Regional Planning Commission, Park District, Department of Planning and Development, Department of Community Planning, Department of Zoning; and the Cincinnati Recreation Commission, Department of City Planning and Buildings, Department of Community Development, Department of Economic Development, Office of Environmental Quality, Parks Department, CDOTE, Port Authority, and the OKI Regional Council of Governments. Discussions of planned watershed projects would be coordinated with any of the cities or villages that are located partially or entirely in the watershed.

The following regional plans should also be reviewed for applicability to the watershed: Agenda 360 (www.agenda360.org), a regional action plan for four counties of Southwest Ohio, including Butler, Clermont, Hamilton and Warren, the Hamilton County Community COMPASS (www.communitycompass.org/v2/about.asp), and Plan Cincinnati (www.plancincinnati.org/).

Identify and Coordinate with Watershed Partners

As part of the early planning phase, the following actions related to stakeholders and watershed partners should be completed:

1. Identify stakeholders and their roles in the watershed.
2. Discuss stakeholder goals, objectives, and involvement.
3. Clarify these objectives if necessary and identify methods of incorporating them in the process.
4. Develop coordination plan to be used by the organization and the stakeholders.

DELIVERABLE:
Inventory Analysis Report

The end product of the data compilation phase is an Inventory Analysis Report, which includes a characterization of the watershed to be used to identify opportunities and constraints for watershed management in Step 2 of the planning process. The report includes summaries of the data compiled, an analysis of the existing conditions and understanding of the watershed, and preliminary goals and objectives based on the understanding of the watershed. The report also includes an overview of data gaps, a recommendation for how the missing data could be filled, and an estimate of the cost, timeline, and value added for the data collection.

The Inventory Analysis Report includes both narrative and visual summaries of all data discussed previously, such as maps of the spatial data collected and a discussion of the results of these data. Each dataset is evaluated and discussed as it relates to identifying sustainable watershed management strategies. For example, the topography of the watershed identifies steep hillsides, low-lying basins, historical stream channels, and flood-prone areas, all of which are applicable to designing sustainable infrastructure. Statistical analyses are used to describe the extent of watershed characteristics and to identify defining characteristics of subareas of the watershed. For example, the Inventory Analysis Report includes the average market value of properties in the watershed, as well as the proportion and distribution of various market value ranges. The quantitative and qualitative assessment of the watershed in the Inventory Analysis Report forms the basis for identifying watershed management strategies.

Discussions about a community's major environmental, economic, and social development should include active participation of watershed stakeholders, such as local officials, local government departments, residents, the business community, nongovernmental organizations, and other community groups. Active participation allows varied interests to provide input to the development of the vision for the community. This promotes greater support and cooperation for infrastructure improvements, economic development, and urban renewal while utilizing sustainable environmental solutions. Perhaps most importantly, active participation encompasses a shared vision for better solutions and better communities.

Developing stakeholder support is important during the inventory and analysis phase, and is critical to the success of the overall SWEPP. Examples of potential watershed stakeholders include:

- Non-profit organizations
- Neighborhood associations
- Civic/community groups
- City departments/divisions
- County departments/divisions
- Property owners
- Industry leaders
- Business owners

Revisit Watershed Goals and Objectives

At this phase in the planning process, a large amount of data, policy issues, and watershed plans have been compiled and inventoried. The goals and objectives identified from a basic understanding of the watershed should be refined and updated based on the comprehensive inventory analysis. MSDGC and the partner agencies identified for the watershed should collaboratively revisit the watershed goals and objectives and refine and update them as necessary. Any changes to the goals and objectives should be recorded, and associated changes to KPIs should be entered into the Sustainability LENS Tool. The main function of the Sustainable LENS Tool is to document and assist in identifying the KPIs to be part of the Watershed Master Plan.

DELIVERABLE:

Current Watershed Level of Service Report

The Current Watershed LOS Report details the existing stormwater and wastewater LOSs provided in the watershed, including those related to the KPIs selected for the specific watershed. The existing LOS will continue to be updated as more detailed analyses occur, such as water quality and H&H modeling; however, the Current Watershed LOS Report will serve as the baseline for defining the preliminary proposed LOS and, ultimately, for evaluating the success of the implemented alternatives.

Step 2: Identify Opportunities and Constraints

Step 2 of the SWEPP — Identify Opportunities and Constraints — utilizes information in the Inventory Analysis Report and Watershed LOS Report to model existing conditions in the watershed, identify opportunities to meet the watershed goals and objectives, and define the current and preliminary proposed watershed LOS. Step 2 also includes community involvement through the Communities of the Future, and other watershed stakeholders, to better understand the community's economic, social, and environmental priorities and, in turn, to refine the watershed goals and objectives.

STEP 2: IDENTIFY OPPORTUNITIES AND CONSTRAINTS

Inputs, Outputs, and Tools

Inputs

1. MSDGC-approved Inventory and Analysis Report
2. Current Watershed LOS Report
3. List of stakeholder issues
4. Proposed/aspirational LOS

Outputs

1. List of stakeholder issues, concerns, and priorities.
2. Opportunities and Constraints Report
3. Proposed Watershed LOS Report

Tools

1. MSDGC collection system models for each of the seven WWTP basins (USEPA SWMM 5)
2. MSDGC process models for each of the seven WWTP basins (based on the GPS-X modeling software)
3. MSDGC hydraulic models for each of the seven WWTP basins (Microsoft Excel-based HAZENPRO models)
4. Water quality model (dependent on the water quality improvement targets in the watershed)
5. Urban Audit Tool (Hamilton County Regional Planning Commission's tool will be used by Cincinnati City Planning or Hamilton County Regional Planning Commission to streamline the urban audit process and collect data related to historical development, demographics, economic climate, and existing building conditions)
6. Sustainability LENS Tool- In this step, the web-based tool is used to select the KPIs that are applicable to the watershed goals and objectives (see Appendix C)
7. Risk Assessment Tool

Risks

1. Quality of collection system flow monitoring data - Some sites are very difficult to monitor and thus the quality of the data may not be adequate. This may, in turn, result in models that are not fully representative of MSDGC's system.
2. Managing Stakeholder Expectations - It should be anticipated well in advance that not all of MSDGC's stakeholders will be satisfied with the watershed plans, especially if not all of their major concerns and issues can be addressed via MSDGC's work.

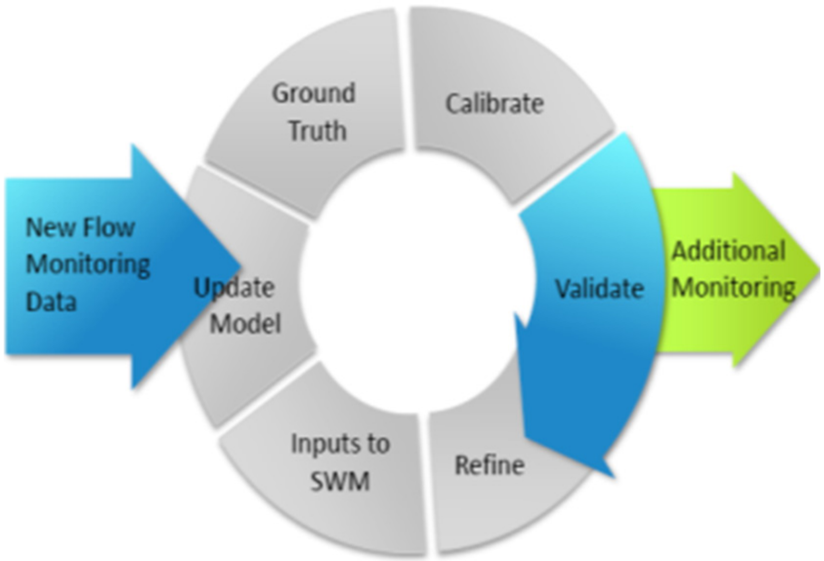
Conduct Existing Conditions Modeling

Based on the data compilation and inventory analysis conducted in Step 1, the current LOS of the watershed was estimated. The first sub-step of Step 2 is to refine the estimated LOS and characterize existing conditions using four MSDGC models: (1) collection system model (USEPA SWMM 5); (2) process model (based on the GPS-X modeling software); (3) hydraulic model; and (4) water quality model. In addition to defining existing conditions and current LOS, model results are the basis of identifying opportunities for meeting the goals and objectives defined for the watershed.

Prior to conducting existing conditions modeling, MSDGC will provide the storm characteristics to be used in the modeling, including the typical year precipitation, monthly precipitation, the direction and velocity of storms in the growing and dormant seasons, and average monthly temperatures. Existing conditions will then be modeled using the collection system model(s) for the watershed and appropriate data collected in Step 1. Existing conditions will be modeled using continuous simulations and design storms. Using the outputs of the collection systems model(s), as well as flow monitoring data, existing conditions will be modeled using the process and hydraulic WWTP models. These results will be used to identify overflows and bottlenecks in MSDGC's sewer system, to direct potential opportunities for improvement. Details of the models and modeling processes are provided below.

In 2006, MSDGC developed a system-side model (SWM) based on USEPA's SWMM 4.0. Since 2006, MSDGC has used an iterative process to refine, verify, and update the model based on long-term flow monitoring data from its network of rain gauges (**Figure 5-4**). The dynamic rainfall-runoff simulation model is used for long-term (continuous) simulation of runoff quantity and quality for watershed management planning.

Figure 5-4 MSDGC's Iterative Approach to SWM Updates

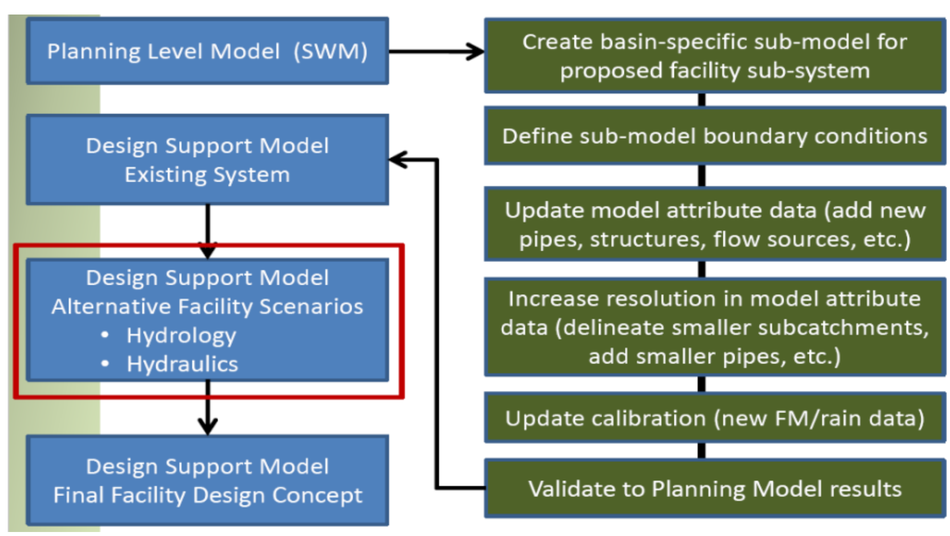


During this step of the SWEPP, data collected during Step 1 are used by SWM to design a support model to refine existing conditions. **Figure 5-5** demonstrates the steps taken to model existing conditions in SWM. Existing conditions will be modeled in accordance with MSDGC Modeling Standards Volume I System Wide Model (http://mymsd/PBD/ModelingMonitoring/Shared%20Documents/Forms/AllItems.aspx) (Revision 0, July 29, 2011).

SWM provides the following information, based on storm data provided by MSDGC, for each watershed or subwatershed boundary defined:

- Hydrologic Flow Volumes
- Hydraulic Model Inflow Volumes
- Hydraulic Model Outflow Volumes

Figure 5-5 Approach for Modeling Existing Conditions with SWM



Identify Opportunities for Integrated Watershed Strategies

Opportunities, at either the watershed or site level, leverage the overarching watershed goals and objectives to provide TBL benefits. With the comprehensive data collection and inventory analysis and existing conditions modeling complete, a broad understanding of watershed opportunities may be realized. The identification of opportunities will include multiple stakeholder collaborations; an LOS defined for current conditions within the watershed; and a desired LOS given the inventory and analysis. These would be used to identify the optimum solution set for the watershed, which would include direct impact, enabled impact, and inform & influence projects, as well as asset management and facilities improvement projects.

At this point in the planning process, the planning team should determine how to approach the identification and development of sustainable watershed solutions. To achieve volumetric reductions, as well as water quality and biological improvements, MSDGC has elected to pursue strategic (partial) separation in its service area watersheds. Partial separation involves installing new storm system infrastructure in the watershed's priority area (main channel) and implementing source control measures in non-priority areas (uphill portions of the watershed, hillsides, ridge-top neighborhoods). The project team identifies and refines which areas would be logically selected for separation or not, as well as other potential CSO reduction or other necessary improvements. Potential "enabled impact partners" and associated source control projects may also be identified.

Identify Watershed Constraints

With the identification of watershed opportunities, constraints specific to each can be identified. These may be identified based on model results (e.g., channel constraints) or during coordination with watershed partners (e.g., funding constraints). At this phase of the planning process, issues associated with the watershed opportunities will be identified, and will be considered when identifying specific source control, product control, and conveyance/storage options for the watershed. A primary source of watershed constraints is the list of stakeholder/watershed issues compiled as part of Step 1. As a component of the partner/stakeholder coordination, a list of stakeholder issues, concerns, and priorities will be documented. These will help determine areas/issues in the watershed that stakeholders expressed a great deal of concern about. Other activities to identify constraints include an evaluation of constructability issues, legal/legislative obstacles, property acquisition obstacles, etc. Watershed constraints will be refined when the watershed opportunities are developed into a comprehensive set of holistic and sustainable watershed projects, in Step 3 of the SWEPP.

Develop a Watershed Strategy

Development of a watershed strategy involves identifying projects that may be combined to develop a comprehensive set of holistic and sustainable watershed projects. A watershed strategy may include source control, conveyance and storage, and/or product control options, all described below.

As previously discussed, identifying the most cost-effective, sustainable, and beneficial combinations of infrastructure types for a specific watershed is the underlying goal of MSDGC's wet weather strategy. MSDGC evaluates multiple infrastructure combinations (including source control, product control, and conveyance/storage options) to determine the most cost-effective way to achieve a desired community benefit, while also meeting the required CSO reduction and SSO elimination requirements. These infrastructure options (or opportunities) will form the basis of watershed alternatives. MSDGC is leading the evaluation with source control alternatives to reduce the liability on the assets and the liability that stormwater and natural drainage represent with regard to triggering overflows.

USEPA's current integrated watershed policy framework for stormwater and wastewater recognizes that funding should be invested wisely to address locally defined and prioritized water quality/quantity solutions (USEPA, 2012). MSDGC is committed to developing public-private partnerships to help implement long-term, sustainable solutions that are best matched with current conditions to improve the LOS. For example, MSDGC has Memorandums of Understanding (MOUs) with partners, such as Cincinnati Parks Board, whereby maintenance can be implemented and the private property owners may be billed for the service.

Source control opportunities (see Section 3) are categorized as:

1. Direct Impact Projects (require direct investment by MSDGC)
2. Enabled Impact Projects (involve a leveraged infrastructure investment, or are opportunities for cost sharing and collaboration)
3. Inform & Influence Projects (elements that engage and educate watershed partners)

Identify Source Control Options

Table 5-6 outlines potential source control options, including Direct Impact, Enabled Impact, and Inform & Influence projects. Potential locations for each of these project types are based on extensive inventory

Table 5-6 Examples of Source Control Technologies

Source Control Option	Characteristics for Opportunity Potential
Stream/hillside stabilization	Unstable areas (areas where projects are separating flow and discharging it to natural areas)
Bioinfiltration	Permeable sublayers, undeveloped land; low-lying land
Deep infiltration	Permeable sublayers, undeveloped land; low-lying land
New detention basins	Existing topography that allows for natural detention areas; adjacent to large sections of separate storm sewer
Detention basin retrofit	Existing detention basin providing inadequate water quality or channel protection
Redevelopment opportunities	Sites, such as parks, that offer an opportunity for both stormwater management features and recreational improvements; underutilized sites, brownfields, obsolete retail centers
Downspout disconnections	Urban headwater zones that receive first flush rain events
Rain gardens	Urban headwater zones that receive first flush rain events
Swales	Existing topography that allows for natural retention; undeveloped land
Bioretention	Existing topography that allows for natural retention; undeveloped land
Reconfiguration of existing use	Existing impervious parking lots (e.g., to convert to a green parking lot, to use for a farmers market, during off-peak hours)
Stream restoration	Areas where the channel cannot accommodate the volume or velocity of stormwater
Historical stream daylighting	Piped or buried stream channel that could be used to convey stormwater
Reforestation	Canopy-deficient areas along major interstate corridors, road ROWs, and steep slopes
Separate Stormwater Conveyance System	Connections between other Direct Impact Projects
Extended detention wetlands	Existing topography that allows for natural retention; undeveloped land
Curbside bump-outs	Residential neighborhoods, urban areas
Pervious/permeable pavement	Parking lots, driveways
Sediment forebays	Existing topography that allows for natural detention areas; adjacent to large sections of separate storm sewer

and analysis of natural and built systems, investigation of historical development patterns, evaluation of community needs, functionality and compatibility in the area of implementation, and existing conditions modeling, as outlined in **Table 5-7**. Opportunities are also based on potential watershed partners. For example, if a "Complete Streets Corridor" is a desired outcome in the watershed, these could be closely coordinated as part of a watershed plan where opportunities exist and public partners are integral to the development of solutions. These solutions should address water quality and quantity issues and goals/objectives. It is important to have a good understanding of these issues, and the community goals, to select the appropriate technologies and watershed partners in specific areas of the watershed.

Other opportunities that may be identified include Enabled Impact Projects and Inform & Influence Projects. These projects may be implemented by entities other than MSDGC, such as watershed stakeholders or large property owners.

Enabled Impact Projects may include:

- Creating a partnership with a public or private entity to cost-share the implementation of a source control opportunity
- Green Demonstration Projects identified in areas where MSDGC can provide resources for project partners to install green infrastructure on their property (to date, these have included bioinfiltration, green roofs, pervious paving, rainwater storage, storm sewer separation, stormwater dry cells, and rain gardens)
- Early Success Projects, in priority watersheds, in areas where water quality and quantity benefits can be realized, and where the project would build support and trust within the community and with watershed stakeholders

Inform & Influence Projects may include:

- Projects implemented through the influence and education efforts of MSDGC by an outside entity, such as schools, parks, open spaces, institutional properties, educational facilities, road ROW, and vacant, abandoned, and foreclosed properties
- Influencing changes to local and /or state policies (e.g., changes to land development codes, watershed zones, tiered watershed zones, transfer of development rights, establishment of conservation easements)

Table 5-7 Summary of Conveyance/Storage Options Based on Existing Conditions

Conveyance/Storage Option	Characteristics for Opportunity Potential
Constructing underground storage tanks	Large impervious parking lots; adjacent to large sections of separate storm sewer
Rebuilding portions of the aging sewer system	Areas of the sewer or other equipment in relatively poor condition and operating efficiencies
Expansion of conveyance and storage infrastructure (elimination of HSTSs)	Un-sewered areas of Hamilton County
Upgrades/repairs to existing infrastructure to reduce I/I	Deteriorating infrastructure, such as sewers, manholes, and sewer lines
Constructing large underground storage tunnels to capture excess wastewater and to transport wastewater to WWTPs	Large areas, where topography allows for underground tunnel
CSS improvements (e.g., real-time control measures)	Deteriorating, aging portions of the sewer system
Sanitary sewer improvements	Existing sanitary sewer lines
Construction of new tunnel system(s)	Next to existing sewer lines, topography allowing for drainage

- Land development codes, watershed zones, tiered watershed zones with the potential for updating, or areas without these codes/zones currently; undeveloped or underutilized land areas

Identify Conveyance/Storage Options

Conveyance and storage options include grey infrastructure options, designed to control the volume of sanitary sewage and stormwater in the sewer system. Elimination of HSTSs, and addressing SSOs, PSOs, and sewage backups, in many cases might be the most significant improvement to water quality and could also increase MSDGC's customer base, if desired. MSDGC has put forth significant effort to make pump stations and other facilities fit into the community to enhance aesthetics of its facilities. Conveyance and storage options can include upgrading or constructing built systems, using natural systems, or integrating both natural and built systems. **Table 5-7** summarizes the various conveyance/storage solutions that could be used to meet the watershed goals and objectives.

Identify Product Control Options:

"Product control" refers to upgrading existing treatment plants to handle more wastewater or constructing EHRT facilities to treat flows at the CSO outfall prior to discharge (http://projectgroundwork.org/solutions/index.htm). Product control options include grey infrastructure solutions intended to treat combined flows, including upgrading existing treatment plants to handle more wastewater or constructing EHRT and/or chemically enhanced HRT (CEHRT) pump stations. In addition to construction of storage tunnels, the default solution for Cincinnati includes an EHRT to treat combined flow.

Potential EHRT facilities must be based on the "EHRT Design and Performance Criteria" (MSDGC, 2009), including the following parameters:

A. Design numeric criteria goals for high rate sedimentation treatment and disinfection treatment.

B. Design criteria specifics for unit processes. Each EHRT facility will include the following unit processes:

   1. Fine screens
   2. Coagulant-assisted sedimentation
   3. Coagulant feed and storage
   4. Hypochlorite disinfection
   5. Disinfectant feed and storage
   6. Disinfectant removal (dechlorination)

C. Each EHRT will be designed with the following attributes:

   1. Effective mixing at each point of chemical addition
   2. Separate sedimentation and disinfection contact zones
   3. A minimum total nominal detention time of 27 minutes
   4. A minimum nominal disinfection contact time of 10 minutes
   5. A maximum nominal sedimentation zone surface loading rate of 7,000 gallons per day/square foot

Each EHRT facility must comply with all requirements of state and federal laws and permits applicable to such discharges.

MSDGC has the opportunity to evaluate alternatives to the default solution, including the use of green infrastructure to control stormwater at the source.

DELIVERABLE:
Opportunities and Constraints Report

The purpose of the Opportunities and Constraints Report is to present the opportunities identified for the watershed, as well as any potential constraints to implementation of these opportunities. For each opportunity, water quality and water quantity benefits will be estimated using the CLM approach. Calculations will be based on project extent and type (area, estimated runoff reduction percentage, and estimated pollutant removal percentage), existing conditions modeling (annual stormwater runoff), and GIS inventory analysis (impervious and pervious drainage area). The estimated volume removal potential and pollutant removal potential will be used in the next step, the development of alternatives from the opportunities. The strategies that best meet the required volumetric reduction should be identified initially. These will be refined in subsequent steps, based on additional factors such as water quality improvement, social benefits, economic benefits, and specific community needs.

The Opportunities and Constraints Report will include a "decision matrix," with each opportunity listed and the associated constraints and identified risk. The report will be presented to the CFAC and watershed partners, after which changes may be made before finalizing the report. The watershed opportunities and constraints will be revised based on CFAC engagement and collaboration between MSDGC and watershed partners. The opportunities and constraints will form the basis of the watershed alternatives, established in Step 3 of the SWEPP.

Identify Urban Audit Corridors and Conduct Urban Audits

Urban audit corridors are identified by the MSDGC Planning Department. Urban audits are conducted by City Planning or by Hamilton County Regional Planning Commission and are implemented based on watershed land use and potential for conflicts between wet weather alternatives and urban areas. Information on property values and economic conditions in the watershed can be used to help identify potential redevelopment opportunities that could be linked with reductions in stormwater runoff and opportunities with public/private partners to improve communities and make them more livable and desirable places to work, live, and play. For each watershed, MSDGC will identify specific urban audit corridors, or blocks of buildings to be included in an urban audit.

The urban audit includes an inventory of each building in the corridor to collect data related to historical development, demographics, economic climate, and existing building conditions. Data will be collected through a desktop inventory as well as field visits to the corridor. **Table 5-8** summarizes the data to be collected in the urban audit. Analyzing the historical development of a corridor can provide insight into its character and susceptibility to change. Also, mapping changes in topography and development over time can indicate the location of historical wetlands and streams, former agricultural lands, sensitive landscape features that have been lost, and remaining natural features that may merit preservation. Understanding the economic health and social structure of a community helps to identify areas where the community can support additional land uses, services, infrastructure improvements, or development.

As part of the Lower Mill Creek Coarse Evaluation, a previous watershed evaluation conducted by MSDGC, the Hamilton County Regional Planning Commission developed a Building/Housing Survey Form for use in field-data collection and an ARC GIS 9.2 Urban Audit Tool. The form is used to collect the data summarized above, and the tool creates a GIS database of survey data, property photographs, and special comments. After compilation of the urban audit data, a report by block as well as for the total study area will be prepared. This report will identify the major property owners, total assessed value, overall vacancy rate, and a detailed description of property conditions as well as any other essential facts about the study area or specific parcels of interest. The urban audit will inform and influence the environmental, economic, and social components of the watershed management strategies identified in Step 2 of the planning process.

CFAC Engagement

The Communities of the Future framework, used to strategically link MSDGC efforts to broader community revitalization and sustainable infrastructure goals, is detailed in Section 4. MSDGC provides meeting schedules, meeting summaries, and presentations on the CFAC website (http://projectgroundwork.org/cfac/meetings.htm). MSDGC has developed an approach to incorporate these community elements, as well as input from public and private organizations, residents, and watershed stakeholders, in planning sustainable water resources infrastructure. In order to find all the opportunities to maximize the benefits from Project Groundwork, MSDGC is committed to engaging the community throughout the planning process.

Engagement with CFAC members will allow MSDGC to integrate community

Table 5-8 Summary of Urban Audit Data and Data Sources

Urban Audit Data Category	Dataset(s) to Compile	Source(s) of Data
Historical Development	– Pre-settlement conditions and historical landscape features – Early settlement conditions – Historical land uses – Significant industrial/commercial development – Critical points in a neighborhood's development (e.g., a prominent employer) – Connections to the urban core (i.e., downtown Cincinnati and first-ring suburbs)	– CAGIS – U.S. Geological Survey (USGS)
Demographics	– Population (historical, existing, projected) – Distribution of gender, age, and race/ethnicity – Educational attainment – Households (number, average size, characteristics) – Income (median household income, per capita income) – Housing data (housing types, tenure, median value) – Employment data	– United States Census Bureau – Cincinnati Department of Community Development – Hamilton County Department of Community Planning
Economic Climate	– Employment sectors – Employment trends (growth and/or decline by sector) – Real estate trends (growth and/or decline by land use type) – Real estate market demand – Growth sectors and employment activity nodes	– Contract economist – United States Bureau of Economic Analysis – Cincinnati Department of Economic Development – Hamilton County Department of Planning and Development
Property Information	– Building age and condition – Building use – Building rating – Blighting Influences – Historical designation – Foreclosure status – Parcel size, location, ownership – Description of property use (as classified by County Auditor) – Property value (land and improvements) – Overall building rating	– Field data collection – Hamilton County Auditor – Cincinnati Department of City Planning and Buildings

needs into its planning efforts. CFAC involvement will help MSDGC remain engaged in existing regional and local policy documents and processes, and in the priorities and needs of the whole region. CFAC input will be used to develop plans, facilitate stronger partnership with City Planning and the Hamilton County Regional Planning Commission to create solutions that are addressing multiple issues, and allow MSDGC to be kept up-to-date on watershed-specific issues and priorities. CFAC will also help to identify additional key stakeholders in the watershed.

Coordinate with Watershed Partners

In addition to community engagement, MSDGC is committed to coordinating with its watershed partners throughout the planning process. While coordination will occur throughout the planning process, MSDGC will share new information collected in Step 2 and preliminary opportunities and constraints identified during this step. MSDGC will share new information, discuss any changes to the watershed, and evaluate the preliminary opportunities and constraints. Issues identified by the watershed partners will be a key component of developing the proposed LOS for the watershed and for developing watershed alternatives.

Revisit Watershed Goals and Objectives

After completing hydrologic, hydraulic, and water quality modeling of existing conditions, MSDGC and partner agencies will verify and enhance the watershed goals and objectives. The identified opportunities and constraints will allow the group to update goals and objectives, so that they can be quantified. Any changes to the goals and objectives should be recorded, and associated changes to KPIs should be entered into the Sustainability LENS Tool. Based on this information, the Sustainability LENS Tool will be used to input target watershed information and to output the proposed LOS.

DELIVERABLE:
Proposed Watershed LOS Report

The Proposed LOS Report will define the desired stormwater and wastewater LOS provided, including LOS related to the KPIs selected for the specific watershed. The proposed LOS will be based on existing conditions, community input, stakeholder and watershed partner input, and the outputs of the Sustainability LENS Tool. The Proposed LOS Report will serve as the basis for identifying potential watershed projects and alternatives and, along with the Current LOS Report, will be used to evaluate the success of the implemented alternatives.

Step 3: Develop and Evaluate Alternatives

Step 3 of the SWEPP — Develop and Evaluate Alternatives — utilizes information in the Opportunities and Constraints Report and the Proposed Watershed LOS Report to identify, evaluate, and prioritize sustainable watershed management alternatives. Step 3 is a planning exercise for alternative prioritization. The end product of Step 3 is the Preliminary Watershed Master Plan, which is the recommended alternative for the watershed. The Preliminary Watershed Master Plan will outline all projects recommended to be carried forward, including direct impact, enabled impact, asset management, facilities improvements, and inform & influence projects. The Preliminary Watershed Master Plan, which will include an implementation timeline and cost allocation schedule, will be presented to CAPEX as the final step in Step 3 of the SWEPP.

Identify Watershed Alternatives

Using the opportunities identified in Step 2, a comprehensive set of watershed alternatives will be developed. The set of alternatives will include combinations of grey and green infrastructure, following the strategic separation plan established in Step 2. As mentioned in the previous step, coarse water quality and water quantity benefits are estimated for each potential opportunity. These benefits are used to identify logical combinations of opportunities to form each alternative. Each alternative developed should be designed to independently meet the watershed goals and objectives, including volumetric CSO reduction and economic, environmental, and social elements. Whenever possible, the alternatives should aim to: reconnect stormwater to natural systems; improve and restore terrestrial and aquatic habitats and wildlife corridors; restore natural hydrologic patterns and increase natural base flows; improve regional water quality; and build upon community connectivity.

A key basis for selecting MSDGC's watershed alternatives is the need to manage water resources by different zones and tiers within the watershed. MSDGC applies a watershed transect to create sustainable systems. Zones of opportunity are identified based on watershed characteristic such as forested hillsides (opportunity to capture natural streamflow), highly developed communities (opportunities for near source controls such as downspout disconnection or rain gardens), and open space corridors (opportunity to enhance existing community and recreational uses). An example of zones of opportunity is provided in Section 4. As an example, the Lick Run watershed was divided into: (1) ridgetop communities, (2) forested hillsides, (3) community core, and (4) open space corridors (see Section 4).

Conduct Detailed Modeling for Watershed Alternatives

In the previous step, coarse estimates of stormwater runoff and pollutant loads for the watershed were developed. After the comprehensive set of alternatives is established in the beginning of Step 3, a detailed model analysis is conducted to evaluate the benefits of each alternative, based on expected changes from the existing conditions modeled in Step 2 and refined in Step 3. MSDGC's modeling process was summarized previously. This same process will be followed to model each watershed alternative identified in the first sub-step of Step 3.

Alternatives will be modeled in accordance with MSDGC Modeling Standards Volume I System Wide Model (http://mymsd/PBD/ModelingMonitoring/Shared%20Documents/Forms/AllItems.aspx) (Revision 0, July 29, 2011). MSDGC's current version of SWM utilizes the USEPA SWMM 5.0.021 engine, in which USEPA extended SWMM 5 to explicitly model the hydrologic performance of specific types of LID controls, such as porous pavement, bio-retention areas (e.g., rain gardens, green roofs, and street planters), rain barrels, infiltration trenches, and vegetative swales. SWM is used to conduct a discharge mass balance for each alternative for the typical rainfall year simulation. The model estimates the reduction in CSO discharges, which is input to the Sustainability LENS Tool, as a component of benefit quantification. The PBD Modeling group will determine which version of the models should be used.

Additional models, such as HEC-RAS, may need to be utilized for projects that would affect Federal Emergency Management Agency (FEMA)-defined floodways and/or floodplains.

Based on the water quality assessment conducted in Step 2 as part of existing conditions modeling where pollutants of concern (POCs) were identified, water quality modeling in Step 3 is conducted to

STEP 3: DEVELOP AND EVALUATE ALTERNATIVES

Inputs, Outputs, and Tools

Inputs

1. Life cycle cost data
2. Model parameter data
3. Proposed and Existing LOS
4. As-needed Field Survey Result
5. Feedback from watershed partners, stakeholders, and community engagement

Outputs

1. Class V cost estimates
2. Model results and estimated LOS for alternatives
3. Preliminary Watershed Master Plan (i.e., alternatives analysis and a detailed description of all recommended projects, including direct impact, enabled impact, asset management, facilities improvements, and inform & influence projects)

Tools

1. MSDGC collection system models for each of the seven WWTP Basins (USEPA SWMM 5)
2. MSDGC process models for each of the seven WWTP basins (based on the GPS-X modeling software)
3. MSDGC hydraulic models for each of the seven WWTP basins
4. Water quality model (dependent on the water quality priorities in the watershed)
5. Sustainability LENS Tool
6. Financial Analysis Manual and associated MSDGC cost estimating standards
7. Project Development and Alternatives Development Guidelines
8. Risk Assessment Tool

Risks

1. Quality of collection system flow monitoring data — Some sites are very difficult to monitor and thus the quality of the data may not be to the desirable level. This may, in turn, result in models that are not accurately representative of MSDGC's system.
2. Managing Stakeholder Expectations — It should be anticipated well in advance that not all of MSDGC's stakeholders will be satisfied with the watershed plans, especially if not all of their major concerns and issues can be addressed via MSDGC's work.
3. Level of detail associated with cost estimates. The cost estimates at this step are Class V (planning-level) estimates and therefore have a greater degree of inaccuracy than, for example, 90% design level cost estimates. Market conditions are unpredictable. The development of these plans and the cost estimates associated with them are a "snapshot in time." The economy, price of materials, etc. may cause the plan to change in the future.

evaluate the benefit of alternatives that aim to achieve water quality improvement.

Model outputs will be used to quantify the KPIs applicable to the watershed goals and objectives. These will be input to the Sustainability LENS Tool to evaluate the benefits of each watershed alternative. The Sustainability LENS Tool (see Section 4 and Appendix C) will quantify alternative benefits (on a definitive set of metrics), as they relate to CSO and SSO reduction, pollutant removal, and the selected economic, environmental, and social benefits.

Develop Class V Life Cycle Cost Estimates

MSDGC's Financial Analysis Manual was developed to establish standard financial guidelines to increase the accuracy of business case cost evaluations. Many costs may be associated with the O&M of an asset throughout its useful life. The elements of the asset life cycle may include maintenance, relocation, modification, preparation, improvement, or other improvement of the utility of the asset. Evaluation of any investment requires knowledge of the cash flows during the asset's life. It is essential to estimate the initial investment of all operating costs, based on the information obtained during a feasibility study. Items not examined in the current MSDGC Financial Analysis Manual will be subject to different life cycle cost estimates. These cost estimates will be developed based on previous studies, literature costs, and local cost information. The cost estimate will include an evaluation of the costs of any projects recently completed by MSDGC.

After the estimate is developed, the usual practice is to apply discounted cash flow techniques to the data in order to generate a measure of its economy.

In accordance with the most up-to-date Financial Analysis Manual (http://mymsd/PD/ProjectControls/Estimating/Estimating%20Forms/Financial%20Analysis%20Manual/Financial%20Analysis%20Manual.pdf), MSDGC will use the following discounted cash flow techniques for each alternative:

- Life cycle cost analysis
- Present value analysis
- TBL analysis

The results of these analyses will be utilized in the evaluation and prioritization of watershed alternatives.

Coordinate with Watershed Partners

With new information collected in Step 3, and watershed alternative benefit and cost estimates completed, MSDGC will organize a meeting with watershed partners and stakeholders. The purpose of the meeting will be to share new information, discuss any changes in the watershed, and discuss the preliminary findings. The outcome of this meeting will be a key component of revisiting the watershed goals and objectives and refining the alternatives to the subwatershed level.

Revisit Watershed Goals and Objectives

The watershed goals and objectives are refined and updated based on the comprehensive inventory and analysis completed in Step 1 and on the identification of opportunities and constraints in Step 2. At this phase, hydrologic, hydraulic, and water quality modeling of existing conditions and future conditions with alternative implementation has provided greater insight into the opportunities for CSO reduction and SSO elimination, as well as social, economic, and environmental community benefits. Based on this new information, MSDGC and the watershed partner agencies should again collaboratively revisit the watershed goals and objectives and refine and update them accordingly. Any changes to the goals and objectives should be recorded, and associated changes to KPIs should be entered into the Sustainability LENS Tool.

Evaluate Watershed Alternatives and Refine to Subwatershed Alternatives

Two primary tools will be used to evaluate and prioritize the watershed alternatives: (1) Project Development and Alternatives Development Guidelines, and (2) Risk Assessment Tool. The Project Development and Alternatives Development Guidelines will be used to evaluate the cost-benefit ratio of the watershed strategies. Outputs of the Sustainability LENS Tool (i.e., the quantified alternative benefits, or LOS) and Class V life cycle cost estimates will be the inputs to the alternatives prioritization process.

Community Engagement — Open House to Vet Existing Conditions and Initial Opportunities and Constraints

The support of the community is vital to the success of any planning project, including large-scale infrastructure projects like Project Groundwork. Community support is most easily gained through public involvement, which facilitates dynamic interaction among the project team, residents, and watershed stakeholders. Consequently, public interaction creates an informed constituency that can be involved in planning initiatives, review of proposals for plan consistency, and collaborative implementation of plan alternatives.

MSDGC has a Project Groundwork communications plan and will define a watershed-specific preliminary public relations strategy, including the intended audiences, the issues and opportunities relevant to the watershed and the project, targeted outreach materials, and ideas for hands-on workshops, surveys, public meetings, and materials to be distributed. MSDGC will engage the community throughout the planning process, with the first steps being conversations with local community members and groups and meetings and discussions with key stakeholders. At this step, MSDGC will present the information gathered in Steps 1 and 2 of the SWEPP to the community. Feedback provided from all community engagement activities will be carried forward to the recommendations in the Preliminary Watershed Master Plan.

Conduct Refined Modeling and As-needed Field Assessments for Subwatershed Alternatives

For many of the subwatershed alternatives identified, MSDGC will have sufficient information to evaluate the feasibility, benefits, constructability, etc. However, certain alternatives may require field surveys prior to evaluation. At this phase in the planning process, MSDGC will conduct as-needed field surveys, such as assessments of utilities, topography, wetlands, protected species, and cultural resources.

DELIVERABLE:
Alternatives Decision Matrix

Using the Project Development and Alternatives Development Guidelines and Risk Assessment Tool, the planning team will develop a “decision matrix,” with each alternative listed considering the associated cost-benefit ratio, and identified risk. The benefits to be measured will include those identified as KPIs for the watershed, including CSO reduction, water quality improvement, SSO and sewer backup elimination, and community enhancement. Based on the results of the alternatives analysis, the watershed alternatives will be refined to the subwatershed level, so that a more detailed analysis may be conducted on those alternatives carried forward.

After field surveys (if needed) are completed, the subwatershed alternatives will be modeled to evaluate the benefits. This same process will be followed to model each subwatershed alternative identified. Model outputs will be used to quantify the KPIs applicable to the watershed goals and objectives. These will be input to the Sustainability LENS Tool to evaluate the benefits of each subwatershed alternative. The Sustainability LENS Tool (see Section 4) will quantify alternative benefits (on a definitive set of metrics), as they relate to CSO reduction and SSO elimination, pollutant removal, and the selected economic, environmental, and social benefits.

Develop Refined Class V Life Cycle Cost Estimates

Class V life cycle cost estimates will be developed for the subwatershed alternatives. The cost estimating process was previously summarized.

Evaluate Subwatershed Alternatives

Similar to the evaluation of watershed alternatives, the subwatershed alternatives will be evaluated using the Project Development and Alternatives Development Guidelines and Risk Assessment Tool. Inputs to the Project Development and Alternatives Development Guidelines include outputs of the Sustainability LENS Tool and the Class V life cycle cost estimates. This step may require additional internal facilitation and meetings with external stakeholders to present proposed plans. The end product of this step will be a prioritized list of subwatershed alternatives for the watershed.

Present Preliminary Watershed Master Plan to CAPEX

Once developed, CAPEX will be the owner of the Watershed Master Plan. Using information provided in the Preliminary Watershed Master Plan, the Cross Functional Core Team (CFCT) will establish the projected CAPEX and Operations and Maintenance Expenditures (OPEX) timeline for the watershed. This information will aid in the development of cash flows and achieving/maintaining the watershed's LOS as well as determining the current or existing "Customer" LOS and the gap between it and the "Target" LOS sought by customers through public outreach. The CFCT will also determine the enterprise-level responsibilities for each of the watershed projects (i.e., who manages the projects, such as PBD, PD, EMP, external stakeholders, etc.).

DELIVERABLE:
Preliminary Watershed Master Plan

Using the information gathered throughout the SWEPP, MSDGC will develop the Preliminary Watershed Master Plan. The report will include the alternatives analysis and final recommended projects in the watershed, including direct impact, enabled impact, asset management, facilities improvement, and inform & influence projects. The alternatives analysis will use the Project Development and Alternatives Development Guidelines and will be used to develop the project-specific BCEs. The plan will include a detailed description of all projects, including the estimated LOS and the entity responsible for managing the project. An example outline of a Preliminary Watershed Master Plan is included as Appendix D to demonstrate the necessary components. Upon approval of the plan by CAPEX (see next step), the plan would be presented to CFAC and other watershed stakeholders for additional input. Additional coordination with the watershed partners should be completed at this stage to address project sequencing to minimize potential project conflicts and duplication of effort (i.e., on transportation or related development projects).

Recommendations will be based on conceptual level engineering and planning. Step 5 of the overall process is intended to conduct detailed planning before moving into design and eventually construction.

Step 4: Develop Master Plan

Step 4 of the SWEPP — Develop Master Plan — involves developing a Watershed Master Plan, based on projects identified in the Preliminary Watershed Master Plan. Step 4 is a prioritization process for implementation of specific projects. During this phase, alternatives will be prioritized and only the most cost-effective ones will remain. MSDGC's CFCT will be involved in defining watershed project responsibilities and conducting CIP prioritization and planning for the watershed. The Master Plan will include multiple technologies, and therefore Step 4 is highly collaborative and involves multiple divisions within MSDGCto determine which projects will be included in the Master Plan. When Step 4 is complete, the final Watershed Master Plan will outline the prioritized action plan for the watershed with implementation timeline, construction sequencing, cost allocation, and responsibilities.

STEP 4: DEVELOP MASTER PLAN

Inputs, Outputs, and Tools

Inputs

1. Preliminary Watershed Master Plan
2. CAPEX involvement
3. Feedback from watershed partners, stakeholders, and the community
4. Preliminary engineering

Outputs

1. Class V cost estimates
2. Watershed Master Plan (i.e., a prioritized action plan for the watershed with implementation timeline, construction sequencing, cost allocation, and responsibilities for all recommended projects)

Tools

1. Project Development and Alternatives Development Guidelines
2. Risk Assessment Tool
3. Sustainability LENS Tool

Risks

The major risks associated with this step are the same risks identified for Step 3.

Capital Improvement Planning and Prioritization

Once the enterprise-level responsibilities are determined, projects included in the Preliminary Watershed Master Plan will be subject to the CFCT's review and prioritization process. PBD has developed documents that will be used during this step: Planning Fact Finding and Questionnaire (http://mymsd/PD/MPMPv2/Pages/default.aspx, Section 11, Volume III, PBD-SAP-11-008) and Planning Review Checklist (http://mymsd/PD/MPMPv2/Documents/MPMP-11-04%20Planning%20Turnover%20to%20Project%20Delivery%20Procedure.pdf).

CFAC Engagement

The Preliminary Watershed Master Plan will be presented at the quarterly CFAC meeting (http://projectgroundwork.org/cfac/meetings.htm). CFAC will provide feedback on the watershed master plans and help MSDGC determine the most important facilitation tools for the community engagement meeting to present the BCE. Any changes to the proposed plan will be noted and may be incorporated into the Watershed Master Plan.

Community Engagement — Open House to Present Preliminary Watershed Master Plan

MSDGC will continue to engage the community throughout the planning process. One community engagement strategy that may be undertaken at this step would be an open house to continue

DELIVERABLE:

Watershed Master Plan

The end result of Step 4 of the SWEPP is development of the Watershed Master Plan, which is essentially a CIP for a watershed. It will detail all projects that are selected to advance into the detailed planning and design phase, including estimated LOS, implementation timeline, construction sequencing, cost allocation, risk management plan, monitoring plan, anticipated impacts on other watersheds, and responsibilities (i.e., entity responsible for managing each project). In addition, the initial results of the BCE will be verified with the Sustainability LENS Tool to evaluate how well the final plan meets the sustainability objectives identified throughout the planning process.

Additional coordination with the watershed partners should be completed at this stage to address project sequencing to minimize potential project conflicts or duplication of effort (i.e. on transportation or related development projects). The following will be considered when sequencing projects within a watershed:

- Ability to measure goal to achieve or maintain the chosen LOS
- The timeline to achieve the LOS
- The necessity of joint projects
- Staffing/skill set issues among MSDGC personnel
- The minimization of rate increases
- Permits required for construction
- Easement purchase
- Property purchase
- Remediation of property
- Partner coordination

The MSDGC Executive Director has authority for the ultimate approval of the MSDGC Master Plan, after which CAPEX becomes the owner of the plan.

to inform the community of SWEPP progress. At this point, MSDGC has developed a watershed BCE, based on the needs of the community. MSDGC would share the results of the BCE and determine additional community concerns/issues.

Step 5: Implement Master Plan

Step 5 of the SWEPP — Implement Master Plan — involves the detailed planning, design, and construction of projects included in the Master Plan. Depending on the project type, this step will be led by the appropriate MSDGC division. The step involves developing project-specific business case evaluations, implementation plans, engineering design plans, and monitoring plans. Once constructed, projects will be tracked in the Capital Improvement Planning Book and will be monitored and evaluated according to Step 6 of the SWEPP.

Conduct Detailed Design

The first component of implementing the Master Plan involves conducting additional analysis and using these results to refine, update, and verify alternatives. The following assessments/studies/designs will be conducted, and the results will be used to make any necessary revisions to the conceptual designs:

- Preliminary Design
- Detailed Topography Assessment
- Utility Location Assessment
- Environmental Assessment
- Geotechnical Survey
- Historical and Archaeological Surveys
- Alternatives Funding Review

Project-Specific BCEs

At this phase of the planning process, there is sufficient information to make a business case for the watershed. MSDGC has developed a Business Case Evaluation template (http://mymsd/PD/MPMPv2/Pages/default.aspx, Section 11, Volume III, PBD-SAP-11-002) to streamline and systematize selection and approval of watershed management alternatives. This template will be used to conduct a coarse BCE to ensure that all steps have been taken and all information considered before moving forward in the planning process. The BCE should identify any gaps in alternatives analysis, such as:

- Regulatory requirements/restrictions
- Applicable laws
- Adherence to WWIP schedule
- Key stakeholders
- Sustainability LENS Tool analysis
- Affordability
- Impact on other planned projects
- Capacity analysis
- Staffing/skill set issues
- Communities of the Future vision/engagement

The end result of each BCE will be an evaluation of the value measurement (life cycle cost per defined benefit) and potential risks. Each BCE will include the following components:

- Problem
  - Problem statement
  - Condition assessment
  - Problem diagnosis
  - Problem boundary
  - Project objectives
- Strategies:
  - Development
  - Initial screening (O&M, equipment, training, construction)
  - Analysis
- Alternatives
  - Description

STEP 5: IMPLEMENT MASTER PLAN

Inputs, Outputs, and Tools

Inputs

1. System Modeling
2. Environmental Assessment
3. Detailed Survey Results (topography, utilities, geotechnical, cultural and archaeological, protected species, etc.)
4. Alternatives Funding Review

Outputs

1. Project-specific BCEs
2. Construction Plans
3. Project Monitoring Plans

Tools

1. MSDGC's Engineering Guidelines
2. MPMP
3. Engineering Design Tools
4. Capital Improvement Planning Book

  - Development methodology
  - Analysis methodology (regulatory requirements/restrictions, impacts to WWIP schedule, key stakeholders, Sustainability LENS Tool analysis, affordability, impact on other work in the watershed, capacity analysis, project risk, organizational risk, energy efficiency / carbon footprint, staffing/skill set issues, Communities of the Future, value added),
  - Comparison
  - Recommendation
- Execution plan
  - Steps
  - Timeline
  - Roles and responsibilities
  - Technical baseline
  - Project risks
  - Cost estimate and budget
- Engineering documents
  - Conceptual report
  - Preliminary engineering analysis report
  - Basis of design report
  - Cost estimates
  - VE study

Once the Final BCE Report has been signed for approval, it will be handed over to MSDGC PD for implementation.

Develop Engineering Design and Construction Plans

At this phase in the planning process, engineering plans will be developed for the prioritized watershed projects. These engineering plans will be a key component of the Watershed BCE. If necessary, a VE Study will also be completed to optimize preliminary engineering plans. MSDGC's Engineering Guidelines and MPMP (http://mymsd/PD/MPMPv2/Pages/default.aspx) should be considered during development of the engineering plans.

DELIVERABLE:

Final Engineering Documents as Approved by MSDGC

Final engineering documents for recommended projects will be developed for implementation by MSDGC.

Develop Project Monitoring Plan

A monitoring and reporting system will need to be developed to determine the effectiveness of the watershed improvements. These will be measured against the watershed's functional requirements and reviewed against the design criteria to determine a need to revise those improvements should a watershed's goals not be met. Quality objectives and metrics will be established to monitor the trending of watershed performance over time and action levels established.

The details of the proposed monitoring locations and success criteria are specific to each watershed and will be identified in the design phase of alternative implementation (post-SWEPP). These may be updated during the construction and implementation phase of the process and vary by direct impact and enabled projects.

DELIVERABLE:

Project Monitoring Plan

The Project Monitoring Plan will include regularly scheduled activities aimed at tracking project sustainability and identifying conditions which might pose a risk to the overall project success.

Construction

At this point in the master planning process, construction of the recommended project will take place.

Step 6: Monitoring, Reporting, and Evaluation

Step 6 of the SWEPP — Monitoring, Reporting, and Evaluation — involves all post-construction activities, such as performance monitoring, O&M, CIP tracking, benchmarking, and (if necessary) adaptive management. These sub-steps occur throughout the life of the project, from development to implementation. Step 6 serves as an input to all other steps of the SWEPP by compiling the lessons learned throughout the entire SWEPP and applying these lessons to the next implementation of SWEPP.

Performance Monitoring of LOS Goals

The performance of alternative projects, specifically their success in achieving the desired LOS, will be evaluated according to the Project Monitoring Plan developed in Step 5. The responsible entity for performance monitoring, as well as the type of monitoring that will be conducted, will depend on the project type and owner. The Monitoring Plan will include an adaptive management approach to post-construction monitoring. Adaptive management includes an internal feedback loop for continuous improvement,

STEP 6: MONITORING, REPORTING, AND EVALUATION

Inputs, Outputs, and Tools

Inputs

1. Project Monitoring Plan
2. O&M Plan
3. Updated Project Monitoring Plan (through feedback loop)

Outputs

1. Project Monitoring Report
2. Updated Project Monitoring Plan (if necessary)
3. Lessons Learned Report
4. Adaptive Management (if necessary)

Tools

1. Water quality sampling tools
2. Biological assessment tools
3. Peak flow monitoring tools
4. Conveyance tools
5. CIP tracking tools/processes
6. Sustainability LENS Tool

as well regular review and updates to the plan as necessary based on new information from project implementation or monitoring. It should be noted, however, that monitoring is voluntary and is not a requirement of the Final WWIP. Dependent on the specific project, MSDGC may elect to conduct monitoring; however, post-construction monitoring is not required until the LMCPR is complete.

Water Quality Monitoring and Biological Assessments

MSDGC source control projects will be evaluated based on water quality and biological monitoring assessments conducted by the EPM Department. In 2011, MSDGC initiated a comprehensive watershed assessment process consisting of water quality and biological assessment, so that all watersheds in the MSDGC service area are assessed on a four year rotation. The goal of the program is to evaluate current conditions and identify water quality and biological trends, using a comparison to historical data collected by MSDGC and Ohio Environmental Protection Agency. The ultimate goal of this watershed assessment program is the development of an integrated prioritization system that will allow MSDGC and stakeholders to determine which restoration and abatement projects have demonstrated the highest degree of success in improving stream quality.

MSDGC began bioassessments within its watersheds to identify the POCs and impairments of waterways so that its CIPs can better align with projects that help achieve water quality goals through prioritization. The lack of an acceptable base flow as well as channelization were identified as major impairments to Mill Creek through such bioassessments. BMPs upstream are evaluated in the watershed and based on land use analysis/etc., the appropriate BMPs will be evaluated to address the POCs identified.

Peak Flow Monitoring

MSDGC's Modeling and Monitoring Group is in the process of developing a methodology for peak flow monitoring. The methodology will be drafted in a document titled MSDGC Flow Monitoring Program: Guidelines and Standards, the first version of which will be available in 2012. Currently, the WWC Division depends on their consultants to follow the industry procedures for flow monitoring. The DIW sampling procedures are currently being updated and are not available at the time of this draft.

Enabled Projects

MSDGC has utilized partnerships to implement sustainable solutions — the premise of the sustainability program is to enable impacts through these partnerships, and monitoring and measuring success is an area where partnerships are especially useful. Through its monitoring of the Enabled Impact Projects, MSDGC has worked collaboratively with CPB, USEPA National Risk Management Research Laboratory, and universities to identify and evaluate monitoring options. MSDGC has leveraged these partnerships to perform qualitative monitoring using seasonal site inspections and wet weather inspections. Specifically, Cincinnati Parks is performing routine site inspections on all completed enabled impact projects either annually, semi-annually, or quarterly (depending on the type of controls present), with the property owners present to help inform and influence the owner on BMPs for long-term sustainability of the green infrastructure.

Site inspections are periodically conducted after high-intensity wet weather events to assess performance of the controls and overflow structures. The purpose of these inspections is to record site conditions over the long term, assess long-term viability of the green controls, and identify potential issues related to functional operation, maintenance, and vegetative success (where vegetation exists).

Inspection forms for each type of green infrastructure and site-specific photo-documentation protocols have been developed for the Enabled Impact Program. The inspection forms ensure that a thorough inspection is uniformly and consistently performed. The photo-documentation protocol allows direct comparison of conditions at each location over time. All data collected during qualitative monitoring are entered into a Microsoft® Access-based database located on shared MSDCG/CPB servers. This database can generate site summaries, maintenance reports, and maintenance follow-up reports. Longer term, MSDGC is interested in potentially considering other partnerships for monitoring and could entertain options where community groups or watershed groups might take a more active role in this Enabled Impact Program monitoring to also broaden the inform & influence opportunity that these projects present.

Currently, maintenance issues identified during either seasonal or wet weather site inspections and suggested corrective actions are shared with the property owner (who has the responsibility for addressing these issues) via a standardized form letter and other correspondence. Follow-up inspections are scheduled with the property owner to ensure that maintenance has been performed. Quarterly reports are developed, and excerpts from select projects are included, providing examples of the inspection forms and level of detail included with each site inspection.

DELIVERABLE:
Project Monitoring Report

After each scheduled monitoring event, a Project Monitoring Report will be developed and submitted to MSDGC for review. The report will include the monitoring methodology, results, and a comparison to the success criteria outlined in the Project Monitoring Plan. Project Monitoring Reports will be used to determine project success, identify trends over time in performance indicators, track project sustainability, identify any conditions that may pose a risk to the overall project success, and identify necessary changes to performance monitoring and/or O&M.

Operations and Maintenance

Depending on the project type, the appropriate department is responsible for providing O&M procedures for the project. Currently, projects associated with SMU follow the City of Cincinnati, Stormwater Operation & Maintenance Master Plan (May 2005). This document is currently being updated.

DELIVERABLE:
Updated Project Monitoring Plan

In accordance with an adaptive management strategy, which will be assumed for each MSDGC project, Project Monitoring Plans will be updated, as needed. Updates will be based on performance monitoring results and/or conditions identified during regular O&M of the project site.

Adaptive Management

In order to optimize long-term success and stewardship of a Watershed Master Plan project, an adaptive management strategy will be followed. While risks and uncertainties are characterized throughout the planning process, adaptive management plans are established so that unforeseen conditions can be addressed. Adaptive management may be required in the case of unforeseen risk, or in case post-construction monitoring information suggests that minor changes to the project are needed to better achieve the success criteria and objectives. Measures may include changes to O&M, project monitoring, and/or physical changes to the project itself. Adaptive management will be watershed-specific and will be used to adapt plans created during a specific SWEPP. Adaptive management procedures are not intended to revise the Watershed Master Planning Process. Any process-oriented changes will be documented as part of the "lessons learned," detailed below.

CIP Tracking

MSDGC uses a 5-year capital planning cycle for the repair, replacement, or improvement of its physical infrastructure assets. PD manages implementation of planned capital projects including detailed design, easements and property, acquisition, preparation and presentation of related legislation, and project management through all project phases.

Benchmarking

Monitoring data collected pre- and post-construction will be used to benchmark watershed plans and to continue to evaluate project success. The Sustainability LENS Tool (see Appendix C) will be used to input monitoring data (related to KPIs) and to use the outputs to evaluate key aspects of sustainability aligned with projects goals and objectives. The Sustainability LENS Tool can also be used to compare and track the success of multiple watersheds.

Lessons Learned

Throughout the Watershed Master Planning Process, the watershed team will document lessons learned to carry forward to other watershed planning efforts. The watershed team will identify the optimal methods for capturing and presenting lessons learned based on the specific watershed effort. These methods may include a Lessons Learned Memorandum submitted to all MSDGC departments and/or an interdepartmental debriefing session. The lessons learned process is considered a critical component of the Watershed Master Planning effort and will be emphasized throughout the entire process.

SECTION 6

References

Agenda 360 and Vision 2015. September 2010. Our Region by the Numbers, 2010 Regional Indicators Report for Greater Cincinnati and Northern Kentucky.

Beach, C., R. Judd. 2003. Natural States. Cited in Targeted Watersheds Grants Program: Urban Watershed Capacity Building Grant. www.epa.gov/watershed/initiative/pdf/twg_uwrfp.pdf. Accessed July 2012.

Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. USEPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington, D.C.

Endreny, T. 2008. Naturalizing urban watershed hydrology to mitigate urban heat-island effects. Hydrological Processes. 22:461–463.

Environment Canada. 2001. Stormwater Planning Guidebook for British Columbia.

Freeman, M.C., C.M. Pringle, and C.R. Jackson. 2007. Hydrologic connectivity and the contribution of stream headwaters to ecological integrity at regional and global scales. Journal of the American Water Resources Association 43:5-14.

Gunderson, J., R. Roseen, T. Janeski, J. Houle, and M. Simpson. May 2011. Economical CSO Management. Journal for Surface Water Quality Professionals. http://stormh2o.com/SW/Articles/Economical_CSO_Management_14216.aspx. Accessed July 30, 2012.

Hamilton County, Ohio, Community Compass. 2030 Implementation Plan and Framework. www.communitycompass.org/cgi-sys/suspendedpage.cgi.

Hedeen, S. 1995. "The Mill Creek - An Unnatural History of an Urban Stream". Rivers Unlimited Mill Creek.

Karr, J. R., K. D. Fausch, P. L. Angermeier, P. R. Yant, and I. J. Schlosser. 1986. Assessing Biological Integrity in Running Waters, a Method and Its Rationale. Illinois Natural History Survey Special Publication 5.

Karr, J.R. and C.O. Yoder. 2004. Biological assessment and criteria improve TMDL planning and decision-making. Journal of Environmental Engineering 130(6): 594-604.

Ladson, A., I. Rutherfurd, M. Stewardson. 2004. Evaluating Stream Rehabilitation Projects: Reasons Not To, and Approaches if you have to. Australian Journal of Water Resources, Vol. 8, No. 1, 2004: 57-68, http://search.informit.com.au/documentSummary;dn=474525286245745;res=IELENG.

Metropolitan Sewer District of Greater Cincinnati. 2009. History of Stormwater Management Utility. http://msdgc.org/stormwater/history.htm. Accessed October 17, 2011.

Metropolitan Sewer District Of Greater Cincinnati. 2009. Final Wet Weather Improvement Program.

Metropolitan Sewer District of Greater Cincinnati. 2011. Strategic Plan - Expanding Our Horizons: Vision 2012-2014. www.msdgc.org/downloads/strategic_plan/msd_strategic_plan.pdf.

Metropolitan Sewer District of Greater Cincinnati. May 2012. Lick Run Watershed Master Plan. http://projectgroundwork.org/projects/lowermillcreek/sustainable/lickrun/cdw1.htm#masterplan.

Metropolitan Sewer District of Greater Cincinnati. July 2012. Lower Mill Creek Partial Remedy. Alternatives Evaluation Preliminary Findings Report. http://projectgroundwork.org/downloads/reports/lmcpr_alternatives_eval_prelim_findings_report_25jun2012.pdf.

Meyer, J.L., D.L. Strayer, J.B. Wallace, S.L. Eggert, G.S.Helfman, and N.E. Leonard. 2007. The contribution of headwater streams to biodiversity in river networks. Journal of the American Water Resources Association 43: 86-103.

Midwest Biodiversity Institute, 2011. Biological and Water Quality Study of Mill Creek and Tributaries. Prepared for MSDGC. 90 pgs.

National Register of Historic Places Database. Accessible at http://nrhp.focus.nps.gov/natreghome.do?searchtype=natreghome.

Odefey, J., S. Detwiler, K. Rousseau, A. Trice, R. Blackwell, K. O'Hara, M. Buckley, T. Souhlas, S. Brown, and P. Raviprakash. April 2012. Banking on Green: Look at How Green Infrastructure Can Save Municipalities Money and Provide Economic Benefits Community-wide. AmericanRivers, the Water Environment Federation, the American Society of Landscape Architects and ECONorthwest.

Paul, Michael and Judy L. Meyer. 2001. Streams in the Urban Landscape. Annual Review of Ecology and Systematics. 2001. 32:333–65.

Plan Cincinnati – A Comprehensive plan for the future DRAFT. www.plancincinnati.org/#draft.

Porter, M.E. (1998) On Competition, Boston: Harvard Business School, 1998.

Rosgen, D. L. 1994. A classification of natural rivers. Catena, 22, 169–199. www.wildlandhydrology.com/html/references_.html.

Strahler, A. N. 1952. Hypsometric (area-altitude) analysis of erosional topography. Geological Society American Bulletin, 63, 1117–1142.

United Nations (UN), Food and Agriculture Organization (FAO). 2009. How to Feed the World in 2050. Discussion paper published September 23, 2009. Rome, Italy.

U.S. Department of Agriculture (USDA). 2006. Urban Watershed Forestry Manual. Part 3: Urban Tree Planting Guide. Forest Service. Newtown Square, PA. September 2006. NA-TP-01-06.

U.S. Environmental Protection Agency (USEPA). 1995. Environmental indicators of water quality in the United States. USEPA 841-R-96-002. Office of Water, Washington, DC 20460. 25 pp.

U.S. Environmental Protection Agency (USEPA). 2002. National Water Quality Inventory 2000 Report. Office of Water. Washington, D.C. USEPA-841-R-02-001

U.S. Environmental Protection Agency (USEPA). 2007a. Memorandum on Using Green Infrastructure to Protect Water Quality in Stormwater, CSO, Nonpoint Source and other Water Programs. Benjamin Grumbles, EPA's Assistant Administrator for Water, March 2007. http://water.epa.gov/infrastructure/greeninfrastructure/gi_regulatory.cfm.

U.S. Environmental Protection Agency (USEPA). 2007b. Memorandum on use of Green Infrastructure in NPDES Permits and Enforcement. August 2007. Linda Boornazian, EPA's Water Permits Division. http://water.epa.gov/infrastructure/greeninfrastructure/gi_regulatory.cfm.

U.S. Environmental Protection Agency (USEPA). 2008. NPDES Program Combined Sewer Overflows Demographics. http://cfpub.epa.gov/npdes/cso/demo.cfm?program_id=5. Accessed October 25, 2011.

U.S. Environmental Protection Agency (USEPA). 2009. White Paper on Condition Assessment of Wastewater Collection Systems. Office of Research and Development. Washington, D.C. USEPA/600/R-09/049.

U.S. Environmental Protection Agency (USEPA). 2011. Laws and Regulations: History of the Clean Water Act. www.epa.gov/lawsregs/laws/cwahistory.html. Accessed October 24, 2011.

U.S. Environmental Protection Agency (USEPA). 2012. Planning for Sustainability – A handbook for Water and Wastewater Utilities. EPA-832-R-12-001.

Walker, Jason S., Nancy B. Grimm, John M. Briggs, Corinna Gries, and Laura Dugan. 2009. Effects of urbanization on plant species diversity in central Arizona. Frontiers in Ecology and the Environment 7: 465–470.

Ward, Andy, Jessica L. D’Ambrosio, and Dan Mecklenburg. 2008. Stream Classification Fact Sheet. Ohio State University Extension.

Wenger, Seth J., Allison H. Roy, C. Rhett Jackson, Emily S. Bernhardt, Timothy L. Carter, Solange Filoso, Catherine A. Gibson, W. Cully Hession, Sujay S. Kaushal, Eugenia Marti, Judy L. Meyer, Margaret A. Palmer, Michael J. Paul, Alison H. Purcell, Alonso Ramırez, Amy D. Rosemond, Kate A. Schofield, Elizabeth B. Sudduth, and Christopher J. Walsh. 2009. Twenty-six key research questions in urban stream ecology: an assessment of the state of the science. Journal of the American Benthological Society. 28(4):1080–1098.

Yoder C.O., R.J. Miltner., D. White. 1999. Assessing the status of aquatic life designated uses in urban and suburban watersheds. In Proc. Natl. Conf. Retrofit Opportunities for Water Resour. Prot. Urban Environ., pp. 16–28. USEPA/625/R-99/002.

Yoder, Chris O. 2011. Watershed Monitoring and Bioassessment Project Study Plan for the MSDGC Greater Cincinnati Service Area: Year 1 Subwatersheds, Hamilton County, Ohio. Prepared on behalf of Metropolitan Sewer District of Greater Cincinnati. Submitted by Center for Applied Bioassessment and Biocriteria, Midwest Biodiversity Institute. June 2011.

Appendix A
Background on Urban Watersheds

This appendix provides an overview of urban watersheds and key characteristics that should be considered in the evaluation of existing watershed conditions and the development of appropriate sustainable strategies for wet weather management. This supporting information is intended to focus on key watershed issues in the Metropolitan Sewer District of Greater Cincinnati (MSDGC) service area.

Hydrologic Processes and Land Use

Changes in natural hydrologic processes and land use are major physical effects of urbanization. In natural systems, the physical processes of the hydrologic cycle (primarily precipitation, evaporation, evapotranspiration, condensation, infiltration, and runoff) serve to purify water, replenish land with freshwater, and transport minerals. However, in urban systems, altered land uses cause changes to the natural hydrologic cycle. Although the amount of rainfall and specific percentages of runoff and infiltration vary by ecoregion, **Figure A-1** illustrates the influences of increased impervious surfaces on the natural hydrologic cycle.

- *Understanding both natural and altered systems is important when modeling and planning for sustainable infrastructure and source control for watershed management.*

Precipitation/Interception/Evapotranspiration/Soil Water Storage

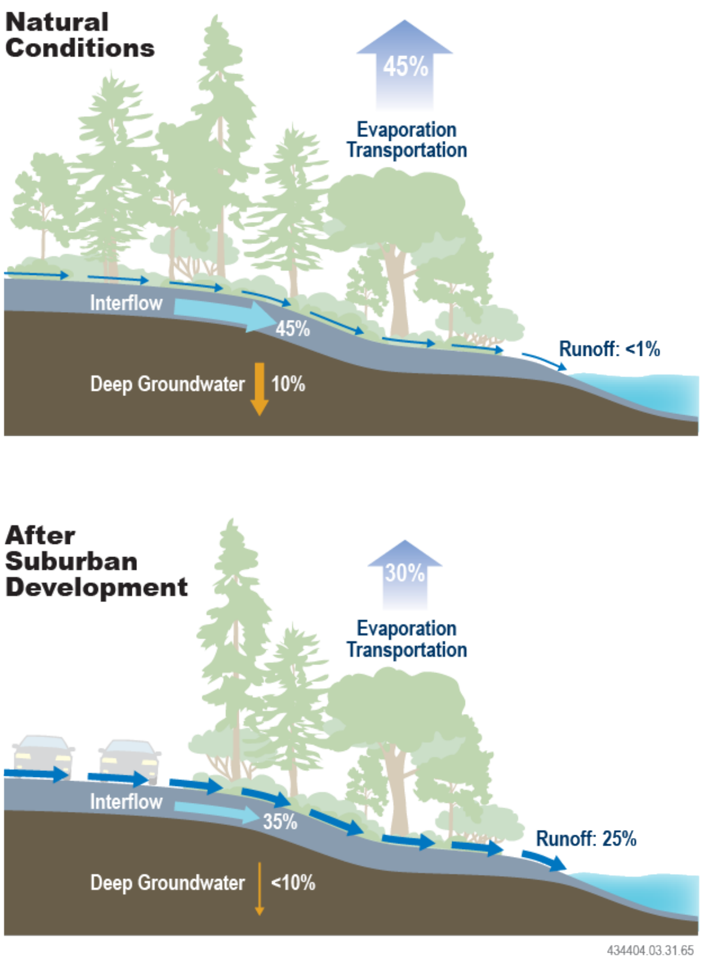
Urban areas support a relatively large and dense population and are typically characterized by land uses with a high percentage of impervious surfaces. While land use does not have a direct effect on precipitation, indirect effects are apparent throughout the hydrologic cycle. Precipitation characteristics (such as seasonal variations, frequency, amounts, and types) vary across environments, some of which can be attributed to the impacts of land use on air temperatures. Regardless of the environment, however, water falls to the earth as rain, snow, sleet, hail, fog drip, or sleet.

- *Characterizing precipitation is necessary in hydrologic modeling and helps identify the potential locations and types of infrastructure needed to control wet weather flows.*

Precipitation may fall to the earth or be intercepted by vegetation. Tree canopy is an important component of natural systems, as it allows for interception, absorption, and filtering of stormwater. Urban watersheds have less tree canopy available for interception, and therefore more precipitation reaches the earth's surface to become infiltrated or flow to streams, lakes, rivers, and oceans. It has been estimated that 60 percent of precipitation infiltrates the ground or becomes runoff in a forested area, compared to 70 percent in a highly impervious area (i.e., 75 to 100 percent imperviousness) (Paul and Meyer, 2001).

Precipitation may eventually evaporate (after forming surface water or soil moisture) or transpire (after undergoing uptake by vegetation). The degree of evapotranspiration that occurs in a watershed is dependent on interception, percent impervious cover, and the soil water storage capacity (or the ability of the land to retain water). In highly urban areas, evapotranspiration is

Figure A-1 Example of the Effects of Urbanization on the Hydrologic Cycle



relatively low (less precipitation is intercepted), but the availability of soil for infiltration is also relatively low, due to the presence of structures, infrastructure, and other impervious surfaces. While evaporation and transpiration rates can be high in urban areas as they increase with the rise in surface temperatures, they both generally occur at lower rates than in natural conditions. The soil water storage capacity is also dependent on soil properties and the underlying water table, both of which should be accounted for in modeling the hydrology of a watershed.

- *The amount of vegetative cover available for intercepting precipitation can be estimated using land use/land cover data, an important input to hydrologic models.*
- *Low soil water storage capacities, paired with a high degree of precipitation reaching the earth's surface, could indicate areas with potential for flooding and soil erosion.*

Infiltration/Surface Runoff/Streamflow

Precipitation that reaches the earth's surface (rather than being intercepted) can: (1) infiltrate to become soil moisture or groundwater, (2) flow to nearby waterbodies as surface runoff, (3) move within a channel as streamflow, or (4) be captured by a manmade structure. Infiltration is dependent on the soil water storage capacity, the availability of exposed soil/ground cover, and the amount of vegetation available to intercept precipitation or to slow runoff to channels. Urban environments, with relatively low infiltration and interception rates, have a high degree of surface runoff. A developed watershed often has "flashy" streamflow: during wet weather events, the high volume of surface runoff results in streams with high velocities and peak flows; during dry weather, streamflow is low, due to the decline in infiltration and groundwater supply to streams. The altered infiltration, surface runoff, and streamflow in urban environments can increase the amount of nonpoint source pollution to waterbodies and can increase the peak flow, volume, and frequency of flooding events.

- *Land use/land cover data, as well as soil types and topography, are important in hydrologic modeling, to assess the streamflow and surface runoff patterns in a watershed. These patterns help to identify areas of potential high-volume and high-velocity surface runoff, where stormwater controls are needed, particularly in areas where stormwater is removed from the combined sewer system and new flows are returned to natural drainage areas. In some cases, channel geomorphology and bedload/sediment transport may need to be evaluated and modeled and restoration techniques developed.*

Groundwater

Land use/land cover types directly affect the amount of water that is infiltrated to become soil moisture or groundwater. In urban environments, a smaller proportion of infiltrated water reaches underlying aquifers, resulting in less groundwater available to supply streams or human needs (Paul and Meyer, 2001). Urban environments tend to have lower groundwater levels, since there is less infiltration potential (as discussed above) and a greater chance for shallow infiltration.

- *Identifying significant groundwater recharge areas and understanding the availability of groundwater are necessary for characterizing streamflow patterns.*

Vegetation Management/Water Yield/ Streamflow Pattern

Vegetation management has a physical effect on hydrologic processes and can play a role in the water yield and streamflow patterns of a watershed. In urban areas with limited tree canopy and a high percentage of impervious surfaces, a greater proportion of precipitation becomes surface runoff, and the unit water (catchment, watershed, or river basin) yield is reduced (Paul and Meyer, 2001). In addition, the surface runoff contributes to altered streamflow patterns and can result in increased flood events and a decline in ecological systems. An increase in vegetation can increase the unit water yield, by increasing interception and evapotranspiration, and by increasing infiltration through slowing stormwater runoff.

- *Climate, geology, soils, and topography are important factors in characterizing the physical attributes of an area and identifying sustainable vegetation that could be used to manage hydrologic processes.*

Erosion/Sediment Yield/Channel Process

In addition to hydrology, urbanization has physical effects on geomorphology. As natural streams are piped, filled-in, and paved over, the drainage density of a watershed decreases, with less stream area available to capture precipitation. Drainage density losses can be dramatic in urban areas, causing changes in sediment supply and channel dimensions (Paul and Meyer, 2001). Erosion that results from construction during urbanization contributes sediments to streams and decreases channel capacities. Decreased channel capacities lead to an increase in peak flow and stream velocities, which in turn erode and widen the channel. These geomorphologic processes, specific to urban watersheds, can lead to changes in instream habitat (including channel substrates and velocity/flow regimes), increased flood frequency and volume, changes in sediment supply, and altered ecological processes.

- *Channel dimensions, stream sediment classification, and existing bank erosion are necessary to model geomorphologic conditions and expected changes in stream channels.*

Stream Classification

Stream classification systems were developed to help understand the similarities and differences among stream reaches. Some commonly used systems classify a stream based on its relative position within a network, or stream order (such as Strahler, 1952), and others on channel geomorphologic patterns (such as Rosgen, 1994, www.wildlandhydrology.com/html/references_.html).

Geomorphologic stream classifications can be used in watershed management to understand the history and existing condition of a stream and to use this information to predict future changes in stream pattern. Stream pattern is important to understand the expected ecological function of a stream reach. Geomorphologic stream classifications are based on physical characteristics of a stream channel and require measurements of the channel's cross-sectional profile, longitudinal profile, and stream pattern. Urban streams are often characterized as having low sinuosity, a lack of stabilizing vegetation on the banks and in the floodplain, channel modifications such as straightening, and/or manmade hydraulic control structures (e.g., road crossing, weir, or a log jam).

- *Management decisions for a specific stream reach should take into account the stream's natural and anticipated processes, based on its classification, to ensure that solutions are effective and sustainable.*

Water Mass Balance

The mass balance of water in urban watersheds differs from the mass balance in natural environments—specifically, it involves the hydrologic processes outlined above, as well as other major categories of engineered infrastructure components: (1) water supply, (2) drinking water, (3) wastewater, and (4) stormwater.

- *To develop a mass balance of water in an urban watershed, the following data, in addition to hydrologic data, are needed:*
  - *Water sources, (rivers, lakes, reservoirs, groundwater)*
  - *Water withdrawals (irrigation, municipal/industrial, power generation, potable water treatment plants)*
  - *Point source water discharges (WWTPs, industry)*
  - *Nonpoint source water discharges (industrial, construction, municipal).*

In urban watersheds, the human use of water is intimately related to the hydrologic cycle and should be considered when planning sustainable infrastructure.

Water Quality and Sources of Pollution

The integrity of water resources is determined primarily by the safety and quality of drinking water supplies, safety of fish consumption, assimilation of wastewater, and health and diversity of aquatic biota. USEPA (2002) identifies urban runoff as one of the leading sources of water quality impairment in surface waters. Point and nonpoint source discharges in urban environments contribute pollutants to local waterways and can adversely impact water quality.

- *Land use has an impact on the quality and volume of surface runoff, as human activities and development contribute pollutants to the earth's surface and, in turn, to its water sources through nonpoint source pollution.*

Water Quality Characteristics

Urban watersheds have many stressors to water resources integrity, which can be characterized by water chemistry (discussed below), habitat structure, energy dynamics, biotic interactions, and hydrology (flow regime). The primary chemical variables that relate to the integrity of water resources include alkalinity, nutrients, organic and inorganic compounds, dissolved oxygen, pH, turbidity, hardness, and temperature.

As an integral part of the watershed framework, causes and sources of pollution and impairments within a watershed must be understood and characterized. A watershed-based risk assessment also includes (1) broad stakeholder participation, (2) evaluation of available water quality data, (3) modeling to define risks and to evaluate costs and benefits, and (4) development of an action plan to implement reductions and improvements. These are logical and systematic ways of evaluating the problem and devising solutions.

- *Integrating information from water quality data, as well as biological data, habitat assessments, hydrological investigations, and land use data, provides a comprehensive assessment of impacts to water resources integrity.*

Pollution Sources/Land Use – Pollution Data

Water quality and aquatic communities in urban areas are affected by both point and nonpoint sources of pollutants. Point sources are identifiable, fixed locations (such as pipe outfalls) where pollutants are discharged, and nonpoint sources are those that cannot be traced to a specific location, such as stormwater runoff. Potential sources of pollution that are commonly found in urban areas include: WWTPs permitted to discharge to waterways, land application systems, urban, industrial, and residential stormwater runoff, industrial stormwater discharges, areas of construction, runoff from roads and highways, landfills (active or inactive), hazardous waste sites and facilities, surface mines (active or inactive), stormwater management structures, sanitary sewer lines and structures, domestic animals, and local wildlife.

- *Identifying the potential point source pollutants in a watershed, as well as the various land use types (to identify expected nonpoint source pollutants), is critical in evaluating water quality and associated biological integrity and in developing solutions for improving water quality conditions. MSD has embarked upon a multi-prong water quality and bioassessment program to assess and evaluate water quality and sources of nonattainment; recent efforts have focused on Mill Creek in 2011 and the Little Miami River in 2012. In the absence of actual sampling data, MSD relies on the National Stormwater Quality Database (aligned with land use data within a watershed) and utilizes existing TMDLs for evaluating pollutant loading and impacts from selected alternatives and BMPs to provide water quality improvements. MSD also has a rich database and extensive knowledge about industrial uses and associated conditions as part of its pretreatment program. Through inspections and sampling, such information must be considered as part of the opportunities and constraints of green infrastructure and source control.*

Urban Ecological Systems

The previous sections summarize the physical and chemical effects of urban land uses on a watershed. Specifically, industrial, commercial, and municipal land uses contribute nonpoint source pollutants to nearby waterways, and high percentages of impervious cover increase stream volume, velocity, discharge, and temperature; decrease baseflow; and alter natural sediment loadings. The physical impacts of urbanization include water quality degradation, flooding, loss of habitat, soil erosion, and altered hydrology. Changes to the overall ecological system in urban environments are discussed below.

Streams in Urban Landscapes

Streams in an urban landscape can be affected by altered land use, sediment inputs, water quality pollution, and direct human modification such as piping. Direct human modification patterns have changed over time. To accommodate increasing populations and population densities, streams are often piped underground or filled, and then covered by impervious structures. This process is common, especially in communities with CSO systems, with the stream reaches most often being headwater streams (Wenger et al., 2009). Other direct modifications include straightening channels (e.g., between housing units, along rights-of-way), lining channels with concrete to avoid changing hydrology, and placing shoring structures on streambanks to prevent erosion. These practices decrease the availability and diversity of instream and riparian habitats, disconnect streams from the floodplain, and increase downstream hydrologic and geomorphic impacts (Wenger et al., 2009).

Climate Change and Urban Heat Islands

It is estimated that urban centers produce more than 78 percent of global greenhouse gases (Paul and Meyer, 2001), increasing air temperature in urban cores. This "urban heat island" effect of climate change leads to streams with a higher baseflow water temperature. Other aspects of urban landscapes also contribute to higher surface water temperatures, such as runoff from heated impervious surfaces, a lack of stream shade, and point source discharges. The elevated surface water temperatures found in urban environments can lead to a loss of cold-water species, altered respiration patterns, and changes in available food sources for benthic macroinvertebrate species (Wenger et al., 2009). Additionally, climate change impacts critical design storms, which may worsen hydrologic systems that have been affected by urbanization (Wenger et al., 2009). While some aspects of climate change are unpredictable, sufficient documentation exists to require that it be considered when determining infrastructure sizing for watershed plans.

- *Biofiltration methods, a green source control solution, could potentially cool urban cores that are subject to the "urban heat island" effect (Endreny, 2008).*

Biological Communities/Biotic Integrity of Aquatic Life

Benthic macroinvertebrate and fish communities represent the overall ecological integrity (i.e., the chemical, physical, and biological integrity) of a waterbody (Barbour et al., 1999). These biological communities have been adversely affected by changes in hydrology, geomorphology, water quality, and physical habitat across the United States, resulting from urbanization. Multiple studies have indicated a decline in species richness, species diversity, and biotic integrity of fish and benthic macroinvertebrates, with increasing urbanization (Paul and Meyer, 2001; Wenger et al., 2009). This decline has been shown to be correlated with impervious cover, with degradation thresholds identified at as low as 10 percent impervious cover in some studies (Paul and Meyer, 2001). Extensive biological surveys in major Ohio urban watersheds suggest that fish Index of Biotic Integrity (IBI), Invertebrate Community Index (ICI), and overall biotic integrity decrease when urban land use reaches between 8 and 33 percent (Yoder et al., 1999).

More than 75 percent of the streams in Ohio are considered small headwater streams, which drain less than 5 square miles (Ward et al., 2009). These headwaters streams, which are disproportionately modified in urban landscapes, can provide habitat for unique aquatic and semi-aquatic species, offer refuge from competitors and environmental conditions, and contribute to the downstream food supply (Meyer et al., 2007; Freeman et al., 2007). Additionally, it has been estimated that more than 10 percent of the macroinvertebrate biomass in a typical stream network exists in the headwaters (Meyer et al., 2007).

- *Source control solutions, including green infrastructure and stormwater BMPs, may be able to compensate for ecosystem function lost through damage to headwater streams (Wenger et al., 2009). However, the direct restoration of degraded headwater stream habitats is also an essential abatement action in conjunction with source controls. MSDGC has begun developing an Integrated Priority System based on a Comprehensive Biological Assessment. Watershed Action Plans (WAPs), like those developed for the Lower Mill Creek subwatersheds of Hamilton County, can be used as examples for other watersheds. WAPs are collaborative plans-- developed with stakeholders--that identify numerous actions to improve water quality. WAPs are completed following at least one updated bioassessment and once the master plan is complete for the watershed. Some projects that MSDGC may be implementing or recommending may be within a WAP; others that are complementary of MSDGC direct impact projects may also be identified in the WAP and could be used as supplemental environmental enhancements to incorporate into a SWEPP.*

Flora of Big Cities

Development in urban areas has impacts on the native plant species diversity and community composition. There are numerous stressors within an urban landscape, such as poor soil quality and storage capacity, aging or deteriorating infrastructure, pollutant sources, stormwater runoff from impervious surfaces, temperature extremes, and hydrologic modifications. These tend to minimize the extent of abiotic sorting that takes place to increase species diversity and plant density (Walker et al., 2009). This, in turn, promotes invasive species growth and prevents the maintenance of a healthy tree cover to intercept precipitation, provide stream shade, and slow and treat stormwater runoff.

- *Source control solutions that successfully incorporate urban plantings, such as stormwater wetlands, bioretention areas, bioswales, vegetated filter strips, and hillside revegetation, can have positive effects on the quality and quantity of stormwater entering urban streams. Newly planted trees in urban areas have an average life expectancy of 10 to 15 years, compared to just 7 to 10 years for existing trees along urban streets (USDA,* *2006). An increase in vegetative cover in an urban watershed can decrease the volume and velocity of stormwater runoff, and therefore nonpoint pollution, entering streams. Removal of invasive plant species and planting of riparian vegetation can also improve water quality and aquatic ecosystems by shading streams, providing habitat and shelter in the form of root masses and woody debris, providing leaf litter as a food source to organisms, and reducing bank erosion and sediment loading to the stream.*

References

Freeman, M.C., C.M. Pringle, and C.R. Jackson. 2007. Hydrologic connectivity and the contribution of stream headwaters to ecological integrity at regional and global scales. Journal of the American Water Resources Association 43:5-14.

Meyer, J.L., D.L. Strayer, J.B. Wallace, S.L. Eggert, G.S.Helfman, and N.E. Leonard. 2007. The contribution of headwater streams to biodiversity in river networks. Journal of the American Water Resources Association 43: 86-103.

Paul, Michael and Judy L. Meyer. 2001. Streams in the Urban Landscape. Annual Review of Ecology and Systematics. 2001. 32:333–65.

Rosgen, D. L. 1994. A classification of natural rivers. Catena, 22, 169–199. www.wildlandhydrology.com/html/references_.html

U.S. Department of Agriculture (USDA). 2006. Urban Watershed Forestry Manual. Part 3: Urban Tree Planting Guide. Forest Service. Newtown Square, PA. September 2006. NA-TP-01-06.

U.S. Environmental Protection Agency (USEPA). 2002. National Water Quality Inventory 2000 Report. Office of Water. Washington, D.C. USEPA-841-R-02-001

Wenger, Seth J., Allison H. Roy, C. Rhett Jackson, Emily S. Bernhardt, Timothy L. Carter, Solange Filoso, Catherine A. Gibson, W. Cully Hession, Sujay S. Kaushal, Eugenia Marti, Judy L. Meyer, Margaret A. Palmer, Michael J. Paul, Alison H. Purcell, Alonso Ramırez, Amy D. Rosemond, Kate A. Schofield, Elizabeth B. Sudduth, and Christopher J. Walsh. 2009. Twenty-six key research questions in urban stream ecology: an assessment of the state of the science. Journal of the American Benthological Society. 28(4):1080–1098.

Appendix B
Sustainability LENS Tool Application

Sustainability LENS Application for Evaluating Sustainable Infrastructure

Sustainability LENS Version 1.0 web-based technology, developed by CH2M HILL, provides the structure application needed to effectively screen and evaluate key aspects of sustainability aligned with projects goals and objectives. Sustainability LENS Version 1.0 consists of (1) a user interface for inputting data, (2) a database function for storing data in an organized format for easy retrieval and archiving, (3) dashboards interface to help users understand what the results are [showing, and (4) a reporting section to print the results shown on dashboards. Sustainability LENS Version 1.0 is designed with flexibility to accept, analyze, and report from a number of sustainability-related indicators which are developed and aligned for each community's goals and objectives.

Sustainability LENS Access

Before you can log in to the Sustainability LENS tool, you must obtain a user name and password from the System Administrator. If you need access to Sustainability LENS system, please contact your supervisor and obtain approval. Once you get approval, contact the Sustainability LENS System Administrator to obtain the link to the Sustainability LENS system, and your user name and password.

Login

To log in to Sustainability LENS: Enter your user name and password in the appropriate space, and then click LOGIN (**Figure B-1**).

Login Failure

If you enter the wrong user name and/or password, you will see an error message in the Login screen. Please re-enter your username and password. If you still have issues logging in, please contact the System Administrator.

Figure B-1 Sustainability LENS Login Screen

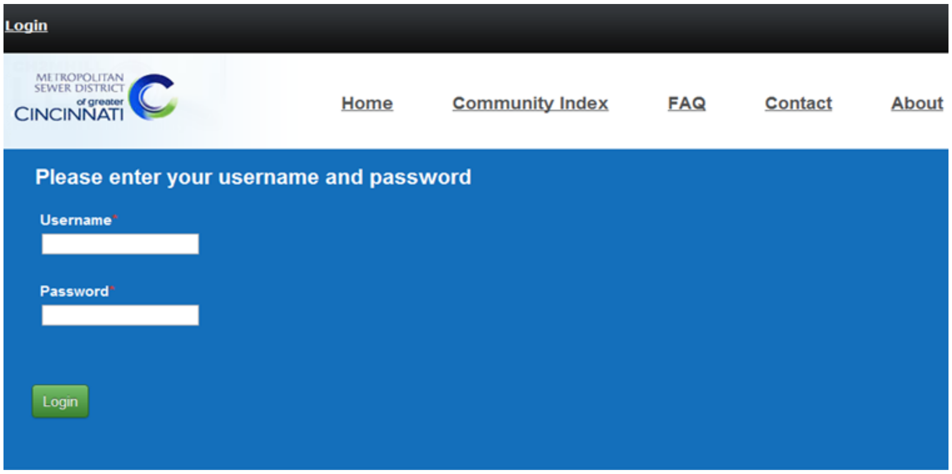


Figure B-2 Sustainability LENS Home Page

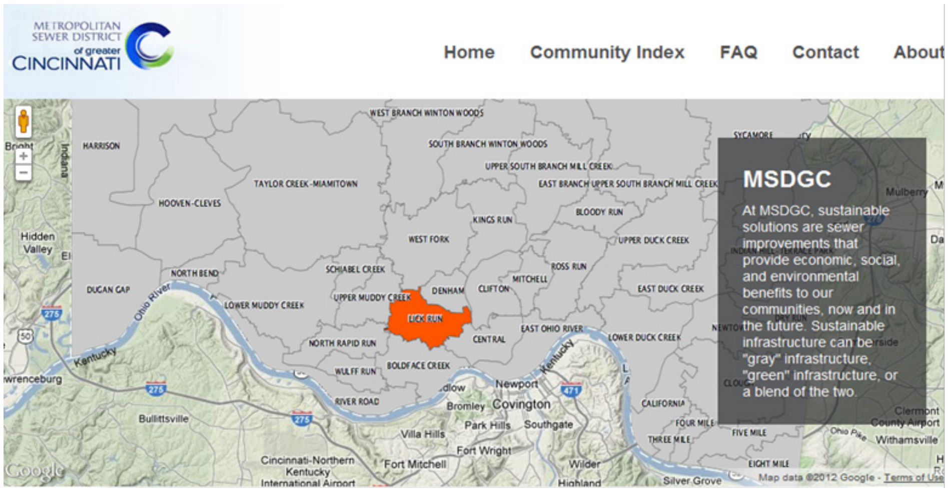
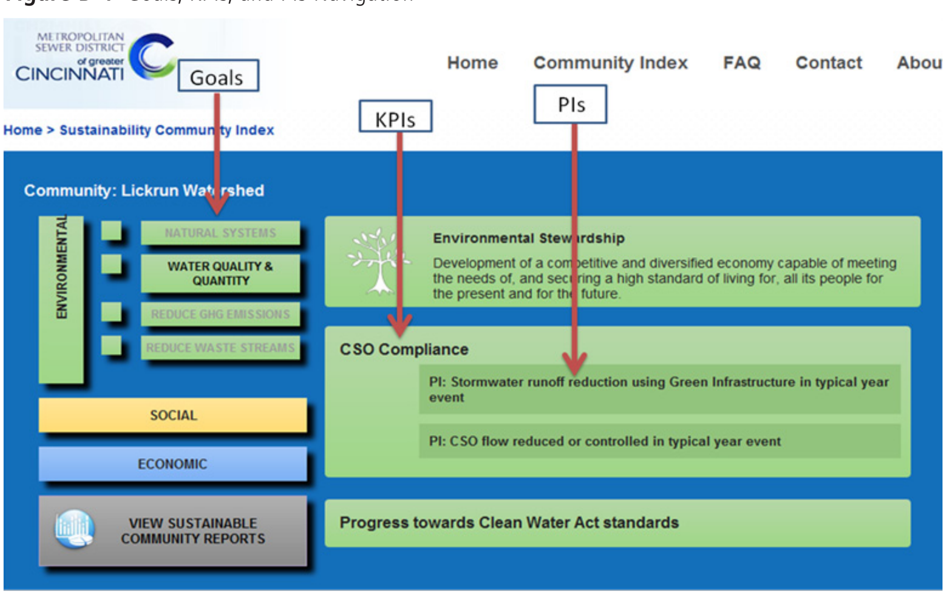


Figure B-3 Sustainability LENS Community Page

Figure B-4 Goals, KPIs, and PIs Navigation



Login Success

Once you are logged in to the Sustainability LENS, you will be taken to the home page (**Figure B-2**). The current Sustainability LENS model is set up for the Lick Run watershed; in subsequent versions other communities will be available to the User for performing TBL analysis.

Sustainability LENS Community Index Page Layout

The Sustainability LENS allows you to select the Watershed/Community from the GIS map (**Figure B-3**). The Primary Navigation consists of three themes: Environmental, Social, and Economic. Under each theme there are set of Goals, a set of Key Performance Indicators (KPIs) that can help meet Goals, and a set of Performance Indicators (PIs) that will be useful in meeting KPIs. Once the User clicks on each of the themes, it displays associated Goals. Clicking on Goals, aligned KPIs will be shown, and under KPIs associated PIs will be shown (**Figure B-4**).

For each community, the associated Goals, KPIs, and PIs are developed by the MSDGC System Administrator. The User's role is to input data for each of the PIs to obtain an overall sustainability score for the community. A screen showing the input for PI is depicted in **Figure B-5**.

Below are the inputs that are available to the User, (each item below refers to a number on **Figure B-5**):

1. **Target:** The target for each PI is established by the System Administrator; target and associated unit of measure are different for each PI and they are established using a stakeholder process.

2. **Scenarios and PI Value Input:** Three scenarios are available to the User for data input: Current (current conditions in the watershed/community), Stretch

(meet state and federal standards if applicable), and Aspirational (exceeds state and federal standards if applicable). The User inputs actual values associated with the PIs for the three scenarios.

3. **PI Dashboard:** For each PI, the System Administrator has set a range of values when the score is Red, Orange, Yellow, Light Green, and Dark Green. Once the User inputs actual values associated with the PI, the PI dashboard will show the appropriate color for the PI.

4. **CSO Planning Toolkit:** This toolkit is available to the User when evaluating options of Green versus Gray Infrastructure; an aligned PI CSO reduction shows this option. This toolkit is not available for PIs that do not deal with CSO reduction.

5. **Save:** For each PI after the User has input actual values, the User can save the data.

6. **Compute Output:** Once the User has completed inputs to all PIs, Sustainability LENS will compute the Sustainability Score for the community.

CSO Planning Toolkit

For CSO reduction and associated PI targets, the CSO Planning Toolkit is available to the User to evaluate and screen Green Infrastructure, Regional BMPs, and Direct MSDGC Projects (they consist of Strategic Separation and/or Surface Storage). The input screen to the CSO Planning Toolkit is shown in **Figure B-6**. It consists of two tabs where User inputs data for the community the system is being applied, namely, Inputs and Plan Scenarios. The **Runoff Profile tab** computes runoff and water quality loads based on impervious area that was calculated based on GIS Impervious layer dataset and the event mean concentrations are used to calculate water quality loads. Impervious area and runoff coefficients are used to calculate runoff volumes and these runoff volumes are multiplied by event mean concentrations to estimate water quality load. MSDGC System Administrator can change the event mean concentrations and impervious area for each of land surfaces. The Summary tab provides overall summary of CSO controls established by User in the community.

Figure B-5 Data inputs for PIs and Saving Data

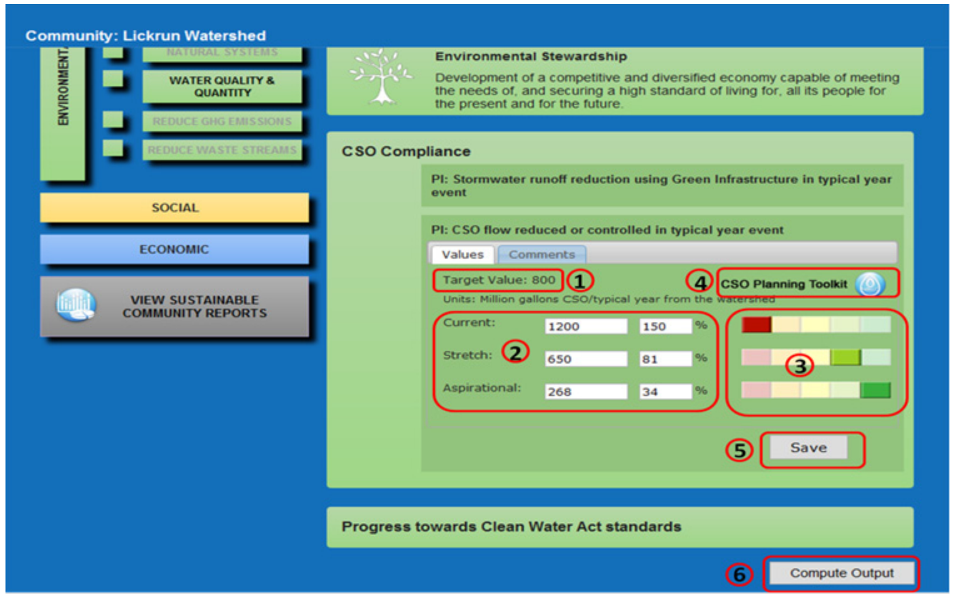
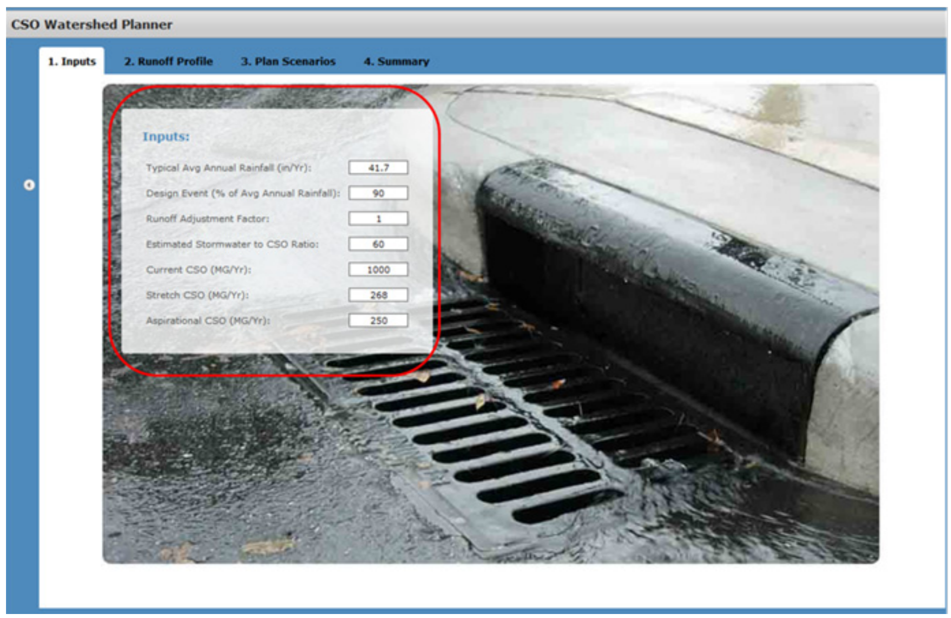


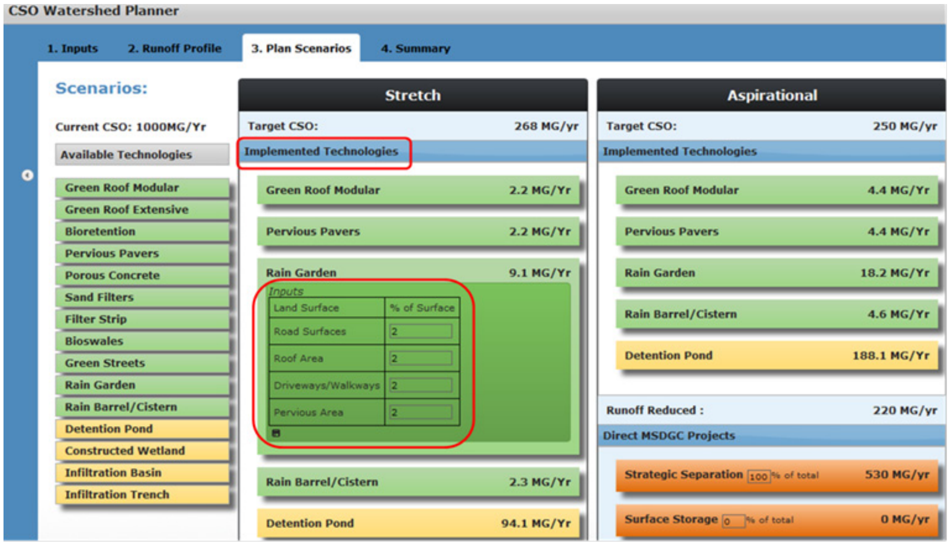
Figure B-6 CSO Watershed Planner System Inputs



The **Input tab** allows Users to input:

1. Typical Average Annual Rainfall (used in CSO evaluations)
2. Design Event (% of Average Annual Rainfall)
3. Runoff Adjustment Factor
4. Estimated Stormwater to CSO Ratio
5. Current, Stretch, and Aspirational CSO targets

Figure B-7 Selection of Green Infrastructure and Regional BMPs and Defining of Areas Served



All the parameters listed above can be changed based on local Community where the system is used by the User.

The **Plan Scenario tab** allows Users to select:

1. Green Infrastructure BMPs (Sustainability LENS database currently includes 12 Green Infrastructure BMPs, and additional BMPs can be added by MSDGC System Administrator). Green Infrastructure cost data for six BMPs was provided by MSDGC, they are, 1) pervious pavers (includes underdrain), 2) porous concrete (includes underdrain), 3) modular roof, 4) extensive green roof, 5) rain garden (includes underdrain), and 6) bioswale (includes underdrain). User can drag and drop Green Infrastructure BMPs in Implemented Technologies and identify the area that will be served by each of the BMPs (**Figure B-7**).

2. Four Regional BMPs can be selected and sized based. User can drag and drop Regional BMPs in Implemented Technologies and identify the area that will be served by each of the BMPs.

3. Direct MSDGC Projects, the User specifies amount of Strategic Separation of versus Surface Storage Option, the sum of this has to equal 100 percent.

Once the User has selected appropriate Green Infrastructure BMPs and the area they serve along with Regional BMPs, the User will save the data which will be then to compute the amount MSDGC Direct Projects required to meet the CSO Goal for the community.

Community Sustainability Analysis

After the User has input data for all PI values for the three themes of Environmental, Economic, and Social, overall Sustainability Rating of the community can be computed. The **Compute Output Tab** as shown in **Figure B-5** (highlighted by Number 6) is available to the User. The results obtained from the analysis are shown below.

Sustainability LENS Results

The results are provided in two formats, one is graphically using dashboards and a summary Technologies Report that provides results user selected Green Infrastructure and Regional BMPs. **Figure B-8** provides dashboards reports:

1. Circular dashboard provides results related to goals associated with TBL themes.

2. KPI Strengths and Weakness for each Scenario is are also available to the User.

The dashboards provide a guide to User to select other alternatives that will enhance the overall sustainability score.

Figure B-8 Dashboard Outputs Provide Visual Comparison of Results

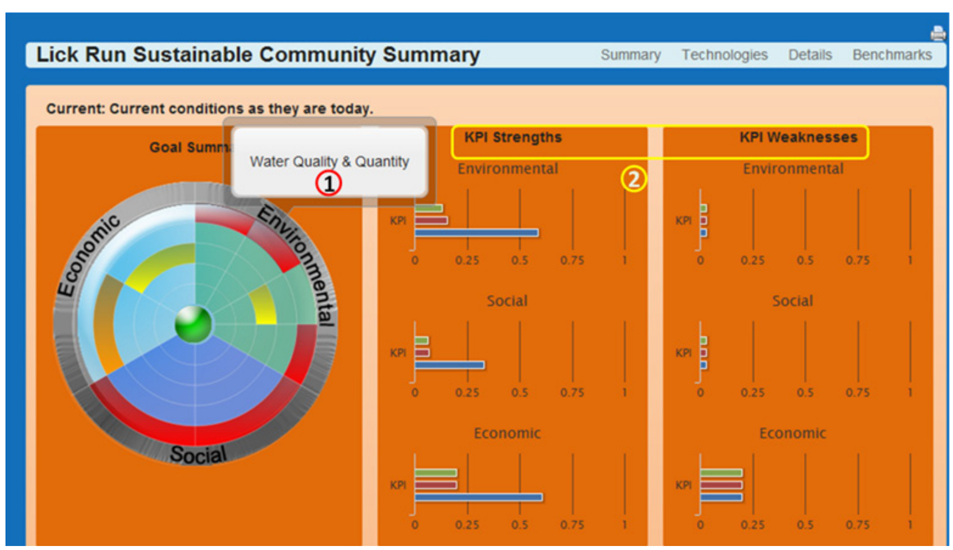
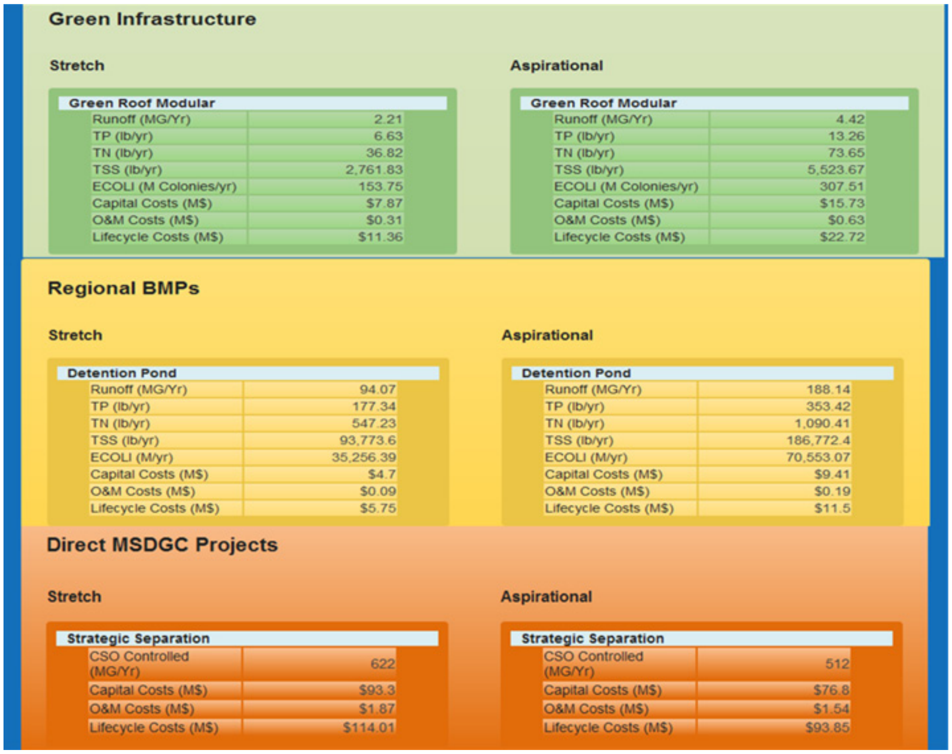


Figure B-9 Technology Report for Green – Gray Scenario Evaluation



Green Infrastructure

Stretch

Green Roof Modular	
Runoff (MG/Yr)	2.21
TP (lb/yr)	6.63
TN (lb/yr)	36.82
TSS (lb/yr)	2,761.83
ECOLI (M Colonies/yr)	153.75
Capital Costs (M$)	$7.87
O&M Costs (M$)	$0.31
Lifecycle Costs (M$)	$11.36

Aspirational

Green Roof Modular	
Runoff (MG/Yr)	4.42
TP (lb/yr)	13.26
TN (lb/yr)	73.65
TSS (lb/yr)	5,523.67
ECOLI (M Colonies/yr)	307.51
Capital Costs (M$)	$15.73
O&M Costs (M$)	$0.63
Lifecycle Costs (M$)	$22.72

Regional BMPs

Stretch

Detention Pond	
Runoff (MG/Yr)	94.07
TP (lb/yr)	177.34
TN (lb/yr)	547.23
TSS (lb/yr)	93,773.6
ECOLI (M/yr)	35,256.39
Capital Costs (M$)	$4.7
O&M Costs (M$)	$0.09
Lifecycle Costs (M$)	$5.75

Aspirational

Detention Pond	
Runoff (MG/Yr)	188.14
TP (lb/yr)	353.42
TN (lb/yr)	1,090.41
TSS (lb/yr)	186,772.4
ECOLI (M/yr)	70,553.07
Capital Costs (M$)	$9.41
O&M Costs (M$)	$0.19
Lifecycle Costs (M$)	$11.5

Direct MSDGC Projects

Stretch

Strategic Separation	
CSO Controlled (MG/Yr)	622
Capital Costs (M$)	$93.3
O&M Costs (M$)	$1.87
Lifecycle Costs (M$)	$114.01

Aspirational

Strategic Separation	
CSO Controlled (MG/Yr)	512
Capital Costs (M$)	$76.8
O&M Costs (M$)	$1.54
Lifecycle Costs (M$)	$93.85

Technology reports summarizing the results of Green Infrastructure and Regional BMPs and MSDGC Direct Projects is depicted in **Figure B-9**. The results show Capital, O&M and Life Cycle cost, the MSDGC System Administrator has flexibility to change interest rates and the life of project.

Summary Sustainability LENS

Residents and stakeholders of each community within a city value their community highly, expecting that they will provide high quality, ‘livable’ urban environments. But these expectations are challenged by the competing issues of burgeoning population and associate impacts of development required to support this population on resources available within a community.

MSDGC has embraced and is implementing principles of sustainability in the community it serves. In 2010, MSDGC took its focus on sustainability further by developing a landmark approach for evaluating sustainable solutions in terms of a community’s long-term sustainability goals. Sustainable Community Index developed using Sustainability LENS promotes a community-based approach to sustainability planning, defining a community’s sustainability “baseline” and evaluating the contributions of individual projects toward the community’s goals in the areas of environmental, economic, and social benefits. Specific key performance indicators can be selected against which to gauge a community’s sustainability and the benefits of individual projects. Sustainability LENS system – a customizable web application help facilitates evaluation and communication of sustainability benefits achieved via individual infrastructure projects. The developed system provides a highly effective means of communicating project benefits to the full range of community stakeholders.

Appendix C

MSDGC Asset Hierarchy Diagrams

Figure C-1 MSDGC WWC Division Collection System Hierarchy

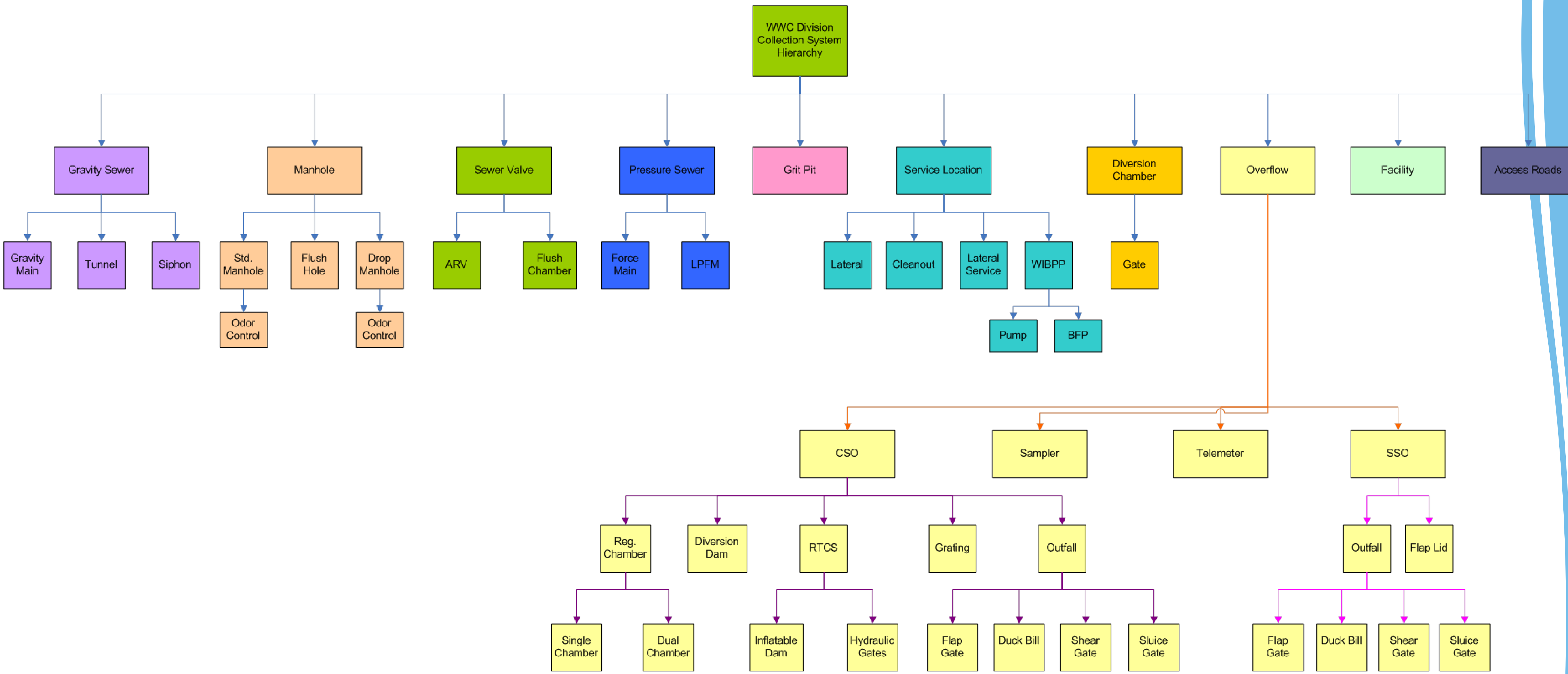
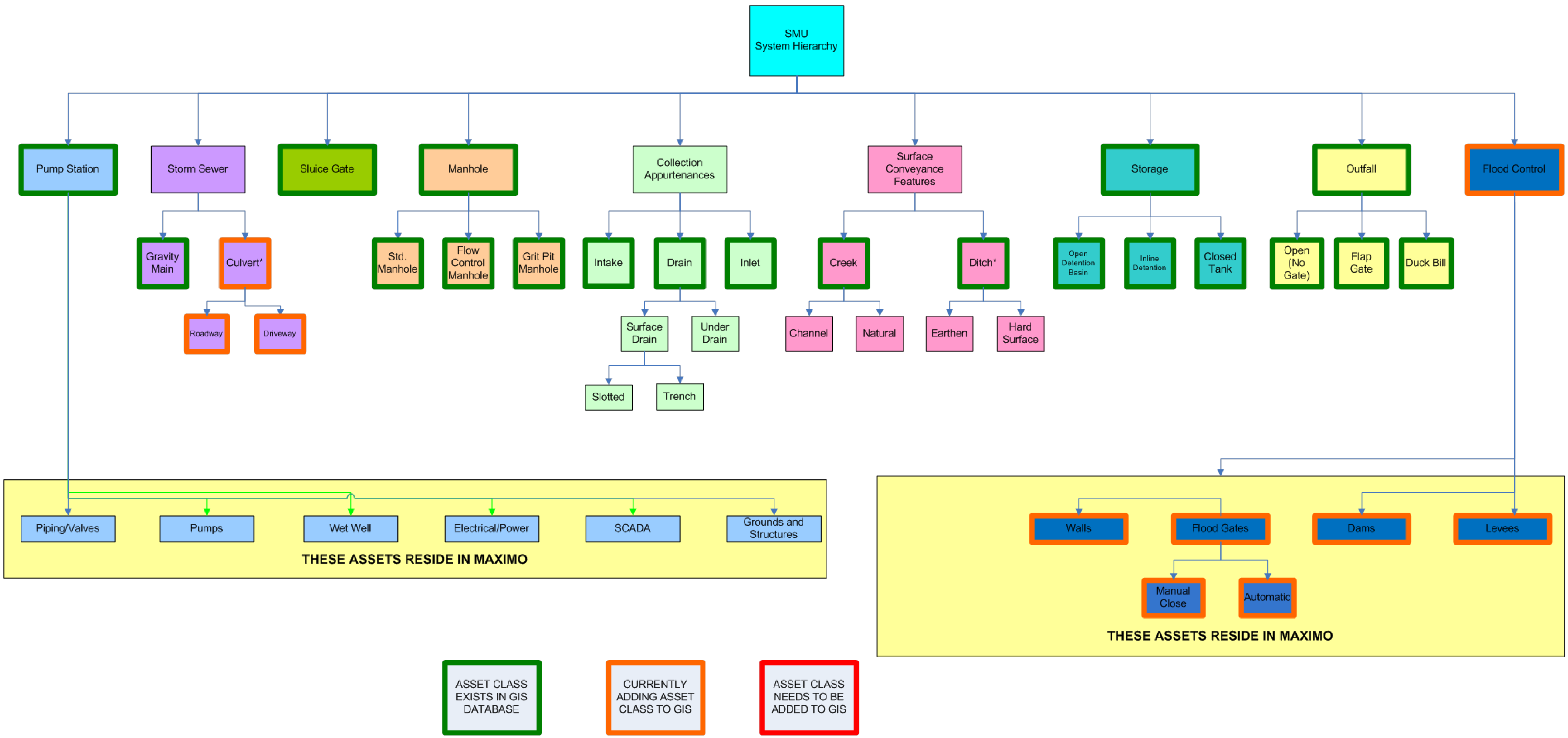


Figure C-2 MSDGC SMU System Hierarchy



Appendix D

Example Preliminary Watershed Master Plan Outline

METROPOLITAN
SEWER DISTRICT
of greater
CINCINNATI

Example Watershed

Preliminary Watershed
Master Plan

PROJECT GROUNDWORK

Preliminary Watershed Master Plan for
Example Watershed

Contents

Section **Page**

METROPOLITAN
SEWER DISTRICT
of greater
CINCINNATI

www.msdgc.org

MaryLynn Lodor
Metropolitan Sewer District of Greater Cincinnati
Environmental Program Manager

Office of the Director
1600 Gest Street
Cincinnati, OH 45204

Email: marylynn.lodor@cincinnati-oh.gov

Telephone: 513-244-5535
Fax: 513-244-1399