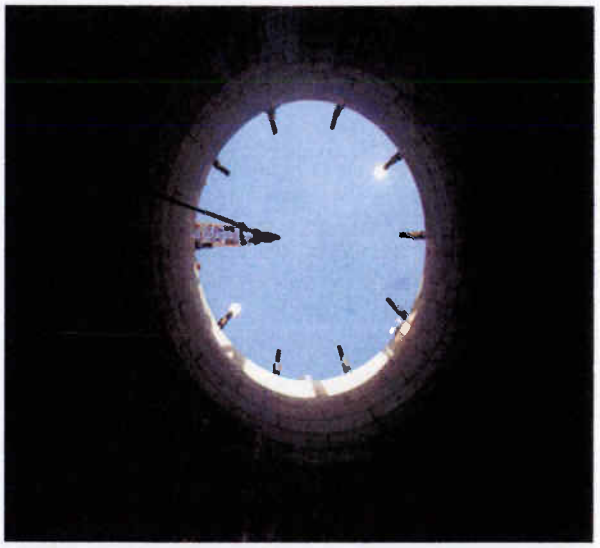
Lower Mill Creek Partial Remedy

MSD Response to County Monitor's Cost Certainty Analysis



September 18, 2012

METROPOLITAN SEWER DISTRICT of greater CINCINNATI

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AACE	Association for the Advancement of Cost Estimating
ADA	American with Disabilities Act
ASIWPCA	Association of State and Interstate Water Pollution Control Administrators
ASLA	American Society of Landscape Architects
BG	billion gallons
BMP	Best Management Practice
BoCC	Board of County Commissioners
CAGIS	Cincinnati Area Geographical Interface System
CAPP	Capacity Assurance Program Plan
CDOTE	Cincinnati Department of Transportation & Engineering
CDR	Comprehensive Design Report
CFAC	Communities of the Future Advisory Committee
CIP	Capital Improvement Program
CPB	Cincinnati Parks Board
CPS	Cincinnati Public Schools
CPTED	Crime Prevention through Environmental Design
CRC	Cincinnati Recreation Commission
CSO	Combined Sewer Overflow
CSS	Combined Sewer System
DB	Detention Basin
DOE	Department of Energy
DOT	Department of Transportation
DWF	Dry Weather Flow
EHRT	Enhanced High Rate Treatment Facility
EI, EIP	Enabled Impact Project
EPA, USEPA	United States Environmental Protection Agency
ESA	Environmental Site Assessment
FEMA	Federal Emergency Management Agency
FHWA	Federal Highway Administration
GAO	Government Accounting Office
GCWW	Greater Cincinnati Water Works
HCTID	Hamilton County Transportation Improvement District
HMS/HEC	Hydraulic model of water flow through natural rivers and other channels
HRT	High Rate Treatment Facility
HSG	Hydrologic Soil Group
I/I	Infiltration & Inflow
LID	Low Impact Development
LMC	Lower Mill Creek
LMCFR	Lower Mill Creek Final Remedy

LMCPR	Lower Mill Creek Partial Remedy
LTCP	Long Term Control Plan
MG	million gallons
MGD	million gallons per day
MOT	Maintenance of Traffic
MSD, MSDGC	Metropolitan Sewer District of Greater Cincinnati
NACWA	National Association of Clean Water Agencies
NASA	National Aeronautics & Space Administration
NEPA	National Environmental Policy Act
NFS	National Forestry Service
NORDS	Northeast Ohio Regional Sewer District's
NPDES	National Pollutant Discharge Elimination System
NPS	National Parks Services
NRDC	Natural Resources Defense Council
NSQD	National Stormwater Quality Database
O&M	Operations & Maintenance
OAC	Ohio Administrative Code
ODNR	Ohio Department of Natural Resources
ODOT	Ohio Department of Transportation
OEPA	Ohio Environmental Protection Agency
OEQ	Cincinnati Office of Environmental Quality
ORC	Ohio Revised Code
OUPS	Ohio Utilities Protection Service
PACP	Pipeline Assessment & Certification Program
RDII	Rainfall Derived Inflow and Infiltration
ROW	Right-of-Way
RTC	Real Time Control Facility
RTK	Abbreviation for hydraulic parameters
SFBA	South Fairmount Business Association
SFCC	South Fairmount Community Council
SHPO	State Historic Preservation Office
SI	Sustainable Infrastructure
SMU	Stormwater Management Utility
SSO	Sanitary Sewer Overflow
STP	Surface Transportation Program
SWEP	Sustainable Watershed Evaluation Plan
SWEPP	Sustainable Watershed Evaluation Planning Process
SWIM	Stormwater Wastewater Integrated Management
SWM	System-Wide Model
TPC	Total Project Cost
ULO	Underground Locate Openings

URA	Uniform Relocation Act
USACE	United States Army Corps of Engineers
USFRA	United States Federal Railroad Administration
USGS	United States Geological Survey
VCS	Valley Conveyance System
VE	Value Engineering
WERF	Water Environment Research Foundation
WQS	Water Quality Standard
WRRSP	Water Resources Restoration Partner Program
WWIP	Wet Weather Improvement Program

1. EXECUTIVE SUMMARY

The Lower Mill Creek Study (LMC) is a submission required under the Final Wet Weather Improvement Plan approved under the federal Consent Decree entered into by Co-Defendants Hamilton County and the City of Cincinnati and Plaintiff Regulators USEPA, Ohio EPA and ORSANCO. One purpose of the LMC Study is to examine and propose alternative projects to fulfill the requirements of the WWIP for a Lower Mill Creek Partial Remedy project. The LMC Study will outline any such alternatives so that the Regulators can determine, under the standards applicable for Clean Water Act CSO Consent Decrees, whether an alternative is satisfactory and approvable. If an alternative does not meet EPA standards, it will not be approved.

The alternatives analysis performed for the Lower Mill Creek Study (LMCPR Revised Plan) is essentially the same, but greatly enhanced, as that performed in the preparation of the Final WWIP as contemplated under the federal Consent Decree. The extensive WWIP project selection and cost analysis set the groundwork for the cost analyses that have been performed to-date. Costs are reported in 2006 dollars to enable direct comparison with the WWIP costs. EPA cost-effectiveness analysis guidelines were used for the WWIP and still govern for this type of planning document which is essentially an equivalent to a small Long-Term CSO Control Plan. This is the legal framework under which the LMC Study must be undertaken. This is the relevant industry standard.

Great care was taken in the preparation of design concepts and cost estimates to address lessons learned from past WWIP estimates (viz. LMC Tunnel; Werk & Westbourne EHRT) and to develop costs that are less likely to increase as projects proceed through the detailed planning, design, and construction phases. The feasibility of drop shaft and consolidation sewer locations was examined before costs were developed. Influent pumping was added for EHRT facilities. Preliminary geotechnical and environmental investigations and utility searches were conducted in Lick Run to identify factors that could increase implementation costs. The WWIP was a conceptual planning level document and used a total contingency allowance of 25 percent. This has been increased to 35 percent, with an additional 10 percent project contingency added to account for unforeseen costs that could arise during construction. Projects that are further along in the planning or design phases have progressively lower contingencies to account for the fact that there are fewer unknowns as the project progresses, but the 10 percent project contingency is applied to all projects.

Earlier planning of SI Alternatives presented in Sustainable Watershed Evaluation Process (SWEP) reports and subsequent draft sub-basin planning reports did not include adequate contingency allowances and soft costs, and were not commensurate with LMC Tunnel costs prepared by the tunnel design team. A major focus of the LMC Study team was to make sure that appropriate contingency allowances were added and all soft costs were accounted for in the SI alternatives to enable an "apples-to-apples" comparison of alternatives.

The Final WWIP specifies that any alternative LMCPR proposed by the Co-Defendants must meet three criteria: 1) control a significant annual volume of Lower Mill Creek CSO (as much as 2 BG); 2) be able to be completed by applicable Phase 1 end date; and 3) work within a concept for a Lower Mill Creek Final

Remedy. The alternatives identified to-date are the lowest cost, best grey and sustainable alternatives under the relevant industry standards to meet the applicable requirements of the Final WWIP.

In light of the July resolution by the Board, MSD requested that the County personnel identify a standard that supported the reference to "certainty". Instead of an articulation of a standard applicable to grey and sustainable CSO projects alike, or any recognition of the controlling relevant fact of the primary necessity of federal and state Regulator approval, the County monitor team prepared an "analysis" asserting irrelevant authorities and fundamental misunderstanding of engineering principles and project facts.

The Hamilton County monitor's report (page 1) noted the following "primary concerns" regarding the costing methodology utilized to estimate the cost of the sustainable infrastructure alternative:

a) A departure from industry standard practice occurred.
b) Analysis of overall confidence level was not performed.
c) Significant costs were not included in the estimate.
d) Inconsistencies were noted related to amenities.
e) Estimates based on assumptions inconsistent with industry standards.

THESE ISSUES DO NOT REPRESENT VALID CRITICISMS. The justification presented by the County monitor for each of these concerns is inaccurate, lacks engineering applicability, contradicts prior County direction to MSD, and is not relevant to the LMC Study.

Of particular note are two primary errors. As will be more fully described below, the sensitivity analyses with regard to sewer separation effectiveness conducted by the County is flawed. The sewer flow monitoring results for areas served by separate sanitary and separate storm sewers were misinterpreted by the County monitor, leading to their incorrect calculations of percent effectiveness of sewer separation. It is clear that there is a basic misunderstanding of the type of sewer separation being proposed. Existing sewers are already separated, but the two separate sewer systems both discharge into a common combined trunk or interceptor sewer. The proposed separate storm sewer will be connected to a new storm sewer that parallels the existing combined trunk or interceptor sewer and will have a separate outfall to Mill Creek. Existing combined sewers that serve individual households as well as having storm inlets which are located in non-priority areas will not be separated due to the higher cost and lower effectiveness of this type of sewer separation. This is a very important distinction to understand, but was apparently missed by the County monitor team.

Second, the cost estimating methodology utilized during the LMCPR Revised Plan project was developed to provide consistency for comparison of alternatives against each other as well as the default remedy from the WWIP. The majority of the cost estimating for this project was done using a parametric costing tool based on a conceptual level of design. For the SI projects, more detailed construction costs were often available (due to the higher level of design completion) and therefore the more detailed costs were used as the base construction cost in place of parametric estimates. These SI base construction costs were reviewed by the LMC project team and input into the costing tool to develop capital and life-

programmatic level costs are still considered planning level or Class 4 with an accuracy range of +50% to -30% from the final cost estimate.

The cost estimating methodology for the LMCPR Revised Plan was developed in collaboration with MSDGC and based on guidance from the USEPA Cost Estimating Guidelines, MSDGC Estimating Guidelines, MSDGC Financial Analysis Manual, and also the Association for the Advancement of Cost Engineering International. Standard practices for cost estimating within the wastewater industry were employed during the development of the cost estimating protocols. Risk was considered as a component of the program and was addressed by applying a 10% contingency to each project. The LMC Study team performed a detailed risk analysis to determine project specific risk issues to be addressed during the planning and design stages. MSD not only completed risk analyses but also documented these efforts through multiple reports. The monitor did not recognize the level of analysis invested by MSD for the SI projects and stated contingency factors did not consider project risks. Nothing could be further from the truth. The comments in the report did not cite any references from the wastewater industry which have a project specific risk assessment requirement.

It should be noted that the cost differential between the Grey Alternative and the Sustainable/Hybrid Alternative is $220 million, with the Grey Alternative being 70 percent higher in costs. If the costs were much closer, as they often are in these types of analyses, (they were within less than one percent in the February 9, 2009 White Paper that led to the selection of the LMC Tunnel) then the concerns raised by the County monitor team would be very important. For example, if the estimates for traffic control in SI areas were low by 1.4 percent as suggested, this would not change the conclusion of the alternatives analysis. At the planning level, it is more important to discover more material items that can significantly impact costs, like construction in rock, the need for influent pumping, the presence of a significant brownfield, and items of a similar nature that are part of the base construction cost estimates. Even so, the contingency allowances are intended to cover some of these items and other smaller aspects of the project like traffic control.

The final issue distorted by the County monitor's report relates to the availability of local data and the misconception local data would take precedence over hydraulic modeling. Local data is used to refine the model; however, the model remains the industry standard approach for developing, evaluating, and comparing alternatives. MSD has been collecting flow monitoring data for the past several years.

MSD's approach for developing a flow monitoring plan is consistent with requirements posed by the USEPA. Our approach satisfies ALL industry standards for CSO Wet Weather Programs. Every community addressing wet weather sewer overflows faces challenging but unique conditions. As such, USEPA's issued a draft guidance document for Lower Mill Creek Study outlining the "industry standards" that need to be addressed for development of a suitable flow monitoring program.

The purpose of the guidance is to ensure that MSD has a sound approach and plan to implement to pre- and post- construction monitoring of source control projects. MSD's prior and current flow monitoring efforts throughout the Lick Run basin demonstrates our commitment to identify the unique issues and

efforts throughout the Lick Run basin demonstrates our commitment to identify the unique issues and our diligence to resolve them. A one-size-fits-all approach is not appropriate for Consent Decree Programs. The County monitor's report suggests MSD was negligent or non-responsive to initial approaches recommended by consultants. This allegation is simply not true. MSD has and continues to pursue every available action to collect useful and suitable flow monitoring data. The topography and existing infrastructure have posed unique challenges that continue to be overcome through an iterative process.

MSD has collected flow monitoring data from multiple locations throughout Lower Mill Creek over the past five years. During the LMC Study period, adverse field conditions resulted in the data collected from the Lick Run sub-basin to be unsuitable for the updated system-wide model. However, it is reasonable to expect MSD's system-wide model will correlate well with predictions regarding the flow conditions at CSO 5, because the model results for other key infrastructure (Mill Creek Wastewater Treatment Plant, Mill Creek Interceptor, and Mill Creek Auxiliary Interceptor) match available flow monitoring data from other locations.

MSD remains committed to updating its model with flow monitoring data collected from the Lick Run sub-basin. Recognizing the limitations encountered with collection of raw data at CSO 5, MSD conducted an evaluation to develop detailed percent effective values for the Tier 1 areas within the Lick Run Watershed. The detailed values were then compared to the original percent effective values and any changes were incorporated into the combined sewer model to determine impacts to estimated CSO reduction. The objective of this evaluation was to quantify the volume of stormwater runoff within the Lick Run Watershed that is anticipated to be collected by the proposed storm sewers.

The independent consultant retained by the County and MSD, TetraTech, concluded MSD's model was developed "in accordance with industry standards and with an appropriate standard of care". TetraTech also stated, "Overall, the reasonableness of model calibration and validation is sufficient for the regulatory application". Both TetraTech and MSD recognize the local flow monitoring data were not ideal, but that does not preclude development of an accurate model or an approach for decision making.

The report issued by the County monitor team did not accurately reflect the comprehensive level of effort and technical scrutiny the Sustainable Alternative received throughout the LMC Study.

2. COSTING METHODOLOGY ISSUES

None of the issues presented in the Hamilton County monitor's report with regard to costing methodology represent valid concerns. Specifically, the report (page 1) lists the following "primary concerns" regarding the costing methodology used to estimate the cost of the Sustainable Alternative:

- A departure from industry standard practice occurred.
- Analysis of overall confidence level was not performed.
- Significant costs were not included in the estimate.
- Inconsistencies were noted related to amenities.
- Estimates based on assumptions inconsistent with industry standards.

THESE ISSUES DO NOT REPRESENT VALID CONCERNS. The justification presented by the County monitor for each of these concerns is inaccurate, lacks engineering applicability, contradicts prior BoCC direction to MSD, and is not relevant to the LMC Study.

2.1. Industry Standard Practice

MSD followed the industry standard practice in preparing its cost estimates for the Sustainable Alternative. The suggestion in the monitor's report that the *"Costing methodology is a departure from industry standard practice,"* is simply false, and the "standard" the report alleges should have been followed has no application to the wastewater industry or preparation of cost estimates for EPA review The LMC Study[1] is a wastewater planning project performed for EPA review and approval and conforms to EPA Clean Water Act requirements. The Washington State Department of Transportation Project Risk Management Guidelines, which the monitor's report suggests is the industry standard, has no relevance to wastewater planning projects and is not used by EPA in its design and estimating criteria in any way. Furthermore, the Sustainable Alternative consists of a collection of conventional standard type of utility infrastructure projects with green infrastructure features integrated within a watershed solution, for which MSD has established a rigorous and battle tested process for developing cost opinions and contingency factors.

The cost-effectiveness analysis guidelines, created by EPA shortly after the passage of the Clean Water Act in 1972[2], were used for estimating costs for the projects included in the WWIP. Key elements of the cost-effectiveness analysis guidelines are the use of a short-range planning period (generally 20 years), a constant interest rate, no inflation, and the use of remaining value to account for the remaining useful life and value of long-term assets like sewers when comparing life-cycle costs.

The following industry standard practices are applicable to the LMC Study.

- Hamilton County Metropolitan Sewer District of Greater Cincinnati, City of Cincinnati Department of Public Works Stormwater Management, November 1991, Cost Estimating and Cost Referencing Methodology, Stormwater Wastewater Integrated Management (SWIM), Prepared by Camp Dresser & McKee and Woolpert Consultants.[3]

- R.S. Means. 2005. Building Construction Cost Data, 63rd Annual Edition.[4]
- Estimates, Project No. CS-1314. Detroit Water and Sewerage Department. United States Environmental Protection Agency. December 1976. Cost Estimating Manual – Combined Sewer Overflow Storage and Treatment, EPA-600/2-76/286. Cincinnati, OH: National Risk Management Research Laboratory Office of Research and Development United States Environmental Protection Agency.[5]
- United States Environmental Protection Agency. January 1981. Construction costs for Municipal Wastewater Conveyance Systems: 1973-1979, EPA-430/9-81/003. Washington, D.C.: United States Environmental Protection Agency.[6]
- United States Environmental Protection Agency. January 2002. Costs of Urban Stormwater Control, EPA-600/R-02/021. Cincinnati, OH: National Risk Management Research Laboratory Office of Research and Development United States Environmental Protection Agency.[7]
- "Preliminary Data Summary of Urban Storm Water Best Management Practices", Publication EPA-821-R-99-012, August 1999.[8]
- "Storm Water Technology Fact Sheet Bioretention" Publication EPA-832-F-99-012, September 1999.[9]
- "Storm Water Technology Fact Sheet Wet Detention Ponds" Publication EPA-832-F-99-048, September 1999.[10]
- "Combined Sewer Overflow Management Fact Sheet Sewer Separation" Publication EPA-832-F-99-041, September 1999.[11]
- MSDGC Estimating Guidelines and MSDGC Financial Analysis Manual.[12]
- Guidance document from the Association for the Advancement of Cost Engineering International.[13]

In 2004, MSD developed a set of cost estimating tools used to create the Capacity Assurance Program Plan (CAPP).[14,15] Development of this tool was based on standard cost estimating practice, which has at its core development of a standard set of procedures proven to create consistent estimates from conceptual design to design development and through construction documents. A comprehensive set of potential project types that could be considered for solutions for the CAPP and Long Term Control Plan (LTCP)[16] were assembled and costing tools were developed using Microsoft Excel spreadsheets.[17] These costing tools were used to develop planning level project costs for potential solutions for individual capacity issues throughout the system. Another set of tools was developed to allow multiple projects to

be assembled into a regional solution that is expressed in a present worth life-cycle cost.[18,19,20] This enables a fair comparison of the alternatives including operation and maintenance costs as well as other periodic costs over the planning period such as equipment replacement.

MSD's intent for investing time and money into development of a comprehensive costing tool was to provide defensible data to document the long term costs of the program. Documentation was provided outlining the use of the tools as well as the basis for cost development.[17] These CAPP costing tools became the basis for a more detailed cost estimating tool used to develop MSD's Combined Sewer Overflow LTCP and Wet Weather Improvement Program (WWIP).[1]

The costing tool was developed and refined through the collaborative efforts of many professionals having detailed knowledge of MSD's infrastructure including, but not limited to the following firms:

- A&A Safety
- Black & Veatch
- CH2MHill
- Camp Dresser & McKee
- Greeley and Hanson LLC
- Malcolm Pirnie, Inc.
- Metcalf & Eddy
- Parsons Brinkerhoff
- XCG Consulting Engineers

For the Sustainable Alternative, cost opinions were developed separately for each of the individual projects using historical cost information from actual Contractor bids submitted to ODOT, CDOTE, SMU, and others.[21,22,23] These data sources included relatively large sample sizes for the major project components associated with storm sewer construction. The use of locally available cost data for conventional construction elements such as these is generally considered to provide the most relevant opinion of construction costs in the area for upcoming construction seasons. Even so, these costs were compared to cost opinions derived from an analysis of individual cost components, where estimates were made for labor, equipment, and material costs for individual construction items such as storm sewer construction. These estimates were "reconciled" to provide the adopted cost opinion. While the risk of unknown costs for projects such as these is relatively low to begin with, risk is diminished to insignificant levels through this process. Deviating from this established local standard practice in favor of those generally employed on large scale federal projects, of a singular nature, would provide less confidence in the costing methodology, not more.

In practice, MSD cost methodology has proven to be accurate, and to provide a high level of confidence. To-date one SI project within the Lick Run watershed, the Harrison Avenue Phase A Sewer Separation Project, has been bid out for construction.[24] The design engineer's opinion of probable cost for this project was $1.99M, based on the methodology discussed above. The actual bid price came in at $1.48M. Based on this comparison, the design engineer's opinion of probable cost was 34% above the

actual bid price. As such this project is a local example of using MSD protocols to generate a construction cost estimate. The cost results for this project provide a high level of confidence the methodologies being used to estimate project costs by MSD are conservative. It also demonstrates the highly competitive nature of the local construction industry.

If this were an unusual or extremely complicated project that was not routinely undertaken at the local level, such as the construction of a large diameter tunnel several hundred feet below ground, a stronger case could be made for considering alternate approaches to costing methodology. For projects such as those included within the Sustainable Alternative, however, the local standard of practice and industry standard of practice are one and the same. As such, introducing an alternate costing methodology, as the monitor's report suggests, would actually constitute a departure from the industry standard of practice. Instead, at this stage of a planning-level alternatives analysis, where capital costs of the Grey and Sustainable Alternatives differ by 70 percent, a detailed risk assessment analysis would have little bearing on the overall conclusion. If such an analysis were warranted, the tunnel project would characteristically include much higher risk factors than a conventional storm sewer/channel project. Therefore, the potential cost differences actually appear significantly more compelling in favor of the Sustainable Alternative.

2.1.1. MSD's Cost Control Track Record

MSD has proven the costing tool developed for the CAPP, LTCP, and final WWIP is a reasonable, accurate, and fiscally sound method to forecast project capital costs. Attachment 1B of the Final WWIP identifies 116 specific projects; including the 52 projects listed in Attachment 1A and an additional 64 projects targeted at CSO reduction, which must be constructed no later than December 18, 2018. The capital cost for each of these projects was estimated using the approach described herein.

As of June 30, 2012, MSD has fully completed 88 of the 116 projects; 10 projects are under construction, 5 are in right-of-way, 7 are in design, and 6 are in planning with Business Case Evaluations under development. Of the 88 projects completed, all 88 were constructed within the WWIP established budget. The financial details for each of cost estimate and budgets approved by the 88 completed WWIP projects are presented in Table 1.

MSD takes cost control very seriously. MSD understands large capital programs can only be successful if cost and schedule are well maintained. The remaining 26 projects to be completed by December 2018 are forecasted to be collectively within the original WWIP established cost estimate. The scope of work for some of these projects has been revised from the conceptual status that used to develop those budgets, and as a result some projects have higher capital costs, while others have lower capital costs. The net result is maintaining WWIP expenditures within the Phase 1 cost estimate established in 2006. By contrast, the Lower Mill Creek Partial Remedy (LMCPR) is a highly complex project which has experienced a significant cost variance due to a significant revised scope of work as contemplated under the WWIP LMC Study provisions for which Co-Defendants negotiated. The balance of Phase 1 projects are not as complex.

Table 1 – Budget History of Completed WWIP Projects (2006$)

ID	PROJECT DESCRIPTION	CURRENT STATUS	TOTAL WWIP BUDGET	TOTAL PROJECT BUDGET	BUDGET VARIANCE
10110300	Durango Green-Shady Lane	Closed	$540,150	$540,150	$0
10120340	Streamwood Pump Station Elimination	Closed	$367,607	$286,198	-$81,409
10120360	Pebble Creek Treatment Plant Elimination	Closed	$1,476,446	$923,539	-$552,907
10120380	Hengehold 4th & Yates 3rd PSE	Closed	$1,101,154	$763,116	-$338,038
10120400	Arrow St. WWTP Elimination & North Bend Crossing P.S. Elimination	Closed	$1,397,845	$1,372,731	-$25,114
10120420	Diamond Oaks, Regency Ridge, Windmere 3rd P.S. Eliminations	Closed	$1,643,019	$805,587	-$837,432
10130420	Wulff Run Parallel Sewer	Closed	$152,187	$86,696	-$65,491
10130560	Muddy Creek WWTP Secondary Flow Enhancement	Closed	$11,023,486	$9,774,676	-$1,248,810
10130565	Muddy Creek WWTP Influent Effluent Pumping Upgrade	Closed	$3,409,124	$1,769,281	-$1,639,843
10130680	Harwinton Lane Sewer Replacement	Closed	$1,166,716	$770,636	-$396,080
10131003	Muddy Creek East Branch Interceptor East Half P.S. "A" Mods	Closed	$861,975	$861,975	$0
10131004	East Branch Muddy Creek CSO Elimination River Road Demo	Closed	$246,641	$246,641	$0
10131200	Mt. St. Joseph Sewer Replacement	Closed	$1,030,826	$501,204	-$529,622
10141200	Northbrook Relief Sewer Contract II	Closed	$1,423,853	$1,423,853	$0
10141220	North College Hill Replacement Sewer Phases 2D, & 3	Closed	$5,391,761	$5,391,761	$0
10141240	Sewer 155 Cooper Creek Contracts 2A & 2B	Closed	$5,104,573	$5,104,573	$0
10141260	Springdale-Sharonville Sewer Phase 3	Closed	$2,401,605	$2,401,605	$0
10141300	Camberly Acres PS	Closed	$321,573	$321,573	$0
10141340	Greenridge 5th PS Upgrade	Closed	$668,196	$570,783	-$97,413
10141360	Garden Hill PS Elimination	Closed	$1,065,355	$1,065,355	$0
10141380	N. Bend Rd./Connecticut Sewer	Closed	$1,188,652	$908,865	-$279,787
10141400	Deer Park Relief Sewer	Closed	$2,076,612	$2,076,612	$0
10141420	Centurion Estates PS Elimination	Closed	$692,622	$367,235	-$325,387
10141440	Millbrook 1 PS Upgrade	Closed	$704,872	$544,382	-$160,490
10141480	Mill Rd. Sewer Replacement Ph. 1 & Ph. 2	Closed	$1,855,869	$1,855,869	$0
10141500	Pleasant Run PS Facilities Plan	Closed	$6,817,628	$6,337,323	-$480,305
10141520	Arrowood P.S. Elimination	Closed	$1,038,808	$757,269	-$281,539
10141540	Winton and Sherwood Ph1 PS	Closed	$2,399,094	$2,112,204	-$286,890
10141560	Winton 1 & 2 and Sherwood P.S. Consolidation	Closeout	$1,660,263	$1,013,658	-$646,605
10141580	Mill Creek WWTP Liquid Treatment Process Coarse Screen	Closed	$2,813,073	$2,813,073	$0
10141600	Mill Creek WWTP Coarse Screens Replacement Phase 2	Closed	$3,620,680	$2,885,600	-$735,080

ID	PROJECT DESCRIPTION	CURRENT STATUS	TOTAL WWIP BUDGET	TOTAL PROJECT BUDGET	BUDGET VARIANCE
10141620	Mill Creek WWTP Solids Management Plan Phase 3A	Closed	$2,616,020	$2,616,020	$0
10141640	Mill Creek WWTP Solids Phase 3B - Sludge Thickening	Closed	$10,208,487	$10,208,487	$0
10141660	Norman Ave. Relief Sewer	Closed	$137,501	$137,501	$0
10141680	406 Elliot Ave. Sewer Replacement	Closed	$130,892	$130,892	$0
10141700	Mill Creek WWTP Incinerator Scrubber Aux. Air Supply	Closed	$215,096	$215,096	$0
10141720	Goodman Ave. Sewer Replacement	Closed	$1,607,061	$1,607,061	$0
10141740	St. Clair Ave. & Elizabeth St. Sewer Replacement	Closed	$1,454,250	$1,454,250	$0
10141760	Mill Creek WWTP Raw Sewage Pumps	Closed	$4,018,226	$3,165,237	-$852,989
10141780	Arrowhead Ct. PS Upgrade & Marview Terrace PS Elimination	Closed	$788,641	$626,679	-$161,962
10141820	SSO 700 CEHRS Treatment Facility	Closed	$14,230,459	$13,765,775	-$464,684
10141840	McGrew Ave Pump Station Upgrade	Closed	$309,253	$288,737	-$20,516
10141880	Laboiteaux Ave. Sewer Replacement, SSO 597 Elimination	Closed	$181,725	$181,725	$0
10142000	SSO 574 Elimination	Closed	$794,722	$422,091	-$372,631
10142040	Compton Road Sewer Improvements	Closed	$210,603	$210,603	$0
10142440	7601 Production Dr. Grating	Closed	$226,997	$126,096	-$100,901
10144900	Ludlow Run Relief Sewer	Closed	$3,106,250	$2,608,575	-$497,675
10144920	CSO 4 Modifications Harrison & State Aves. East	Closed	$171,990	$171,990	$0
10144940	CSO 451 Elimination Sawyer Point	Closed	$33,298	$33,298	$0
10144960	CSO 3 High Water/Dry Weather Protection	Closed	$325,357	$325,357	$0
10144980	Ross Run Grit Pit	Closed	$523,746	$523,746	$0
10145000	CSO 29 Elimination Mitchell Ave.	Closed	$615,916	$615,916	$0
10145020	Montana Ave. Sewer Separation	Closed	$138,382	$138,382	$0
10145040	West 3rd St. Ph3 CSO 437	Closed	$356,683	$309,233	-$47,450
10145080	Eastern Ave. Sewer Separation Collins to Bayou Phase 2	Closed	$451,318	$451,318	$0
10145100	Ross Run Sewer Separation	Closed	$1,957,626	$1,509,989	-$447,637
10145120	Eggleston Avenue Tide Gate Replacement	Closed	$64,109	$64,109	$0
10145140	Givaudan Sewer Separation	Closed	$67,933	$67,933	$0
10145180	Mill Creek Interceptor Diversion Chambers	Closed	$1,588,861	$1,207,226	-$381,635
10145200	CSO 450 Elimination Butler St.	Closed	$94,432	$94,432	$0
10145220	Ross Run CSO 487 Twin Outfall	Closed	$4,491,478	$3,914,234	-$577,244
10145240	Este Avenue Flood Remediation Project	Closed	$167,551	$90,009	-$77,542
10145280	CSO 482 Mitchell Avenue Real Time Control Facility	Closed	$2,643,352	$1,962,166	-$681,186
10145300	CSO 125 Badgeley Run Outfall	Closed	$2,922,912	$1,843,251	-$1,079,661
10145320	Lick Run Interceptor Chamber Real Time Control	Closed	$1,453,334	$759,494	-$693,840

ID	PROJECT DESCRIPTION	CURRENT STATUS	TOTAL WWIP BUDGET	TOTAL PROJECT BUDGET	BUDGET VARIANCE
10145400	Samoht Ridge Relief Sewer	Closed	$2,144	$2,144	$0
10145580	Millcreek WWTP Additional Primary Sludge Pumping	Closeout	$1,315,000	$831,968	-$483,032
10150000	Polk Run WWTP Expansion Ph. 2	Closed	$11,186,361	$9,723,694	-$1,462,667
10150011	Polk Run WWTP PS Elimination Phase 3A	Closed	$667,943	$1,978,392	$1,310,449
10150012	Polk Run WWTP Improvements Phase 3B	Closed	$2,127,133	$1,304,139	-$822,994
10150240	Supplemental Agreement for Maple Ave. Sewer Upgrade	Closed	$233,361	$233,361	$0
10160000	Sycamore WWTP Phase 1 & 2	Closed	$29,601,788	$29,134,974	-$466,814
10160005	Sycamore WWTP Phase 3	Closeout	$8,885,201	$7,982,335	-$902,866
10170020	Camargo Rd. Sewer Replacement Ph. 2	Closed	$3,410,084	$3,410,084	$0
10170040	Euclid & Laurel Avenues SSO 570 & 1017 Relief Sewer	Closed	$3,357,676	$3,357,676	$0
10170060	Mariemont Outfall Sewer SSO 679A, 679B & 680 Elimination	Closed	$9,081,115	$8,664,632	-$416,483
10170081	Montgomery and Lester Sewer Replacement (48% WWIP)	Closed	$1,042,580	$565,077	-$477,503
10170560	Britney Acres P.S. Upgrade	Closed	$1,001,671	$668,175	-$333,496
10170780	Little Miami WWTP Activated Sludge Thickening	Closed	$5,776,675	$5,652,142	-$124,533
10170800	Berkley Woods PS Elimination	Closed	$321,991	$197,351	-$124,640
10170820	Gungadin and Paddison Road Relief Sewer	Closed	$3,126,594	$3,126,594	$0
10170840	Johnson Road Pump Station Elimination Phases 1 & 2	Closed	$859,015	$585,747	-$273,268
10170940	CSO 557 Elimination	Closed	$412,420	$412,420	$0
10171420	CSO 86 High Water/Dry Weather Protection	Closed	$244,636	$244,636	$0
10171820	Beechmont Avenue Area Sluice/Shear Gate Replacements	Closed	$1,979,757	$1,847,474	-$132,283
10171980	Eastern Delta Sewer Separation Phase 1A	Closeout	$43,679,717	$39,695,333	-$3,984,384
10172090	Kenwood Rd. P.S. Elimination	Closed	$2,132,375	$1,420,548	-$711,827
10172200	Broadview Drive & Country Club Place Sewer Separation	Closed	$1,521,582	$991,599	-$529,983
	88 Projects in Total		**$255,933,545**	**$230,531,427**	**-$25,402,118**

3. Sustainable Alternative Cost Certainty

3.1. Overall Confidence Level

Each project within the Sustainable Alternative has gone through a risk analysis, and risk registers have been developed in accordance with MSD Master Program Management Plan Procedure MPMP-05-06,[25] allowing the project team to thoroughly understand and plan for risks in their projects and designs. The statement in the County monitor's report (page 3) *"...an important departure from industry standard practice was the lack of a project risk assessment process whereby time and cost related risks to each*

project were identified, evaluated, and valued," is therefore incorrect. The risk registers are provided in Appendix A.

3.1.1. Risk Analyses

MSD employs a risk assessment and management process on each significant design project. A risk register is created that shows risk probability ranges and associated cost ranges to mitigate the risk for a large number of items. The process involves the design team; MSD staff from planning, project delivery, construction inspection, and wastewater collections; and treatment groups, as applicable to a particular project and project phase. This has proven to be an effective tool for communicating and managing risks and their associated costs. This level of risk assessment is not a normal part of a large, conceptual planning project, but is important to consider when alternatives will require significant capital investment. The same is true of sensitivity analyses. Both are of great importance if costs are close and better information is needed to make a decision. In the case at hand, tunnels have proven to have a high degree of inherent risk and a history of large cost overruns, but no mention has been made by the County monitor regarding risk or cost sensitivity analysis associated with the Grey Alternative. The Phase 1 Sustainable Alternative involves a large amount of traditional sewer construction that is much more in the comfort zone of MSD, and MSD has a century of experience analyzing risks and cost sensitivity when it comes to traditional sewer construction projects.

Throughout creation and development of the Sustainable Alternative, MSD continued to adjust cost and schedule in response to risk analyses. MSD has therefore sufficiently accounted for "additional cost value" quantified from detailed risk analyses. On page 7 of the County monitor's report the concept of risk analysis is discussed, but it does not indicate a lack of an appropriate risk analysis for the SI projects. Given the breadth of information presented in this report, combined with the information previously made available to the County team, MSD believes the issue of "risk analysis" has been fully resolved.

In addition, the industry standards referenced in the County monitor's report are not those required by EPA for the LMC Study. As outlined in the costing protocols document and presentation[20] provided to the County monitor on February 23, 2012, the costing protocols used were commensurate with and very close to those used in the preparation of the WWIP. Some deviations were made to the WWIP procedures to specifically address contingency estimates and to bring soft costs more in line with those experienced by MSD on recent, similar types of projects. WWIP contingency allowances were 25 percent for all projects. Additional steps were taken in the LMC Study to shore up some of the deficiencies that were observed in the WWIP estimates for features such as: influent pumping for EHRT facilities; preliminary selection of sites for EHRT and storage facilities so easement and land acquisition costs could be reasonably estimated based on current market values; dewatering and shoring costs for areas of known high groundwater conditions; rock excavation costs for areas of known rock deposits; potential brownfield sites that could be encountered; and increases in unit costs for projects with very short sewers. The above listing includes many of the risk factors associated with the types of projects being proposed, with which MSD is very familiar and experienced.

MSD's infrastructure dates back to the 1800's. As a result, MSD has a clear understanding of the issues, risks, benefits, and costs associated with underground pipeline construction throughout Hamilton County. Because much of the Sustainable Alternative is comprised of underground pipeline construction, we are confident the discrete project level risks have been accounted for within the costing tool that was applied to each specific project.

MSD disagrees with the County monitor's over-reaching statement on page 5 "*Typically the larger the project, the more uncertainty regarding its cost estimate.*" The monitor failed to define "larger project" within the context of its statement. Does "larger" reference a high capital cost, more length of underground pipe, or some other metric? Uncertainty is not necessarily more inherent in larger projects. The type of project is a more significant factor in uncertainty than the size of project. For example, the Sustainable Alternative is comprised largely of conventional utility type infrastructure projects. Individually, these are relatively small, straightforward projects. Collectively they represent a relatively large, straightforward project. On the other hand, the Grey Alternative is a relatively large, specialized project. This difference illustrates the fact that the size of the project may not be as important as the type of project Indeed, greater uncertainty will likely arise with regard to the Grey Alternative, due to its specialized nature and the lack of local experience with projects of its type.

3.1.2. Project Level Risk Analysis

During the LMC Study, MSD developed a detailed risk evaluation for the Lick Run suite of projects,[26] identifying and assessing seven risks and developing the strategies for addressing each. In order to provide the Board with an understanding of the level of effort dedicated to risk evaluation, the details of this effort are discussed herein.

RISK 1 = LAND ACQUISITION

Cost estimating for right-of-way during the early stages of projects is difficult because of the lack of concrete information regarding the extent and nature of property needs. As project designs progress, right-of-way estimates will be updated to reflect changes in property needs. It is anticipated that the majority of projects will experience a reduction in right-of-way costs; however, the potential need for additional property resulting in increased costs cannot be discounted.

Risk Identification:

Property acquisition challenges (relocation, loss of business, funding constraints) may incur additional costs and delays.

Risk Assessment:

Property acquisition is a complex challenge that can affect schedule and budget. The inability to obtain contracts on a large percentage of the properties prior to submitting the Sustainable Alternative to the Regulators could jeopardize the project. A general corridor for the open channel was identified in the hydraulic and hydrologic investigation[27] as generally the area between Queen City Avenue and Westwood Avenue.

Risk Strategy:

Detailed itemization of costs assisted in ensuring all completeness of the estimate as was described in Real Estate Cost Estimation Assumptions dated February 29, 2012[28]. In an effort to mitigate cost overruns, conservative assumptions in estimating right-of-way costs included the following:

- ACQUISITION COSTS: A 1.5 multiplier was applied to the Auditor's Market Value[29] for each parcel as the basis for anticipated acquisition costs. The 1.5 multiplier was derived from a review of properties already acquired within the Lick Run corridor which revealed that appraised values and actual acquisition prices were approximately 50% above Auditor's Market Values. Easement acquisition costs were based on standard estimating principles derived from design consultants currently working on the projects. These estimates are based on square footage and the type of easement being acquired, e.g., permanent residential easement, temporary non-residential easement.
    - The Auditor's Market Values are established pursuant to ORC 5713.33 which requires that every six years, the tax commissioner verify that properties are being assessed in accordance with law. The assessments are intended to equalize imbalances in property values. Examples of why such imbalances occur are: economic trends that vary from neighborhood to neighborhood and among different types of properties; improvements to the property; demolition of structures; and, additional or new tax levies.
    - The most recent reappraisal resulted in new value assessments effective for the January 2011 tax period. The valuations were prepared by Lexur, a company that specializes in property revaluation programs.
- RELOCATION COSTS: Relocation estimates were derived from a review of various guidance materials prepared by ODOT[30], FHWA[31], HUD[32] and other publications prepared for public agencies[33] and specifically to conform with the Uniform Relocation Act (URA). Relocation estimates are very conservative due to the number and size of commercial properties being displaced. Further, industry guidance cautions that relocation costs account for the majority of cost overruns for public acquisition projects.
- PROPERTY MANAGEMENT: Property management cost estimates were derived from actual costs related to properties already acquired by MSD, including Lick Run, North Fairmount and West Fork. Cost overruns associated with property management could result if structures are required to be maintained beyond the time frames included in the base project cost. For the Lick Run corridor the base project cost estimates include real estate property management for 2½ years. Projects outside of the Lick Run corridor included a 12-month service period.

- ENVIRONMENTAL SITE ASSESSMENT (ESA): ESA cost estimates were derived from information provided by Strand, ATC & Associates, Kermada, and the City of Cincinnati Office of Environmental Quality (OEQ).[34,35,36,37]

In an effort to mitigate schedule overruns, conservative assumptions in estimating right-of-way costs included the following:

- SUPPLEMENTAL ASSISTANCE BENEFITS PROGRAM: The USEPA Consent Decree[38,39] places strict acquisition, planning and construction timelines on MSD. MSD believes that early completion of projects will reduce personnel hours, project delivery time and construction costs resulting in significant savings for ratepayers. The City Manager approved the City's use of the Supplemental Assistance Benefits Program for the Lick Run Valley Conveyance System. The Program was developed by the City to incentivize owners to sell their properties and tenants to vacate properties required for time-sensitive projects. Amounts anticipated to be paid under this program were not included in original cost estimates but have been incorporated into the most current updated base project cost. Total costs are approximately $4.9 million.

- QUICK TAKE: Quick take provides MSDGC with the ability to control construction deadlines by authorizing expedited access to and possession of property being appropriated to public use. Such access and possession is contingent upon a complaint for appropriation being filed and the appraised value of the appropriated property being deposited in escrow with the court. Appropriation petitions are filed when an agreement for the purchase of property cannot be reached in good faith.

    - ORC 163.07[40] allows possession of vacant land being appropriated immediately after the complaint is filed and the appraised value is deposited in escrow with the court. For property that includes structures, the owner or occupant is required to vacate the land and structures within sixty days after service of the summons. After the expiration of 60 days, MSDGC has the authority to remove any structures prior to a jury establishing a value to the property. At any time after MSDGC deposits the appraised value with the court, the owner may apply to the court to withdraw the deposit. Withdrawal of the money does not have any impact on the court proceeding except that the sum withdrawn is deducted from the sum of the final verdict or award and no interest accrues or is payable on the amount deposited with the court.

    - In an appropriation proceeding where quick take authority exists, the defendant does not have the right to question or argue the necessity of the project requiring the acquisition of the property or whether the need for the property involves a public use. The defendant is limited to questions of whether the property has been blighted and/or whether the offer represents just compensation for the property. Note that

quick take authority will limit prevalent suppositions that MSDGC is acquiring property in excess to be turned over to private parties for future development.

- STAFFING: The acquisition of property interests for the Kings Run, Lick Run and West Fork watersheds have been estimated to require 134 full takes and 1,906 easements by the end of 2014. [41,42,43] Timely acquisition is essential to clearing the right-of-way to accommodate construction schedules. Staffing concerns that align with and support MSD goals take into consideration typical acquisition activities result in approximately 75-120 easements per year for a full-time acquisition specialist. Likewise, MSD expects to acquire anywhere between 20 to 30 full-takes on an annual basis. Based on these assumptions, and the goal of 2014 for completion of acquisition, MSD is monitoring staffing needs on a regular basis to mitigate potential delays.

- PUBLIC FORUMS TO ACQUIRE BULK EASEMENTS: In an effort to expedite acquisition, MSD is working with ODOT and FHWA to develop a process for purchasing easements at public forums. This technique has been used by public agencies and has substantially reduced project delivery costs and time delays.

- ADVANCED ACQUISTIONS: MSD has proceeded with advanced acquisitions prior to final plan development or approval by the County or USEPA to prevent potential development and increased costs on the preferred location (Protective Buying), and to alleviate hardship to a property owner or owners on the preferred location (Hardship Acquisition). This strategy is allowed under regulatory authority[44].

RISK 2 = STORM WATER VOLUME

Risk Identification:

Corridor does not accommodate storm water volume due to design storm being exceeded; flow model projections are incorrect or other hydraulic issues such as backwater caused by elevated stage levels at Mill Creek or Ohio River.

Risk Assessment:

If the South Fairmount Corridor cannot accommodate the volume of water that is projected to flow through the open channel, localized flooding will occur which could threaten real property and human life.

Risk Strategy:

- FEMA Studies/Floodplain elevations will be conducted as design proceeds. The acquisition plan initially set out to procure of all parcels within the target area for construction of potential solution, including contouring and development of a proper floodplain to accommodate the 100 year storm. Availability of assembled property will be used in design.

- Preliminary Engineering Analysis[45] included HEC HMS/HEC RAS modeling for storm sewer area and channel evaluations. Modeled projections and scenarios are used as design criteria to protect the anticipated future condition for the 100-year floodplain.

- The Valley Conveyance System is a strategy to ensure adequate volume capacity in a hybrid grey and green system of a box conduit underneath a naturalized conveyance system. Detailed designs will be completed. The channel and conveyance system within the corridor are sized to account for the entire watershed draining through the target area; this is conservative design criteria and provides additional protection to reduce likelihood of localized flooding.

RISK 3 = UNKNOWNS

Risk Identification:

Project corridor has historical, archeological, environmental, geotechnical and buried utility unknowns that will be uncovered during construction leading to delays and cost overruns.

Risk Assessment:

The area was first settled in the late 1800s and was a mixed use community with several commercial and some industrial uses[46]. Because of the valley configuration, the geology of the area does have significant amounts of rock and hillside issues to address during design and construction. Because of the proximity to the Mill Creek and other important social, cultural and historical factors, as well as the likelihood of potential on-site disposal from the commercial and industrial operations, there is a possibility for this project to have several unknown characteristics. The exact location and condition of the existing utilities is somewhat uncertain. To address these potential issues, the relocation, protection and/or replacement of underground utilities may be required to fully implement the project plan.

Risk Strategy:

- The area-wide Phase 1 Environmental Site Assessment ESA[34,35,36,37,47] included the completion of four sampling and analysis plans for the 4 focus areas. An area-wide Phase 1 ESA under the USEPA Targeted Brownfield Assessment Program[48] has been completed for the corridor and four primary areas of concern were identified within the project corridor. Phase 2 ESAs of the focus areas have been initiated and completed for the majority of the high risk areas within the corridor. MSD anticipates submitting grant applications for continued assessment and cleanup of brownfield areas that could be integrated with sustainable infrastructure.

- A historical and archaeological consultant has assessed and surveyed the project corridor. The State Historic Preservation Office (SHPO) has been contacted as a courtesy. No project parcels within the target area are listed on the National Historic Registry[49] and corridor was evaluated in 1978, 2002, and 2011 to determine if a historic district exists. All surveys concluded sufficient resources are not present for consideration as a historic district.

- Utility Review, Topographic Review, Geotechnical Review, Intersection Traffic Movement Assessment & subsequent traffic Alternatives Development and Refinement Report[50], Geotechnical Exploration Report[51] have been completed to identify unknowns. All information will be incorporated into project detailed designs.
- Regarding conditions assessment, existing Pipeline Assessment & Certification Program (PACP) information has been reviewed, where available; in most areas pipes greater than 30" had recent inspections conducted. Appropriate measures will be incorporated into the detailed design and construction documents.
- Inventory of underground locate openings (ULOs) that will be necessary to locate to complete design; there are over 100 of these that will require location between the 30-90% design completion phases.
- An ecological investigation will determine whether a field survey will need to be completed to identify threatened and endangered species. The Glenway and Fenton areas have undergone a QHE 1 and HHE 1 analysis of stream conditions as well as jurisdictional determinant request by the USACE.[52]

RISK 4 = AGENCY ALIGNMENT

Risk Identification:

Inability to get alignment/consensus between all agencies and organizations around a community of the future solution leads to suspension/cancelation of the project.

Risk Assessment:

As the driver of the comprehensive, watershed-based wet weather solution, MSD will be dependent upon other agencies and organizations to support this approach and strategy. MSD has limited or no control over these agencies. The inability to get alignment and buy-in around this alternative project is a risk. This project will require MSD to develop new partnerships.

Risk Strategy:

- As part of Project Groundwork, MSD developed a concept called "Communities of the Future," which integrates sustainable sewer infrastructure improvements with urban renewal in areas that experience high volume or frequent CSOs. To assist and guide MSD with this vision, a Communities of the Future Advisory Committee (CFAC) was created in March 2010.[53] The CFAC is comprised of about 100 representatives of a cross-section of public agencies, community members, and members of County Administration and legal team. CFAC meetings are planned, coordinated and scheduled with representatives from Hamilton County Regional Planning. The CFAC has met quarterly throughout the more than two years of the project to provide input to Project Groundwork. Members of the South Fairmount community who have expressed interest have been invited to participate with this group. The President and the Vice President of

the South Fairmount Community Council (SFCC), as well as the President and Vice President of the South Fairmount Business Association (SFBA) attended CFAC meetings as well as meetings of the three sub-groups formed by CFAC to address specific issues.

- Development and refinement of a Communication Strategy & Plan.[54] Materials were created to inform and influence key leaders and potential partners for framing the project need and vision.

- The Lick Run Master Plan[55] completed with the assistance of CFAC, an open house (January 2011) and three community design workshops, provides for an overall plan for an integrated watershed based CSO reduction approach married with consideration for community redevelopment.[56] The Lick Run alternative is an approach to align with the HUD DOT EPA Sustainable Communities Partnership Program[57]. In 2010, the City was awarded a HUD grant for development of a Land Development Code Update[58] specifically identifying Lick Run as a watershed demonstration project.

- Completion of a SWEPP manual[59] to streamline and standardize the systematic watershed approach to identify and develop solutions.

RISK 5 = COMMUNITY SUPPORT

Risk Identification:

Public resistant to the project for a variety of reasons, including lack of public trust and support to community development benefits by sewer projects due to the lack of prior examples.

Risk Assessment:

The South Fairmount community has experienced continued economic decline for decades. Local residents refer to a "feeling of abandonment" and suffer from systematic disinvestment. They perceive the community is being ignored by the City and County governments.

Risk Strategy:

- Community engagement in South Fairmount, Westwood, East and Lower Price Hill and other Lower Mill Creek communities is focused around the Early Success Projects and the LMC Study.

- A Community Open House was held January 2010 followed by three concept design workshops[60,61,62] in 2011 and 2012.

- MSD has had a community relations specialist attend monthly South Fairmount Community Council meetings since July 2010.

- MSD has been engaging the Community to provide complete, up-to-date information in a transparent forum to receive feedback in a positive manner. Two Town Hall meetings were held

in August 2012. All comments received are documented in the Lower Mill Creek Partial Remedy Community Outreach Report to Hamilton County and City of Cincinnati, September 13, 2012 draft.[63]

RISK 6 = PUBLIC SAFETY

Risk Identification:

The resulting proposed project design will require certain mitigation strategies regarding an open waterway to address potential public safety issues.

Risk Assessment:

With daylighting of the Lick Run Channel, there will be concerns about children and others being exposed to a potential health and safety risk. Traditionally, we have used pipe and concrete channels and open water ways are less common; we need to educate the public about open waterway safety practices.

Risk Strategy:

- The channel design will address and mitigate associated impacts. The basis of design report[64] considered the depth of water and potential impact water inflow and is designed to reduce the risk with the proposal of a dual conveyance system - one underground, one above ground so that high flows will be reduced by underground conveyance.

- Mitigate through design to reduce risks by incorporating features such as railing, safe access pathways for viewing and maintaining the channel amenity and incorporation of signage for safety and education.

RISK 7 = REGULATOR SUPPORT

Risk Identification:

Delays in acquiring the necessary federal, state and local permits or regulator support could delay or suspend project implementation.

Risk Assessment:

Failure to gain regulator support/approval, funding or flexibility could suspend or reduce the project. An environmental review document may be required by the provisions of NEPA[65]. NEPA has historically been active in projects requiring federal funding to ensure projects comply with the Act. The nature and extent of the environmental documentation could affect the implementation schedule for the project.

Risk Strategy:

- Seek federal lead agency for Section 106 Historical Review and develop BMP for historical and cultural review should no federal agency be identified.

- USEPA (April 2011) Office of Water and Compliance Enforcement Memo recognized MSDGC for the Lick Run Approach.[66]

- Regulator support for SI projects was documented in the *Green Infrastructure Statement of Intent (April 19, 2007)*[67] - A joint statement signed by USEPA, National Association of Clean Water Agencies (NACWA), Natural Resources Defense Council (NRDC), Low Impact Development Center (LID), & Association of State and Interstate Water Pollution Control Administrators (ASIWPCA).

    - *"The purpose of this Statement is to formalize a collaborative effort among the signatory organizations in order to promote the benefits of using green infrastructure in protecting drinking water supplies and public health, mitigating overflows from combined and separate sewers and reducing stormwater pollution, and to encourage the use of green infrastructure by cities and wastewater treatment plants as a prominent component of their Combined and Separate Sewer Overflow (CSO & SSO) and municipal stormwater (MS4) programs."*

    - *"The objectives of this Statement are to: Affirm the belief by the signatory organizations in the value of green infrastructure as 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..."*

- Regulators recognized utilities need flexibility in addressing wet weather problems. As documented in the *USEPA Report to Congress on the Impacts and Control of CSOs and SSOs (August 26, 200468*[x] . This report was delivered to Congress on Thursday, August 26, 2004. The Report presents a comprehensive characterization of CSOs and SSOs, including the extent of environmental and human health impacts caused by CSOs and SSOs, the technologies used by municipalities to address these impacts, and the resources spent by municipalities to control CSO and SSO discharges.

    - *"It is unlikely that LID techniques alone are sufficient to fully control CSOs, yet they have shown promise as part of larger programs in reducing the size of structural controls (e.g. storage)."*

    - *"Inflow reduction and LID techniques reduce the quantity of storm water runoff that enters a sewer system. Since these controls can reduce both the peak flow rate and volume of storm water delivered to a sewer system, the size of more capital-*

intensive downstream control measures, such as storage facilities or treatment technologies, can be reduced, or, in some cases, eliminated completely."

- MSD and Hamilton County have been vetting the updated baseline model, sustainable projects models, framework for a potential Sustainable Alternative, default grey alternative costs, and Sustainable Alternative costs with USEPA Region 5, Ohio EPA, and ORSANCO. Technical teleconferences or workshops were held with the Regulators on November 17, 2011; December 6, 2011; July 26, 2012, August 6, 8, 16, 23, & 30, 2012; and September 6, 13, 2012. Meeting minutes from these workings sessions are provided in Appendix B. The Regulators have gained confidence in the methodologies and approaches utilized by MSD for development and evaluation of the LMC Study alternatives.

MSD has invested time and resources to identify, assess, and mitigate risks associated with the sustainable alternative. As presented herein, the cost risks identified for these projects were addressed by revising the scope of the project and updating the estimated cost of the project based on the revised scope. The revised project costs were included in the Preliminary Findings Report[69]. MSD does not believe carrying a program reserve will result in improved cost estimates. Rather, a detailed and comprehensive understanding of project components will enable engineering professionals to better scope and estimate each project.

3.1.3. Program Level Confidence Analysis

The confidence level of the program is directly dependent upon and correlates to the confidence level associated with the individual projects. As noted above, MSD has been constructing utility infrastructure for decades, and as such understand the need to identify potential risks in order to gain confidence with estimated costs. The risk analysis performed for the Lick Run project addressed all the issues noted on page 6 of the County monitor's report. MSD disputes the allegation that a risk analysis has not been demonstrated.

The County monitor's report (page 5) states *"An analysis on the overall confidence level of the stated cost has not been performed."* The industry standard answer to the question of overall confidence in project costs is contained in the reference document and corresponding table provided in the MSD Financial Analysis Manual[12] and the LMC Study Technical Memorandum on cost procedures.[19]

Most of the estimates prepared for the LMC Study range from Level 5 conceptual planning estimates through Level 3 (approximately 30% design) estimates. As you can see, the wide variation in costs that are indicated is substantial, but is indicative of the standard of care that can be expected from a historical perspective. At a more practical and general level, the intent of the cost estimating was to cautiously over-predict project costs to avoid future surprises and cost increases as the projects proceed through design and implementation. This cautious, over-prediction of costs was conducted in spite of

the fact that in present economic conditions, recent MSD constructed projects have been completed under budget, and in some instances, well below budget.

3.1.4. Project Level Cost Uncertainty

Project level certainty is increased with more robust and detailed processes available for conducting risk assessments. MSD employs such techniques on its preliminary design and final design projects. At this stage of a planning-level alternatives analysis where capital costs of the Grey and Sustainable Alternatives differ by 70 percent, a detailed risk assessment analysis is not going to change the answer. This is particularly true in this instance, where the Grey Alternative is a tunnel project where cost overruns often result due to unforeseen physical conditions far beneath the ground surface.

MSD considered risks while developing the scope, cost, and schedule of each sustainable infrastructure project. Risks were mitigated through substantial field investigations, engineering evaluations, and project-specific information and considerations.

Comparison of the overall WWIP program with the risks inherent in the default grey solution provides the proper context for evaluation. The Grey Alternative is a massive tunnel project to be completed over a several year period using an estimated nine construction contracts with numerous physical interfaces between the contracts. If the latest risk register is examined for the LMC Tunnel project[70], which is at approximately 60% design completion, there are a considerable number of potentially costly risk factors that remain and are discussed in Section 4 of this report.

There is a considerable amount of risk associated with any construction program that costs $300 to $550 million. Because the LMC Study is a planning level exercise, the type of analysis proposed is far beyond the norm, and is not justified at this stage particularly given the large cost differential between the competing alternatives.

At this stage of alternatives analysis, only fatal flaws need to be identified that would invalidate selection of a much lower cost solution. The probabilistic sensitivity analyses proposed in the monitor report (page 8) would be time consuming, would not overturn the large cost differential, and would likely confirm the certainty that the Sustainable Alternative is lower in terms of both risk and cost. However, the Sustainable Alternative removal effectiveness and volumetric reductions will not be known precisely until construction has been completed. The determinant for the volumetric reduction will be model runs made from pre-existing and post-construction versions of the model, for the Typical Year analysis. Version 3.2 of the updated System Wide Model (SWM)[71] has been accepted by the Regulators *(refer to Meeting Minutes included in Appendix B),* and as such it is considered the pre-existing condition model run from which the Typical Year overflow volumes are defined. The post-construction version of the SWM will have the separated storm sewers removed and will be calibrated based on post-construction flow monitoring data. The calibrated post-construction SWM will be run for the Typical Year to assess the CSO volumetric reduction.

Further, the benefits of the Sustainable Alternative must be considered along with any alleged risk of uncertainty with regard to cost. These include:

- lower initial costs;
- a surplus of $220 million to overcome any shortfalls in volumetric reduction;
- integrated watershed solution that EPA wants to see implemented to gather more information from a national perspective;
- consistency with recent EPA policy regarding integrated watershed planning and development of wet weather control measures;
- addresses water quality in reaches of Mill Creek and its tributaries that are more visible and accessible than the reach between the Ohio River and the Hopple Street Viaduct; and
- potential for an overall LMCFR solution that is lower in cost.

Contractor Capacity Evaluation

In August 2011, MSD retained industry expert, FMI Corporation,[72] to perform an assessment of the Contractor Capacity as compared to the anticipated requirements for the LMCPR. For more than 50 years, FMI has worked with leading contractors, manufacturers, trade engineers, labor associations, and public/private owners. The forecasted trends from the 2009 report conducted for MSD were accurate. The 2011 update report identified the following issues:

- The current and expected labor supply is expected to maintain a narrow labor surplus through 2020. Cincinnati and the surrounding region will not face a shortage of skilled labor outside seasonal peaks for construction labor.
- Shortages are not forecasted in engineering resources through 2020.
- Shortages in three trade occupations are forecasted during peak seasons beginning in 2014 through 2020 (masonry, concrete finishing, and operating engineers).
- All skilled craft categories are forecasted to be near capacity beginning in 2012.
- FMI recommends MSD expedite construction of WWIP projects to benefit from current economies.

3.1.5 Value Engineering

MSD went beyond the typical risk analysis evaluation and conducted a formal Value Engineering Study for the Lick Run project. In December 2010 and January 2011,[73] MSD conducted a Value Engineering exercise on the recommended plan for the Lick Run Wet Weather Strategy, of which the County monitor was informed. An independent team of seven industry experts completed a detailed review of all the supporting documents, analyses, and modeling available at the time. The evaluation was completed based on the preliminary 30% designs for the 14 sewer separation projects and the preliminary engineering plans for the valley conveyance system. The Lick Run VE Study offered a number of

recommendations which are summarized in the *"Lick Run Wet Weather Strategy Value Engineering Study Report."*[74]

Key conclusions of the VE Team

- The approach being taken to control wet weather combined sewer overflows in the Lick Run catchment area – stormwater separation from the sewer system - appears to be sufficient towards achieving the goal of reducing combined sewer overflows by 2 billion gallons in the Typical Year and meeting the USEPA consent decree.

- The model calibration with existing conditions is reasonable, leading one to believe the model results for predicted stormwater capture of the proposed solution is reasonable.

- The 2.18 billion gallons of annual CSO volume reduction is achievable by the sewer separation projects both within and outside of the Lick Run watershed and provides a 1.09 safety factor. Note, this 2.18 BG volume is based on estimates at the time of the VE Study.

Additional analysis has been conducted by the team to evaluate design-related suggestions to reduce cost, such as considering the use of the existing combined sewer system for stormwater conveyance in lieu of installing new stormwater systems. The analysis demonstrated that the cost for constructing all new storm sewers would be over three times more costly than the Sustainable Alternative. The extent of the new sanitary system needed and the condition of the existing combined system both structurally and hydraulically are the primary drivers for these costs. Community impacts were also further examined including maintenance of traffic and associated costs.

The VE study included recommendations for the urban valley conveyance system (VCS). These recommendations addressed issues including water quality, constructability, cost, maintenance, environmental factors and habitat, and community enhancements. MSDGC completed a preliminary evaluation of the recommendations and used this approach to further evaluate and develop ideas that have been incorporated into the Community Design Workshop process and the Lick Run Master Plan. These topics will be further refined during advanced design.

While the strategic separation projects will provide an immediate localized benefit upon implementation, the anticipated CSO reduction benefit is a result of the strategic separation projects in conjunction with the urban valley conveyance system. The conclusions of the VE Study mirror the conclusions contained in previous planning and preliminary engineering studies and analyses, for example, the Lick Run Wet Weather Strategy,[56] and provides a reasonable and cost-effective solution for reducing current combined sewer overflows from the Lick Run Basin.

3.1.6. Sensitivity Analysis

The largest component of the Sustainable Alternative costs is traditional sewer construction. MSD is very well versed in the factors that can affect the costs of sewer construction and has planned for and managed these costs increasingly well over the past few years

Considerable due diligence has been performed during the planning and preliminary design of most of the Sustainable Alternative projects by conducting sewer alignment surveys, assessing potential easement acquisition needs, preliminary geotechnical investigations, Phase I environmental studies, and utilities surveys. These efforts allow MSD to provide adequate cost allowances to the base construction cost estimate, and, in conjunction with additional design contingency factors, reduce the potential risk for bid prices exceeding budget allowances.

Sizing of proposed new storm sewers is based on stormwater system models and the City's Stormwater Management Unit (SMU) requirements to convey a 10-year, 24 hour duration storm with the pipe flowing full, and to convey a 25-year 24 hour duration storm without stormwater exiting the system through manholes or storm inlets.[75] This will improve the level of service in some areas where existing combined sewers do not provide as high a level of service.

The use of a declining scale of design contingencies to cover unknown costs as a project progresses from conceptual planning through final design is a type of cost sensitivity analysis. Conceptual planning estimates have a design contingency factor of 35 percent, in recognition of the fact that there are many unknown factors that could affect costs. This conceptual planning level contingency allowance exceeds that used in the preparation of the WWIP by 10 percent. Even so, there were extra measures taken during the preparation of the LMC Study to consider actual sites for remote facilities during conceptual planning to determine lengths of pipe required, the need for pumping, availability of adequate land for siting of facilities, special good-neighbor features that might be required in affected neighborhoods (like architectural treatments, noise control, and odor control), and easement and site acquisition costs.

3.1.7. Contingency Reserve

The Association for the Advancement of Cost Engineering International (AACEI) guidelines recommends the use of contingency for cost risks[76]. It is a standard practice within the wastewater industry to account for program level risks by assigning a contingency value or percentage of Total Construction Cost to be included in the Capital Cost. This risk factor can be applied as a consistent percentage to the program costs, or a detailed risk assessment can be performed on each individual project to develop project specific risk factors. The project team, in collaboration with MSD, determined that a fixed program contingency of 10% would be used and applied to each project during this evaluation. A more detailed analysis of the risk factors would have been costly and time consuming without providing a clear benefit for the alternatives evaluation.

In accordance with MSD's Estimating Guide, and AACEI Estimate Classification system, contingency factors are included in the cost estimates for both design and construction of all SI elements, to account

for potential unknown project risks. These contingency factors vary based on the level of project design and estimate class.

Projects at a lower level of design, such as long-range planning or planning level, are categorized with a Class 5 or 4 estimate, respectively, and therefore have higher design and construction contingencies applied. Projects at 30% design are categorized with a Class 3 estimate, and have the respective design and construction contingencies applied. As the project design is advanced, and potential unknown project risks are reduced, the contingencies applied to the base construction cost will be reduced accordingly.

Tables 2, 3, and 4 identify areas where a line-item contingency factor was applied to a particular aspect of the project. This approach provides for a more representative estimate in that conditions unique to the projects are explicitly addressed. This also minimizes the level of "unknown" information typically lumped into a construction contingency amount.

Table2 - Line-Item Contingency Cost Estimating Items for all Projects

Line-Item Contingency Item	Description
On-Site General Conditions	Accounts for the cost of items that cannot be associated with a specific element of work but must be furnished to complete a project: supervision, temp facilities, office trailers, utilities, permits, small tools, traffic control, barricades, construction crew parking, testing, staff time for meetings, restoration, OSHA requirements, building code standards, work hour restrictions, pollution controls.
Contractor's Overhead	Accounts for the cost of doing business: historical values, project size and complexity, annual work volume.
Contractor's Profit	Compensation for risk and efforts made to complete the project based on: economic conditions for local construction industry, individual contractor's overhead costs, and perception of risk.
Bonding	Accounts for the cost to the contractor to secure bonding for completion of the work.
Insurance	Accounts for the cost to the contractor to secure insurance against accidents while performing the work.
Administration	Accounts for various administrative costs such as legal fees or use of consultant staff support service for project management. Multiplier varies by project.
Miscellaneous	Accounts for the cost to the project for activities not having a unique line-item cost estimate: permits, plan review fees, inspection fees, geotechnical investigations, environmental investigation and testing, materials testing, paperwork, legal work, training, instrumentation and control, public relations.
Field Engineering & Inspection	Accounts for the cost of personnel used for project engineering and inspection services during construction. Cost dependent on project type.

Table 3 - Line Item Contingency Cost Estimating Items for Sustainable Projects

Line-Item Contingency Item	Description
Construction in Rock	Accounts for the cost of constructing the project in rock by applying a 50% multiplier to construction cost.
Dewatering	Accounts for the cost of trench dewatering to enable construction to proceed by applying a 10% multiplier to construction cost.
Maintenance of Flow	Accounts for the cost of maintaining operations of conveyance, pumping, or treatment facilities during construction: bypass piping and/or pumping, field personnel, energy costs by applying a multiplier to construction cost.
Brownfields	Accounts for the cost of excavation and handling of soil that may be contaminated by applying a 5% multiplier to the construction cost.
Clearing and Grubbing	Accounts for the cost of preparing a site(s) to remove vegetation, trees, structures, misc. to facilitate construction activities based upon pipe size and length of piping impacted.
Maintenance of Traffic	Accounts for the cost of maintaining vehicular and/or pedestrian traffic along roadways, streets, or sidewalks during construction in compliance with local and state regulations. Multiplier varies by project.
Urban Alignment	Accounts for the cost associated with construction of conveyance systems within urban environments subject to an increased level of utility conflicts, differing site conditions, and unexpected field conditions.
Creek Crossing	Accounts for the cost associated with the size of creek to be traversed, the level and frequency of flow, and receiving stream criteria.
Number of Manholes	Accounts for the grade changes, pipe size changes, bends, and intersections of conveyance sewers.
Number of Utility Crossings	Accounts for the cost associated with crossing either over or under existing utilities along the proposed alignment.
Street Width	Accounts for the cost required to resurface roadways after construction is completed.
Small Job Cost Increase	Accounts for the cost of projects involving less than 3,100 feet of sewer.
Storage Tank Configuration	Accounts for the cost differences with construction of an above ground facility vs. a below ground facility requiring excavation, sheeting, bracing, and backfill.

Table 4 - Line Item Contingency Cost Estimating Items for Grey Projects

Line-Item Contingency Item	Description
Number of Pits or Shafts	Accounts for the cost of any additional pits or shafts beyond those included in the initial base project cost.
Average Depth	Accounts for the cost of construction required for vertical lineal feet of construction. Initial cost up to 15 feet of depth is included within the parametric curve and additional $2,200 for each additional foot over 15 feet is added to the base project cost.
Number of Flow Control Structures	Accounts for the cost of incorporating additional flow diversion structures into the project as determined necessary during project planning and design activities.
Jack-and-Bore Construction	Accounts for the cost of constructing infrastructure to depths 6-inches to 36-inches below ground surface.
Micro Tunneling Construction	Accounts for the cost of constructing infrastructure to depths ranging from 21-inches to 72-inches below ground surface.
Macro Tunneling Construction	Accounts for the cost of constructing infrastructure to depths more than 72-inches below ground surface.
Grade < 1%	Accounts for the cost of constructing infrastructure via jack-and-bore method on low grades by adding a 50% increase to the base construction cost.
Grade 1% to 2%	Accounts for the cost of constructing infrastructure via jack-and-bore method on low grades by adding a 30% increase to the base construction cost
Non-Homogenous Subsurface	Accounts for the cost of conditions creating difficulty in selecting the tunneling machine and greater risk of emergency recovery shafts by adding a 50% increase to the base construction cost.
Dewatering Required	Accounts for the cost to dewater trenches to facilitate construction by using a 10% multiplier to the base construction cost.
Railroad Crossing	Accounts for the cost to obtain railroad crossing permits and for additional requirements imposed by the railroad during construction by adding a 2% increase to the base construction cost.

Table 5 identifies the project stage of each of the individual SI projects. As projects move through planning into detailed design, more information is available to inform the estimator of required project costs. Therefore, there is a higher probability for inaccuracy at the lower level of planning. As the survey, geotechnical data, and other utility locations are made available the sewer alignment and elevation become set and the costs become more accurate. This is mitigated by the design contingency and by engineering judgment of unit price assumptions.

Table 5 – Projects for Design Contingency Consideration

CSO	Project Name	Project Stage
Bloody Run Basin		
CSO 181	Strategic Separation (Alternative A)	Preliminary
	Techsolve Basin	Preliminary
	RTC	Preliminary
Denham Basin		
CSO 10	Phases A, B, C, D, and E	Preliminary
	Phase F (RTC)	Preliminary
Kings Run Basin		
CSO 217/483	Stream Removal/Sewer Separation	Preliminary
CSO 217	1.5 MG Tank @ CSO 217 (Replaced 20 MGD HRT)	Conceptual
Ludlow Run Basin		
24, 151, 162, 109, 112, 110	Stream Separation	Conceptual
Lick Run Basin		
CSO 5	Sunset Avenue	30% Design
	Rapid Run Early Success Project	30% Design
	Wyoming Avenue	30% Design
	Harrison Avenue Phase A	90% Design
	Harrison Avenue Phase B	30% Design
	State Avenue	Preliminary
	White Street	30% Design
	Quebec Road	30% Design
	Queen City Ave Phase 2 (Western)	30% Design
	Queen City and Cora Ave (Fenton)	30% Design
	Quebec Heights Phase 1 (Glenway Woods)	30% Design
	Quebec Heights Phase 2 (Wells Street)	Preliminary
	Grand and Selim Ave	Preliminary
	Queen City Phase 3 (Eastern)	Preliminary
	Westwood Ave	Preliminary
	Queen City Ave Phase 1 (Central)	30% Design
	Valley Conveyance (Lick Run Channel)	Preliminary
West Fork Basin		
CSO 117	Fay Apartments Street Separation	Preliminary
CSO 125	Stream Separation	60%
CSO 126	Stream Separation	Preliminary
CSO 127	Stream Separation	Preliminary
CSO 128	Stream Separation / Relocate Regulator	Preliminary
CSO 130	Stream Separation	Preliminary
All	West Fork 84" Interceptor	Preliminary
CSO 130, 204	1.5 MG Tank	Facilities
CSO 125	CSO 125 1.5 MG Storage Tank	Facilities
CSO 528	Street Separation	Facilities
CSO 529	Street Separation	Facilities
CSO 530	Street Separation	Facilities
All	Channel Re-naturalization and Park Amenities	Conceptual

Note: Project stage as of April 2012. Most projects are further advanced and Harrison Road Phase 1 is under construction.

The project cost estimates include three layers of contingency as described below.

- Line-Item Contingencies. The costing tool developed for the CAPP, LTCP, and WWIP provides engineers and estimators with the ability to account for field-specific conditions and apply a contingency to particular activities. A good example of the line-item contingency is the method to estimate Maintenance of Traffic (MOT) costs. There is a multiplier on the "Open Cut Sewer" tab of the costing tool that applies a 1% markup for maintenance of traffic that was utilized for a few projects. There is also the option to include Urban Setting that increases the cost by 50% if a sewer project runs through a city setting to account for extra traffic control as well as the additional delay and resource location issues that affect the contractor. For the sustainable projects MOT costs were included in the estimates in various forms at the consulting engineer's discretion and dependent on the project stage. Consideration was given to the roadways impacted and construction duration. For example, MOT costs were included within the general conditions (as a percentage of the construction cost), or as a separate line item as a percentage of the construction cost or as a cost per linear feet of pipe within the street. These MOT costs were also reviewed through the MSD cost estimate review process.

- Design Contingency. The 5 to 35 percent design contingency was applied to the base construction cost to account for unknown cost elements that diminish as planning and design progress. As a project advances in design, the design contingency is lowered as the unknown elements are minimized with detailed engineering and field gathered information.

- Construction Contingency. The 10 percent construction contingency is intended to cover cost increases that may occur during the construction phase of the project due to unforeseen physical conditions, schedule delays, and other factors.

These three layers of contingency (design contingency, line-item contingencies, and construction contingency) comply with all industry standard practices for estimating project costs. The LMCPR project will be financed primarily through bond proceeds. MSD intends to maximize the use of grants and low-interest loans to the fullest extent possible. Artificially increasing project costs by creating a contingency reserve requirement would increase the capital financing requirements and ultimately result in *higher rates to customers*. Given the level of due diligence invested over the past three years for both the Grey and Sustainable Alternatives, pursuit of a "contingency reserve" in addition to the three levels of cost contingency built into the program is not recommended.

The concept of contingency reserve is also contrary to previous discussions with the County monitor team. When reviewing MSD's 2012 Capital Improvement Plan (CIP) request, the County monitor argued that using a 10 percent project contingency factor seems excessive for MSD's construction projects. Their position regarding the projects included in MSD 2012 CIP directly contradicts the concept of creating an additional level of contingency via a contingency reserve account.

3.1.8. Probability Curves

The S-curve provided on page 8 of the County monitor's report is an example "probability of occurrence" curve that is not directly applicable to a storm sewer or any other project in the Sustainable Alternative. The source of the curve shown is the GAO and NASA, which are organizations that do not pertain to the wastewater industry. The suggestion that probabilistic risk simulation models are considered an industry standard for the types of projects that make up the Sustainable Alternative is not accurate. Conventional projects such as the individual projects in the Sustainable Alternative, exhibit high levels of predictability based on strong historical trends and large sample sizes. Additional modeling of this data is simply unwarranted, as the SI projects do not necessitate the same level of detailed scrutiny and "what-ifs" modeled cost simulations as an aerospace NASA project. MSD has identified the program cost drivers; associated risks, correlation between cost elements; assigned contingency levels; and identified risk mitigation efforts. The results will not change by spending additional resources performing complex Monte Carlo simulated cost and probability models.

Additionally, the GAO document from which that figure was taken, identifies seven steps for addressing certainty through probability distribution curves, and MSD has already performed the relevant actions described in the steps as part of the LMC Study. MSD is therefore confident the level of certainty for the SI project costs will not be furthered by creating a fourth layer of "contingency". Additionally, MSD has decades of experience constructing sewers including separation projects throughout Hamilton County. The uncertainty in estimating sewer construction costs is minimized given the wide breadth of experience, multiple layers of independent review by highly trained professionals, and routine nature of pipeline construction.

3.1.9. USACE Projects

The County monitor report cites (page 5) the US Army Corps of Engineers (USACE) as an entity that requires the use of the Monte Carlo simulation for civil works projects with a total project cost estimate of $40 million or more. This requirement is a long and expensive process typically only mandated for projects where federal funds are being used. It is an acceptable practice within the wastewater industry to streamline the costing process by making assumptions regarding risk and assigning a consistent program contingency to account for it, as MSD has done in the LMC Study.

USACE civil works projects consist of flood control and navigation projects. Since the Lick Run Valley Conveyance System and the West Fork Branch naturalization will control flooding and are surface conveyance systems, these could theoretically potentially fall within that category. Historically, USACE projects include grey infrastructure of channelization and bridges, and therefore the sewer separation projects do not fall into this same category.

The USACE Engineer Technical Letter referenced in the County monitor's report states performing this risk analysis on projects less than $40 million is not mandatory. It goes on to discuss other acceptable methods for assessing risk and contingency based on "on the merit of scope definition, quantity, and estimate confidence by feature, sub feature, major cost elements, and technical complexity". The

USACE does not define "significant risk factor" in the document referenced. Engineer Regulation (ER) 1110-2-1302, Civil Works Cost Engineering, and ER 1110-2-1150, Engineering and Design for Civil Works Projects were also reviewed for risk discussion.

Excerpt from USACE, Engineer Technical Letter 1110-2-573:

> *"6.2.3 To accomplish this process, it is vital to first establish the method or process in risk identification. A recommended process is provided in the flow chart in figure 6-1. The current HQ guidance requires a formal analysis on all projects where the TPC exceeds $40 million. For projects where the TPC is less than the $40 million, a formal risk analysis is not mandatory, but may be prudent. Another accepted method for assessing risk and contingency for projects valued at less than $40 million is to evaluate on the merit of scope definition, quantity, and estimate confidence by feature, sub feature, major cost elements, and technical complexity."*

The LMC Study work completed by MSD and its team of technical experts fully complied with the risk assessment methodology that compares with those cited by the USACE. The Flow Chart referenced as Figure 6-1 in the above excerpt is provided in this document as Figure 1. The steps identified in the flow chart have been discussed in this report including:

- Begin Risk Analysis
- Coordinate with staff for Support
- Customize Risk Analysis for Project Needs
- Conduct Risk Register Brainstorming Workshop
- Identify Risk Items
- Complete Risk Register
- Consider Risk Items in Cost and Schedule for the Project
- Conduct Sensitivity Analysis of Risk(s)
- Identify Key Risk Drivers
- Modify Project Scope as Necessary to Address Risk Items
- Complete Cost Estimate with Contingency & Escalation

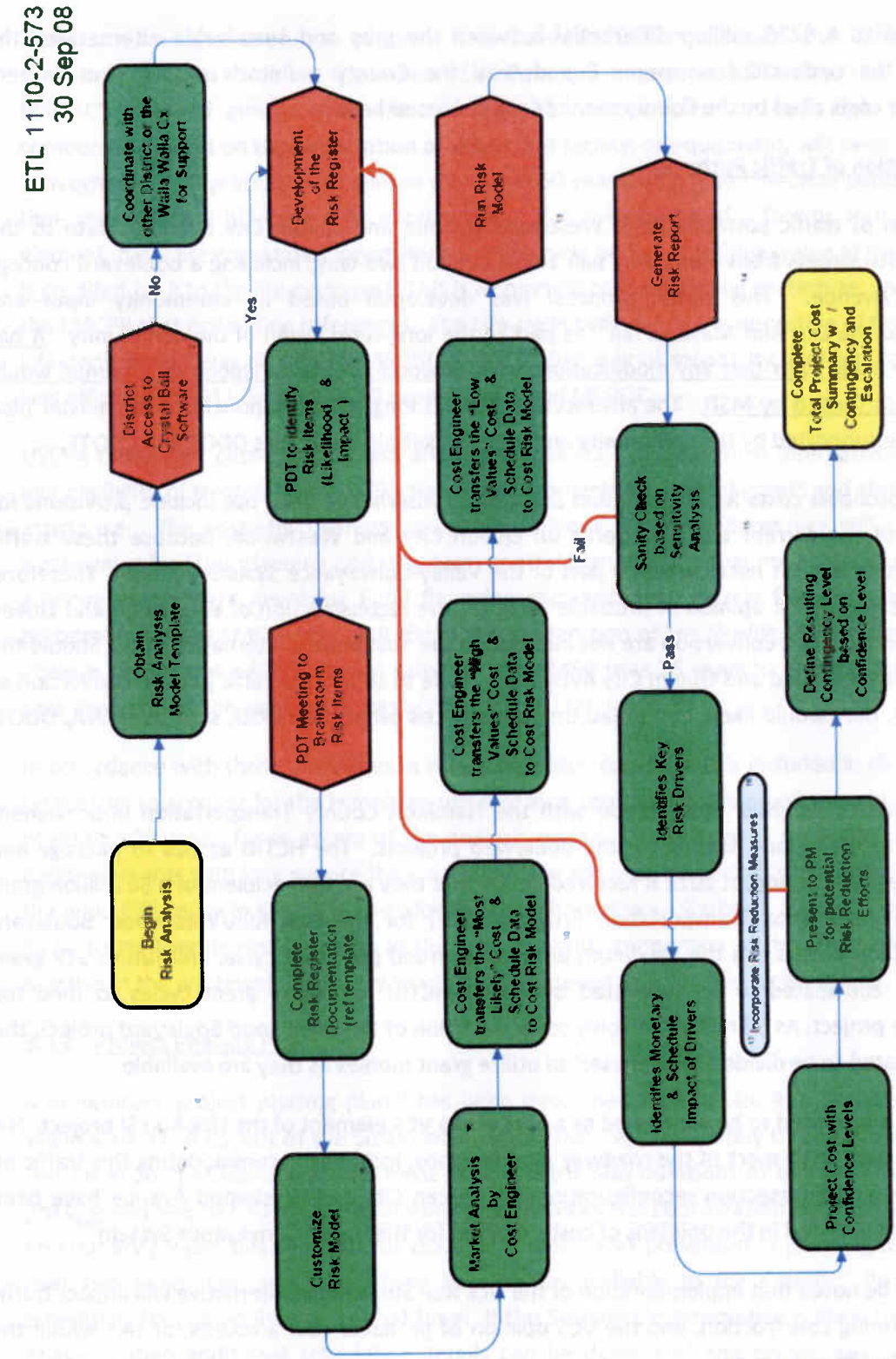


Figure 1 – USACE Figure 6-1 Recommended Risk Analysis Process

A great deal of effort and coordination with local agencies and utilities has gone into Sustainable Alternative project sequencing, to minimize project costs and community disruption. Duke Energy, GCWW, MSD, CDOTE and ODOT all have capital improvement plans that have been taken into consideration for developing the schedule, sharing of construction costs, and maintenance of traffic.

- WEST FORK - Within the West Fork watershed, there are no key sequencing needs or traffic impacts at this time. ODOT has on-going arterial and interchange construction work in this area associated with I-75 and I-74; however, this construction work is anticipated to be complete before the implementation phase begins for the SI projects in the watershed.[79]

- BLOODY RUN - Within the Bloody Run watershed, the key sequencing need is with ODOT regarding potential I-75 construction work which would impact the CSO 181 location. Meetings have been held with ODOT to discuss coordination and schedule. It is anticipated, at this time, that the ODOT work would begin in 2018.[80]

- KINGS RUN/WOODEN SHOE - Within the Wooden Shoe watershed, the key sequencing need is with CDOTE regarding a street improvement project along Winton Road scheduled to begin construction in January 2013[81,82]. In order to coordinate with CDOTE and the project schedule, the design of a phase of the sustainable project within Wooden Shoe – installation of new storm system along Winton Road – is being advanced at this time, to be constructed within the same timeframe. It has been agreed that CDOTE will prepare the maintenance of traffic notes. It should be noted that savings in construction costs will be realized through this coordination effort.

- LICK RUN - Within the Lick Run watershed, there are a number of sequencing needs or traffic impacts with respect to capital improvement projects and schedules for Duke Energy, GCWW, CDOTE and ODOT. The sequencing needs and impacts were accounted in the cost estimates presented for the SI projects. A more detailed discussion of utility coordination is provided in Section 2.5.1 of this report.

    - HARRISON AVENUE - The first SI project to be constructed is the Harrison Phase A Sewer Separation project, which was strategically designed and bid with the CDOTE Harrison Avenue Realignment Project.[24] If MSD had not opted to collaborate with CDOTE to coordination construction needs in this corridor, then project costs would have increased at least $350,000. This accounts for more than a 20% cost savings on the bid price for the MSD portion of the Harrison Phase A Sewer Separation Project. With Harrison Avenue Realignment project under construction, Harrison Avenue will be closed to traffic for the summer months of 2013. CDOTE had requested that no other sewer separation projects be constructed that would affect the detour route on White Street or the alternate through route of Queen City Avenue during this

time. Therefore, the remaining sewer separation projects have a start date that occurs after Harrison Avenue is reopened to traffic.

- SUNSET AVENUE, GRAND AVENUE, QUEBEC ROAD - CDOTE requested that the large parallel collector to be located along streets of Sunset Avenue, Grand Avenue and Quebec Road be sequenced such that they are not under construction at the same time. These projects have then been scheduled to minimize impact to traffic and overall disruption of the community.

- WESTERN HILLS VIADUCT – MSD has performed additional coordination with CDOTE and ODOT related to the Western Hills Viaduct and Brent Spence Bridge projects; as well as with Duke Energy and GCWW on opportunities to synchronize construction schedules for gas and water main rehabilitation/replacement through the corridor to minimize community and traffic disruption.

3.2.4. Operation and Maintenance

MSD will operate and maintain the new infrastructure constructed for the LMCPR. These costs are included in the alternatives analysis. New storm sewers have stormwater best management practices (BMPs) to address water quality concerns and mitigation of those concerns, and costs are also included for constructing, operating, and maintaining the BMP facilities. EPA direction is moving towards integrated watershed planning[83] that addresses quantity and quality of all wet weather discharges, and this is the hallmark of MSD's Sustainable Watershed Evaluation Planning Process (SWEPP).[84]

3.2.5. Class 1 Dam Standards

As MSD reported to the County monitor team on May 4, 2012, detention basin volume and dam height were considered for determination of dam designation as defined in the Ohio Administrative Code (OAC), Section 1501:21-13-01. The intent of the sustainable projects is to design detention basins that are not classified as dams or that minimize dam impacts.

For the six candidate sustainable projects evaluated during the LMC Study, 15 of the 18 proposed detention basins will be automatically exempt from dam classification due to their capacities of not more than 15 acre-feet of total storage. Of the remaining three detention basins, one has been reviewed by ODNR and would be classified as a Class 1 Dam (Wooden Shoe Measure 3). The other two remaining detention basins (Techsolve in Bloody Run and North Basin in CSO 125 stream separation) exceed the volume limit and have been designed such that the height is lower than the regulated limit and therefore would not be classified as dams.

For Phase 1 (Lick Run, West Fork and Kings Run watershed projects), there are 15 detention basins in the Sustainable Alternative as shown in Table 6. [Note: The three remaining detention basins are scheduled to be included in the Phase 2 LMC evaluation (Techsolve basin at CSO 181, two Denham basins).] The

Kings Run Measure 4 basin dropped out due to geotechnical issues. For the West Fork North Basin, the dam height must be 10 feet or less since the capacity of these basins is between 15 and 50 acre-feet. A dam's height is defined as the vertical dimension as measured from the elevation at the downstream or outside toe of a dam to the elevation of the top of the dam. The North Basin located in the CSO 125 Stream Separation project is being designed to be exempt by maintaining the height requirement. Wooden Shoe Measure 3 is being evaluated in accordance with meetings with ODNR.

The Measure 3 basin is located above CSO 217. Its purpose is to detain surface run-off and discharge it back into the combined sewer system. The size of the detention basin affects the sizing of the CSO storage tank located at CSO 217. Since the capital costs of building a larger Measure 3 basin of 20 ac-ft was not defined and had been complicated by ODNR proposing the existing detention basin should be classified as a Class 1 dam, the LMC Study team maintained the planning level size of 5.2 ac-ft to correspond to the consultants cost estimate. In addition, by keeping the detention basin small, the downstream CSO tank was sized larger to accommodate the smaller basin size. The CSO tank size downstream of the smaller detention basin is 1.5 MG. If the detention basin is sized to be 20 ac-ft, then the CSO tank size would be 1.3 MG. The large cost of the CSO was preferred to account for the worst case scenario of not being able to construct the larger detention basin.

The Engineer will be performing an alternative analysis on Measure 3 detention: Retrofitting the existing basin or building a new basin upstream of the existing. Both would be classified as a dam but the type of classification (1, 2, 3, or 4) will be a part of the analysis. Although a conservative approach was applied for the sizing of the 217 CSO storage tank, costs for larger dam construction and dam permit requirements were not included. MSD will include the estimated $471,000 cost for the dam in the updated capital cost in 2006$.

Table 6 - Phase 1 Sustainable Alternative Proposed Detention Basins and Capacities

Sub Basin	CSO of Interest	Basin Name	Proposed Capacity as of 03/2012 (acre-ft)	Automatic Exemption as Dam?	Notes
Wooden Shoe	217/483	Measure 1	2.3	Yes	
		Measure 2	1.0	Yes	
		Measure 3	20.0 or 5.2	No	Under review due to dam permit issues. 5.2 ac-ft used in LMCPR study to match planning cost estimate. Larger size being considered in design phase.
		Measure 4	0.7	Yes	Basin eliminated due to geotechnical issues.
		Measure 15	12.0	Yes	
Lick Run	5	DB 01 (Queen City Ave Phase 2)	1.2	Yes	
		DB 02 (Queen City Ave Phase 2)	1.4	Yes	
		DB 07 (Queen City and Cora Aves)	2.5	Yes	
		DB 09 (Queen City and Cora Aves)	4.0	Yes	
		DB 10 (Queen City and Cora Aves)	8.6	Yes	
		DB 14 (Queen City Ave Phase 1)	1.6	Yes	
		DB 17 (Quebec Heights Phase 1)	2.4	Yes	
		DB 21 (Sunset Ave)	0.5	Yes	
West Fork	125	Martha Basin	2.2	Yes	
		North Basin	21.2	No	Exceeded ODNR volume threshold; therefore exemption from dam permit will be based on height requirement

3.2.6. Other Known Costs

Upon continued review of the costs since the Preliminary Findings Report[69] was provided to the County in April 2012, some costs have been identified to be incorporated into the next update. Changes in design (i.e., replacement of CSO 217 20 MGD EHRT with a 1.5 MG CSO storage tank) and some minor QA/QC adjustments reflect a new cost of $308,763,000 down from the previous $317,447,000 in the Preliminary Findings Report (in 2006 $).

Items added to updated base project cost

- DEMOLITION - Demolition of properties for Lick Run, Kings Run, and West Fork had not been previously included and 2006$ estimates will be incorporated into the Phase 1 sustainable alternative: Lick Run - $3,771,000, Kings Run (Wooden Shoe) - $121,000 and West Fork - $692,000 (MSDGC participation only; FEMA grant received for the balance of the cost).

- SUPPLEMENTAL BENEFITS PROGRAM: $4.9 million in current dollars (converted to 2006$ for the analysis = $4.1 million).

- ODNR CLASS 1 DAM - The $471,000 capital cost in 2006$ of the ODNR Class 1 dam will be added to the cost estimate. This high-level cost is yet to be determined. The alternatives analysis for this basin will be conducted in 2013.

Items originally included in base project cost

- BROWNFIELDS - Brownfield mitigation costs are accounted for in the costs presented in April 2012 with 25% of all Lick Run valley conveyance system excavation costs to include hazardous materials within the corridor.

- MISCELLANEOUS - Costs for replacement for grating replacements, and installation and removal of temporary connections are accounted for in the Lick Run project. Replacement or rehabilitation of the combined sewer system is not included because these needs will be addressed through MSD's Asset Management Program. In areas where the SI projects are removing direct inlets to combined sewers located under streams, field assessments were conducted. Subsequent to the assessments, minor repairs of leaky manholes were completed to ensure stream inflow will be removed from the combined sewer system.

Items conservatively included in base project cost

- PROPERTY ACQUISITION - Over the past year, we have documented property acquisition and easement costs against budgets and updated with the 60-percent design submittals. In the development of the costs, MSD was conservative due to the difficulty of estimating property acquisition costs and being consistent between projects. The approach and methodology developed has greatly increased the confidence that the budgets are adequate and conservative. The updated capital cost values also reflect the reduction of property acquisition costs for Sunset, Queen City Ave Phase 1, and Valley Conveyance. Projects advancing to detailed design during the past six months, adjustment of required parcels were made and the decrease in capital cost in 2006$ is: Lick Run total -$2,827,085. More specifically: VCS - $1,956,994, Sunset -$295, 470, and Queen City Ave Phase 1 -$574,621.

3.3 Project Amenities

The County monitor's report (page 1) stated, *"Inconsistencies were noted for amenities not mandated by the Final WWIP."* To characterize this situation as showing "inconsistencies" is premature and fails to recognize the process required to make informed design decisions for these elements. The fit and finish of certain elements in the VCS area of the SI project have not been finalized. Bridge architecture and retaining wall types are primary examples of these elements. Other less significant elements include accommodation of public access to the area and educational aspects that might be provided. As a result there are variations and options that are still being considered and these will be refined in the design phase, which can be expedited if MSD is able to end the 'dual-track' design requirements currently dictated by the Final WWIP and the lack of specific direction toward one alternative. Thus, for estimating purposes certain assumptions concerning these elements were necessary to use. These assumptions are not intended to influence the final product but were only intended to establish a representative budget for the project. Furthermore, the term "amenity" in this regard is not appropriate as all elements intended for the project are expected to provide essential and functional public value directly related to providing long-term assurance consistent CSO reduction.

The "drawings" (more properly referred to as "renderings") prepared by MSD are based on the desires and preferences of workshop participants in the affected neighborhoods and the features necessary to achieve CSO reduction requirements. While the Sustainable Alternative does include a fair amount of separate stormwater pipes, it also includes a substantial amount of green infrastructure components that play critical functions in CSO reduction. Specifically, where MSD would be the implementer and owner of green infrastructure such as a naturalized conveyance system or a valley conveyance system the project includes maintenance access pathways, lighting, and safety features that are essential to providing long term assurance of the CSO reduction effectiveness of the Lick Run project. These features and components were highlighted and recommended by the Value Engineering Study.

Nonetheless, these necessary CSO control components may have companion community benefits. For example, maintenance access pathways could serve as community walking trails, lighting around the water features protect it from vandalism, and railings along the waterway protect the public from high channel flows that anticipated during wet weather conditions. Additionally, retaining walls are required to protect existing system assets of MSD (i.e. 19.5 foot diameter combined sewer to remain in operation) as well as roadways and other utilities.

Best Management Practices will be incorporated into the valley conveyance system to improve the water quality prior to conveying it to the receiving stream. Sustainable solutions are recognizably different from conventional/traditional solutions and as such, MSD has developed and added project costs to maintain the green infrastructure features to provide long term assurance the asset will function as designed for CSO reduction. MSD considers these features to be essential to meet Regulator and Community expectations. For features that are not essential to the sustainable infrastructure solution, such as a community amphitheater or boulevard, there are no definitive arrangements in place

to cover the cost of such desired improvements. Other project partners would take the lead on developing them as they are not essential for reduction of combined sewer overflows.

The Sustainable project that is being referenced in Attachment 1 of the County monitor's report was based on the preliminary planning document for the VCS. This preliminary planning document has since been subjected to an extensive community review process per USEPA Guidance[85] to MSD for submittal of a Revised Original LMCPR to the Regulators. The preliminary planning document has been vetted, revised, and updated based on a strong level of participation and support by the community, and formulated into a Lick Run Master Plan, which was provided to the County monitor team.

In summary, all elements included in the base project of the Master Plan are considered essential to achieving the CSO reduction objectives in a manner consistent with the values of the local neighborhood and community at large. Necessary elements of the Sustainable projects will be integrated in the community to assure the long term stability and maintenance of the asset.

3.3.1. Clarification Regarding Amenities

The following summary provides clarifications concerning the use of various project elements and their connection with the project as a whole as previously mentioned in Attachment 1 of the County monitor's report as "Non-Essential". These items have been revised and updated based on the community design and review process completed in February 2012. The amenities MSD included in the base cost are reflective of what USEPA has indicated is part of CSO reduction related expenses for an alternative solution. The following features are included in the base cost for the SI alternative in order to achieve a reduction in CSO volume.

- Boardwalks, Pedestrian Bridges, and Railings
- Maintenance Access Paths
- Safety and Interpretive Signage
- Trailhead Parking
- Safety Lighting
- Benches, Trash Receptacles, Bike Racks
- Terraced Stone Walls, Natural Stone, and Boulders
- Landscape Plantings
- Trees for Wooded Areas & Stormwater Planters
- Native Plantings.
- Reforestation and Meadow Plantings
- Stormwater Planters along Westwood & Queen City Avenues
- Irrigation System

The following features are included in the base cost for the SI alternative in order to replace existing infrastructure impacted by construction.

- Westwood Avenue Walkway
- Intersection Pavement and Crosswalks
- Playground on CRC Property
- Shelter on CRC Property
- Bike Racks on CRC Property
- Basketball Courts on CRC Property
- Street Lighting along Queen City Avenue
- Concrete Walkways in Civic Space
- Multi-purpose Lawn Areas in Civic Space

The following features are NOT included in the base cost for the SI alternative.

- Feature Lighting
- Islands
- Public Gardens
- Drinking Fountains
- Picnic Grove & Tables
- Recreational Baseball and Half Football Fields
- Architectural Walls
- Public Art
- Western Hills Gateway Plaza
- Western Hills Fountain

Figure 2- Rendering of CSO Reduction Features of Potential Lick Run VCS

Narrow Channel Zone

Looking south towards Westwood Avenue

Detailed clarification regarding amenities:

1. Boardwalks and Railings around the Wetland Forebay. Boardwalks have been removed from the base project and replaced with a pedestrian bridge to provide access for maintenance staff, maintain public access and provide an educational vantage point to view educational components and interpretive elements associated with water quality features within the wetland forebay. The railings are incorporated in the bridge as a safety element for pedestrians.

2. Pedestrian Bridges and Railings. The VCS is designed to meet volumetric stormwater conveyance needs, but it will cut off several pedestrian connections through the CRC property. The community expressed concern about the VCS being a barrier to the community and dividing the north and south areas of South Fairmount. At the community's request, pedestrian bridges have been incorporated in the base project to allow these connections to continue safely but in a limited area. The bridges also provide ADA accessible public access to the channel and educational vantage points for water quality feature observation. Railings are provided for safety wherever local or state requirements need to be met, for fall distances adjacent to public access.

3. Decorative Railing. Railings will be provided as required for public safety at walls and bridges. Specific railing style and type will be selected during the VCS design phase through a review process that attempts to match function and durability with community standards and values.

4. Maintenance Access Paths. The VCS is a functioning water conveyance system that will need maintenance and therefore maintenance access. The concrete pathway along the channel will act as this maintenance access, so service vehicles can access the VCS at any given point, as well as provide protection and access to the large diameter combined sewer that is located beneath the concrete pathway. When the concrete access path is not being used for maintenance, it will provide public access, allowing for a dual purpose out of this public investment. The public access provisions of the path will enhance available pedestrian routes through the corridor, as well as offset disruptions and barriers to existing pedestrian routes resulting from the construction of the VCS.

5. Safety & Interpretive Signage. Signage serves two purposes. One is safety signing to communicate the inherent risks associated with high water/flood elevations, flowing channels, and/or bodies of water. Secondly, signage is for educational purpose through interpretive signage and messages intended to meet the EPA Phase 2 Stormwater Regulations.[86] The interpretive signage included for the VCS is to educate the public on MSD's improvements to the area and provide information on the function of the VCS, including an overview of watershed-wide information down to the project-specific channel. Providing visual support to aid MSD in communicating its commitment to water quality and sustainable infrastructure is not a new approach. Similar features have been developed and incorporated within various MSD facilities, such as the mini- wastewater treatment process example at the entrance to MSD Engineering Building, green roofs, and rain gardens on MSD's campus.

6. Trailhead Parking – including porous pavement, brick pavers, trees, lighting and landscape plantings. The block in which this parking lot is situated will be significantly impacted by the construction of the VCS portion of the SI project. Existing parking and traffic conditions are inadequate to provide reasonable site access during and following construction. The parking

area will provide construction access and staging areas for the VCS and adjacent SI projects during construction, and maintenance access for these facilities following construction.

7. Safety Lighting. Lighting in accordance with recommendations of CPTED (Crime Prevention Through Environmental Design)[87] principles (a widely-accepted planning and design tool) will be provided to enhance safety. All lighting shown in the base plan is for pedestrian and maintenance safety along the channel, as recommended by CPTED principles.

8. Benches, trash receptacles, bike racks. Seating has been provided at minimal distance along the maintenance corridor to accommodate seniors and other pedestrians with mobility challenges where lack of refuge areas might otherwise exclude their participation in the use of the public elements associated with the project. Trash receptacles are being provided as a public service to users of the area. By including trash receptacles there will be a reduction in maintenance in the way of daily trash pick-up in concentrated use areas. Bike racks have been placed in key areas at a minimum. The more accommodations for pedestrian access and use, the more users will feel safe and encouraged to use the space.

9. Terraced Stone Walls. The walls are in-stream elements or within flood limits used to provide transition for grades in the area of the CRC property and at the daylighting feature. They are used only when necessary to transition grades making them an essential function of the channel. The terraced stone walls are intended to stabilize the edges of the channel at different flood levels below the 100 year flood event.

10. Ledge rock, natural stone and boulders. These elements are all essential elements of the channel for stability, depth control, energy dissipation, water quality and aerating the water within the channel. Over time the stone will grow algae and other organisms that will continue to improve water quality

11. Brick Pavers. Specialized pavements have been minimized in the base project to areas providing VCS maintenance access. These areas include entrances to the maintenance access pathway, to provide visual cues to pedestrians and vehicles for potential intersections. Other special pavements include the functional access from on-street parking on Westwood Avenue to the multipurpose trail along Westwood for pedestrians to cross over the stormwater planters running parallel to the street. These costs are included in the VCS cost opinion.

12. Plantings and trees. Plantings and trees are added minimally to provide a varied ecoscape capable of providing low level habitat while stabilizing ground areas from erosion and attenuating storm water runoff. Porous pavement and/or brick pavers attenuate stormwater runoff, reducing overall peak flows in areas that are otherwise impervious

13. Landscape Plantings. All plantings are within disturbed or impacted areas of the channel construction. Plantings and trees are added minimally to provide a varied ecoscape capable of providing low level habitat while stabilizing ground areas from erosion and attenuating storm water runoff. The plantings are focused on native species that require less maintenance once established.

14. Trees for making wooded areas. Trees are included within the waterway in planted areas as essential landscape elements. Trees have proven to provide value in stormwater reduction, carbon sequestration and particulate removal. In addition, their long term benefit includes maintenance reduction

15. Trees in Stormwater Planters. Trees are included within the stormwater planters as essential landscape elements. Trees have proven to provide value in stormwater reduction, carbon sequestration and particulate removal. In addition, their long term benefit includes maintenance reduction. These costs are included in the VCS cost opinion.

16. Stormwater Planters. Bioswales have been updated to be individual stormwater planters along Westwood and Queen City Ave in strategic locations for the greatest stormwater benefit. The stormwater planters are envisioned to be water quality features that will slow and clean stormwater runoff from Queen City and Westwood Avenues prior to its discharge into the VCS. These costs are included in the VCS cost opinion.

17. Steps and open space turf. Steps have been reduced to the minimum required to provide access from the CRC property to the VCS. Access to the channel in this area is similar to the pedestrian bridge at the channel headwater in that it is for public access and educational vantage point for water quality feature. Turf is replacing the multi-purpose lawn that existed prior to the channel construction.

18. Meadow. Meadow is part of the outer edge of the channel within the flood level. This riparian edge is critical to the health of the channel and this edge needs to be flexible in its habitat because it could be flooded with water or dry. A native meadow is one of the best applications for this type of function. These costs are included in the VCS cost opinion.

19. Reforestation and Meadow Plantings. The water quality feature at the east end of the channel provides essential water quality elements at the end of the channel. As stated in previous comments on plantings and trees, these living elements are essential to water quality

20. Irrigation. Irrigation has been included as a project element to protect the District's investment in plantings and landscaping. In turn, the health and well-being of these features protects against erosion and reduces overall stormwater runoff. Reliance on in-ground permanent irrigation systems is becoming widely recognized as a cost saving tool that helps minimize staff

labor and therefore costs associated with landscape management activities for open space areas such as those proposed for the VCS portion of the SI project.

3.3.2. Replacement of existing infrastructure impacted by the project and included in the Base Cost

1. Shelter. The shelter within the CRC property is being impacted by the construction of the VCS and will be restored as part of the project to replace what was removed for construction. Shelter type and style will be selected during the initial design phase through a review process that attempts to match performance and durability requirements with community standards and values, including strict conformance with ADA accessibility requirements.

2. Relocated existing basketball courts. The basketball courts within the CRC property are being impacted by the construction of the channel and will be restored as part of the project to replace what was removed for construction.

3. Picnic Grove – trees, picnic tables and trash receptacles. Picnic grove and associated elements in preliminary planning documents have been removed from base project.

4. Recreational Field – Baseball and half football field. The recreational fields shown in preliminary planning documents have been removed from the base project.

5. Drinking fountains. Drinking fountains have been removed from the base project. The only drinking fountains that may be included are those within the CRC property that are being impacted.

6. Playground. The playground within the CRC property is being impacted by the construction of the VCS and will be restored as part of the project to replace what was removed for construction. However, modern performance and safety requirements with conformance with ADA accessibility requirements will need to be provided.

7. Multi-purpose trail and trail lighting. All lighting shown in the base project is for safety of pedestrian and maintenance, as recommended by CPTED principles. The existing walkway along Westwood will be impacted as a result of the VCS construction, and is being replaced to current standards that support and encourage multi-modal traffic in the area.

8. Crosswalks – brick pavers. Safety is of particular concern to the community and providing safer, more visual crosswalks is essential. The intersection pavement and crosswalks will disturbed during construction of the SI projects, and will need to be restored. The proposed colored concrete crosswalks offer a contrast in pavement to the adjacent asphalt road surface and improve visibility

for motorist who may not be accustomed to the changes in pedestrian movements that will likely occur as a result of the VCS.

9. Street Lighting along Queen City Avenue. Any street lighting included in the base project is replacing existing street lights being impacted by the channel construction, in a manner consistent style throughout the impacted corridor. All other lighting is not included as a part of the base project.

10. Green Streets – bioswales, street trees, street lighting. Any street lighting included in the base project is replacing existing street lights being impacted by the VCS construction, or for safety of pedestrian and maintenance personnel as recommended by CPTED principles.

11. Lawn areas. Lawn areas are replacing the multi-purpose lawn that existed prior to the VCS construction. These costs are included in the VCS cost opinion.

12. South Fairmount Civic Space. We are assuming the South Fairmount Civic Space that is being questioned is what the current VCS Base Plan refers to as the Recreation Hub. This area contains the existing CRC property, which will be impacted by the alignment of the VCS and the associated floodplain. Based on public feedback and coordination with the City of Cincinnati, the CRC property is and has been a vital public open space for the community. The community overwhelmingly expressed concerns for the potential loss of public open space. Through the extensive community design input process, the community requested that any loss of existing open space should be offset through property reallocation.

13. Concrete walk. Concrete walks included in the base project are replacing those existing access ways being impacted by the construction of VCS. The VCS is designed to meet volumetric stormwater conveyance needs, however has cut off several pedestrian connections through the CRC property. The community expressed concern about the VCS being a barrier to the community and dividing the north and south areas of South Fairmount. Therefore, provisions to maintain this public access are included. These costs are included in the VCS cost opinion.

3.3.3. Features not included in Base Cost

Other items in which the costs are not included in the VCS base plan opinion of probable costs, but shown in renderings are as follows.

1. Gardens. In the more recent base project, gardens have been: 1) incorporated into native planting with the channel or 2) have been removed.

2. Architectural walls at Gateway Feature. Architectural walls that were not necessary for elevation changes, soil retention and/or erosion control have been removed from the VCS base project. At the western daylighting feature, the retaining wall is used to retain surrounding

grade to allow the below grade pipe to be daylighted in a safe and stable manner. The costs associated with retaining walls are included in the cost opinion.

3. Feature lighting. All feature lighting has been removed from the project. All lighting shown in the base project is for safety of pedestrian and maintenance personnel. Lighting is a recommendation of CPTED principles.

4. Public art. All public art has been removed from the base VCS project.

5. Plaza – including public art and trees. All public art has been removed from the base VCS project. Plazas have been minimized in the base project to areas only of importance to the VCS access. Any trees included in plazas are minimized to allow for easy access for maintenance vehicles and provides shade benefit to the plaza.

6. Western Hills Gateway Plaza. This Western Hills Gateway Plaza has been removed from the VCS Base project.

7. Western Hills Gateway Plaza Fountain. This Western Hills Gateway Plaza fountain has been removed from the VCS Base project.

8. Islands. Islands have been removed from the base project.

3.3.4. Potential Funding Sources

As outlined in the Lick Run Master Plan, a number of potential partners and funding sources have been identified for components of the long-term community vision not associated directly with MSD's wet weather improvements are summarized in Figure 3 and further detailed in Table 7.

Figure 3 - Potential Funding Sources for Non-CSO Amenities

		Potential Partners & Funding Sources					
	MSD	National (public)	National (private)	State (public)	State (private)	Local (public)	Local (private)
Urban Waterway	●					●	
Transportation Network	●					●	
Waterway & Infrastructure Maintenance Access, Public Access	●					●	
Cultural Resources: Mitigation Strategies	●					●	●
Recreation Facilities: Maintaining Existing Uses	●					●	
Natural Conveyance Systems	●			●		●	
Separate Storm Sewer Network, Detention	●					●	
Enabled Impact Projects	●			●	●	●	
Future Recreation/Open Space						●	●
Environmental Education	●	●	●	●	●	●	●
Queen City/Westwood: Further Technical Analysis		●		●		●	
Neighborhood/Business Zone Investment			●		●		●
Streetscape Improvements		●		●		●	
Improved Access to Public Transportation				●		●	
Urban Design Guidelines						●	●
South Fairmount Cultural Trail	●	●	●	●	●	●	●
Public Art, Interactive/interpretive Elements		●	●	●	●	●	●
Sustainable Systems	●	●		●		●	
Watershed Planning Tools	●	●				●	●

Table 7 - Potential Partners and Funding Sources

Potential Partners and Funding Sources	
National Level – public entities	US Environmental Protection Agency (USEPA) USEPA/HUD/DOR Sustainable Communities Partnership Federal Highway Administration (FHWA) National Parks Services Recreational Trails (NPS) National Forestry Service (NFS) Department of Energy (DOE) US Geological Survey (USGS)
State Level – public entities	Water Resource Restoration Partner Program (WWRSP) Ohio Environmental Protection Agency (OEPA) Ohio Department of Natural Resources (ODNR) Ohio Department of Transportation (ODOT) Ohio Department of Development (ODOD)
Local Level – public entities	Cincinnati Dept. of Transportation & Engineering (CDOTE) Cincinnati Recreation Commission (CRC) Cincinnati Park Board (CPB) Greater Cincinnati Water Works (GCWW) Cincinnati Public Schools (CPS)
National & State – private entities	Corporate Foundations Non-Profit Organizations
Local Level – private entities	Community Development Corporations Greater Cincinnati Foundation Corporate Foundations Non-Profit Organizations Duke Energy Businesses (existing and future) Developers Banks

The base plan referenced in these responses has been through an extensive community process, and revised since preliminary planning documents as guided by the USEPA draft guidance document. The base plan has been vetted, revised, and updated based on a strong level of support by the community. Some of these funding sources have already provided funding assistance to SI projects.

3.4 Assumptions for Specific Costing Topics

All assumptions for costing were based on requirements typically sought by USEPA for this specific type of planning document and alternatives analysis. Thus, the statement in the County monitor's report (page 1) that *"Some estimates were based on assumptions inconsistent with industry standards,* "is incorrect." The cited industry standards cited in the report are not applicable. USEPA provided MSD and the County with a list of items to be addressed in an alternative plan to the Default LMC Tunnel.[85] The only items relating to costs were that adequate O&M costs be provided for SI type projects. Page 10 of the County monitor's report noted the following specific areas in which they question the

assumptions used for development of cost estimates. MSD has addressed each of these areas in accordance with industry standards.

3.4.1. Utility Coordination

Through the development of the sustainable alternative, MSD design teams have coordinated directly with utilities to gain confidence in the impact as well as cost of utility relocation. The type of costs being referred to, i.e. utilities relocation costs, are the types of costs included in design contingency allowances in the early planning phases of a project. Costs are not normally included in the base construction costs, before the addition of contingencies, until design of a project is begun. A range 6.5 to 9 percent is cited on page 10 of the County monitor's report for utilities relocation costs, before contingencies are added. When both design contingencies and project contingencies are added, this range will increase to 10 to 15 percent.

A great deal of effort and coordination with local agencies and utilities has gone into sustainable project sequencing, to coordinate construction and utility impacts, minimize project costs and community disruption. Duke Energy, GCWW, MSD and CDOTE all have capital improvement plans (CIP's) that have been taken into consideration for developing the schedule, sharing of construction costs, and maintenance of traffic. Coordination and communication for West Fork, Bloody Run, Kings Run/Wooden Show and Lick Run has occurred via Ohio Utilities Protection Service (OUPS) requests, County Wide Construction Coordination System, and planning or design meetings.

For example, in the case of Lick Run, specifically the 31 utility coordination meetings have taken place, with the respective agencies as noted in Table 8, in which meeting minutes are available upon request:

Table 8 - Utility Coordination Meetings

Utility	Meeting Dates
CDOTE	February 14, 2011; March 6, 2011; June 3, 2011: July 8, 2011; August 31, 2011; September 23, 2011; October 14, 2011; December 20, 2011; March 7 & 9, 2012
Cincinnati Bell	August 31, 2011; October 6, 2011; January 25, 2012; March 7, 2012
Cincinnati Parks Department	July 31, 2011; January 25, 2012
Duke Energy	June 1, 2011; July 13, 2011; August 17 & 31, 2011; January 25, 2012
Greater Cincinnati Water Works	June 1, 2011; July 13, 2011; October 6, 2011; March 7, 2012
SMU	June 1, 2011; July 13, 2011; August 31, 2011; January 25, 2012; March 7, 2012
Time Warner Cable	September 12, 2011

The key points of coordination at this time include:

- **Cincinnati Bell** does not have any CIP's that are scheduled in conjunction with the SI projects.

- **Duke Energy** has a significant gas main replacement CIP on Harrison and Queen City Avenues, from the intersection of Harrison Avenue/State Street at Mill Creek, west to Queen City Avenue/Quebec Road. This project was initially scheduled to be constructed in 2013; however in an effort to coordinate projects and share/reduce overall construction costs, Duke will be constructing the gas main replacements in conjunction with the SI projects.

- **GCWW** is replacing small and aged water mains in areas that SI projects are being constructed. GCWW had these CIP's quite a bit further out in their schedule, however the ability to coordinate projects and share/reduce overall construction costs was favorable enough for GCWW and MSD these CIP's were moved up in schedule to coincide with the SI projects.

As is typical, utility coordination is on-going through the respective advanced planning and detailed design phases. Additional meetings have occurred and will continue for some of the sewer separation projects to further refine utility impact needs and to properly account for costs.

As a standard rule of practice MSD Estimating uses its information database to estimate water and gas line, electrical and cable relocations. MSD receives budgetary quotes from Duke Energy for power pole support or relocation, and other items. For other specific scopes of work MSD obtains quotes from the specific utility. MSD estimating allows for additional labor & equipment time to excavate and backfill around existing utilities. In the Lick Run basin there are allowances contained in the base cost estimate for water and gas lines, and electrical structure and wire relocates.

3.4.2 Maintenance of Traffic

Maintenance of traffic (MOT) cost estimates are incorporated into projects during the detailed design phase. Soft cost factors and contingency factors adequately cover this minor aspect of the project at the planning and preliminary design stage. For detailed cost estimates, as were done in the case of the SI projects, MOT is part of the estimated base construction costs developed by design consultants and vetted through the MSD's Cost Estimating group. The understanding of the level of effort required for MOT on any given project is dependent on the level of design when the estimate was submitted and the area where the construction is to take place. Based on the number of consultants, projects, and the various levels of design completion for each project, it would be expected that the MOT factor would vary somewhat across the SI projects. The MOT will vary based on level of design completion for each project as well as the specific traffic related costs anticipated by the design consultant developing the cost estimate.

A good example of the line-item contingency is the method to estimate MOT costs. There is a multiplier on the "Open Cut Sewer" tab of the costing tool that applies a 1% markup for maintenance of traffic. There is also the option to include "Urban Setting" that increases the cost by 50% if a sewer project runs through a city setting to account for extra traffic control as well as the additional delay and resource location issues that affect the contractor. For the SI projects MOT costs were included in the estimates

in various forms at the consulting engineer's discretion and dependent on the project stage. Consideration was given to the roadways impacted and construction duration. For example, MOT costs may have been included within the general conditions (as a percentage of the construction cost), or as a separate line item as a percentage of the construction cost or as a cost per linear feet of pipe within the street. These MOT costs were also reviewed through the MSD cost estimate review process. MSD's estimates for projects being constructed in an urban area have been recently vetted through the Harrison Avenue Phase A project. Bids received by ODOT were all lower than the MSD estimate. Hence, the estimating approach used by MSD is conservative enough to account for project details, but robust enough to garner benefits from current level of competition for construction projects.

The ODOT document referenced in the County monitor's report (page 11) states *"Based on previous projects, Maintaining Traffic in rural areas is about 1% of the total construction budget cost, and in urban areas, maintenance of traffic is around 3% of total construction budget cost."* The document goes on to say that heavy traffic volumes can increase this cost (ODOT. July 2011. *Procedure for Budget Estimating*). According to ODOT, the MOT factor of 3% is probably excessive for work on local streets but could possibly be more than 3% in the urban areas with high volumes of traffic on major streets. All contingency values used in the LMC Study cost estimates fall within the ranges of both the ODOT estimating procedures and the MSDGC Financial Analysis Manual.

With respect to the level of confidence in the approach used for the SI projects, using Lick Run as an example, the cost reconciliation between the Planning Consultant and MSDGC for the valley conveyance system portion of the project, where the likelihood of traffic impacts are highest, determined the maintenance of traffic cost estimate (1.4% of construction cost) to be conservative based on engineering judgment and local experience.

2.5.3 Annual Operations & Maintenance Costs

Some references to O&M cost development for Sustainable Alternative are provided in the Working Draft Document including the Sustainable Costing Information[88] that was provided to the County in July 2012. All references to costs were eliminated for the public/regulatory agency version of this document at the County's request. For example, if the O&M costs needed to be higher, say even twice as high as projected, then Sustainable Alternative life-cycle costs would increase another 2 percent. Given the large differential in life-cycle costs between the grey and sustainable alternatives, this is almost negligible.

Because the objective of the SI projects is to reduce CSOs in a more sustainable and cost effective manner, the immediate and long-term impacts of the SI projects need to be considered., These include the costs and ease with which the SI projects can be constructed and maintained, coordination with and impact to other utilities and agencies, the disruption and maintenance of traffic, and the impact to the surrounding community during and following construction.

Consideration of community impact is standard procedure in the wastewater industry. In the instance of construction a pump station or well, water or wastewater treatment plant, solid waste disposal, highway, etc. The standard of care is to provide a facility that does not negatively impact the surrounding properties and public, or would compromise the smell, sight, sound, safety or health. Odor control facilities may be installed; sight screening, landscaping or architectural construction embracing the surrounding community; sound barriers or noise reduction; safety fencing or other such precautions; and lastly monitoring of water and air quality for public health. All of these items listed are vital parts to a project, however very few if any are *necessary* for the day-to-day function of the facility.

O&M Data Sources

A number of local and national sources were used for general guidance in the operation and maintenance of green infrastructure, specifically policies and procedures, maintenance implementation, maintenance needs, and maintenance costs. Sources include, but are not limited to:

- USEPA Green Infrastructure Program
- Water Environment Research Foundation's (WERF's) 2005 Performance and Whole Life Costs of Best Management Practices and Sustainable Urban Drainage Systems
- A.J. Erickson, J.S. Gulliver, P.T. Weiss and C.B. Wilson 2005 "The Cost and Effectiveness of Stormwater Management Practices"
- 2009 "Survey of Stormwater BMP Maintenance Practices", along with numerous municipal BMP manuals through the United States

Most recently, the Cincinnati Park Board provided their annual maintenance plan[89] and budget for a local urban park similar in size and complexity to the upslope areas of the proposed Lick Run Valley Conveyance System. The park maintenance plan included a spreadsheet with a breakdown of hours associated with each task, a staff breakdown of each task, and staff pay rate. For all typical landscape elements (lawns, planting beds, tree maintenance, site furnishings) this information was used to estimate rates and hours based on area, frequency, schedule and average annual cost. This data was adapted to the elements and areas shown on the Lick Run Master Plan.

For all riparian edges and biofeatures of the Lick Run Valley Conveyance System, a recent competitive bid for maintenance for a local company's campus was used in comparison from a Spring 2012 bidding effort. The maintenance scope and scale was similar to the proposed Lick Run Valley Conveyance System for the native planted areas in the riparian edges and biofeatures. A weekly maintenance cost was included, based on the known acreage of that project, extrapolated an average per-acre cost, and then applied to Lick Run for similar areas with similar maintenance scope (tasks and frequency).

4. SUSTAINABLE ALTERNATIVE CSO VOLUME REDUCTION

In comparing the conceptual sustainable alternative with the grey alternative, it was recognized early on that there was a need to efficiently advance both projects. This need arose to ensure both alternatives were sufficiently vetted to identify issues necessary to making a decision in advance of the December 2012 submission deadline. In recognition of this concern, limited targeted flow monitoring was conducted in 2010 and 2011 for both the Default LMC Tunnel project and in the larger sub-basins for the Sustainable Alternative (Lick Run and Bloody Run). Flow monitoring in other SI sub-basins (West Fork Creek, Ludlow Run, and Kings Run) was also conducted for updated model calibration in those areas. More than 40 flow monitors were installed during this two-year period.

Flow monitors installed in large combined sewers could not produce reliable data due to frequent outages of equipment caused by sudden flow surges, solids accumulations, and debris. In addition, level monitors were installed in the large diameter combined sewer near CSO 5. Results obtained from smaller sewers were more complete and useful, whereas the level monitor in the large diameter sewer was found to be a better predictive tool for calibrating and validating system modeling. Local data was collected as practicable based on budgetary constraints and realities imposed by adverse conditions in large sewers.

Conclusions from the modeling data provide a compelling argument for the advancement of the SI project. Assumptions and data used in the development of the model are based on the both the physical characteristics of the basins, and actual monitoring data. Using this blended information representing the best available data offsets the weakness of individual data elements and provides a reasonable interpretation of actual conditions. Sensitivity analyses confirm that changes in certain data elements does not materially affect the overall objectives of the SI project.

Tier II type SI projects have been identified should additional CSO reductions be desired to increase the certainty that the project can perform to the minimum levels required to meet the targeted CSO values.

According to modeling results, the relationship between storm sewer effectiveness and CSO reduction is not a direct linear relationship. For the Lick Run Basin, in general, for every 25% of reduced effectiveness, there is an approximate 15% reduction in CSO removal. Results for other basins included in the Sustainable Alternative show similar attributes. As such, reduced effectiveness of the Sustainable Alternative does not translate into a 1:1 increase in CSO removal costs. If sewer separation effectiveness is reduced, it is true that the unit costs of CSO removal increase. It is highly unlikely that the effectiveness values would be reduced by 50 to 75% given the nature of the separation projects. That it might be reduced by 15% is an acceptable sensitivity to consider, and it has been considered, but not for public distribution as yet. When eliminating the CSO reduction due to already constructed RTC projects, Sustainable Alternative costs per gallon of CSO removed increase from $0.16 to $0.24. Similarly, for the Phase 1 Grey Alternative, costs per gallon of CSO removed increase from $0.24 to $0.36. If the Phase 1 volumetric target is lowered, the denominator in this equation changes, and the suite of projects selected for inclusion in the numerator is more flexible with the Sustainable Alternative,

not burdened by a large fixed cost for the basic tunnel elements. If necessary, this can be more fully discussed and demonstrated in a meeting or workshop session with the County Team.

4.1. Availability of Local Data

The County monitor's report (page 12) states *"Modeling for the SI alternative is supported by little to no direct local data."* The projects that are mentioned by the County monitor are low impact development (LID) type projects that are considerably smaller in scale and which are not being counted towards the CSO reduction goals during Phase 1 but could provide measureable benefit when integrated into a sub-watershed solution. Some of these smaller LID projects have pre- and post-construction monitoring data but results have not been completed. The most representative type of monitoring that could be done for the proposed type of separation projects is to monitor separate sanitary and storm sewers in an area proposed for separation. Existing storm sewers will be routed to new storm trunk and interceptor sewers, while sanitary sewers will continue to discharge to combined trunk and interceptor sewers.

4.1.1. Local Flow Monitoring Data and Modeling

Direct measurement of overflow volume reduction at CSO structures always is difficult to measure, if not impossible, due to many factors including, but not limited to:

- large influent pipe size,
- highly variable flow and hydraulic conditions,
- hydraulic interference (i.e. receiving water levels),
- characteristics of combined wastewater (i.e. debris), and
- remote CSO structure locations.

Even if direct measurements of CSO volumes were practical to obtain, comparison of CSO volume measurements obtained before removal of stormwater from the combined sewer system with CSO volume measurements obtained following removal of stormwater from the combined sewer system as a result of constructing the SI projects, would be of limited use given the highly variable nature of wet weather events and their impact on receiving collection systems.

For instance, if pre-construction data were collected in a relatively dry period, and post- construction data were collected in a relatively wet period, it would be difficult to reach any meaningful conclusions concerning the impact that the SI projects had on CSO volume reductions. The pre- and post-measurement periods would need to occur over a substantial amount of time, so that normalcy can be applied to both conditions. Therefore, given the limitations associated with the use of direct measurements for the purpose of comparative analysis, hydraulic modeling is an industry standard developed and used to provide a more reliable comparison.

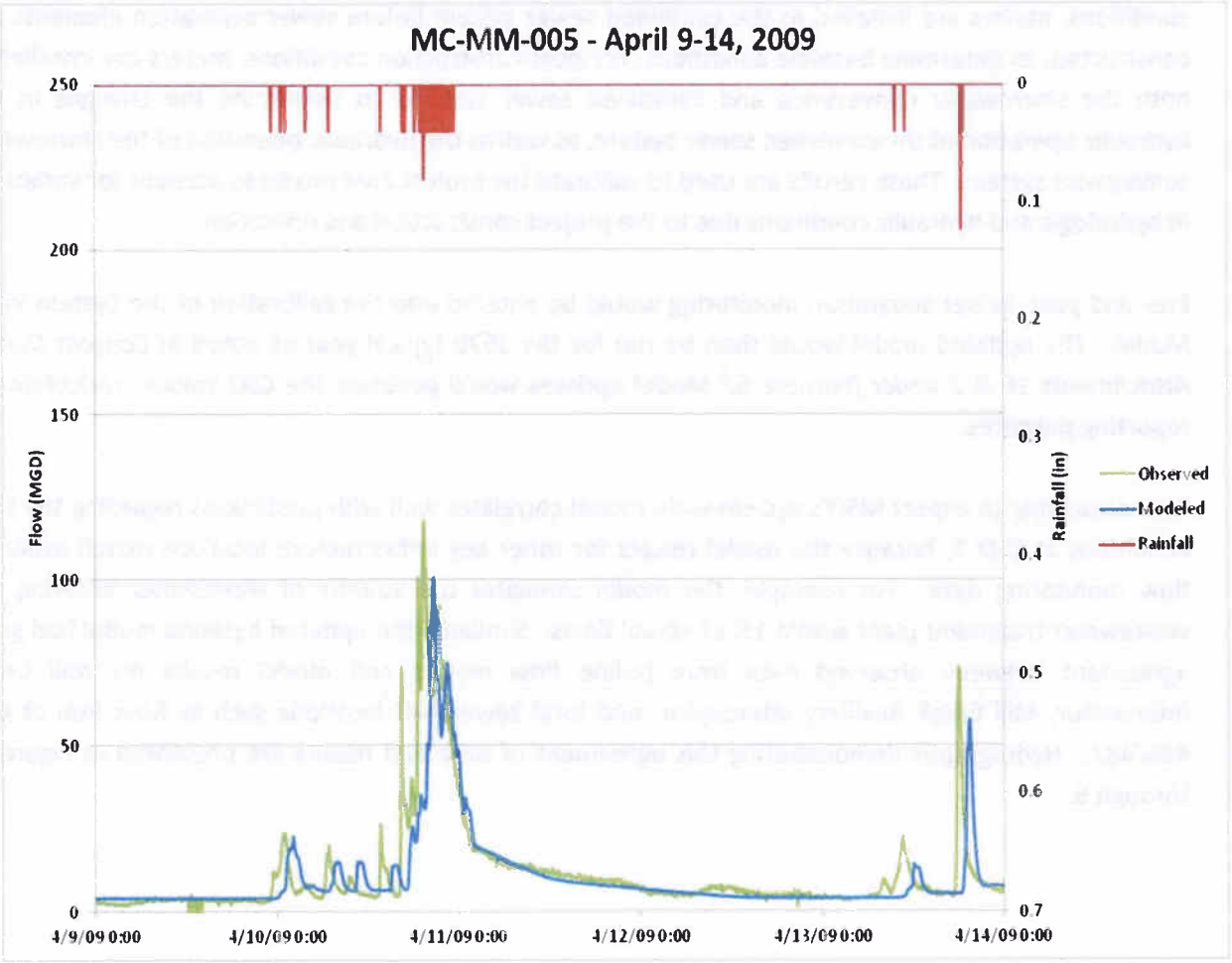
Hydraulic models of the system can be systematically created and calibrated to provide a useful understanding of overall system performance and ultimately CSO volume reduction. In order to

construct these models for this situation, direct measurements of sewer flows would be obtained at the sewer separation project areas, ideally both pre- and post- construction. For pre-construction conditions, meters are installed in the combined sewer system before sewer separation elements are constructed, to determine baseline conditions. For post-construction conditions, meters are installed in both the stormwater conveyance and combined sewer systems to determine the changes in the hydraulic operation of the combined sewer system, as well as the hydraulic operation of the stormwater conveyance system. These results are used to calibrate the project area model to account for variations in hydrologic and hydraulic conditions due to the project construction and operation.

Pre- and post- sewer separation monitoring would be entered into the calibration of the System Wide Model. The updated model would then be run for the 1970 typical year as noted in *Consent Decree Attachments 1B & 2 under footnote 6.*[1] Model updates would generate the CSO volume reduction for reporting purposes.

It is reasonable to expect MSD's system-wide model correlates well with predictions regarding the flow conditions at CSO 5, because the model results for other key infrastructure locations match available flow monitoring data. For example, the model simulates the volume of wastewater entering the wastewater treatment plant within 1% of actual flows. Similarly, the updated baseline model had good agreement between observed data from in-line flow meters and model results for Mill Creek Interceptor, Mill Creek Auxiliary Interceptor, and local sewershed locations such as Ross Run at CSO 485/487. Hydrographs demonstrating this agreement of data and results are presented in Figures 4 through 6.

Figure 4 - Comparison of Model Results with Ross Run Flows at CSO 485/487



Ross Run is one of MSD's five largest CSOs.

Figure 5 - Comparison of Model Results with Mill Creek Interceptor above West Fork

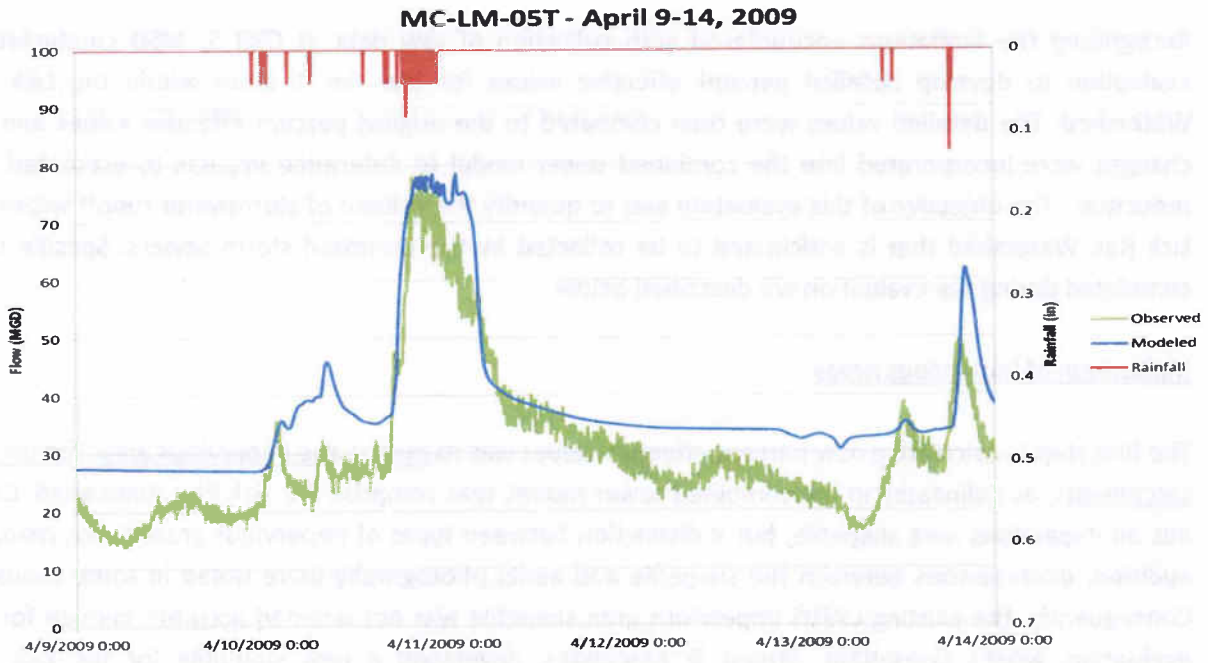
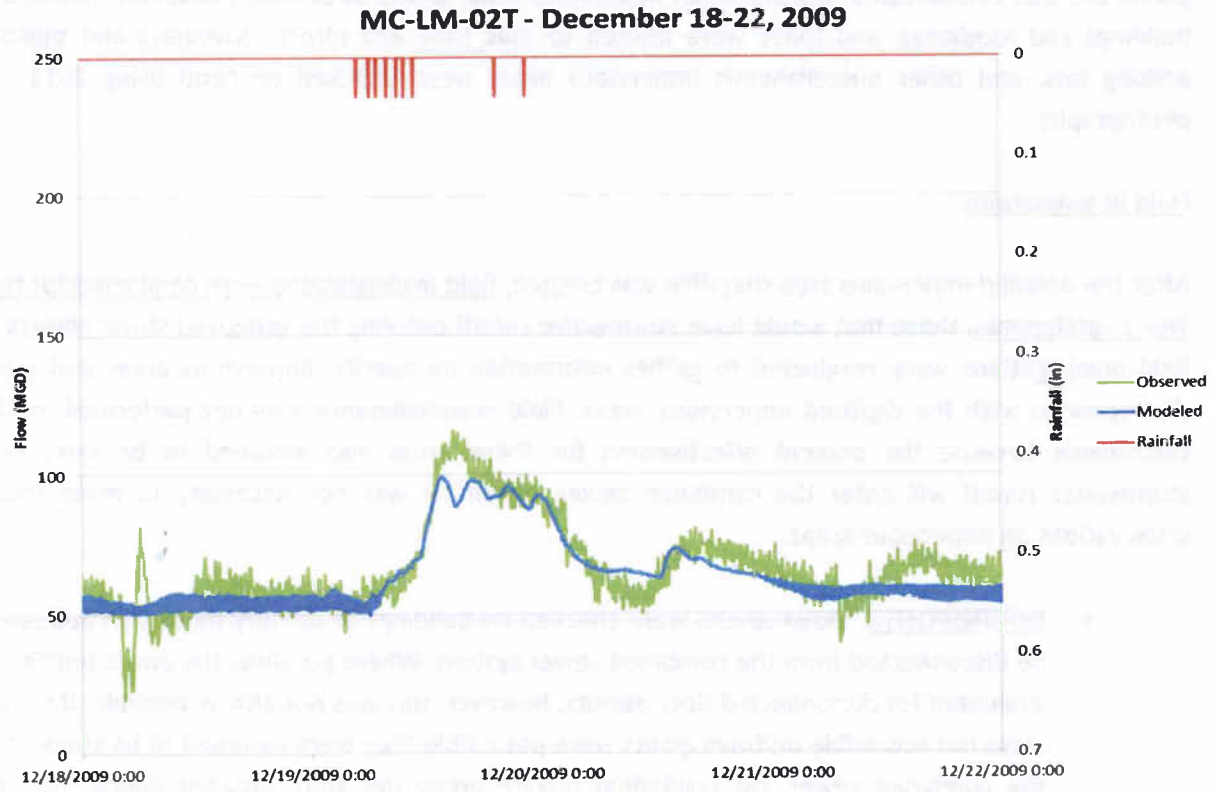


Figure 6 - Comparison of Model Results with Mill Creek Auxiliary Interceptor



4.1.2. Local Field Verification Data

Recognizing the limitations encountered with collection of raw data at CSO 5, MSD conducted an evaluation to develop detailed percent effective values for the Tier 1 areas within the Lick Run Watershed. The detailed values were then compared to the original percent effective values and any changes were incorporated into the combined sewer model to determine impacts to estimated CSO reduction. The objective of this evaluation was to quantify the volume of stormwater runoff within the Lick Run Watershed that is anticipated to be collected by the proposed storm sewers. Specific tasks completed during the evaluation are described below.

Digitization of Impervious Areas

The first step in calculating new percent effective values was to digitize the impervious areas for the 125 catchments, as delineated in the combined sewer model, that comprise the Lick Run Watershed. CAGIS has an impervious area shapefile, but a distinction between types of impervious areas is not made. In addition, discrepancies between the shapefile and aerial photography were noted in some locations. Consequently, the existing CAGIS impervious area shapefile was not deemed accurate enough for this evaluation. MSD's Consultant, Strand & Associates, developed a new shapefile for the Lick Run Watershed which subdivided impervious area into buildings, roadways, driveways and sidewalks, parking lots, and miscellaneous impervious areas. Any area that was severely compacted, such as a gravel lot, was considered a miscellaneous impervious area. CAGIS does have individual shapefiles for buildings and roadways, and those were utilized to save time and effort. Driveways and sidewalks, parking lots, and other miscellaneous impervious areas were digitized by hand using 2011 aerial photography.

Field Investigations

After the detailed impervious area shapefile was created, field investigations were conducted for the 87 Tier 1 catchments, those that would have stormwater runoff entering the proposed storm sewers. The field investigations were conducted to gather information on specific impervious areas and identify discrepancies with the digitized impervious areas. Field reconnaissance was not performed in Tier 2 catchments because the percent effectiveness for these areas was assumed to be zero, i.e. all stormwater runoff will enter the combined sewer system, it was not necessary to make detailed observations on impervious areas.

- DOWNSPOUTS. Downspouts were checked on buildings to identify those that appeared to be disconnected from the combined sewer system. Where possible, the entire building was evaluated for disconnected downspouts; however, this was not always possible. If buildings were not accessible or downspouts were not visible they were assumed to be connected to the combined sewer. No residential private properties were entered during this effort. Downspouts were assumed to be disconnected if they met one of the following criteria:

- The downspout entered the ground but a pipe from the property discharged to the curb.

- The downspout was connected to a building within a larger development, e.g. a school or apartment complex, that is served by a separate storm sewer system according to CAGIS.

- The downspout had fittings, bends, and/or appurtenances allowing runoff to flow overland.

- In several instances downspouts did not enter the ground, but the disconnection did not appear to be intentional. For example, a section of downspout was missing and appeared to have fallen off or a section of gutter was missing. In these cases it was assumed that at some point, the downspout could easily be re-connected to the combined sewer and therefore the disconnection was termed accidental. For this evaluation, no credit was taken for accidental disconnections.

- This downspout survey increased percent effective calculations because stormwater runoff from disconnected downspouts was assumed to flow overland and eventually enter the proposed storm sewer system. The original percent effective values were developed assuming rooftop areas drain to the combined sewer system with the exception of buildings that meet the second criteria listed above.

- PARKING LOTS. Large parking lots were also investigated to attempt to identify drainage patterns. Inlets, structures, and topography were noted, and used in conjunction with CAGIS information and record drawings, to determine the routing of stormwater runoff. This information was used to determine the volume of runoff anticipated to be captured by the proposed storm sewer system, and therefore the percent effective values were affected. The original percent effective values were developed assuming stormwater runoff from parking lots within the Tier 1 areas would enter the proposed storm sewer system.

- DRIVEWAYS. Driveway slopes were observed to determine if stormwater runoff was directed toward the street or the building. Stormwater runoff from driveways that sloped toward the street was assumed to enter street inlets while runoff from driveways that sloped toward the building was assumed to enter the combined sewer system directly. This impacted the percent effective calculations because runoff entering street inlets is anticipated to be rerouted to the proposed storm sewers. The original percent effective values were developed assuming stormwater runoff from driveways within the Tier 1 areas would enter the proposed storm sewer system.

In addition, portions of the existing landscape changed since the 2011 aerial photograph was developed, including the demolition of houses and parking lots. Based on the results of the field reconnaissance, several modifications to the detailed impervious area shapefile were made.

Data Input

Following the field investigations, the data was compiled and entered into the detailed impervious area shapefile. Each impervious area shape was assigned a percent removed factor, used to represent the estimated amount of the area that would enter the proposed storm sewer system. For example, if a parking lot had a separate storm sewer system that was being rerouted to the proposed storm sewer system, it was assigned a percent removed factor of one. Single-family, detached residential buildings were assumed to have four downspouts unless more were observed during the field investigations. So if a building in this category had one disconnected downspout then a percent removed factor of 0.25 was assigned (i.e., stormwater runoff from one out of four downspouts will enter the proposed storm sewer system and therefore be removed from the combined sewer system). A percent removed factor of zero was used for all areas that would stay connected to the CSS.

Other impervious area shapes, including roadways, driveways and sidewalks, parking lots, and miscellaneous impervious areas, were assigned a percent removed factor of either zero or one. In cases where stormwater runoff from one of the impervious areas listed above is anticipated to enter both the proposed storm sewer system and the combined sewer system, the shape was split to accurately reflect drainage areas to each of the primary conveyance systems.

In some cases the stormwater collection and conveyance system in parking lots was not obvious through field investigations and review of available record drawings. Consequently, an accurate determination regarding the downstream connectivity of the stormwater infrastructure from these sites required additional information from MSD.

4.1.3. Local Demonstration Projects Data

Beginning in 2010, as part of the Enabled Impact (EI) Program, MSD engaged in a multi-faceted effort to document and evaluate the overall performance and localized effectiveness of sustainable stormwater infrastructure. This is being accomplished through identification and implementation of various types of monitoring practices with different objectives conducted at different scales. The objectives include:

1. Quantifying stormwater runoff and CSO volume reductions;
2. Identification of design lessons-learned;
3. Identification of constructability constraints;
4. Determining vegetative successes;
5. Summarizing operational/functional issues;
6. Clarifying maintenance needs and long-term viability.

These objectives lend themselves to both quantitative and qualitative monitoring approaches, depending on the nature of a specific project. MSD outlined its approach to meet these objectives in the *Enabled Impact Program Interim Summary Report, December 2011,*[90] and the *Enabled Impact Project Monitoring Program Interim Summary Report, January, 2012.*[91] The EIP Interim Summary Report for September 2012 is provided in Appendix C. In December of 2012, MSD plans to update these reports in a combined document summarizing accomplishments through the end of 2012.

Included in these reports is information summarizing progress of the EI program, including flow monitoring data collected at select EI projects throughout the program, as well as examples of the post-construction site inspections performed on completed projects and comprehensive summaries of all active and completed EI projects.

In order to maintain objectivity in the monitoring efforts, and to capitalize on expertise available in the industry, MSD initiated strategic partnerships to assist and collaborate in the collection and evaluation of sustainable stormwater infrastructure. These strategic partners, along with MSD, have been collecting data on select projects throughout the implementation of the EI Program. The table below summarizes these efforts, which are described in detail in the previously mentioned interim summary reports.

Table 9 – Existing & Planned Enabled Impact Program Monitoring Efforts

Entity	Project	Monitoring Effort
MSD	Clark Montessori	CSS flow monitoring
	Cincinnati State	
	University of Cincinnati	
	Cincinnati Zoo	
Cincinnati Park Board	(all completed projects)	Post-construction site inspections on a quarterly basis
University of Alabama	Cincinnati State	Development of monitoring strategies
	Cincinnati Zoo	
University of Cincinnati	University of Cincinnati	Implementation of monitoring strategies
	Cincinnati State	
	Cincinnati Zoo	
	University of Cincinnati	
USEPA	St. Francis Court Apartments	Groundwater level and soil moisture monitoring.
	Clark Montessori School	
	Cincinnati State	
USGS	St. Francis Court Apartments	
	Cincinnati Zoo	
Civic Garden Center	Green Learning Station	Groundwater level, soil moisture, water balance, rainwater harvesting, infiltration monitoring

Following recommendations from Dr. Robert Pitt of University of Alabama, MSD has modified project designs at the Cincinnati State, University of Cincinnati, and Cincinnati Zoo projects to accommodate the installation of monitoring equipment at ideal locations to assess performance of the installed sustainable stormwater infrastructure. Dr. Robert Pitt has more than 40 years for experience in research and development of stormwater controls and has partnered with the Center for Watershed Protection to develop the National Stormwater Quality Database (NSQD), of which local projects will feed into. Additionally, USEPA and USGS engaged during construction of the St. Francis Court Apartments, Clark Montessori, and Cincinnati State projects to install groundwater sensors and moisture probes within the bioinfiltration and pervious pavement systems on these projects. These partnerships have yielded a substantial amount of data; primarily useful in establishing baselines for pre-existing conditions at each of the localized project sites. This information will be invaluable in determining each project's percent stormwater capture and overall CSO volume reductions from the CSS.

To-date, recent conditions have shown that the series of gardens at St. Francis Court Apartments can absorb and retain peak flows from the catchment area during heavy precipitation. Recent experience with a storm event has shown that as much as 3" of rain over a two-day period was retained entirely within the system.[91]

At the Cincinnati State project, USEPA has evaluated multiple methods of flow measurement within certain section of the pervious pavements, and is evaluating data to determine if lower cost solutions provide comparable results to more costly technologies. A draft journal article has been prepared on the density of sensor locations needed for porous pavement moisture monitoring. The paper should be ready for submittal by the end of September.[92]

This baseline of pre-existing conditions is complemented by post-construction site inspections performed by Cincinnati Park Board on all completed projects, and post-construction monitoring data collected at the St. Francis Court Apartments, Clark Montessori, Cincinnati State, and Cincinnati Zoo project sites. Following at least two years of data collection, this monitoring will provide a dataset suitable to characterize the performance of the installed sustainable stormwater infrastructure. As MSD and its partners continue to move forward in implementing the monitoring program, the evaluation of this comprehensive dataset will provide MSD with objective data supporting the effectiveness of sustainable stormwater infrastructure. MSD will utilize facility performance characterizations to properly size future sustainable stormwater infrastructure projects, and ultimately optimize the CSS.

4.1.4. National Stormwater BMP Database

MSD is not unique in having limited information regarding performance of stormwater infrastructure projects. USEPA has recognized a need to conduct a study of stormwater practices. In 1999 USEPA partnered with the American Society of Civil Engineers (ASCE) to develop a database of stormwater BMP design and performance criteria.[93] Today the BMP database is the work of several sponsor agencies:

- Water Environment Research Foundation (WERF)
- American Society of Civil Engineers (ASCE)
- Environmental and Water Resources Institute (EWRI)
- American Public Works Association (APWA)
- Federal Highway Administration (FHWA)
- United States Environmental Protection Agency (USEPA)

The July 2012 Report developed by the sponsor agencies titled *"International Stormwater Best Management Practices Database Narrative Overview of BMP Database Study Characteristics"* states the following:

> ***"The Database is intended to provide a consistent and scientifically defensible set of data on Best Management Practice ("BMP") designs and related performance."***

The BMP Database has been created using data from 512 studies involving the projects comprising MSD's Sustainable Alternative including, but not limited to, bioretention, detention basins, infiltration basins, manufactured devices (Vortex units), porous pavement, retention ponds, wetland basins, wetland channels, and maintenance practices. This information represents actual field-verified information that can be used to model the impact the sustainable infrastructure projects will have on MSD's system. Similar to MSD's iterative hydraulic and hydrologic modeling approach, the BMP database is considered a living document that will continue to be updated with high quality data sets (flow monitoring and water quality). In 2012 the sponsors intend to expand their efforts to "dig deeper" into watershed and design related considerations for BMP categories.

4.2 Flow Monitoring Program

The monitoring flow meter data that has been collected from the four locations indicated in the County monitor's report is from areas that were originally constructed as separate storm and combined sewer systems, and not from areas that were originally designed as combined sewer only. The SI projects are different from these monitored locations, in that they were originally constructed as combined systems that are being strategically separated after original construction.

MSD has not yet completed construction on any separation projects that can be monitored. The Ault Park project[94] is nearing completion, and Harrison Phase A[24] is under construction. These, as well as the Westwood Northern projects will be the first to provide this type of data within MSD's service area. MSD has on an on-going program of monitoring the combined sewer areas throughout its service area. The program has three major focuses:

Overall Monitoring of the Combined Sewer System - The overall monitoring uses long term flow monitoring sites on major pipes and interceptors that can be used to calibrate and validate the System Wide Model.

Specific Project Monitoring - Specific project monitoring uses a number of monitoring sites in and around near term projects to develop calibration of detailed models of the project area. The project area calibration supports the sizing of the specific project, modeling the impacts of the proposed project, and adds areas of detailed calibration to the System Wide Model.

Overflow Monitoring - Overflow monitoring consists of level monitors at the overflow locations. The overflow monitoring is focused on detecting dry weather overflows and to aid in developing overflow reports to regulators. While not intended for model calibration, the overflow monitoring data can be used as a check on the overflow modeling.

4.2.1. Pre and Post Construction Monitoring Program

The primary objective of pre- and post-construction monitoring is to obtain the flow data necessary to refine the System-Wide Model (SWM) to generate pre- and post-construction typical year overflow volumes at a given CSO(s). The principal model elements to be refined are hydrologic parameters and RTK values. Seasonal changes in average dry weather flows should also be examined, as they influence the calculations of RTK values and overall wet weather volumes.

Comparison of overflow remaining volume or percent control to the individual CSO requirements will be performed to determine if the reduction goal has been met. In the case for the LMCPR, there is an aggregate goal that will also need tracked to ensure the overall goal is met.

An overall concern might come from the fact that MSD is calibrating different portions of the model using flow monitoring data collected at different points of time. Ideally, using a consistent flow monitoring period across the entire CSO service area would be preferred. This approach was not feasible for MSD's system-wide model and is seldom viable from a practical standpoint. It will be important to note differences in the flow monitoring periods; to try to select a broad range of storms that are reflective of typical year storms; to ensure good seasonal coverage with selected storms; and to possibly try to compensate for particularly wet or dry periods in the final selection of model parameters.

4.2.2. Lick Run Flow Monitoring

As noted in the Lick Run Calibration/Validation report[95] and in previous discussions, MSD efforts to-date have focused on identifying viable alternatives for the purposes of alternative evaluation and not for detailed design of specific projects. In the Lick Run calibration, the data sets did not agree and there were various aspects (depth of flow, flow rate, volume of flow, percentage of rainfall captured) that were not in agreement from one year to the next. In reconciling the data, MSD considered and evaluated level data for the RTC and CSO 5 and compared four years of data with the 2011 level data. The data set that best matched up and were most appropriate to use were identified. MSD remains confident in the model results for Lick Run.

MSD has begun additional monitoring at 11 locations (10 temporary, 1 permanent) shown on Figure 7 to confirm and refine model calibration in the continuing, iterative modeling refinement efforts. Additional flow monitoring data collected during the design phase, which is typical in all WWIP projects, will be used for Lick Run projects for the purpose of validating pre-construction conditions. MSD is confident that its approach represents sound engineering practice and a solid, common-sense approach to the demands of this project.

Extensive flow monitoring throughout a sewer system as large as the Mill Creek basin is not practical or cost-effective for planning level alternatives evaluation. MSD has focused its efforts on getting to the point of alternative selection and its technical experts have indicated that model version 3.2 is suitable for alternative selection, while recognizing refinements will be needed as design advances. MSD is now at a point where viable alternatives have been identified and further focused flow monitoring and model refinements are needed to determine precise facility sizing and projected costs.

As previously noted, MSD continues to conduct additional monitoring beginning in September 2012 as part of more detailed design of specific projects. Due to the large size of pipes and the large swings in depth and velocities during wet weather, the Lick Run system is challenging to measure. As noted in the Lick Run Calibration Report,[95] the 2009 flow monitoring data set was not usable for validation because of the high flows and velocities in the 19.5-foot diameter sewer coupled with the lack of reliable flow and velocity measurements from the monitoring devices deployed in 2009. The 2009 data set did not compare well with volumes and rainfall as well as other metrics; it was concluded that the solution is to conduct additional flow monitoring at more suitable locations to collect more data for model validation.

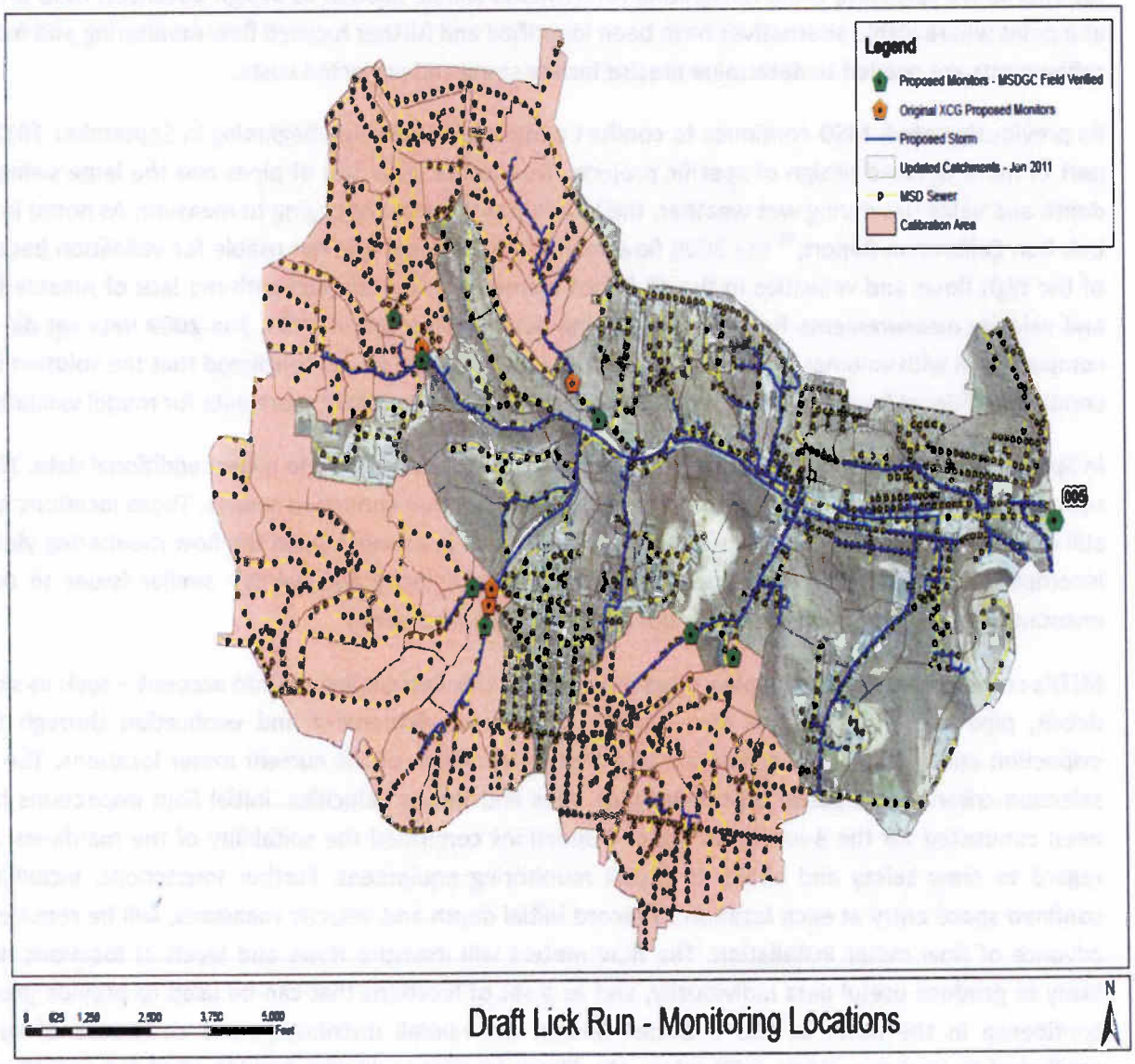
In Spring 2011, MSD conducted some flow monitoring in the watershed to collect additional data. Three upstream locations were selected for flow metering in Lick Run combined sewers. These locations were still in relatively large diameter pipes (78-inch and 84-inch in diameter) and the flow monitoring yielded incomplete and unreliable data due to excessively high velocity and debris - similar issues to those encountered when monitoring the 20-foot diameter combined sewer.

MSD's current flow monitoring plan takes many of the Lick Run challenges into account – such as slope, debris, pipe size, velocity. The plan recently underwent refinement and verification through field inspection and includes the installation of 8 meters upstream of the current meter locations. The site selection criteria were based on smaller pipe sizes and slower velocities. Initial field inspections have been conducted for the 8 locations. These inspections confirmed the suitability of the manholes with regard to crew safety and ability to install monitoring equipment. Further inspections, including a confined space entry at each location to record initial depth and velocity measures, will be required in advance of flow meter installation. The flow meters will measure flows and levels at locations more likely to produce useful data individually, and as a set of locations that can be used to provide greater confidence in the flows at CSO 5 outfall and in the rainfall distribution and conditions of runoff attributed to land use, slope, infiltration, etc. These locations will also provide good pre-construction data flow data for many of the Lick Run separation projects. This additional monitoring data will help

refine the design of the remainder of the projects and verify that the proposed projects will meet the overall reduction objectives.

In summary, the draft Flow Monitoring Plan will monitor flows in the upstream areas of the watershed in pipes no greater than 66-inch diameter and maximum velocities no greater than 12 feet per second. The sensors measure velocity and depth and MSD's selected sites are within the reliable range of the equipment. Historical data shows that there is greater success when focusing on sewers smaller than approximately 60-inch diameter and velocities less than 12 feet per second.

Figure 2 - New Flow Monitoring Locations



As flow monitoring continues, MSD will use the data to refine the calibration for Lick Run for the pre-construction conditions; after improvements are made, a modified model will be developed for post-construction conditions. Following construction, a recalibration of the model based on the installed improvements and the post construction monitoring will proceed. The 1970 year storm will be run through the models and the difference will be the actual CSO reduction achieved.

Modeling is a continuous, iterative process that advances to support viable solutions and MSD will continue to update and refine modeling consistent with its process for detailed design of projects.

4.2.3. USEPA Draft Guidance Criteria to Develop a Plan for Monitoring

MSD's approach to developing a flow monitoring plan is consistent with requirements posed by the USEPA[85]. MSD's approach satisfies ALL industry standards for CSO Wet Weather Programs. Every community addressing wet weather sewer overflows faces challenging but unique conditions. As such, USEPA issued a draft guidance document for Lower Mill Creek Study outlining the "industry standards" that need to be addressed for development of a suitable flow monitoring program.

> *"Unique issues that could arise in the context of developing the Post-Construction Monitoring Study required by Section X of the CSO Decree, in light of the source control/green infrastructure measures in the proposed Revised Original LMCPR (EPA Guidance-Draft for Discussion, October 2011)."*

The purpose of the guidance is to ensure that MSD has a sound approach and plan to implement to pre- and post- construction monitoring of source control projects. The discussion of MSD's prior and current flow monitoring efforts throughout the Lick Run basin demonstrates a commitment to identify the unique issues and diligence to resolve them. A one-size-fits-all approach is not appropriate for Consent Decree Programs. The County monitor's report suggests MSD was negligent or non-responsive to initial approaches recommended by consultants. This allegation is simply not true. MSD has and continues to pursue every available action to collect useful and suitable flow monitoring data. The topography and existing infrastructure have posed unique challenges that continue to be overcome through an iterative process.

4.3. Stormwater Removal Assumptions

The County monitor's report (page 13) states *"Data to prove performance does not support effectiveness assumption."* The monitor team appears to misunderstand the type of sewer separation being proposed. Service areas that have individual house laterals and stormwater inlets connected directly to a single sewer in a street or alley are truly combined sewer service areas, and are located in non-priority (Tier 2) sewer separation areas. Service areas with dual pipe systems, one collecting sanitary flow and RDII and the other dedicated for collecting public stormwater connections (curb inlets, area drains) comprise the priority separation areas (Tier 1). The monitor's statement on page 13 *"The data could then be analyzed to more accurately measure the effectiveness of a storm water separation project and*

used for planning projects in the future." is incorrect. Stormwater collected in the existing separate storm sewers will be conveyed in a new system of storm trunk and interceptor sewers for direct discharge to streams. Sanitary wastewater and RDII in the existing separate sanitary sewer system will continue to be conveyed in combined trunk and interceptor sewers.

An explanation of the cited percentages (23-41%) is needed for clarification. Although the percentages appear to be related to the effectiveness of the storm sewer system to capture rainfall, there is no bearing on the percent effectiveness of sewer separation. The calculation of percent effectiveness is the volume of stormwater removed from the combined sewer system when storm sewers and stormwater inlets are disconnected from the combined sewer system, divided by the total wet weather volume currently conveyed by the combined sewer system. The percent effectiveness values are much higher (52-91%) than the percentages cited by the monitor (23-41%) based on the flow monitoring that was completed. Priority area separation projects will disconnect separate storm sewers and stormwater inlets from open channels, ditches, and ravines and reconnect them to new storm sewers. Combined trunk and interceptor sewers will retain the flow from upstream sanitary sewers (including RDII) and combined sewers, if any, in non-priority combined sewer areas.

The County monitor's discussion only pertains to the larger, downstream pipes in the combined sewer system (part of the combined trunk and interceptor sewer network), and the opportunity for the additional infiltration being described is very limited, unless the sewers are frequently below the ground water table. Frequent high ground water conditions exist along the Ohio River, but not in the SI sub-basins. The argument appears to be that removing storm water from the large combined sewers will cause flow depths in those sewers to be lowered. This would leave a larger fraction of joint area above the water line subject to infiltration. It should be noted that the periods of higher flow depths due to storm water conveyance are relatively short, and that infiltration opportunities will remain nearly the same as the flow depth subsides. There will be very limited opportunity for infiltration to increase during the storm event, particularly if there are not high groundwater conditions present. Again, it is important to recognize the separation concept, and to understand that widespread, single-pipe combined sewer systems are not being separated. This might be a greater issue if it were.

The monitored areas can serve as a guide to the effectiveness of sewer separation in combined sewer areas. By combining the observed sanitary and storm sewer flows during wet weather events, a combined sewer model can be developed and calibrated.

4.4. Rainfall Derived Inflow & Infiltration (RDII)

In the existing conditions system wide model, the surface runoff (stormwater) and any RDII added based on observed data was calibrated to the observed data. In the separation alternatives, the surface runoff volume is maintained in both volume and hydrograph shape by splitting the subcatchment into two new subcatchments and adjusting the widths. The fraction of the original subcatchment that is routed to the storm sewer is the percent effectiveness of the separation. If the percent effectiveness is 75%, then three quarters of the original subcatchment is routed to the proposed storm sewer and the remaining 25% is routed to the combined sewer.

4.4.1. RDII Modeled in System

RDII was added to the existing conditions system wide model along with the surface runoff to the combined system, if the flow monitoring data and the calibration adjustments indicated the need for additional flows. The surface runoff subcatchments were adjusted to match the rising limb, the peak, and the early recession limb of the observed hydrographs. If the later portions of the recession limb of the hydrograph or subsequent peak flows needed additional flows to achieve calibration, RDII was added to the combined sewer flows.

Using the RTK method of three RDII hydrographs (short term, intermediate term, long term), the short term RDII was assumed to be included in the surface runoff modeling and not added to the combined sewer modeling. Short term RDII is the direct connections to the sewer such as downspouts, yard and driveway drains, etc. The RDII added to the combined sewer based on the flow monitoring was assumed to be slower infiltration sources such as leaking laterals and mains. The assumption used in the alternative model reflecting sewer separation was that the intermediate and long term RDII remained in the existing combined sewer while the new storm sewer was installed as a tight pipe with only surface runoff.

4.4.2 RDII Entry into System

The occurrence of infiltration and inflow (I/I) in gravity sewers is influenced by a number of factors, including depth of groundwater, condition of structures, manhole casting type and condition, condition of pipe, pipe joint type and condition, porosity of surrounding soils, topography, flooding susceptibility, sewer hydraulic capacity and cross connections, among other things. For combined sewers and storm sewers, I/I is generally not a significant concern other than it could be an indicator of advanced deterioration of a piping segment. I/I is made up of 2 components, infiltration, and inflow. Infiltration is generally considered to be related to groundwater that leaks continuously into the pipe, at pipe and manhole joints, or through cracks in the pipe or manhole walls. Inflow on the other hand is generally considered to be related to direct sources of flow such as water from a running stream that might run into the top of a manhole or directly connected flows such as downspouts or driveway drains. Often inflow is event driven with peak conditions occurring during periods of extremely wet weather.

When combined sewers and storm sewers are operating at surcharged conditions, the infiltration component of I/I is minimal whenever the groundwater elevations are below the top of the pipe. Under severe surcharged sewer conditions, where water is actually exiting sewer structures (exfiltration or overflowing), the inflow component of I/I is likewise affected. A combined sewer is sized to accommodate inflow up to a certain design runoff event, after which it no longer can accept additional inflow.

The addition of a storm sewer system that operates in parallel with a combined sewer will significantly reduce the occurrence of inflow into the combined sewer, by capturing the storm water runoff that previously had entered the combined sewer. This reduction presumably will reduce the overall hydraulic loading on the combined sewer, to the point where it will see fewer episodes of surcharged operation.

In certain situations, the elimination of surcharged conditions could lead to increased I/I. As previously noted, if groundwater conditions are below the top of the pipe, under surcharged conditions, infiltration of this groundwater into the pipe cannot occur. However, if the surcharged conditions are relieved the opposite is true, and infiltration can occur- when groundwater is present.

For the Lick Run Basin, infiltration is not expected to occur as groundwater conditions throughout the project areas are typically well below the existing combined sewers. Groundwater elevations from over 300 borings that were completed by MSD's soil consultant for the various SI projects provide documentation of these conditions.[96]

In addition to the existing groundwater conditions, the terrain and soils of the basin provide conditions that would also minimize infiltration. Soil conditions throughout the basin are generally Hydrologic Soil Group (HSG) Type C *(Table 2.02-1 of the Lick Run CDR64)*[64], and restrict the free movement of groundwater. This in turn minimizes the groundwater available for pipe infiltration. Furthermore, the vast majority of the Tier 1 areas include hillside slopes in excess of 15 percent *(Figure 2.02-3 of the Lick Run CDR)*[64]. This type of terrain provides for well drained conditions that minimize the potential for groundwater infiltration, in turn also minimizing the groundwater available for pipe infiltration. With these conditions in place, a reduction in surcharged pipe conditions in the combined sewer is unlikely to produce any meaningful changes in the occurrence of pipe infiltration.

The occurrence of inflow into the combined sewer is largely a surface related phenomenon. As with infiltration, the steep, well drained slopes, and relatively tight soils found within the Lick Run Basin provide conditions that would discourage inflow into the combined sewer so long as surface entry points were properly sealed. Replacement of grated lid castings on the combined sewer with watertight castings and elimination of cross connections with storm water inlets and other clear water sources such as drain tiles and roof drains are the types of controls that would further restrict any significant changes in inflow to the combined sewer regardless of its propensity to operate in a surcharged condition.

For Lick Run in particular and for other CSOs generally, the RDII required to cause or extend an overflow is much larger than the dry weather flow (DWF) for the CSO. For Lick Run, the underflow capacity is

approximately 30 cfs while the DWF is around 5.5 cfs. Other CSOs have similar ratios of underflow capacity and DWF rates. For the RDII to cause flows at the CSO regulator to be than greater the underflow capacity for meaningful durations, the RDII flows would be apparent during the calibration of the surface runoff against the observed data. The modeled hydrograph would consistently underestimate the recession limb of the hydrograph for most storms. However, that is NOT what the data and hydrographs show.

4.5. Sensitivity Analysis

MSD's sensitivity analysis regarding sewer separation effectiveness was completed prior to having the more detailed flow monitoring data, so extreme departures from the estimated percent effectiveness values were examined (i.e. as much as 50 or 75 percent). After a thorough review of how the percent effectiveness values were estimated, including two or three iterations in some sub-basins, the percent effectiveness values were lowered. The values were adjusted further based on the flow monitoring results in separate sanitary and storm sewer areas. With further review MSD is now confident that a lower "effectiveness limit" is 15% departure, with a 25% departure being a very pessimistic upper boundary. There is not a linear relationship between a lowering of percent effectiveness and the corresponding lowering of the modeled CSO volume. The lowering of the CSO volume is less on a percentage basis.

4.5.1. Sustainable Projects Sensitivity Analysis

Section 4.6.3 in the Working Draft Sustainable Projects Lower Mill Creek Partial Remedy, July 16, 2012 Report[97] summarizes the sensitivity analysis performed by MSDGC for the suite of six candidate projects considered for the Sustainable/Hybrid Alternative. As shown in *Table 4-26 of the Working Draft Report*, the analysis based on SWM model runs showed that a 25% reduction in separation areas (analogous to a 25% lower-than-expected effectiveness from separation) for the six sustainable projects in total still reduce CSO volumes by more than 2 billion gallons. With the specific CSO volumetric reduction requirements for Phase I currently under discussion, these six candidate projects provide the co-defendants with significant flexibility to meet the proposed Phase I goal while minimizing cost.

Focusing on the Phase I Sustainable/Hybrid alternative, Tables 10 and 11 below correct the County monitor's sensitivity analysis, as presented on pages 14 and 15 of the County monitor's report, using CSO volume reduction from MSD's SWM-based sensitivity analysis. In these model runs, decreased success in separation was simulated by assuming uniform reductions in the runoff drainage area diverted to storm systems through separation (i.e., additional area remained tributary to the combined sewer system). For example, the "15% Reduction in Separation Area to Storm" scenario involves a 15% reduction in the total area being routed to the storm system for areas being separated, with corresponding increases in tributary area and runoff volume routed to the combined sewer system.

Table 10 - Sensitivity Analysis for Phase 1 Sustainable Alternative Including RTCs

Sensitivity Analysis for Phase I Sustainable/Hybrid Alternative[1]			
Scenarios	Total Annual CSO Volume Reductions (Phase 1 SI projects + Existing RTCs)[2]	Total Reduction Over (Under) Target (MG)	
		2.013 BG	1.785 BG
Baseline (e.g., Phase I Sustainable/Hybrid Alternative)	2,058 MG[3]	45	273
Baseline with 15% Reduction in Separation Area to Storm[4,5]	1,925 MG	(88)	140
Baseline with 25% Reduction in Separation Area to Storm[4,5]	1,832 MG	(181)	47
Baseline with 50% Reduction in Separation Area to Storm[4,5]	1,592 MG	(421)	(193)
Baseline with 75% Reduction in Separation Area to Storm[4,5]	1,332 MG	(681)	(453)

Notes

1. Phase I Sustainable/Hybrid Alternative includes partial separation for the Lick Run, West Fork, and Wooden Shoe watersheds only paired with RTC at Bloody Run and storage at CSO 488.
2. Annual CSO volume reductions include reductions associated with all proposed Phase I projects and the existing RTCs.
3. CSO volume reductions were calculated from the Phase 1 Maximum Sustainable Infrastructure Plus (or Phase I Max Green) scenario results, *Lower Mill Creek Partial Remedy Study Revised Plan Phase 1 Report, June 2012*. Values for Bloody Run RTC benefit are cited as 93 MG in the same report (page 15).
4. Decreased success in separation was simulated by assuming uniform reductions in the runoff drainage area diverted to storm systems through separation for Lick Run, West Fork, and Wooden Shoe watersheds. For example, the "15% Reduction in Separation Area to Storm" scenario involves a 15% reduction in the total area being routed to the storm system within the areas being separated, with corresponding increases in tributary area and runoff volume routed to the CSS.
5. Incremental decreases in annual CSO volume reductions were calculated using sensitivity model runs described in Section 4.6.3, *Working Draft Sustainable Projects Lower Mill Creek Partial Remedy Study Report, July, 16, 2012.*

Table 11- Sensitivity Analysis for Phase 1 Sustainable Alternative Excluding RTC

Sensitivity Analysis for Phase I Sustainable/Hybrid Alternative[1]			
Scenarios	Total Annual CSO Volume Reductions, Phase 1 SI projects only[2]	Total Alternative Cost[2]	Alternative Cost Per Gallon[2]
Baseline (e.g., Phase I Sustainable/Hybrid Alternative)	1,321 MG[3]	$315,107,000	$0.24
Baseline with 15% Reduction in Separation Area to Storm[4,5]	1,188 MG	$315,107,000	$0.27
Baseline with 25% Reduction in Separation Area to Storm[4,5]	1,095 MG	$315,107,000	$0.29
Baseline with 50% Reduction in Separation Area to Storm[4,5]	855 MG	$315,107,000	$0.37
Baseline with 75% Reduction in Separation Area to Storm[4,5]	595 MG	$315,107,000	$0.53

Notes

1. Phase I Sustainable/Hybrid Alternative includes partial separation for the Lick Run, West Fork, and Wooden Shoe watersheds only paired with RTC at Bloody Run and storage at CSO 488.
2. Annual CSO volume reductions include reductions associated with all proposed Phase I projects only. CSO reductions at the existing RTCs are not included.
3. CSO volume reductions were calculated from the Phase 1 Maximum Sustainable Infrastructure Plus (or Phase I Max Green) scenario results, *Lower Mill Creek Partial Remedy Study Revised Plan Phase 1 Report, June 2012*. Values for Bloody Run RTC benefit are cited as 93 MG in the same report (page 15).
4. Decreased success in separation was simulated by assuming uniform reductions in the runoff drainage area diverted to storm systems through separation for Lick Run, West Fork, and Wooden Shoe watersheds. For example, the "15% Reduction in Separation Area to Storm" scenario involves a 15% reduction in the total area being routed to the storm system within the areas being separated, with corresponding increases in tributary area and runoff volume routed to the CSS.
5. Incremental decreases in annual CSO volume reductions were calculated using sensitivity model runs described in Section 4.6.3, *Working Draft Sustainable Projects Lower Mill Creek Partial Remedy Study Report, July, 16, 2012.*

The data and analysis summarized in Tables 10 and 11 demonstrate that the relationship between stormwater capture and CSO reduction is not linear.

For the Phase 1 projects including the existing RTCs

- 15% reduction in separation area = 6.5% decrease in the annual CSO volume reduction
- 25% reduction in separation area = 11% decrease in the annual CSO volume reduction
- Focusing on Lick Run including the RTC, a 25% reduction in separation area results in a 14% decrease in the annual CSO volume reduction.

For the Phase 1 projects excluding the RTCs

- 15% reduction in separation area = 10% decrease in the annual CSO volume reduction
- 25% reduction in separation area = 17% decrease in the annual CSO volume reduction

Focusing on Lick Run only without RTC

- 15% reduction in separation area = 13% decrease in the annual CSO volume reduction
- 25% reduction in separation area = 23% decrease in the annual CSO volume reduction.

4.5.2. Shortfall Replacement Cost

No industry standards exist regarding potential shortfall replacement costs. An acceptable level, if any, must be determined on a case-by-case basis using site-specific information. Once the volumetric reduction goal is defined, then the suite of projects can be identified keeping in mind the diversity of projects that are candidates for Phase 1. The amount of shortfall replacement costs could then be calculated to account for a specific deviation from meeting the goal based on the sensitivity analysis results.

Options to Consider for Shortfall Replacement

- There are projects incorporated into the model version 4.2 that are included in both the grey and sustainable alternative – CSO 25 for example. This asset management project for flood control provides 23 million gallons of CSO reduction. Currently, this is not a Phase 1 project in the WWIP but a Phase 2 LMCFR project. CSOs 37 and 39 regulator improvements are examples of Phase 2 projects that were completed in Phase 1 resulting with a combined total CSO reduction of 4 million gallons. Itemizing projects like these in the LMCPR would provide certainty of meeting the required goal.

- As previously mentioned, a larger SI project such as Ludlow Run could be considered in the future if post construction monitoring demonstrates the overall Phase 1 goal is not achieved. In the context of meeting a 2 billion gallons CSO reduction goal, the sensitivity analysis would suggest Ludlow Run SI projects could be added to assure compliance with the goal, increasing the Phase 1 SI Alternative capital cost by $33.7 million or approximately 10 percent. The 10 percent increase in Phase 1 costs would be the maximum potential downside of implementing the SI Alternative if percent effectiveness values are over-estimated and the corresponding CSO volumetric reduction is under-estimated. There would be less impact due to a similar sensitivity analysis if the volumetric goals are lowered to 1.8, 1.5, or 1.25 billion gallons.

- Although considered 'icing on the cake' and not incorporated toward the reduction goal, enabled impact projects provide a level of CSO reduction to the system. Burnet Woods is within the Clifton Watershed and is a joint MSDGC and City of Cincinnati Parks potential enabled impact project. Burnet Woods[98] provides some daylighting through the park as well as additional detention that when integrated with University of Cincinnati's enabled impact proposal would reduce and detain flow from entering the combined system. Although Burnet Woods was considered within the Clifton mini-model, the Clifton watershed was not one of the six confirmed projects for the LMC study. Therefore the Burnet Woods project is not included in the system wide model runs for the Max Sustainable Alternative and could provide additional benefits for CSO reductions above of those projected in the LMC study.

- Specifically in Lick Run, the most cost effective stormwater removal has already been incorporated in the priority areas (Tier 1). Moving up the system to perform separation in Tier 2 would result in a higher cost per gallon. While it is evident that there are higher costs associated with utilizing the Tier 2 sewer separation area for capturing additional stormwater flows, resulting in additional CSO reduction, this does present additional stormwater separation opportunities.

- MSD has been working closely with ODOT to address CSO reduction needs associated with highway reconstruction and specifically coordinating stormwater management infrastructure and strategic separation projects to reduce flows to CSOs. There are several locations along I-75 where separation pipes are being designed and constructed under I-75 with ODOT's active construction projects that will provide CSO reduction benefits in near term but the primary purpose and benefit of coordinating with ODOT are the additional reductions that can occur in the future once the separation barriers are eliminated through the coordination efforts along the highway. These benefits have not been included in the LMCPR estimates. The planning and coordination done now will help to facilitate a more sustainable final remedy in Clifton, Mitchell and Bloody that currently lack a separate conveyance to the Mill Creek. The design and construction coordination efforts in phase 1 are conservatively estimated to be approximately 10 million gallons. However, post 2018 when future projects could strategically separate flows

within Clifton, Bloody or Mitchell, additional reductions could reasonably be expected to exceed 200 MG.

These additional initiatives provide an additional margin of safety that was not considered by the County monitor. The information regarding these projects was included in *MSD's Lower Mill Creek Alternatives Preliminary Findings Report* that was submitted to the County in April 2012 and made available to the public in June 2012.

4.5.3. Cost per Gallon Evaluation

Tables 12 and 12 show the cost and cost/benefit based on revised cost and model data that has been developed subsequent to the Preliminary Findings Report[96] based upon model runs completed in August 2012. Generally the cost-per-gallon metrics were similar between the two sets of numbers.

Table 12 - Sustainable Alternative Phase 1 Excluding Existing RTC Benefit and Cost

Watershed/Project	Capital Cost (2006$)	Gallons Removed	Cost per gallon
Lick Run	$200,492,000	726,000,000	$0.28
West Fork	$73,971,000	299,000,000	$0.25
Kings Run	$26,572,000	156,000,000	$0.17
CSO 488 Storage	$10,651,000	47,000,000	$0.23
Bloody Run	$3,421,000	93,000,000	$0.04
TOTAL SI Alternative	**$315,107,000**	**1,321,000,000**	**$0.24**

Table 13 - Sustainable Alternative Phase 1 Including Existing RTC Benefit and Cost

Watershed/Project	Capital Cost (2006$)	Gallons Removed	Cost per gallon
Lick Run	$200,492,000	726,000,000	$0.28
West Fork	$73,971,000	299,000,000	$0.25
Kings Run	$26,572,000	156,000,000	$0.17
CSO 488 Storage	$10,651,000	47,000,000	$0.23
Bloody Run	$3,421,000	93,000,000	$0.04
Four Existing RTCs (1)	$8,301,000	737,000,000	$0.01
TOTAL SI Alternative	**$323,408,000**	**2,058,000,000**	**$0.16**

Note (1) Existing RTCs Project Costs based on actual October 2011 costs

- *CSO 487 Ross Run Twin Outfall RTC $4,122,210*
- *CSO 482 Mitchell Avenue RTC $2,157,630*
- *CSO 125 Badgeley Run Outfall RTC $2,041,070*
- *CSO 5 Lick Run Interceptor Chamber $914,122*
- *Total Actual Capital Cost for RTCs = $9,235,033*
- *De-escalation 4Q2009 to 3Q2006 dollars = 1.112482*
- *Total Actual Capital Cost for RTCs in 2006 dollars $8,301,000*

Additional CSO reduction resulting from "green" projects will provide a greater margin of volume capture certainty. The stormwater capture and therefore potential CSO reduction from the enabled impact projects is not included in the modeling results, and would provide a greater margin of volume capture.

5. GREY ALTERNATIVE COST CERTAINTY

The County monitor's report did not address the issues of risk and cost certainty with respect to the grey alternative. This section presents an abbreviated overview of these issues.

5.1. Tunnel Risk Analysis

During the LMC Study, MSD developed a detailed risk evaluation for the default grey remedy[70] identifying and assessing risks and developing the strategies for addressing each. This information has been published and available to the County monitor team since May 6, 2011. In order to provide the County with an understanding of the level of effort dedicated to the tunnel risk evaluation, the details of this effort are discussed herein.

RISK 1 = LAND ACQUISITION

As with the SI projects, cost estimating for right-of-way needed for the grey alternative is difficult because of the lack of concrete information regarding the extent and nature of property needs. As project designs progress, right-of-way estimates will be updated to reflect changes in property needs. It is anticipated that the majority of projects will experience a reduction in right-of-way costs; however, the potential need for additional property resulting in increased costs cannot be discounted.

Risk Identification:

The tunnel project faces additional land acquisition risks beyond those required for the SI projects. The Risk Register identified potential competing right-of-way needs with the Brent Spence Bridge Replacement and Rehabilitation Project. Concerns were also expressed regarding state law restrictions on the use of lands and ROW permits needed from the Mill Creek Conservancy District.

Risk Assessment:

Property acquisition is the complex challenge that can affect schedule and budget. The grey alternative will require property for drop shaft locations, construction staging, tunnel alignment, and consolidation sewers. Coordination will also be required early on during the project for federal and state permitting associated with ROW.

Risk Strategy:

In an effort to mitigate cost and/or schedule overruns, conservative assumptions in estimating right-of-way costs included the following:

- ACQUISITION STEPS IN COMMON WITH SI ALTERNATIVE: Refer to Section 3.1.2 of this report for the strategy MSD has implemented with respect to quick take, public forums, and advanced acquisitions.

- EARLY IDENTIFICATION OF NEEDS: Drop shaft locations were identified early in the project and put on the list of potential property acquisition needs. The shaft locations were refined as geotechnical data became available. MSD continues to update the amount and quality of information available regarding the subsurface along the tunnel alignment and at drop shaft sites.

- PROJECT COORDINATION WITH OTHERS: Early coordination was performed at the 30% design stage for both the Brent Spence Bridge Project and with the Mill Creek Conservancy District. Project information, permit forms and applications were provided to ensure the tunnel project sites conform to the general stipulations set forth by the permitting agency for both subsurface and surface entry.

RISK 2 = RAILROAD COORDINATION & PERMIT

Risk Identification:

The tunnel project will require approval by the US Federal Railroad Administration given its close proximity to more than 40 active rail lines maintained and operated by CSX. As with any new infrastructure project, coordination with railroad entities tends to be cumbersome and lengthy. The USFRA may require multiple submittals of information, respond such that Consent Decree milestone deadlines are impacted, or impose unusual and costly requirements on the project.

Risk Assessment:

In order to adequately assess the risks associated with working near the railyards, MSD needs to obtain access to the site to conduct a geophysical investigation. The complexity added to the project via the railroad coordination may also limit the number of bidders willing to bid the project and indemnify project participants – particularly for soft ground tunneling areas.

Risk Strategy:

- IDENTIFY EXISTING INFRASTRUCUTRE: During the course of preliminary engineering, MSD identified existing utility and railroad infrastructure. Discussions with CSX provided a clear understanding of the impact the tunnel project would pose on railroad operations. One step taken to mitigate the risk of impacting railroad operations was to relocate CSO diversion structures.

- SOFT GROUND TUNNELING: The tunnel project was designed to avoid soft ground crossing of the railroad. The updated design is discussed in the Revised Concept Design Report.[100]

- COORDINATION WITH RAILROAD: MSD's tunnel consultant began dialogue with USFRA and CSX regarding the detailed coordination required to successfully implement this project. The various forms, attachments, applications, and back-up documentation required for a ROW permit to be issued were discussed.

RISK 3 = UNKNOWNS

Risk Identification:

Project corridor has historical, archeological, environmental, geotechnical and buried utility unknowns that will be uncovered during construction leading to delays and cost overruns.

Risk Assessment:

As was discussed for the Sustainable Alternative unknown conditions encountered during the course of the project pose a risk to cost and schedule. Given the magnitude of infrastructure to be constructed several hundred feet below ground for the deep tunnel, it is expected at some point conditions contrary to those anticipated will be encountered. The Contract Documents will explain how such situations are to be addressed during construction. Prior to construction it is important for the project team to initiate and maintain communications with Regulators to ensure permits are submitted timely and received such that the Consent Decree milestone compliance dates are not impacted.

Risk Strategy:

- UNSEEN CONDITIONS FOR 401 PERMIT: The project team planned steps for proper coordination, communication, identification, and resolution of issues, including but not limited, to encountering threatened or endangered species; confusion over jurisdiction; environmental impact statements; and identification of required permits.

- UTILITY COORDINATION: The project team is planning on conducting thorough planning to coordinate the project with existing and planned utilities with Duke Energy for electrical and gas services; with Cincinnati Bell and AT&T for telecommunication services; and with the City of Cincinnati for water, sewer, and stormwater services. The project team will work to identify bypass piping and pumping needs to allow flows to be maintained during each stage of construction.

- UNFORESEEN HAZARDOUS MATERIALS: The project team recognizes the probability for encountering unforeseen hazardous materials is high for these types of projects. Several measures have been taken to minimize and mitigate this risk, including but not limited to, designing a geotechnical investigation[101] to identify ground conditions; completing a Phase II Environmental Site Assessment to determine how to accurately handle contamination in the contract documents; prepare a geologic profile to ascertain the presence of Lexington Limestone Logana Member (shale with gas) at various elevations. A geologic profile will also assist with reducing the risk of rock conditions causing the tunnel boring machine to be stuck during excavation.

RISK 4 = COMPLEX CONSTRUCTION

Risk Identification:

Tunnel construction is a highly complex technical feat that has several opportunities to introduce or increase risk of project success and cost control. This type of construction has not been completed by MSD and poses challenges that are unique and not applicable to conventional pipeline conveyance projects.

Risk Assessment:

Damage claims due to construction from third parties close to the surface construction sites may lead to cost and schedule impacts as well as loss of stakeholder support.

Risk Strategy:

- THIRD PARTY CLAIMS: To minimize the impact of third party claims, the project will develop a pre-construction structural assessment to document conditions near the project site before contractor mobilization. In addition, a groundwater monitoring plan will be developed to identify potential risks of impacting local groundwater wells.

- POWER AVAILABILITY: Tunneling operations consume large amounts of power. Extensive advance coordination will be required with Duke Energy to ensure an adequate supply of power is available during construction and system operation. A Power System Plan will be developed for the project.

- LACK OF QUALIFIED CONTRACTING POOL: Tunneling projects cannot be led by local general contractors. The complexity and high-risk require specialized contractors experienced with deep tunneling. A high workload in the tunneling industry may result with qualified contractors having full order books and a limited availability for MSD's project. The project team will initiate communications early with contractors regarding prequalification; bidding schedule; and preferred construction packages. Prequalification of contractors should reduce the risk of a contractor defaulting on the project in the event the cost of completing the work exceeds payments remaining to be made plus withheld amounts.

- BACKFLOODING FROM OHIO RIVER OR MILL CREEK: Inadequate flow control at the CSO diversion structures could lead to the capacity of the tunnel being reduced due to backflooding from either the Ohio River or Mill Creek. The contract documents will include tide gates to keep the Ohio River out of the tunnel. MSD's operating staff needs will be identified prior to initiating construction to ensure adequate personnel are available to address tunnel construction and operations.

RISK 5 = COMMUNITY SUPPORT

Risk Identification:

Public resistant to the project for a variety of reasons, including lack of public trust, concerns regarding traffic detours; perceptions associated with tunnel construction.

Risk Assessment:

Any project of this magnitude impacts the community. It is important to start and maintain venues for residents and business owners to discuss the project and how their specific issues will be addressed and resolved.

Risk Strategy:

- PUBLIC OUTREACH: Community engagement to South Fairmount, Westwood, East and Lower Price Hill and other Lower Mill Creek communities is focused around the Early Success Projects and the LMC Study. A Community Open House was held January 2010. MSD has had a community relations specialist attend monthly South Fairmount Community Council meetings since July 2010. MSD has been engaging the Community to provide complete, up-to-date information in a transparent forum to receive feedback in a positive manner. Two Town Hall meetings were held in August 2012. All comments received are documented in the Lower Mill Creek Partial Remedy Community Outreach Report to Hamilton County and City of Cincinnati, September 13, 2012 draft.[63]

- CONTRACTUAL ISSUES: The project team recommends a community liaison be appointed to identify and address issues in advance, where possible. An experienced tunnel construction manager is recommended to monitor working operations to ensure contract requirements associated with odors, dust, noise, vibration, and traffic impacts are enforced.

RISK 6 = PUBLIC SAFETY

Risk Identification:

The resulting proposed project design will require certain mitigation strategies regarding deep tunnel construction to address potential public safety issues.

Risk Assessment:

Public safety is an important consideration that must be planned and orchestrated during all phases of the project. Safety issues extend from coordinating with emergency responders to ensure the project is design in a manner to minimize the potential for collapse, settlement and heaving.

Risk Strategy:

- EMERGENCY RESPONDER COORDINATION: The project requires early and continuing coordination with Fire, Emergency Management Services and Police Departments. The coordination needs to be initiated during project design so recommendations can be

incorporated into the contract documents. Coordination is also required with Homeland Security and EROC to identify and resolve issues with maintaining emergency routes at all times. For example construction activities cannot isolate portions of State Avenue such that access by emergency vehicles is impaired.

- CONSTRUCTION MEANS AND METHODS: The project team must specify which construction methods are not permissible – particularly for shaft construction. This approach will ensure blasting is not utilized in sensitive areas identified by the City or County staff. Throughout the construction duration, the project team will maintain a quality control log of the contractor's means and methods. Similar attention will be provided to confirm adequate shoring is in place behind the tunnel boring machine and starter tunnel.

- SURFACE SETTLEMENT/HEAVING: Drop shaft locations will be identified such that they minimize the potential for area structures to experience settling or heaving. The contract documents will include a QA/QC protocol for addressing these situations.

RISK 7 = REGULATOR SUPPORT

Risk Identification:

Delays in acquiring the necessary federal, state and local permits or regulator support could delay or suspend project implementation.

Risk Assessment:

Failure to gain regulator support/approval, funding or flexibility could suspend or reduce the project. The nature and extent of the environmental documentation could affect the implementation schedule for the project. Regulator support is required on multiple federal, state, and local levels including but not limited to, permits for tunneling beneath ROW; sediment and erosion control permits; USACE permits; joint USACE/ODNR permits; and environmental based permits.

Risk Strategy:

- REGULATOR COORDINATION: The project team will begin coordination early with ODOT, ODNR, USACE, SMU, and other entities are required to identify all permits required to implement the grey project as well as permit conditions likely to be imposed on the project.

As with the Sustainable Alternative, MSD has invested time and resources to identify, assess, and mitigate risks associated with the grey alternative. As presented herein, the cost risks identified for these projects will be addressed by revising the scope of the project and hence updating the estimated cost of the project.

4.2. Grey Cost Certainty Analysis

The monitor's arguments regarding certainty for the Sustainable Alternative in Section 3 of this report apply equally to the Grey Alternative. As shown in Table 14_ stripping out the RTC CSO reductions volumes increases the tunnel unit cost to $537 M/1,500 MG = $0.36/gal. There remains a high differential cost between the Grey and Sustainable Alternatives.

Table 14 – Grey Alternative Phase 1 Benefit and Cost

Grey Alternative	Capital Cost (2006$)	Gallons Removed	Cost per gallon
Grey Alternative Excluding RTCs	**$537,409,000**	**1,502,000,000**	**$0.36**
Four Existing RTCs[1]	$8,301,000	737,000,000	$0.01
Grey Alternative	$537,409,000	1,502,000,000	$0.36
Grey Alternative Including RTCs	**$545,710,000**	**2,239,000,000**	**$0.24**

Note (1) Existing RTCs Project Costs based on actual October 2011 costs

- *CSO 487 Ross Run Twin Outfall RTC $4,122,210*
- *CSO 482 Mitchell Avenue RTC $2,157,630*
- *CSO 125 Badgeley Run Outfall RTC $2,041,070*
- *CSO 5 Lick Run Interceptor Chamber $914,122*
- *Total Actual Capital Cost for RTCs = $9,235,033*
- *De-escalation 4Q2009 to 3Q2006 dollars = 1.112482*
- *Total Actual Capital Cost for RTCs in 2006 dollars $8,301,000*

6. SIMILAR PROJECTS ACROSS THE COUNTRY

The components and features proposed by MSD for the Sustainable Alternative are not new or untested technology. In fact a literature review of the work on-going by similar utilities has determined nearly every City faced with meeting Consent Decree milestone compliance deadlines is turning the sustainable infrastructure.

6.1. Literature Review

Rooftops to Rivers: Green Strategies for Controlling Stormwater and Combined Sewer Overflows (June, 2006)[102] - *a* report written by the Maryland Institute for Public Policy and the Low Impact Development Center for the Natural Resources Defense Council. The report was commissioned by Nancy Stoner, then co-director of NRDC's Water Program, and currently EPA's Acting Assistant Administrator for Water.[103]

Table 15 - Green Infrastructure Methods Used by Select Cities

	PROGRAM ELEMENTS		TYPE OF GREEN INFRASTRUCTURE USED				
City	Used for Direct CSO Control	Established Municipal Programs & Public Funding	Green Roofs	Rain Gardens/ Vegetated Swales & Landscape	Permeable Pavement	Downspout Disconnection/ Rainwater Collection	Wetlands/ Riparian Protection/ Urban Forests
Chicago	✔	✔	✔	✔	✔	✔	
Milwaukee	✔	✔	✔	✔			✔
Pittsburgh	✔		✔	✔		✔	✔
Portland	✔	✔	✔	✔		✔	
Rouge River Watershed			✔	✔	✔		✔
Seattle	✔	✔	✔	✔		✔	
Toronto		✔	✔			✔	✔
Vancouver		✔	✔	✔	✔		✔
Washington			✔	✔	✔		

- *"In urban areas, green infrastructure will be most cost-effective when it is incorporated as part of an overall redevelopment effort or when large improvements to infrastructure are required. In these instances, the costs of green infrastructure are minimized relative to the scope and costs of the overall project. While green infrastructure may be more costly than conventional stormwater or CSO controls in certain instances, the added costs should be weighed against the enhanced stormwater control and other environmental benefits gained from their use."*

- *"Some jurisdictions and cities have chosen green infrastructure as a preferable method of stormwater or CSO control based upon the specific needs and goals of the municipality. Others have installed green infrastructure to experiment with innovative stormwater or combined sewer*

overflow pilot projects. But all of these efforts demonstrate how it can be successfully integrated into urban communities."

- *"City leaders are finding that when faced with the simultaneous challenges of regulatory requirements, infrastructure limitations, and financial constraints, green infrastructure often emerges as an appropriate means of satisfying each."*

Banking on Green: A Look at How Green Infrastructure Can Save Municipalities Money and Provide Economic Benefits Community-wide (April, 2012)[104] - a collaborative report co-authored by the American Society of Landscape Architects (ASLA), American Rivers, ECONorthwest, and the Water Environment Federation.

- *"Green infrastructure alternatives have demonstrated a positive economic effect in a number of communities, particularly for those using these approaches to both reduce polluted stormwater and CSOs. Communities across the country are demonstrating that CSO control plans that incorporate green infrastructure elements as a way to achieve pollution reduction goals add cost-effective complements to grey infrastructure and provide additional value to the local community. The lesson learned so far by early adopter communities who have already implemented green infrastructure in a significant fashion is that a wide-ranging commitment to including green infrastructure stormwater approaches, on public as well as private properties, can result in long-term fiscal savings for local governments as well as provide numerous, tangible economic and community benefits through related ecosystem services."*

Green Infrastructure Practices Offer Cost-Effective Solutions

American Society of Landscape Architect's Green Infrastructure Survey

As part of its efforts to collect information about green infrastructure, EPA asked ASLA to collect case studies on projects that successfully and sustainably manage stormwater. ASLA members responded with 479 case studies from 43 states, the District of Columbia, and Canada. Not only do these projects showcase landscape architecture, they also demonstrate to policymakers the value of promoting green infrastructure policies. Green infrastructure and low-impact development (LID) approaches, which are less costly than traditional grey infrastructure projects, can save communities millions of dollars each year and improve the quality of our nation's water supply.

Project type:

Institutional/Education	21.5%
Open Space/Park	21.3%
Other	17.6%
Transportation Corridor/Streetscape	11.9%
Commercial	8.6%
Single Family Residential	5.5%
Government Complex	4.2%
Multifamily Residential	3.7%
Open Space Garden/Arboretum	2.9%
Mixed Use	1.8%
Industrial	1.1%

Green Infrastructure type:

Retrofit of existing property	50.7%
New development	30.7%
Redevelopment project	18.6%

Did use of green infrastructure increase costs?

Reduced costs	44.1%
Did not influence costs	31.4%
Increased costs	24.5%

Analysis

- Over 300 ASLA members and other practitioners responded with 479 case studies from 43 states, the District of Columbia, and Canada.
- 55 percent of the projects were designed to meet a local ordinance.
- 88 percent of local regulators were supportive of the green infrastructure projects submitted.
- 68 percent of the projects received local public funding.

Details about the study and its results are available here: www.asla.org/stormwater

Cost Comparison of Conventional Gray Combined Sewer Overflow Control Infrastructure versus a Green/Gray Combination (June, 2012)[105] - a study conducted by researchers at the University of Hartford, the Urban Watershed Management Branch of the USEPA, and Ports Engineering. The study compared the 50-year life-cycle costs of a proposed grey/conventional solution and a hybrid grey/green solution to a 120 million-gallon overflow in the Turkey Creek basin in Kansas City, MO. The hybrid solution involved using numerous rain gardens in areas of highest feasibility for their use.

- *"Replacing a portion of gray infrastructure with LID in attempts to manage stormwater in the Turkey Creek Basin could provide a present worth cost savings of up to $35 million over the life-cycle of the gray and green infrastructure, depending on the type of rain garden retrofits. The rain garden density analysis supports the notion that the required number of rain gardens could fit in the Turkey Creek CSO Basin."*

Reflections on Green Infrastructure Economics (December 2010)[106] - This paper summarizes key findings of the report submitted by the Illinois Environmental Protection Agency to the state general assembly and governor on June 30, 2010, in response to Section 15 of the Illinois Green Infrastructure for Clean Water Act of 2009, Public Act 96-26. This Act required IEPA to investigate, among other topics, the cost-benefit analysis of green versus grey solutions to stormwater.

The study examined, through life-cycle analyses, the direct current and projected savings (both in dollars and in the storm-water volume averted from a collection system) of green infrastructure, but deliberately did not examine the ecosystem-services benefits of green infrastructure from an economic perspective, since the study's authors did not want the inclusion of indirect methods of calculating cost savings to make the side-by-side comparison of green and grey infrastructure unnecessarily complex.

- *"Based on a review of 57 peer-reviewed journal articles (representing 173 sites), the Illinois green infrastructure study found that, although the practices showed wide variability in their effectiveness, properly designed and maintained green infrastructure is, on average, at least as effective as gray infrastructure in reducing storm-water runoff volume and peak flow in the sites examined by this literature."*

- *"...the study found that, if properly scaled, sited, and maintained, most green infrastructure practices can deliver equivalent hydrological management of precipitation at comparable or lower costs than conventional stormwater conveyance and treatment infrastructure under different development scenarios."*

- *"...most of the six green infrastructure practices evaluated in this model—disconnection of downspouts to rain gardens, replacement of the half the lawn area with native landscaping, the use of porous pavement used for on-site paving, green roofs, additional tree cover for 25% of the lot, and the use of vegetated swales rather than pipes for storm-water conveyance—are more cost-effective than gray infrastructure at all scales and time periods, with the possible exception of green roofs. Moreover, not only are these green practices initially more economical than conventional infrastructure in terms of their construction costs, but the practices are also able to divert millions of gallons of storm water from conventional storm-water conveyance systems over their useful lives, thus also avoiding the indirect costs of providing additional detention capacity and, in the case of combined sewer systems, dealing with potential sewage overflow problems."*

A Comparison of Runoff Quantity and Quality from Two Small Basins Undergoing Implementation of Conventional and Low-Impact-Development (LID) Strategies: Cross Plains, Wisconsin, Water Years 1999–2005 (2008)[107] - The U.S. Geological Survey, in cooperation with the Wisconsin Department of Natural Resources, studied two residential basins in Cross Plains, Wis., during water years 1999–2005. A paired-basin study design was used to compare runoff quantity and quality from the two basins, one of which was developed in a conventional way and the other was developed with LID. The LID basin consisted of grassed swales, reduced impervious area (32-foot street widths), street inlets draining to grass swales, a detention pond, and an infiltration basin. The two basins averaged around 165 acres in drainage area, and they were located geographically adjacent to one another to support a more direct comparison of results.

- *"Smaller, more frequent precipitation events that produced stormwater discharge from the conventional basin were retained in the LID basin. Only six events with precipitation depths less than or equal to 0.4 inch produced measurable discharge from the LID basin. Of these six events, five occurred during winter months when underlying soils are commonly frozen, and one was likely a result of saturated soil from a preceding storm. In the conventional basin, the number of discharge events, using the same threshold of precipitation depth, was 180, with nearly one-half of those resulting from precipitation depths less than 0.2 inch."*

- *"During the 2004–2005 study years, when the LID basin was near complete build-out, 95 percent of the annual precipitation was retained onsite. Much of the runoff reduction was attributed to a combination of low-impact practices such as lawns, grassed swales, a detention pond, and forested hillslopes."*

6.2. Sustainable Infrastructure Case Studies

6.2.1 New York City

In September 2010, New York City introduced a $1.5 billion plan to implement green infrastructure technologies across the City to help manage the stormwater runoff that overwhelms the City's water infrastructure and causes an estimated 1.25 billion gallons of untreated sewage to flow directly into the City's waterways every year. That is in addition to a $2.9 billion grey infrastructure plan. The City's Department of Environmental Protection predicts that this combination of green and grey infrastructure will cut stormwater runoff volumes by 3.8 billion gallons every year. This means that the combined sewer overflow events in the city will be reduced by as much as 40 percent by 2030. To get the same reductions using only grey stormwater management, the City would need to invest an additional $2.4 billion.[108]

6.2.2 Philadelphia

Prior to development of solutions for the City's sewer overflow problem, Philadelphia experienced a deluge, more than one-third of the City's businesses and one in four homes face sewage backups and overflows. The City conducted a "triple-bottom-line analysis" of the economic, environmental, and social benefits of installing green infrastructure. It concluded that a 50 percent green option would bring bigger benefits in all three categories when compared to a 30-foot diameter tunnel. The City expects to spend $1.6 billion on green stormwater infrastructure for the overflow control plan.[109] More specifically, the plan is to manage the first inch of runoff on one third of the impervious cover within the City's combined sewer drainage area and restore nearly 20 miles of urban stream corridor. The green aspects of this plan include tree trenches, street/sidewalk planters, bioswales, rain gardens, porous pavement, green roofs, living walls and infiltration beds on both public and private land.[110]

Other regulatory methods to Philadelphia's stormwater control program include:

- Some of the nation's strongest stormwater regulations that require developers to manage stormwater on-site. This reduces the collective costs for managing stormwater in Philadelphia.
- A "cost of service" stormwater charge which encourages land owners to use their properties in a sustainable manner—using pervious pavement in parking lots, carving out green space on the site, or planting trees, for example—or pay for the privilege of the City collecting rain water on their behalf.
- Encouraging developers and property owners to use green infrastructure approaches like green roofs to meet stormwater requirements. This guidance has made Philadelphia #2 in the nation's race to construct green roofs, behind Chicago.
- A first-in-the-nation urban in-lieu fee program to help developers identify sites for remediation as a trade-off for water takings or wetland losses due to construction activities. This encourages the re-development of industrialized riverfront properties by expediting an often arduous process with federal agencies for wetlands protection. In addition, an evaluative tool was developed to allow mitigation funds to be used to improve urban streams and wetlands in areas of the City often overlooked and underfunded for such activities.[111]

6.2.3. Portland

Portland has actively promoted education and funding for innovative stormwater management since the late 1990s, and it is now a leader in the utilization of various BMPs and researching/testing their success. Bioswales, green roofs, infiltration planters, and sustainable street design are just some of the City's preferred approaches. A cost-effectiveness analysis (using the marginal cost per gallon removed from the CSO system as a metric) demonstrated that downspout disconnections, curb extensions that include vegetated swales, and parking lot infiltration were among the most cost-effective options (including conventional) for meeting their CSO abatement goals.[112] The costs for these approaches ranged from $0.89 to $4.08 per gallon removed. As part of a dual approach to managing CSOs, the City has also spent $1.4 billion on conventional deep tunnel technology.[113]

Portland has also encouraged sustainable stormwater management through a series of policy initiatives. City code now requires on-site stormwater management for new development and redevelopment. New city-owned buildings are required to have a green roof that covers at least 70% of the roof area; the remaining roof area must be covered with Energy Star roofing material. The City offers a zoning bonus, allowing for additional square footage for buildings featuring a green roof, and in 2006 it will began offering a stormwater fee discount of up to 35% for properties with on-site stormwater management. These programs are built upon the successful participation in the downspout disconnection program, in which homeowners can receive $53 per downspout disconnected from the

combined sewer system. The City estimates that more than 45,000 households participate in the program, allowing infiltration of more than 1 billion gallons of stormwater annually.[114]

6.2.4 Detroit

The Rouge River Watershed covers approximately 450 square miles, including major portions of urbanized and industrialized Detroit. Constructed wetlands along the Rouge River were installed in the late 1990s to treat stormwater before it enters the river. A five-year monitoring study evaluated the effectiveness of the wetlands at improving the quality of the stormwater runoff. In addition to dampening stormwater flows, the wetlands reduced concentrations of total suspended solids by 80%, total phosphorus by 70%, BOD by 60%, and heavy metals by 60%. Another focal point of the watershed is the Ford Motor Company's 450,000 square-foot green roof, the largest in the world, which is designed to capture the first inch of rainfall.[115]

Detroit recently cancelled two major conventional infrastructure projects on the City's west side, including the construction of a 7.5-mile-long tunnel (total cost of terminated projects: about $1.3 billion), and replaced them with an $814 million plan ($764 million in gray, $50 million in green) to solve the same needs. And, since Detroit has an abundance of vacant land - as much as 30 percent of the City - green infrastructure allows for spot fix-ups and smaller scale pipe systems.[116]

6.2.5 Seattle

One of Seattle's most successful approaches to sustainable stormwater management is its on-street water detention and infiltration projects. An early example was a redesign of a 660-foot block on 2nd Street, which was narrowed from 25-feet to 14-feet to allow for swales and permeable paving applications. Hydrologic monitoring of the project indicates a 99% reduction in total potential surface runoff, and stormwater runoff has not been recorded at the site since December 2002. A modeling analysis indicates that if a conventional curb and gutter system had been installed along 2nd Avenue instead of the sustainable street design, 98 times more stormwater would have been discharged from the site.[117]

6.2.6. Milwaukee

In the 1980s and 1990s Milwaukee invested in a deep tunnel system to manage CSOs. The $2.3 billion Deep Tunnel System project, completed in 1994, provided 405 million gallons of underground sewer storage. Prior to the system becoming operational, Milwaukee averaged 50 to 60 CSO events a year, which discharged 8 to 9 billion gallons of sewage and stormwater. The Deep Tunnel System was designed to limit CSOs to 1.4 events per year; in the first 10 years of operation, from 1994 until 2003, annual average CSO discharges were 1.2 billion gallons from 2.5 average annual events. Heavy rains in the spring of 2004 resulted in 1 billion gallons of CSO discharges during a two-week period. Although the Deep Tunnel System has substantially reduced CSO events, excessive quantities of stormwater can still

trigger overflows, and the City has committed an additional $900 million to an overflow reduction plan.[118]

To complement this system, the Milwaukee Metropolitan Sewerage District is investing in green infrastructure projects to reduce stormwater inflow into the combined sewer system and mitigate stormwater runoff. Green roofs, rain gardens, residential and commercial downspout disconnection, and wetlands restoration are just a few of the ways the District has already implemented green infrastructure solutions.[119] City leaders are on board with enhancing the sustainable approach- as Milwaukee Mayor Tom Barrett quipped, "You can't have a picnic or tailgate party in a deep tunnel."[120]

6.2.7 Chicago

In 2019 Chicago hopes to complete a $3.4 billion deep tunnel project that broke ground in the 1970s. The system will have approximately 18 billion-gallon CSO storage capacity. As population and land development have increased in recent decades, the City has started to investigate and implement green infrastructure practices as well. Today the City is emerging as a leader in green development, with an extensive green roof program, environmentally sensitive demonstration projects, and municipal policies that encourage decentralized stormwater management.[121]

6.2.8. Kansas City

Kansas City's sewers release approximately 6.4 billion gallons of CSOs every year. Like numerous other cities, Kansas City is pursuing a combined grey/green approach to solving their sewer overflow problems. According to USEPA, by supplementing gray infrastructure investments with above-ground, green infrastructure approaches, the city aims to provide cleaner air, cooler ambient air temperatures, recreational and aesthetic amenities, and economic opportunities.[122]

In its 2009 Overflow Control Plan, Kansas City officials outlined a nearly $50 million green infrastructure component of the plan that will complement traditional overflow reduction approaches.[123] Elements of this Plan directed to promoting and enhancing the City's overall program of green solutions include:

- Dedicated funding for public education and outreach.
- An enhanced "10,000 Rain Gardens" and downspout disconnection program.
- Funding for job creation and work force development initiatives related to specific program objectives, including "green collar" jobs.
- Enhanced technical models, complemented by a "triple bottom line" evaluation framework, including specified social, economic, and environmental metrics.

- Substantial funding for green infrastructure pilot projects and partnerships in the CSS basins. Large scale pilot projects will be used to gather the information required to effectively implement green infrastructure on a broad scale while simultaneously constructing a portion of the basin-specific solution. Green infrastructure partnerships will focus on creating private sector participation in the pilot projects and proposed basin solutions.

6.2.9. Cleveland

The Northeast Ohio Regional Sewer District's (NEORSD) consent decree with the USEPA includes a minimum of $42 million of green infrastructure projects, aimed at capturing 44 million gallons of CSO volume after full implementation of the planned $3 billion grey solution.[124] NEORSD has been tapped by USEPA as one of 10 partners nationwide to help lead the way in developing green stormwater management solutions. It represents the EPA's Great Lakes Region. The recognition was partially due to the sewer district's idea of linking stormwater management with neighborhood revitalization. The USEPA's Bob Newport said "I think they realize there's a big payback in getting this double benefit of soaking in the stormwater and also providing an amenity for the community, helping stabilize some of these neighborhoods." The grey component of NEORSD's consent decree centers on spending nearly $3 billion to build seven massive underground tunnels to store storm water until it can be pumped back to the surface and treated. But federal officials are now saying that these grey projects may be swapped for green ones depending on the success of projects in Cleveland and other cities.[125]

6.2.10. St. Louis

As part of the Metropolitan St. Louis Sewer District's 23-year, $4.7 billion settlement with the USEPA in December of 2011, at least $100 million will be earmarked for green infrastructure projects.[126]

6.2.11 Washington D.C.

One-third of the nation's capital is served by combined sewers, and annual discharges total 2.5 billion gallons. The City's approved LTCP will cost approximately $1.9 billion and focuses primarily on a deep tunnel system and sewer separation, but also recognizes the importance of incorporating green infrastructure within the City, setting aside at least $6 million for sustainable projects. The City hopes to install 20 million square-feet of green roofs over the next 20 years, capturing stormwater volumes equal to 15% of the deep tunnel's capacity.[127]

6.2.12 Toronto

Toronto has 2,800 miles of storm sewers and over 2,600 outfalls. The City's approach to dealing with their overflow problem consists of a mix of green and grey solutions. Toronto's program involves a significant downspout disconnection effort to prevent runoff from entering both the stormwater and

combined sewer systems. The City will disconnect residences for free and provide splash guards or rain barrels to protect residential foundations. As of June 2000, Toronto estimated that approximately 20,000 homes had been disconnected. Downspout disconnection efforts have been targeted at areas that either experience localized flooding or have a significant runoff impact on Toronto's beaches. The City has also embarked on wetland and stream restoration programs to facilitate stormwater management that will achieve cleaner streams and enhanced wildlife habitat; $106 million has been committed for the capital costs to restore over 40 miles of streams. Toronto currently has over 100 green roofs, including an intensive installation on the Toronto City Hall. Even before green roof plants had reached maturity, monitoring showed that green roofs in the City were achieving nearly 60% flow reductions, and peak flow rates of 25% to 60% during summer and 10% to 30% in late fall of those measured from conventional roofs.[128]

6.2.13. Northern Kentucky- SD1

Sanitation District No. 1 covers 220 square miles in northern Kentucky and signed a consent decree in 2007 to address combined sewer overflows and sanitary sewer overflows. The first plan developed relied solely on grey infrastructure, but was seen as too costly. In response, SD1 developed an integrated watershed-based plan that provides cost savings of up to $800 million and reduced bacteria and nutrient pollution relative to the traditional grey-only plan initially developed. The current total consent decree costs are approximately $1.2 billion, and include $150 million in planned green infrastructure projects that will annually reduce CSO burden by 500 million gallons.[129]

6.2.14. Louisville

Louisville Metropolitan Sewer District is implementing an Integrated Overflow Abatement Plan that utilizes green infrastructure to right-size the proposed grey CSO controls. The District identified 19 potential locations for green infrastructure demonstration projects. These 19 demonstration projects represent an estimated $1.5 million in construction costs to remove approximately 12 MG of stormwater from the combined sewer system. The District is coordinating the locations for the demonstration projects with the schedule for the implementation of grey projects in an effort to maximize opportunities to reduce the need for gray controls. The budget of the Green Infrastructure Program was developed for a 15-year period. However, The District is specifically committed to implementing green programs at this level for the first six years. The District plans to commit approximately $6 million per year for the first six years, followed by an allocation of $1 million per year for nine additional years. These committed funds, plus the $1.5 million committed for the green demonstration projects, result in a comprehensive Green Infrastructure Program budget of $47 million.

6.2.15 Vancouver

Analysis conducted by the City of Vancouver indicates that retrofitting green infrastructure into locations with existing conventional stormwater controls will cost only marginally more than

rehabilitating the conventional system, but introducing green infrastructure into new development will cost less.[130]

6.2.16. Pittsburgh

The Allegheny County Sanitary Authority estimates that repairing a deterioration regional infrastructure system using traditional sewage infrastructure strategies will cost more than $3 billion. When the Sanitary Authority released its $3.6 billion plan to control CSOs in July of 2008, it did not include any green infrastructure solutions.[131] In response to this, the push for green infrastructure solutions to Pittsburgh's CSO problems has come primarily from citizen groups and private investment. One such project is Nine Mile Run, a collaborative effort between the U.S. Army Corp of Engineers, the City of Pittsburgh, and citizen groups such as the Nine Mile Run Watershed Association. The project focuses on the restoration of an existing daylighted stream that was culverted to accommodate development. Restoration efforts include re-creating the natural meandering path of the stream and additional construction of wetlands. There are also efforts in the watershed to infiltrate or capture stormwater before it reaches the stream.[132]

6.2.17. Stream Daylighting and Restoration Case Studies

The concept of "daylighting" streams is not a new idea in that projects have been active in the United States since the 1980s.[133] In the past decade daylighting activity has steadily increased across the United States, and is even more widespread in parts of Europe. Daylighting re-establishes a waterway in its old channel where feasible, or in a new channel threaded between the buildings, streets, parking lots, and playing fields now present on the land. Some daylighting projects recreate wetlands, ponds, or estuaries. More than 65 stream daylighting and restoration projects are presented in Appendix D with an additional 16 international projects noted in Appendix D. This information was compiled by the Hamilton County Planning and Development Department. It is important to note the Lick Run Valley Conveyance project differs from many of these projects because it combines daylighting with creating a new naturalized waterway to collect stormwater from hillsides. The relationship and interworking of the flows, base flows, and water quality enhancement are features in the VCS that take stream daylighting to the next level for addressing wet weather events.

7. OTHER ISSUES

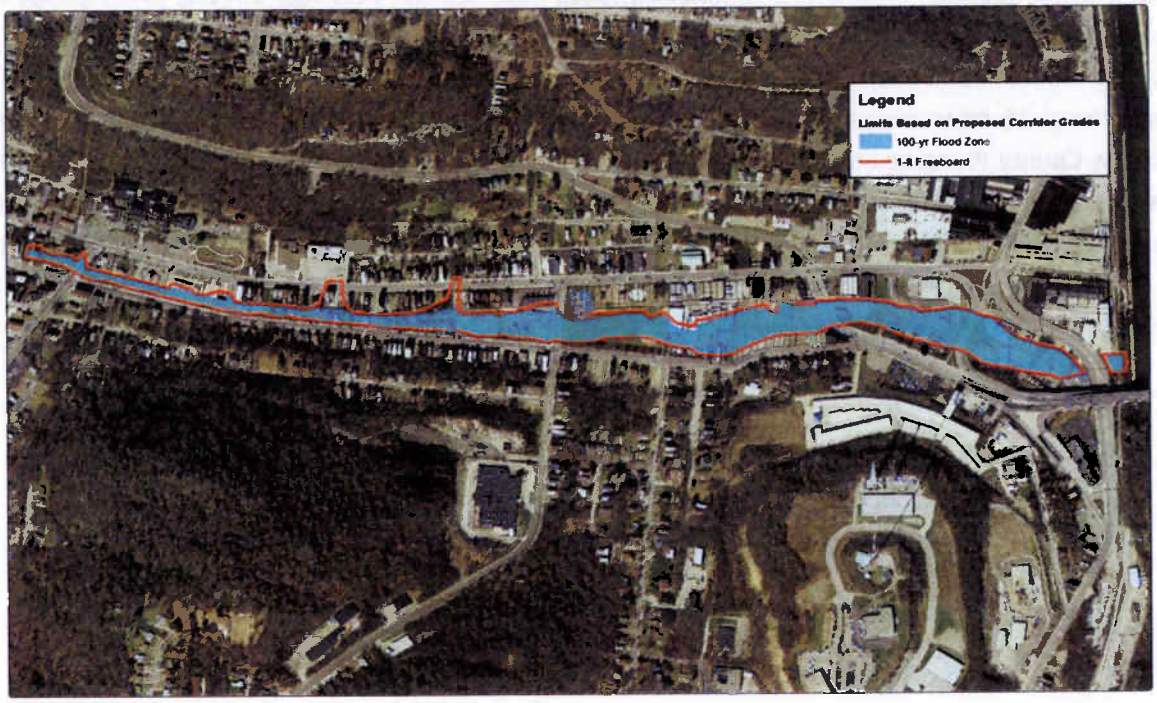
The County monitor report provided comments on page 17 related to additional issues:

- Flooding
- Improved Combined Sewer Level of Service
- Water Quality
- Future Potential Stormwater Quality Regulations

7.1 Flooding

In relation to the Sustainable Alternative, MSD is not establishing new flow routes but rather augmenting stormwater conveyance capacity along existing flow routes. The proposed strategic sewer separation projects are expected to provide a significant increase in the current level of service provided by the existing combined sewer system. By installing a new parallel stormwater conveyance system sized to convey up to 25 year stormwater flows from the Tier 1 areas, accounting for approximately two-thirds of the Lick Run watershed area, MSD is providing significant improvement to the overall stormwater and combined sewer drainage systems serving this community. The VCS is sized to convey up to a 100-year storm event peak flows tributary from the entire Lick Run watershed, with a minimum of 1-ft freeboard to adjacent roadway and bridge infrastructure[64], as well as developed areas remaining after the SI project construction.

Figure 8 - Lick Run VCS 100-year Flood Zone and Freeboard Area



7.1.1 Impact of Peak Flows

MSD does not model the Mill Creek or the Ohio River as part of the system-wide model. The drainage area of the Ohio River is so large that the water level in the river is generally independent of storms impacting MSD's service area. The lower Mill Creek water level is impacted by the water level in the Ohio River either through backwater or the operation of the Barrier Dam. The mouth of the West Fork Channel on the Mill Creek is monitored as having significant impacts (up to 9 feet of standing water) from the high Ohio River levels.

The tributaries located in the combined sewer area and that are independent of Mill Creek and the Ohio River are modeled within the system-wide model. Specific examples include the West Fork Channel, Kings Run, Ludlow Run, and the ponds and channels in Spring Grove Cemetery.

It is anticipated that impacts to Mill Creek associated with peak flows from the proposed SI projects would be relatively minor impacts in comparison to existing conditions. System-wide modeling efforts have indicated, a significant portion of the combined sewer system is inundated during storm events in excess of a 6-month return interval, and existing CSOs provide discharges to Mill Creek for storm events on a similarly frequent basis. In Lick Run specifically, the CSO volume discharged to Mill Creek in the Typical Year is estimated to be approximately 1,000 million gallons (system-wide model version 4.2). After implementation of the Lick Run SI projects, the CSO volume discharged to Mill Creek in the Typical Year is estimated to be approximately 263 million gallons, and the SI project volume discharged to Mill Creek in a typical year is estimated to be approximately 1,070 million gallons. There is a net difference of 333 million gallons. Accordingly, the volume differences between the wet weather flows tributary to Mill Creek pre- and post- SI project construction are anticipated to be relatively insignificant.

Modeling efforts to-date has shown that large portions of the existing combined sewer system are surcharged during storm events as frequent as a two-year event. The Lick Run system-wide model(s)[x] simulate all combined sewers that are 18-inches in diameter or larger, accounting for approximately 150,000 feet of the Lick Run Watershed's total 358,000 feet of CSS (41 percent). Because the Tier 2 areas are highly developed upland areas, with a significant portion of the smaller un-modeled combined sewers, nearly all the combined sewers in the Tier 1 areas are included in the system-wide models and can provide a direct correlation to the effectiveness of the parallel storm water conveyance system on the combined sewer system level of service.

A comparison was performed evaluating the combined sewer system surcharging pre-sewer separation in the Lick Run existing conditions SWM and against the combined sewer system surcharging post-sewer separation in the Lick Run ultimate conditions SWM. A summary of these results is presented in Table 16.

Table 16 - Critical Duration Storm Events[134]

Critical Duration Storm Events (Percent Modeled CSS Surcharged)					
	6 month	2 year	5 Year	10 Year	25 Year
Pre-Sewer Separation CSS Surcharging	8%	28%	36%	42%	46%
Post-Sewer Separation CSS Surcharging	5%	9%	14%	19%	21%
Percent Reduction in CSS Surcharging	**35%**	**67%**	**60%**	**55%**	**54%**

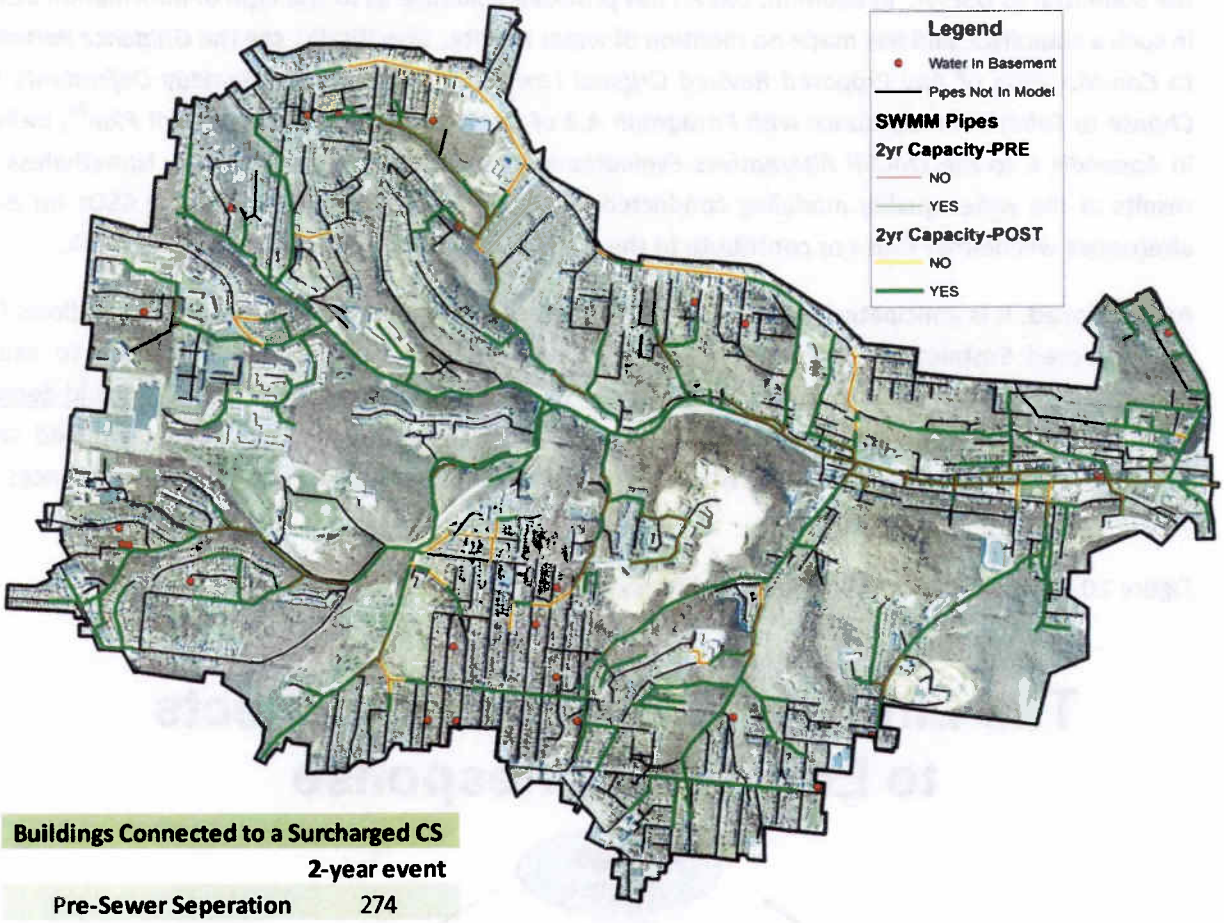
The indication from the results shown in Table 16 is that greater than a 50 percent increase in combined sewer system level of service can be expected in all modeled storm events greater than a six-month return interval. This further translates to an anticipated decrease of localized flooding, of greater than 50 percent during all storm events exceeding a six-month return interval.

The location of the VCS element in the Lick Run SI project is at the lowest point in the watershed, where all wet weather flows that are not able to get into the inundated combined sewer system currently travel overland. Theses flows have established routes to Mill Creek, or otherwise result in localized flooding. As mentioned previously, the VCS is sized to convey up to a 100-year storm event peak flows tributary from the entire Lick Run watershed, with a minimum of 1-ft freeboard to adjacent roadway and bridge infrastructure, as well as developed areas remaining after the SI project construction. As such, localized flooding and/or flow routes currently existing in this area will be controlled to a much higher level. Further, the 100-year capacity of the VCS will provide increased reliability in the performance of the tributary storm sewer connections up to their design limitations.

7.2 Level of Service

There is a potential for Water in Basement (WIB) to be reduced by 103 buildings (38%), with a 67% overall reduction in surcharged combined sewers during a 2-year return interval storm event. WIB potential reduction is due to buildings being connected via service lateral to a combined sewer that is no longer surcharged, as a result of the sewer separation project. Pipes 18-inches and larger are modeled in SWM. The vast majority of the WIB's occur in areas with collector sewers, as opposed to interceptors, that are not modeled. Therefore a greater amount of combined sewer surcharging and WIB's would be anticipated to be relieved than currently modeled. The increased level of service is shown in Figure 9. Similar results were determined for the 5-year and 10-year storm events.

Figure 9- Increased Level of Service for 2-Year Storm Event



Buildings Connected to a Surcharged CS	2-year event
Pre-Sewer Seperation	274
Post-Sewer Seperation	171
Difference	103
% Reduction	38%

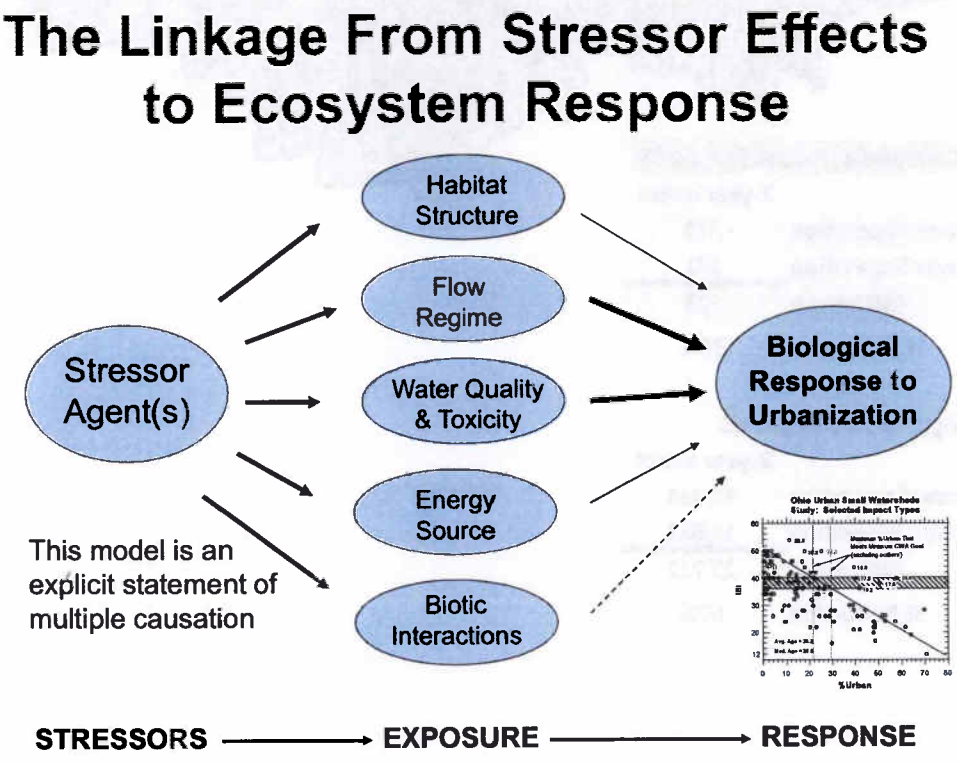
Length of Surcharged CS	2-year event
Pre-Sewer Seperation	41,334
Post-Sewer Seperation	13,622
Difference	27,712
% Reduction	67%

7.3 Water Quality

The WWIP is focused on volumetric control and no water quality criteria are required to be included in the submittal to USEPA. In addition, USEPA has provided guidance as to the type of information desired in such a submittal, and has made no mention of water quality. Specifically, see the *Guidance Pertaining to Consideration of Any Proposed Revised Original Lower Mill Creek Partial Remedy Defendants May Choose to Submit in Accordance with Paragraph A.2 of the Wet Weather Improvement Plan*[85], included in *Appendix C to the LMCPR Alternatives Evaluations Preliminary Findings Report*[69]. Nonetheless, the results of the water quality modeling conducted by MSD suggests that the remaining CSOs for either alternative will neither cause or contribute to the impairment of water quality in the Mill Creek.

As mentioned, it is anticipated that volumetric discharges to Mill Creek associated with peak flows from the proposed Sustainable Alternative would be relatively minor impacts in comparison to existing conditions. However, the pollutant loading discharges to Mill Creek from the SI projects would decrease significantly when compared to existing conditions given the differences between combined sewer overflow and stormwater characteristics. From a regulatory perspective, these differences are substantial.

Figure 10 – Linkage of Stressor Effects and Ecosystem Response



The attainment of designated uses as described in the Ohio WQS for aquatic life and recreation in urban streams can be problematic. As recognized by Chris Yoder and the Midwest Biodiversity Institute *(refer to Appendix* E), MSD has developed a remediation plan that would be effective, but still affordable for local ratepayers. Yoder affirms that MSD's sustainable infrastructure approach includes the consideration of alternatives to classic "grey" engineering alternatives and coupled with the knowledge being generated by the watershed assessment program it provides the opportunity to seek solutions that are more environmentally and cost-effective.

Yoder provides Figure 10 as an illustration of the role of flow as it is integrated with these other factors based on observations from the major urban areas of Ohio and adds that:

> *"Unfortunately, "grey" approaches to pollution abatement frequently ignore the importance of base flow and at times have encouraged practices that degrade the base flow regime in the interest of achieving the "zero discharge" of pollutants. This has already happened to some extent in Hamilton County via the issuance of NPDES permits that in effect "regionalize" sewage flows by diverting them away from headwater streams towards the largest rivers in the area. When such strategies "sweep up" and divert storm runoff from smaller streams, impairment of aquatic life results simply from the lack of sufficient water and habitat. Simply put the streams in the watershed become "flow starved". Shifting our thinking more towards the augmentation of low flows (even with treated effluent) would be a positive step for improving overall chemical, physical, and biological quality and in moving towards the ultimate goal of full use attainment."*

An issue with CSO and SSO flow reduction strategies that divert all flows can result in a worsening of the base flow problem particularly in smaller tributaries of impacted watersheds. Diverting combined sewage and stormwater flows to places of sequestration (e.g., to tunnels or oversized interceptor sewers) may appear to address the overall pollution problem by eliminating those discharges, but it can ignore the need to keep the non-sanitary flows distributed as naturally as is possible within a watershed. Criticisms of such holistic and innovative approaches to urban stormwater management as being esoteric or unconnected to the treatment of such flows reflects a lack of awareness about the complex mechanisms of aquatic life use impairments. An over-reliance on traditional "grey" infrastructure solutions can too easily become disconnected from the overall goals of water quality restoration efforts particularly when the underlying assumptions are focused on administrative measures or surrogate performance targets rather than on direct and more complete measures of designated use attainment (e.g., aquatic life). Innovative approaches that are "green" or a mix of "green" and "grey" can not only be more cost-effective compared to "grey" approaches alone, but are more likely to broadly address the actual designated use goals of water quality restoration (U.S. EPA 2007).[135] Recent studies are documenting that "green" infrastructure and the restoration of natural functions and features can also be important drivers of economic re-development in urban areas (Adelaja et al. 2012).[136]

Ohio offers an advanced setting in having tiered aquatic life designated uses in their WQS which provides an impetus to consider all of the factors that drive quality in rivers and streams. Neither does it hold all waters to a single uniform standard, but rather recognizes that restoration potentials can vary from biologically and physically limited waters to biological unique and diverse waters thus allowing restoration projects to take these differences in potential into account. The potential costs and benefits of properly restoring ecosystem services in urban areas can be complex and a sound scientific basis for guiding water quality management is imperative. Such an ecologically-focused approach allows a broader consideration of ecosystem services that are produced by watersheds including nutrient and waste assimilation, water conservation, recreational attributes, maintenance and protection of biodiversity, as well as more global and diffuse benefits such as carbon and nutrient control and climate change benefits.

7.4 Future Stormwater Quality Regulations

This issue was already resolved in a call between counsel for the County and MSD on February 22, 2012. The notice of EPA's intent[137] to propose new stormwater regulations does not alter this understanding.

It is possible that additional regulations will be imposed on storm water discharges in the future, but their likelihood, requirements, and impact on the Sustainable Alternative are difficult to predict. By contrast, it is inevitable that additional regulations will be imposed on wastewater discharge, and would doubtless affect the operational costs associated with the treatment of combined wastewater detained by the Grey Alternative. The extent and impact of any of these future regulations is likewise impossible to determine with any certainty as they are inherently speculative at this point in time. Given that both options for CSO control could experience future regulatory burdens, their relative cost differences would likely remain similar if these could in fact are accounted for. Therefore, establishing a stormwater connection to Mill Creek as part of the SI project does not result in any more cost uncertainty than it would for the grey alternative. Unfortunately the future costs of future regulatory requirements can't be accounted for under the sustainable or grey alternatives as they are inherently speculative, and the extent to which this level of speculation should be a factor in decision making is likewise quite subjective in nature.

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    - Relocation Planning and Advisory Services
    - Required Relocation Notices
    - Moving Payments - Residential
    - Moving Payments - Non-Residential
    - Replacement Housing Payments
    - Relocation Assistance Non-Residential Brochure - 10/20/2010
    - When ODOT Needs Your Property Brochure - 10/14/2010

- Residential Relocation Assistance Program Brochure - 10/21/2010
- Tenant Owned-Owner Retention Brochure 2012 - 4/23/2012

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    - Uniform Relocation and Real Property Acquisition for Federal and Federally-Assisted Programs; Fixed Payment for Moving Expenses; Residential Moves - 05/16/2005
    - General Relocation Requirements (Federal-Aid Policy Guide, NS 49 CFR 24C) - 02/16/2006
    - Payments for Moving and Related Expenses (Federal-Aid Policy Guide, NS 49 CFR 24D) -02/16/2006
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    - Uniform Relocation Assistance and Real Property Acquisition for Federal and Federally Assisted Programs (Federal-Aid Policy Guide, NS 49 CFR 24A) - 02/23/2007
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    - Acquiring Real Property for Federal and Federal-aid Programs and Projects - 02/07/2006
    - National Business Relocation Study - 11/22/2008
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APPENDIX A

MALCOLM PIRNIE

Metropolitan Sewer District of Greater Cincinnati
West Fork Branch Renaturalization Project
Project Management Plan () - Project Information
Project No.

Prepared By: Chris Weber
Last Updated: 5/11/2011

Red >= 35 ***Yellow*** ***Green <= 10***

Risk #	Threat / Opportunity	WBS #	Risk Event	Description of Impact	Risk Analysis (L/M/H Scale)			Risk Analysis (Numeric)			Type of Response	Risk Response Action and Status	Owner
					Probability (P)	Impact (I)	Risk Level	Probability (P)	Impact (I)	Risk Level (PxI)			
1	**Threat**		Coordination with multiple MSD Divisions leads to delays in decision making.	Delays in decision making lead to schedule delays.	Very High	High	Red	9	7	63	Mitigate	Prepare a detailed communication plan and schedule meetings to involve other department participants. Assign an accountable person or group to make decisions in the absence of consensus. Define to MSD the critical decisions and when they need to be made. Using flow diagram, remind, remind, remind. Identify bottlenecks.	MSD PM Team
2	**Threat**		Public does not support the removal of soccer fields.	Public negative input may disrupt project implementation, schedule, or design.	High	High	Red	7	7	49	Mitigate	Work with recreation commission to locate new soccer fields in close proximity. Explore integrated fields into project site. Keep impacted parties informed. Develop proactive community outreach plan.	MSD PM Team
3	**Threat**		Damaging wet weather event happens during construction.	Completed construction (or surrounding area) is damaged, causing rework, higher costs and longer construction time.	High	High	Red	7	7	49	Mitigate	Schedule construction during summer months. Require phased approach to demolition / construction and daily stabilization of disturbed areas. Provide detailed information on historical rainfall records and regulatory flood elevations in bidding documents.	Design Team
4	**Threat**		Contractor with limited stream restoration experience is awarded the construction contract.	Lack of experience with stream restoration leads to problems during construction (quality of work, schedule, costs) and long-term performance issues.	Low	Very High	Yellow	3	9	27	Mitigate	Incorporate detailed contractor qualifications requirements in project specifications. Ensure that adequate construction administration / oversight is provided. Explore prequalification.	MSD Contracts, MSD PM Team
5	**Threat**		Specialized construction materials (i.e., large rock) unavailable.	Project cannot be completed per the final construction plans.	Low	Medium	Yellow	3	5	15	Mitigate	As construction drawings are prepared, investigate potential sources of any unique construction materials to ensure availability. Explore owner prepurchase if needed for schedule.	Design Team
6	**Threat**		After construction is completed, littering & dumping continues in upstream & surrounding area.	Litter and trash found at the completed project site could impact the public recreational benefit of the project.	High	Medium	Red	7	5	35	Share	Coordinate with Cincinnati Parks Department, Cincinnati Police Department, and other stakeholders to monitor littering / dumping problem and develop outreach and contingency plans. Have a detailed O&M plan.	**MSD**/Local Community/ Parks/ MCRP/ CRC/ SMU

Risk #	Threat / Opportunity	WBS #	Risk Event	Description of Impact	Risk Analysis (L/M/H Scale)			Risk Analysis (Numeric)			Type of Response	Risk Response Action and Status	Owner
					Probability (P)	Impact (I)	Risk Level	Probability (P)	Impact (I)	Risk Level (PxI)			
13	Threat		FEMA buyout grant program and properties not included in grant, are not completed per plan.	Inability to complete buyout program negatively impacts design or schedule of the stream restoration project. Could also create public relations issues for stream restoration project that	Medium	Very High	Red	5	9	45	Mitigate	Continue coordinating with FEMA and buy-out property owners and identify program implementation issues during early stages of WF Sustainable project. Add coordination meetings with OEMA grant project team.	MSD PM Team
14	Threat		Due to configuration of sewer system, interceptor cannot be relocated away from channel centerline.	Conflict with interceptor/tanks negatively impacts stream restoration design and overall benefit of restoration project.	Medium	High	Red	5	7	35	Mitigate	Identify interceptor alignment issues during alternatives analysis. Develop restoration project plans to minimize conflicts.	Design Team
15	Threat		Removal of concrete channel and relocation of interceptor exposes underlying soil / rock to erosion risk from streamflow.	Negative impacts associated with unstable stream channel; ecological, flood protection, damage to existing infrastructure, reduced public recreation benefits.	Medium	High	Red	5	7	35	Mitigate	Perform appropriate geotechnical investigations to support alternatives analysis and 30% design plan preparation.	Design Team
16	Threat		Site constraints (topography, residential structures, interstate highway) at upstream end of restoration reach hinder ability to restore or relocate stream channel.	Increased cost of stream restoration in constrained reaches reduces cost-benefit of overall project.	Very High	Medium	Red	9	5	45	Mitigate	Alternatives analysis will be completed with recognition of relative cost / difficult of restoring different portions of the stream channel. Where cost / difficulty is greatest, explore alternative approaches to ecological restoration that do not involve full removal of concrete channel.	Design Team
17	Threat		Significant flood event occurs after construction is completed.	Stream restoration improvements are damaged.	Medium	Medium	Yellow	5	5	25	Mitigate	Stream improvement designs are based on conservative assumptions and sized accordingly. Include maintenance contract in bid. Include armoring up front.	Design Team
18	Opportunity		Alternative funding received.	Positive budget impact.	Low	Medium	Yellow	3	5	15	Enhance	Review potential grant funding sources and investigate possibility of establishing a completed West Fork project as an approved mitigation bank.	Design Team
19	Threat		Difficulty in acquiring several properties and/or easements.	Delays design/construction schedule.	High	High	Red	7	7	49	Mitigate	Develop preliminary easement plats durign 30% design; pro-actively manage FEMA buyout project and purchase of other required properties.	Design Team and MSD PM Team
20	Opportunity		Economy stays as is.	A lot of competition/ good prices.	Medium	Medium	Yellow	5	5	25	Accept		MSD Contracts
21	Threat		Economy rebounds/ skyrockets.	Little competition/ High bids.	Medium	Medium	Yellow	5	5	25	Accept		MSD Contracts

MALCOLM PIRNIE

Metropolitan Sewer District of Greater Cincinnati
West Fork Branch Renaturalization Project
Project Management Plan () - Project Information
Project No.

Prepared By: Chris Weber
Last Updated: 5/11/2011

Red >= 35 Yellow Green <= 10

Risk #	Threat / Opportunity	WBS #	Risk Event	Description of Impact	Risk Analysis (L/M/H Scale)			Risk Analysis (Numeric)			Type of Response	Risk Response Action and Status	Owner
					Probability (P)	Impact (I)	Risk Level	Probability (P)	Impact (I)	Risk Level (PxI)			
22	**Threat**		Poor integration with other planning/design activities (AM/ WWIP/ WWIP P2).	Rework required, duplication of efforts.	Medium	Medium	Yellow	5	5	25	Mitigate	Follow Risk Response Action plan as described under Threat 1 (Coordination with multiple MSD Divisions)	MSD PM Team
23	**Threat**		Built per plan, not utilized.	Doesn't meet basic project goal, influences future projects.	Medium	High	Red	5	7	35	Mitigate	Actively engage with the local community during all stages of the West Fork project (concept plan development, design, and construction).	Design Team and MSD PM Team
24	**Threat**		Details not mature enough to provide detailed Level 4 Cost Opinion to integrate into 3/2012 plan.	Project unable to be integrated into LMCPR P2 study, opportunity missed.	Low	High	Yellow	3	7	21	Mitigate	Maintain focus on level of detail necessary to support Level 4 Cost Estimates during concept plan development and Alternatives Analysis Report preparation.	Design Team
25	**Threat**		Flow not fully quantified for remaining volume of CSOs	LOS goals not met. Redo, retrofit, redesign. LOS higher than required = costs greater.	Low	High	Yellow	3	7	21	Mitigate	Ensure accuracy of modeling results by coordinating with MSD modeling group and incorporating data from all relevant on-going and completed WF plans / projects.	Design Team
26	**Threat**		Downstream entry points (outside of immediate area) not considered in initial SWEP.	Implementation of future plans and projects in downstream areas of West Fork watershed are negatively impacted (cost, schedule, etc.) by lack of consideration in current project.	Medium	High	Red	5	7	35	Mitigate	Conduct all project tasks with a recognition of potential, future phases of WF channel improvements.	Design Team
27	**Threat**		Traffic, noise, dust, and other public nuisance impacts for local residents.	Lack of public support of completed WF project, resistance to development of similar projects in other locations.	Medium	Medium	Yellow	5	5	25	Mitigate	Actively engage with the local community during all stages of the West Fork project (concept plan development, design, and construction) and incorporate appropriate requirements in bid documents to minimize construction impacts.	Design Team
28	**Threat**		OEPA not adequately included in project.	Lack of coordination with OEPA projects leads to permitting difficulties that could impact schedule of construction.	Low	High	Yellow	3	7	21	Mitigate	Actively engage with OEPA during planning and design of West Fork project through the appropriate MSD / OEPA lines of communication.	Design Team and MSD PM Team
29	**Threat**		ODOT not adequately included in project.	Lack of coordination with ODOT projects leads to MSD / ODOT conflicts during design, construction, or operation of the WF project.	Low	High	Yellow	3	7	21	Mitigate	Actively engage with ODOT during planning and design of West Fork project through the appropriate MSD / ODOT lines of communication.	Design Team and MSD PM Team (Dave Russell)

PROJECT RISK REGISTER

PROJECT NAME: BLOODY RUN WATERSHED - STRATEGIC SEPARATION PROJECT
PROJECT NO: 10180900
DOCUMENT CONTROL NO: 11240020
UPDATED BY: ROSS HORVATH
LAST UPDATED: JULY 26, 2011

IDENTIFICATION					ASSESSMENT					RESPONSE			REPORTING		
ID	RISK	CAUSE OF RISK	CATEGORY	SUB-CATEGORY	CONSEQUENCES	CONSEQUENCE RATING	LIKELIHOOD OF OCCURRENCE RATING	RISK SCORE	RISK CLASS	RISK RESPONSE PLAN	Assigned To (Risk Responder)	Due Date	Resolved On	Status	ACTIONS TAKEN
M.BR.1	PAT 39C - Preferred alignment may change if ROW/easements can not be obtained	Owner is seeking unreasonable reimbursement	Management	Easement Acquisition	Alignment change may increasae cost and possibliy stop project, resulting in delays and possible penalties under CD	10	7	70	Very High	Identify existing ROW / easements via CAGIS, supplemented by records review as needed. Identify owners of properties where possible sewer alignments / facility sites may be needed. Work with MSDGC property acquisition staff to assess risk / likelihood of not receiving easement for a reasonable cost, and take into account during business case evaluation	R. Horvath	~~9/9/2011~~ Continues into 30% design	TBD	Active	BCE defined a preferred alignment. This alignment largely follows public ROW and includes only one of the six recommended detention basins, reducing property/easement acquisition requirements; however, approximately 60 easements will be required along the proposed sewer alignment. MSDGC has begun actions to acquire TechSolve detention basin site. Recommend that availability and acquisition requirements of remaining ROW/easements be confirmed early during 30 percent design.
M.BR.2	PAT 38C - Consensus has not been reached for stormwater design criteria (quantity / quality)	- State / Federal stormwater requirements are in development - Local responsibilities not yet defined	Technical	Conveyance	Ambiguity in design criteria might result in either a less than cost-effective project and/or the need to retrofit the project with additional stormwater controls at a later time.	10	7	70	Very High	Write memo on current local and emerging state / federal storm water design criteria, including criteria in use by other communities using a "green" approach to CSO control. Review memo with MSD staff and prepare "short list" of most likely criteria. Evaluate differences in facility costs / feasibility under various criteria, and evaluate potential future retrofitting opportunities if criteria change. Consider criteria under BCE performed on preferred alternatives and select criterion (or range of criteria) to consider for subsequent design activities.	J. Aldrich	~~9/23/2011~~ Continues into 30% design	TBD	Active	CDM provided briefing on emerging state/federal storm water dulsgn criteria during BCE. Incorporated stormwater quality control features into TechSolve Basin and street restoration (where feasible). BCE also identifies numerous opportunities for additional storm water quality control and strategies for pursuing these opportunities.
M.BR.3	PAT 37C - Timely approvals are not possible for street / rail / highway openings / crossings	Unable to fully establish alignment / cost of the optimized alternative	Management	Easement Acquisition	Components of the optimized alternative may not be able to be constructed within the approved budget / schedule.	10	7	70	Very High	Work with MSDGC Property Acquisition staff to contact local communities, ODOT, and relevant railroads about requirements (written and unwritten) for openings / crossings along preferred alternative alignment. Establish consequence / likelihood of risk of not obtaining timely, acceptable approvals and incorporate into BCE of alternative alignments.	R. Horvath	~~9/9/2011~~ Continues into 30% design	TBD	Active	BCE defined a preferred alignment. This alignment minimizes railroad crossings and identifies options for I-75 crossing. Preferred alignment / method / timing of I-75 crossing is unresolved, but discussions initiated. Recommend method / easement requirements of all rail / I-75 crossings early during 30 percent design.
M.BR.4	PAT 54C - BCE can not be established for the optimized facility	Inadequate data, conservative assumptions, outstanding stakeholder concerns, and/or insufficient time do not allow development of a favorable BCE by project deadline	Fiscal	Economic	A preferred, optimized alternative for Bloody Run is not defined in sufficient time to address CD deadlines, jeopordizing entire "strategic separation" alternative for LMCPRP	10	7	70	Very High	- Perform model sensitivity runs over a range of possible solutions (facility sites, alignments, design criteria, cost factors) - Identify changes in cost, effectiveness over feasible range of design changes - Focus attention on those components / criteria causing most sensitivity in feasibility	M. Wagle	September 23, 2011	December 31, 2011	Closed	Risk response plan completed during execution of BCE and a preferred alterntive meeting MSDGC objectives was developed.
M.BR.5	PAT 40D - Collection system ownership and maintenance responsibilities are not fully defined	BCE relies upon definition of life cycle costs and "triple bottom line" benefits	Technical	Commissioning, Operation & Maintenance	Feasibility of optimized alternative can not be established, potentially increasing project costs to address evolving ownership / maintenance requirements	7	7	49	High	- Early stakeholder meeting(s) to define concerns, requirements. - Provide stakeholders with findings of sensitivity evaluations showing cost / feasibility implications of alternative criteria - MSDGC determines ultimate ownership / maintenance responsibilities and requirements - Optimized alternative defined to address these requirements	OOD EPM	~~8/1/2011~~ Continues into 30% design	TBD	Active	MSDGC has initiated systemwide coordinaton on this risk. Bloody Run-specific coordination will begin at Open House scheduled for Feb 9, 2012. Anticipate that ownership / maintenance responsibilities discussions will continue into 30% design.
M.BR.6	PAT 41D - Streetscape ownership and maintenance responsibilities are not fully defined	BCE relies upon definition of life cycle costs and "triple bottom line" benefits	Technical	Commissioning, Operation & Maintenance	Feasibility of optimized alternative can not be established, potentially increasing project costs to address evolving ownership / maintenance requirements	7	7	49	High	- Early stakeholder meeting(s) to define concerns, requirements. - Provide stakeholders with findings of sensitivity evaluations showing cost / feasibility implications of alternative criteria - MSDGC determines ultimate ownership / maintenance responsibilities and requirements - Optimized alternative defined to address these requirements	OOD EPM	~~8/15/2011~~ Continues into 30% design	TBD	Active	MSDGC has initiated systemwide coordinaton on this risk. Bloody Run-specific coordination will begin at Open House scheduled for Feb 9, 2012. Anticipate that ownership / maintenance responsibilities discussions will continue into 30% design.
M.BR.7	PAT 73C, 74C, 15B - Stakeholder consensus on optimized alternative not reached	Clear, effective, timely communication with key stakeholders is not established	Management	Public Communications	Uncertainty in stakeholder requirements causes uncertainty in cost, feasiblity of optimzed alternative	7	7	49	High	- Develop communication plan for multiple stakeholder audience - Implement plan via timely meetings, correspondence with key stakeholders - Provide findings of sensitivity evaluations as needed to facilitate stakeholder buy-in	OOD EPM	~~July 1, 2011 (plan)~~ ~~August 15, 2011 (correspondence on possible outcomes)~~ Continues into 30% design	TBD	Active	MSDGC has initiated systemwide coordinaton on this risk. Bloody Run-specific coordination will begin at Open House scheduled for Feb 9, 2012. Anticipate that pursuit of stakeholder buy-in will continue into 30% design.
M.BR.8	PAT 4C - Late delivery of project milestones	Failure to monitor schedule, assure timely data delivery, change approach to accommodate available resources	Management	Schedule	BCE defining feasible alternative not delivered by September 30, 2011, causing slippage of entire CD schedule for LMCPRP	10	4	40	High	- Weekly project team meetings and PM conference calls - Weekly updates to cost-loaded project schedule - Weekly updates to risk register and response plan	R. Horvath	Every Tuesday	December 31, 2011	Closed	Risk response plan completed during execution of BCE and a preferred alterntive meeting MSDGC objectives was developed.
M.BR.9	PAT 59B - Capture areas / volumes not confirmed in timely manner	Data delays, inadequate existing data, assumptions with high uncertainty, resource conflicts	Technical	Sewer Separation	Failure to confirm to a reasonable level of certainty that 400 MG/year of CSO reduction is feasible in the Bloody Run basin	10	4	40	High	- Obtain latest CAGIS, RDII, separate storm sewer, and other supporting data in a timely fashion - Delineate possible capture areas, describe separation / diversion requirements, and describe potential constraints / uncertainties - Rank capture areas by likelihood of success and amount captured -- focus attention on best / most lucrative opportunities - Define "high" and "low" probability capture volumes and use model to assess probability of removing 400 MG/yr	J. Aldrich	~~8/8/2011~~ Continues into 30% design	TBD	Active	Risk response plan completed and feasibility of strategic separation confirmed using conservative asumptions of capture area / volume. BCE recommends that additional flow monitoring and neighborhood SSES ~~assessments~~ be included in 30% design to narrow the range of capture area / volume projections.
M.BR.10	PAT 61B - Project does not receive adequate community support	Ineffective engagement, resolution of critical community issues	Management	Public Communications	Optimal alternative can not be implemented due to community opposition and/or opportunities for community enhancements are unknown and unrealized	10	4	40	High	Conduct initial community meeting to receive feedback on potential alternatives and incorporate feedback into BCE	OOD EPM	~~9/15/2011~~ Continues into 30% design	TBD	Active	MSDGC has initiated systemwide coordinaton on this risk. Bloody Run-specific coordination will begin at Open House scheduled for Feb 9, 2012. Anticipate that pursuit of community support will continue into 30% design.

Risk Register Finalized:7/26/11

Project as Risk Treatment: The Lick Run Communities of the Future approach is a treatment stategy for MSD Enterprise Leading Risk 4 - Sustainable Corporate investment portfolio. This project examines (and potentially builds) sustainable alternatives to the WWIP default project (deep tunnel). This project, as envisioned, also is a treatment for LR 5 (Customer base) and LR 7 (Adapting and responding to general economy) since it will help spur economic development in the corridor.

1. RISK IDENTIFICATION		2. RISK ASSESSMENT INFORMATION				3. RISK TREATMENT				4. RISK STRATEGY				
Risk Number	Risk Description / Risk Event Statement	Risk Status Open / Closed / Moved to Issue	Risk Rank	Enterprise Risk	Impact Description	Reduce/ Prevent	Accept	Transfer	Avoid	Completed Actions	Current & Planned Future Actions	Cost of Implementation	Timeline N/M/F	Status of Response N / P / PE / EE
Provide unique identifier for risk	*A risk event statement states (i) what might happen in the future and (ii) its possible impact on the project. "Weather" is not a risk event statement. "Bad weather may delay the project" is a risk event statement. (WHAT)*	*State if the risk is open (still might happen and still has to be managed), closed (has passed or has been successfully mitigated), moved to issue (risk has happened)*	*Enter here H (High), M (Medium), or L (Low) according to impact definitions (Consequence/ Likelihood)*	*Enter here the description and number of the associated risk from the MSD Enterprise Leading Risk Register (LR#)*	*List the specific impact the risk could have on the project; schedule, budget, scope, and quality. Other impacts can also be listed. (WHY)*					*List, by date, all actions taken to respond to the risk. This does not include assessing the risk*	*List, by date, what will be done in the future to respond to the risk*	*Enter here the estimated costs of implementing the risk strategy action*	*Enter here N (Near-term), M (Medium-term), or F (Far-term) according to timeline definitions*	*Enter here N (No Plan); P (Plan but not enacted); PE (Plan enacted but effectiveness not yet known); EE (Plan enacted and effective)*
R 1	**Land Acquisition.** Property acquisition challenges (relocation, loss of businss, funding constraints) may incur additional costs and delays.	Open	MH		Property acquisition is the complex challenge that can affect schedule and budget. The inabilty to have contracts on a large percentage of the properties prior to public and community engagement could jeopardize the project. A general corridor for the open channel was identified in the hydraulic and hydrologic investigation and generally the area between Queen City and Westwood is the target area. As properties are acquired and assembled, the open channel design can be developed and proceed with community engagement.	X				A prioritization of properties within the corridor has been completed. Priority one are properties located with the target area and listed "for sale", in foreclosure/bankruptcy, or those that have expressed an interest in selling to MSD; these are considered Phase 1 acquisition properties - these total 29 project parcels.	MSD has begun a phased land acquisition strategy to acquire property within the Lick Run corridor from Queen City Bypass and Westwood with willing seller agreements. Once Phase 1 properties are under contract, MSD will develop subsequent phases to move forward on.	$0	M	P
										Preliminary acquisition notices have been sent to Phase 1 properties. Because this project has a high liklihood of receiving federal funds, Uniform Relocation Act will be followed in the acquisition of properties and therefore, the preliminary acquisition notice includes standard language that indicates there is a potential for appropriation.				
										To properly identify potential relocation costs, a relocation contract has been executed; MSD is working with Phase 1 property owners to determine potential relocation or reestablishment costs as well as to document the vacancy and reduce tenants from being migrating into "abandoned" properties.				
R 2	**Storm Water Volume.** Cooridor does not accomodate storm water volume due to design storm being exceeded, flow model projections are incorrect or other hydraulic issues such as backwater caused by elevated stage levels at Mill Creek or Ohio River.	Open	HL		If the South Fairmount Corridor cannot accommodate the volume of water that is projected to flow through the open channel, localized flooding will occur which could theaten real property and human life.	X				Preliminary Engineering Analysis included HEC HMS/HEC RAS modeling for storm sewer area and channel evaluations. Modeled projections and scenarios are used as design criteria to protect the anticipated future condition for the 100 year floodplain.	FEMA Studies/Floodplain elevations will be conducted as design proceeds. The acquisition plan requires the procurement of all parcels within the target area for construction of potential solution, including contouring and development of a proper floodplain to accomodate the 100 year storm. Availability of assembled property will be used in design.	$3M	M	P
										The channel and conveyance system within the corridor are sized to account for the entire watershed draining through the target area; this is conservative design criteria and provides some additional protection to reduce liklihood of localized flooding.	Detailed channel designs to be completed.		M	P
R 3	**Unknowns.** Project corridor has historical, archelogical, environmental, geotechnical and buried utility unknowns that will be uncovered during construction leading to delays and cost overruns	Open	HL		The area was first settled in the late 1800s and was a mixed use community with several commercial and some industrial uses. Because of the valley configuration, the geology of the area does have significant amounts of rock and hillside issues to address in the design and construction. Because of the proximity to the Mill Creek and other important social, cultural and historical factors, as well as the liklihood of potential onsite disposal from the commerical and industrial operations, there is a possibility for this project to have several unknown characteristics. The exact location and condition of the existing utilities is somewhat uncertain. To address these potential issues, the relocation, protection and/or replacement of underground utilities may be required to fully implement the project plan.	X				An areawide Phase 1 environmental site assessment (ESA) under the USEPA Targeted Brownfield Assessment Program has been completed for the corridor and identified 4 primary areas of concern within the project corridor.	The areawide Phase 1 ESA includes the completion of 4 sampling and analysis plan for the 4 focus areas; this plans are under development. Phase 2 ESAs of the focus areas will be initiated thereafter.	$750,000	N	P
										No project parcels within the target area are listed on the National Historic Registry.	A historical and archaeological consultant will conduct a survey of the project corridor. SHPO will be contacted if sites are discovered.	$100,000	N	P
										Utility Review, Topographic Review, Geotechnical Review, Intersection Traffic Movement Assessment & subsequent traffic Alternatives Development and Refinement Report, Geotechnical Exploration Report have been completed to identify unknowns.		$250,000		
										Regarding conditions assessment, existing PACP information has been reviewed, where available; in most areas pipes greater than 30" had recent inspections conducted.	Add necessary asset management needs to CIP. Continuation of review of PACP data as more investigation is conducted. Take precautionary measures during design and construction.	$0	M	P
										Inventory of underground locate openings (ULOs) that will be necessary to locate to complete design; there are over 100 of these that will require location between the 30-90% design.	Locate ULOs	$400,000	M	P
											An ecological investigation will determine whether a field survey will need to be completed to identify threatened and endangered species.	$100,000	N	P
R 4	**Agency Alignment.** Inability to get alignment/consensus between all agencies and organizations around a community of the future solution leads to suspension/cancelation of project	Open	MM	LR1 - Maintaining Public Trust	As the driver of the comprehensive, watershed-based wet weather solution, MSD will be dependant upon other agencies and organizations to support this approach and strategy. MSD has limited or no control these agencies. The inability to get alignment and buy-in around this aiternative project is a risk. This project is not a typical sewer project and it will require MSD to develop new partnerhips.	X				MSD has developed an Inform & Influence approach to gain agency support around the Community of the Future Initiative As part of the inform & influence strategy, an Advisory Committee of 40 key thought leaders and influential sponsors has convened. There have been two full Community of the Future Advisory Committee (CFAC) meetings. The Advisory Committee is meeting bi-monthly and breaks out into 3 smaller subcommittees of: Community & Economic Development, Inform & Influence, and Policy. Subcommittees have developed Team Charters and teams are meeting to make recommendations and provide guidance to MSD.	CFAC will continue meeting bi-monthly or as needed with the subcommittees helping to provide guidance to MSD.	$50,000	N	PE
										Shared Need/Vision videos were created to inform and influence key thought leaders and potential partners for framing the project need & vision.	Development and refinement of Communication Strategy & Plan.	$100,000	N	PE
										Draft Community Opportunities Plan is developed that identifies potential linkages and opportunities for community revitalization around the comprehensive wet weather approach.	Master Plan for Community Redevelopment will be refined from the Draft Community Opportunities Plan, linking the project to the HUD DOT EPA Sustainable Communities Program.	$350,000	M	P
R 5	**Community Support.** Public resistant to the project for a variety of reasons, including lack of public trust and support to community development benefits by sewer projects due to the lack of prior examples	Open	MM	LR1 - Maintaining Public Trust & LR 6 - Material Lawsuits	South Fairmount community has experienced continued economic decline for decades. Locals point to feeling of abandoned and suffer from systematic disinvestment and what is percieved as being ignored by the city and county government.	X				Community engagement to South Fairmount is focused around the Early Success Projects and the on-going study and analysis of alternative projects for Phase 1 of the LMCPR.	Community engagement to South Fairmount, Westwood, East and Lower Price Hill and other Lower Mill Creek communities is focused around the Early Success Projects and the on-going study and analysis of alternative projects for Phase 1 of the LMCPR.	$3M(1)	N	PE
R 6	**Public Safety.** Resulting proposed project design will require certain mitigation stategies with the open waterway to ensure against potential safety impacts.	Open	HL		With the opening up and daylighting of the Lick Run, there will be concerns about children and others being exposed to a potential health and safety risk. Traditionally, we have used pipe and concrete channels and open water ways are less common; we need to educate the public about open waterway safety practices.	X				Basis of design considers the depth of water and potential impact water inflow and is designed to reduce the risk with the proposal of a dual conveyance system - one underground, one above ground so that high flows will be reduced by underground conveyance.	Channel design addresses and mitigates associated impacts within 2013.	$225,000	F	P
R7	**Regulator Support.** Delays in acquiring the necessary federal, state and local permits or regulator support could delay or suspend project implementation.	Open	MM		Failure to gain regulator support/approval, funding or flexibility could suspend or reduce the project. An environmental review document may be required by the provisions of NEPA. The nature and extent of the environmental document could effect the implementation schedule of the project.	x				Coordinated with and met with USEPA Region 5, ACOE and Ohio EPA.	Coordinate with the appropriate federal, state, and local agencies to ensure timely permit reviews and approvals.	$0	M	P

(1) early success projects are included in the implementation costs

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1 RISK IDENTIFICATION		2 RISK ASSESSMENT INFORMATION				3 RISK TREATMENT				4 RISK STRATEGY				
MSD Risk Number	Risk Description/Risk Event Statement	Risk Status	Risk Rank	Enterprise Risk	Impact Description	Reduce / Prevent	Accept	Transfer	Avoid	Completed Actions	Current & Planned Future Actions	Cost of Implementation	Timeline MMP	Status of Response
Provide a unique identifier here	*A risk event statement states (i) what might happen in the future and (ii) its possible impact on the project. "Weather" is not a risk event statement. "Bad weather may delay the project" is a risk event statement. (WHAT)*	*State if the risk is open (still might happen and still has to be managed), closed (has passed or has been successfully mitigated), moved to issue (risk has happened)*	*Enter here H (High), M (Medium), or L (Low) according to impact definitions (Consequence/ Likelihood)*	*Enter here the description and number of the associated risk from the MSD Enterprise Leading Risk Register (LRR)*	*List the specific impact the risk would have on the project: schedule, budget, scope and quality. Other impacts can also be listed. (WHY)*					*List, by date, all actions taken to respond to the risk. This does not include accepting the risk*	*List, by date, what will be done in the future to respond to the risk*	*Enter here the estimated costs of implementing the risk strategy action*	*Enter here N (near-term), M (Mediu-m-term) or F (Fa-rterm) according to timeline definitions*	*Enter here N (No Plan); P (Plan but not enacted); PE (Plan enacted but effectiveness not yet known); EE (Plan enacted and effective)*
R 1	**Land Acquisition.** Property acquisition challenges (relocation, loss of busines, funding constraints) may incur additional costs and delays.	Open	MH		Property acquisition is the complex challenge that can affect schedule and budget. The inability to have contracts on a large percentage of the properties prior to public and community engagement could jeopardize the project. A general corridor for the open channel was identified in the hydraulic and hydrologic investigation and generally the area between Queen City and Westwood is the target area. As properties are acquired and assembled, an open channel design can be developed and proceed with community engagement.	X				A prioritization of properties within the corridor has been completed. Priority one are properties located with the target area and listed "for sale", in foreclosure/bankruptcy, or those that have expressed an interest in selling to MSD; these are considered Phase 1 acquisition properties - these total 29 project parcels.	MSD has begun a phased land acquisition strategy to acquire property within the Lick Run corridor where properties are listed for sale, in foreclosure or have otherwise, willing sellers	$1,000,000	M	EE
										Preliminary acquisition notices have been sent to Phase 1 properties.	As of November 2010, 8 parcels have been acquired.	$1,500,000	N	PE
										Because this project has a high likihood of receiving federal funds, Uniform Relocation Act will be followed in the acquisition of properties and therefore, the preliminary acquisition notice includes standard language that indicates there is a potential for appropriation. To properly identify potential relocation costs, a relocation contract has been executed.	MSD is working with Phase 1 property owners to determine potential relocation or reestablishment costs as well as to document the vacancy and reduce tenants from being migrating into "abandoned" properties.	$100,000	N	PE
										MSD has identified 31 properties for securing purchase options for likely necessary or opportunity properties for the Lick Run corridor, to limit risk of purchasing property prior to USEPA approval.	As of November 18, 2010, 13 option letters have been delivered with owners	$300,000	N	PE
										Properties acquired are managed by MSD Real Estate.	A preliminary Property Management Plan has been developed.	$100,000	N	PE
R 2	**Storm Water Volume.** Corridor does not accomodate storm water volume due to design storm being exceeded flow model projections are incorrect or other hydraulic issues such as backwater caused by elevated stage levels at Mill Creek or Ohio River.	Open	HM		If the South Fairmount Corridor cannot accommodate the volume of water that is projected to flow through the open channel, localized flooding will occur which could threaten real property and human life.	X				Preliminary Engineering Analysis included HEC HMS/HEC RAS modeling for storm sewer area and channel evaluations. Modeled projections and scenarios are used as design criteria to protect the anticipated future condition for the 100 year floodplain.	FEMA Studies/Floodplain elevations will be conducted as design proceeds. The acquisition plan requires the procurement of all parcels within the target area for construction of potential solution, including contouring and development of a proper floodplain to accomodate the 100 year storm. Availability of assembled property will be used in design.	$3M	M	P
										The channel and conveyance system within the corridor are sized to account for the entire watershed draining through the target area; this is conservative design criteria and provides some additional protection to reduce liklihood of localized flooding.	Detailed channel designs to be completed.		M	P
R 3	**Unknowns.** Project corridor has historical, archeological, environmental, geotechnical and buried utility unknowns that will be uncovered during construction leading to delays and cost overruns	Open	HL		The area was first settled in the late 1800s and was a mixed use community with several commercial and some industrial uses. Because of the valley configuration, the geology of the area does have significant amounts of rock and hillside issues to address in the design and construction. Because of the proximity to the Mill Creek and other important social, cultural and historical factors, as well as the likihood of potential onsite disposal from the commerical and industrial operations, there is a possibility for this project to have several unknown characteristics. The exact location and condition of the existing utilities is somewhat uncertain. To address these potential issues, the relocation, protection and/or replacement of underground utilities may be required to fully implement the project plan.	X				An areawide Phase 1 environmental site assessment (ESA) under the USEPA Targeted Brownfield Assessment Program has been completed for the corridor and identified 4 primary areas of concern within the project corridor.	The areawide Phase 1 ESA includes the completion of 4 sampling and analysis plan for the 4 focus areas. this plans are under development. Phase 2 ESAs of the focus areas will be initiated thereafter.	$750,000	N	P
										No project parcels within the target area are listed on the National Historic Registry.	A historical and archeological consultant will conduct a survey of the project corridor. SHPO will be contacted if sites are discovered.	$100,000	N	P
										Utility Review, Topographic Review, Geotechnical Review, Intersection Traffic Movement Assessment & subsequent traffic Alternatives Development and Refinement Report, Geotechnical Exploration Report have been completed to identify unknowns.	Incorporate into design.	$250,000	N	P
										Regarding conditions assessment, existing PACP information has been reviewed, where available; in most areas pipes greater than 30" had recent inspections conducted.	Add necessary asset management needs to CIP. Continuation of review of PACP data as more investigation is conducted. Take precautionary measures during design and construction.	$0	M	P
										Inventory of underground locate openings (ULOs) that will be necessary to locate to complete design; there are over 100 of these that will require location between the 30-90% design.	Locate ULOs	$400,000	M	P
											An ecological investigation will determine whether a field survey will need to be completed to identify threatened and endangered species.	$100,000	N	P
R 4	**Agency Alignment.** Inability to get alignment/consensus between all agencies and organizations around a community of the future solution leads to suspension/cancelation of project	Open	MM	LR1 - Maintaining Public Trust	As the driver of the comprehensive, watershed-based wet weather solution, MSD will be dependant upon other agencies and organizations to support this approach and strategy. MSD has limited or no control these agencies. The inability to get alignment and buy-in around this alternative project is a risk. This project is not a typical sewer project and it will require MSD to develop new partnerships.	X				MSD has developed an Inform & Influence approach to gain agency support around the Community of the Future Initiative. As part of the inform & influence strategy, an Advisory Committee of 40 key thought leaders and influential sponsors has convened. There have been two full Community of the Future Advisory Committee (CFAC) meetings. The Advisory Committee is meeting bi-monthly and breaks out into 3 smaller subcommittees of: Community & Economic Development, Inform & Influence, and Policy. Subcommittees have developed Team Charters and teams are meeting to make recommendations and provide guidance to MSD.	CFAC will continue meeting bi-monthly or as needed with the subcommittees helping to provide guidance to MSD.	$50,000	N	PE
										Shared Need/Vision videos were created to inform and influence key thought leaders and potential partners for framing the project need & vision.	Development and refinement of Communication Strategy & Plan.	$100,000	N	PE
										Draft Community Opportunities Plan is developed that identifies potential linkages and opportunities for community revitalization around the comprehensive wet weather approach.	Master Plan for Community Redevelopment will be refined from the Draft Community Opportunities Plan, linking the project to the HUD DOT EPA Sustainable Communities Program. City was awarded a HUD grant for development of a Uniform Development Code, of which will be focused around MSD Communities of the future Projects like Lick Run.	$350,000	M	P
R 5	**Community Support.** Public resistant to the project for a variety of reasons including lack of public trust and support to community development benefits by sewer projects due to the lack of prior examples	Open	MM	LR1 - Maintaining Public Trust & LR 6 - Material Lawsuits	South Fairmount community has experienced continued economic decline for decades. Locals point to feeling of abandoned and suffer from systematic disinvestment and what is percieved as being ignored by the city and county government.	X				Community engagement to South Fairmount is focused around the Early Success Projects and the on-going study and analysis of alternative projects for Phase 1 of the LMCPR	Community engagement to South Fairmount, Westwood, East and Lower Price Hill and other Lower Mill Creek communities is focused around the Early Success Projects and the on-going study and analysis of alternative projects for Phase 1 of the LMCPR. Open House scheduled for January 2010.	$3M(1)	N	PE
R 6	**Public Safety.** Resulting proposed project design will require certain mitigation strategies with the open waterway to ensure against potential safety impacts	Open	HM		With the opening up and daylighting of the Lick Run, there will be concerns about children and others being exposed to a potential health and safety risk. Traditionally, we have used pipe and concrete channels and open water ways are less common, we need to educate the public about open waterway safety practices.	X				Basis of design considers the depth of water and potential impact water inflow and is designed to reduce the risk with the proposal of a dual conveyance system - one underground, one above ground so that high flows will be reduced by underground conveyance.	Channel design addresses and mitigates associated impacts within 2013.	$225,000	F	P
R7	**Regulator Support.** Delays in acquiring the necessary federal, state and local permits or regulator support could delay or suspend project implementation.	Open	MM		Failure to gain regulator support/approval, funding or flexibility could suspend or reduce the project. An environmental review document may be required by the provisions of NEPA. The nature and extent of the environmental document could effect the implementation schedule of the project.	X				Coordinated with and met with USEPA Region 5, ACOE and Ohio EPA.	Coordinate with the appropriate federal, state, and local agencies to ensure timely permit reviews and approvals.	$0	M	P

(1) early success projects are included in the implementation costs

PROJECT GROUNDWORK

PROJECT-LEVEL RISK REGISTER

PROJECT NAME: CSO 30 STREAM SEPARATION PHASE A
PROJECT ID: 11143100
UPDATED BY: DAVID RUSSELL
LAST UPDATED: 12/19/11

METROPOLITAN SEWER DISTRICT of greater CINCINNATI

IDENTIFICATION					ASSESSMENT					RESPONSE			REPORTING		
ID	RISK	CAUSE OF RISK	CATEGORY	SUB-CATEGORY	CONSEQUENCES	CONSEQUENCE RATING	LIKELIKOOD OF OCCURRENCE RATING	RISK SCORE	RISK CLASS	RISK RESPONSE PLAN	Assigned To (Risk Responder)	Due Date	Resolved On	Status	ACTIONS TAKEN
M.12.1	Unforeseen constructability issues are encountered	Contractor methods and capabilities do not address project complexities	Technical	Construction - General	Safety issues or change orders to design to guard against safety issues, schedule delays	10	6	60	Very High	Work closely with MSD Construction Management, Stantec, and the contractor to direct methodoligies as necessary to ensure safety	David Russell	December 16, 2011	TBD	Active	
M.12.2	Legislation not approved for payment to ODOT	ODOT contractor bids project over project agreement amount	Fiscal	Financing	Major delays or dissolution of MSD/DPS partnership	10	5	50	High	Work with MSD Governance and upper management to ensure that all requested project information is provided in a timely fashion	David Russell	September 16, 2011	TBD	Active	
M.12.3	Utility/power pole relocations are not performed per the schedule	Poor coordination with other utilities	Technical	Construction - General	Schedule delays, redesign of utility services	8	6	48	High	Ensure coordination with utilities well in advance of construction	David Russell	November 18, 2011	TBD	Active	Utility meeting have been held in the field to coordinate with other utilities
M.12.4	Collection system ownership and maintenance responsibilities are not fully defined	MSD/SMU coordination is inadequate	Technical	Commissioning, Operation & Maintenance	Project support waivers as a result of an inability to resolve fundamental end-goal issues	6	8	48	Medium	Engage SMU from the inception of the project to ensure coordination throughout design, construction, and turnover	David Russell	September 21, 2011	TBD	Active	SMU has been involved from the beginning and an understanding is in place that MSD will own and maintain until the proposed storm sewer accepts public flow, at which time SMU takes over
M.12.5	ODOT contractor builds MSD option incorrectly	Poor understanding of MSD Option	Management	Schedule	Project delays	10	4	40	High	Work with ODOT to ensure that bidders have an adequate understanding of the MSD Option prior to submitting a bid	David Russell	September 20, 2011	TBD	Active	MSD and ODOT have a solid relationship that should provide the foundation for mitigating this risk
M.12.6	Contractor coordination is inadequate	Poor mix of prime & subontractors due to different expertise	Management	Schedule	Schedule delays, misunderstanding of responsibility	5	5	25	Medium	Develop a unified construction coordination team consisting of MSD engineers and construction managers, SMU, ODOT, and the responsible contractors	David Russell	November 18, 2011	TBD	Active	A solid relationship is already in place will all parties except for the yet-to-be-identified construction contractors
M.12.7	Construction encounters unforeseen field conditions	Existing conditions doesn't identify all field conditions	Technical	Construction - General	Schedule delays, increased cost of construction	6	4	24	Medium	Evaluate existing data versus that available from ODOT and other sources and possible need for additional investigations	Greg Fritsch	September 16, 2011	TBD	Active	MSD has conducted soil borings in addition to evaluating ODOT boring data in the area

PROJECT RISK MANAGEMENT PLAN

PROJECT #:
PROJECT RISK REGISTER
PROJECT ID:

PROJECT NAME: WINTON ROAD SEWER SEPARATION PROJECT
PROJECT ID NO.: 10240021
PROJECT SEWER ID NO.: 6275
UPDATED BY: AARON BURKHARDT, BHE ENVIRONMENTAL, INC.
LAST UPDATED: SEPTEMBER 6, 2012

IDENTIFICATION					ASSESSMENT							RESPONSE				REPORTING		
ID	RISK	CAUSE OF RISK	CATEGORY	SUB-CATEGORY	CONSEQUENCES	CONSEQUENCE RATING	LIKELIHOOD RATING	RISK SEVERITY SCORE	RISK SEVERITY CLASS	Submitted by	Submitted On	RISK RESPONSE PLAN	Assigned On	Assigned To	Due Date	Resolved On	Status	ACTIONS TAKEN
WR.KR.1	Complete disconnection of sanitary discharges to existing combined sewer converted to storm only sewer	Lack of survey information, underground records and/or TV reports for pipes being converted	Environmental, Health & Safety	Contamination	Untreated sanitary sewage flows are discharges untreated to surface waters	2	1	2	Very Low			Research existing underground records, obtain survey information and all available TV reports for pipes planned to be converted from combined to storm only. Complete TV reports for those runs of pipe with no or unacceptable existing TV reports.					Active	
WR.KR.2	Construction in and near steep hillsides	Instability of hillsides in project area	Technical	Design	Inadequate design or construction procedures may lead to negative impacts during construction and possible negative impacts to the infrastructure after construction	2	2	4	Very Low			Proper design of required elements to ensure safe construction of the project and to decrease the risk of possible infrastructure failure or damage. Include design requirements of registered geotechnical engineer with experience in Cincinnati area and knowledge of region and challenges					Active	
WR.KR.3	Easement acquisition	Owners may require unreasonable reimburstment	Management	Easement Acquisition	Inability to obtain required easements may require additional time be added to the project schedule or reassement of the project alignment	2	4	8	Low			Begin easement acquisition process at earliest available point in project design. Have available design or construction options for those locations where easement acqusition proves to negatively impact construction start time.					Active	
WR.KR.4	Local Resident Acceptance	Residents may not agree with aspects of the project	Management	Public Communications	Uninformed or unhappy residents may cause additional time to be required to complete construction or design	2	2	4	Very Low			Conduct public outreach					Active	
WR.KR.5	Late project construction completion	Failure to monitor project construction schedule, inefficient coordination with other onsite contractors	Management	Schedule	Late project construction completion can lead to cost overruns and impact completion date of Cincinnati Dept. of Transportation & Engineer project	7	2	14	Medium			Monitor construction progress, provide factor of safety in schedule for issues, stress coorindation between contractors, plan and contract notes					Active	
WR.KR.6	Design Miscoordination / Miscommunication	Separate projects, designed by separate entities	Technical	Design	Design failures and miscommunication can lead to construction issues and cost overruns	4	2	8	Low			Stress coodination between Cincinnati DOTE and MSD design engineer to ensure construction and design issues are addressed. Press interal reviews of projects togetehr and separately.					Active	
WR.KR.7	Increased vehicular or pedestrian incidents	Additional vehicular access point along Kings Run Drive	Technical	Construction - General	Construction traffic control could lead to traffic or pedestrian incidents, adding to construction time and resulting in cost overruns	2	1	2	Very Low			Proper coodination between constractors onsite and proper planning in the design stage to assist in traffic/pedestrian control during construction.					Active	
WR.KR.8	Collection system ownership not yet fully defined	Conversion of MSD assets (combined sewers) to SMU assets (storm only sewers)	Technical	Commissioning, Operation & Maintenance	Some assets (combined sewer converted to storm only sewers) may not be transferred at project completion to SMU. Asset transfer would have to be completed at a later date.	1	2	2	Very Low			Address SMU concerns for asset transfer early in project, prior to construction. Create plan with MSD if assets are not transferred and must stay under MSD control					Active	
WR.KR.9	OEPA Permit to Install for sanitary sewer	Outfall and channel improvements near proposed storm sewer outfall and existing CSO 217 outfall	Technical	Design	PTI not in hand in time for legislation; construction not able to start. Impacts to project completion date and possible additional cost overruns.	4	2	8	Low			Address ACOE permit concerns early in project design stage					Active	
			#N/A					0	#N/A									
			#N/A					0	#N/A									
			#N/A					0	#N/A									
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			#N/A					0	#N/A									
			#N/A					0	#N/A									

CSO 483 Sewer Separation

PROJECT RISK MANAGEMENT PLAN

PROJECT #:
PROJECT ID:

METROPOLITAN SEWER DISTRICT of greater CINCINNATI

IDENTIFICATION					ASSESSMENT							RESPONSE				REPORTING		
ID	RISK	CAUSE OF RISK	CATEGORY	SUB-CATEGORY	CONSEQUENCES	CONSEQUENCE RATING	LIKELIHOOD RATING	RISK SEVERITY SCORE	RISK SEVERITY CLASS	Submitted by	Submitted On	RISK RESPONSE PLAN	Assigned On	Assigned To	Due Date	Resolved On	Status	ACTIONS TAKEN
KR.1	Lack of Experience with Design, Construction and Operation of Unique Projects (Underground Storage)	Lack of MSD staff experienced with design/construction of large underground storage tanks	Management	Management Capability	Lack of MSD staff experienced with design/construction of large underground storage tanks and tank contracting leads to schedule delay, cost escalation and exposure of MSD to claims. Lack of MSD staff experienced with operation and maintenance of large underground storage tanks leads to accidents, unnecessary overflows and damaged or poorly maintained equipment.	10	4	40	High			Evaluate feasibility of establishing a separate management team comprised of MSD staff and consultants (serving as the Owner's representative) with requisite expertise. Capitalize on opportunities for OTJ learning and formal mentoring of MSD staff during design and construction. Assign organizational responsibility for O&M of the new facility. Prepare staffing plan for O&M of the new facility.					Active	
KR.2	Underground Storage System ownership and maintenance not fully defined	Underground Storage tank management is not clearly defined inside MSD	Management	Management Capability	No clear MSD entity identified to maintain the underground storage may lead to improper or untimely maintenance procedures	7	4	28	Medium			Work with MSD to clearly define the appropriate internal entities to perform the required O&M work, and ensure these entities have the proper personnel with training and equipment					Active	
KR.3	Impact mapped wetlands	Improper construction and/or restoration procedures,	Management	Mitigation/Permit Compliance	Status of minor wetlands impacted by construction is at discretion of regulatory agency(ies); expected procedures when completing construction in or near wetlands may lead to additional compliance requirements.	1	2	2	Very Low			Clearly define on the construction documents and to the contractor the importance of maintaining proper construction techniques when completing work in or near mapped wetlands in the project vicinity						
KR.4	Construction in and near steep hillsides	Instability of hillsides in project area	Technical	Design	Inadequate design or construction procedures may lead to negative impacts during construction and possible negative impacts to the infrastructure after construction	2	2	4	Very Low			Proper design of required elements to ensure safe construction of the project and to decrease the risk of possible infrastructure failure or damage						
KR.5	Easement acquisition	Owners may require unreasonable reimburstment	Management	Easement Acquisition	Inability to obtain required easements may require additional time be added to the project schedule or reassement of the project alignment	4	4	16	Medium			Begin easement acquisition process at earliest available point in project design						
KR.6	Local Resident Acceptance	Residents may not agree with aspects of the project	Management	Public Communications	Uninformed or unhappy residents may cause additional time to be required to complete construction	2	2	4	Very Low			Conduct public outreach						
KR.6	Late project construction completion	Failure to monitor project construction schedule	Technical	Construction - General	Late project construction can lead to cost overruns	4	4	16	Medium			Monitor construction progress						
KR.7	Increased vehicular or pedestrian incidents	Additional vehicular access point along Kings Run Drive	Technical	Design	New access points may lead to vehicular or pedestrian accidents	2	2	4	Very Low			Proper design of the access point including any additional required signage						
KR.8			#N/A					0	#N/A									
			#N/A					0	#N/A									
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APPENDIX B

MSDGC Update – Lower Mill Creek Partial Remedy
US EPA Meeting
July 26, 2012
Meeting Notes

Conference Call Attendees & Participants	
Barbara VanTil, USEPA Region 5	Tom Lyon, MSDGC
Sudhir V. Desai, USEPA Region 5	Leisha Pica, MSDGC
Bob Newport, USEPA Region 5	Phil Gray, XCG
Jonathan Moody, USEPA Region 5	David Moughton, XCG
Mark Klingenstein, USEPA Region 5/SAIC	Carol Hufnagel, Tetra Tech
Jon Grosshans, USEPA Region 5	Erica Spitzig, MSDGC/McMahon DeGulis
Gary Pritchard, USEPA Region 5	Carrie Turner, LimnoTech
Leslie Allen, DOJ	John Lyons, Strand & Associates
Bonnie Buthker, OEPA	Jeff Aluotto, Hamilton County Commissioners
Marianne Piekowski, OEPA	Blake Roe, Hamilton County Monitor
Joshua Jackson, OEPA	Mark Norman, Vorys, Sater, Seymour & Pease LLP
Sam Dinkins, ORSANCO	Jeff Proctor, Hamilton County Monitor
Tony Parrott, MSDGC	Karen Ball, Hamilton County
MaryLynn Lodor, MSDGC	Colleen McCafferty, Hamilton County Prosecutor
Terry Nester, City Solicitor's Office	Charles Anness, Hamilton County Prosecutor

Summary of Meeting Discussion

The meeting began with Mr. Aluotto welcoming the group and offered some opening remarks thanking everyone for coming to or participating in the meeting. He expressed an appreciation in advance for help to expedite coordination so the County can make a timely decision. He explained the relationship and unique governing structure between Hamilton County and MSD. In 1968, sewer service was integrated throughout the County. Under the terms of the agreement, the City of Cincinnati has the sole responsibility for operations. The County's role under the 68 agreement the County retained principal control over the district and such things as raising rates, issuing debt, setting policy etc.. As such, the County a s a Co-Defendant is in the process of determining what will be submitted to the Regulators this Fall.

Mr. Parrott began the presentation by reminding everyone that modeling is the key parameter for evaluation of an alternative remedy. A letter, July 19, 2012 was issued in advance of the meeting to Barbara VanTil summarizing the updated model results in advance of the meeting. Mr. Parrott also highlighted that numerous discussions on this topic were had in 2011 on the updated revised model; specifically, a conference call on November 17, 2011 was held where the co-defendants presented the refined model and USEPA had provided concurrence with the approach and use of the refined model. Mr. Parrott indicated MSD has invested a lot of time and money into the modeling efforts. The results presented are based on the detailed model runs, which were completed on June 1, 2012. Results presented to the County on April 2nd were based on consolidated model runs completed prior to that

point in time. Today's presentation will respond to the questions MSD received last Fall regarding how an alternative would be shaped into reality. MSD is continuing its analysis and a suite of other projects may be submitted to the Regulators for consideration. One of the purposes of this meeting is to present information related to each issue included in the October 2011 draft USEPA guidance document which provided a list of criteria necessary for consideration of an alternative remedy.

MODELING

Mr. Lyon presented MSD's updated baseline model which reflects significant reductions of inflow and overflow volumes. This information is a continuation of the discussion held in October 2010 and January 2011 regarding MSD's conversion from a kinematic wave model to a fully dynamic model. Mr. Lyon also clarified the Original baseline model overflow in the LMCPR Study excludes areas directly tributary to the Ohio River, as identified as the West Ohio and East Ohio sub-basins on slide 6. The CSOs in this sub-basins discharge directly to the Ohio River and have no impact on Mill Creek. As such, they were not included in the study area. Mr. Parrott asked if the Regulators need any clarifications or further information related to how the baseline model was updated. Mr. Klingenstein said USEPA has just begun review of the model update and will have some follow-up discussions with MSD.

Mr. Lyon discussed the updated baseline model volumes and the resulting equivalent CSO reduction goal. Mr. Parrott clarified the 1.25 billion gallons (BG) represents an equivalency ratio from a rational mathematical approach and does not necessarily represent the Co-Defendants' offer. He asked if the approach presented is reasonable. Mr. Klingenstein indicated he will need additional information and discussion regarding storm event selection, criteria for storms, and the calculation processes so he can understand the universe MSD started with and where it is with the updated baseline model. Ms. VanTil said USEPA needs some time to digest and review the information presented today. She committed to setting up follow-up discussions. Mr. Aluotto said it is crucial that feedback be received quickly. The Board of County Commissioners ideally would like to have a broader public input process so they can make a decision in September/early October. He asked the MSD and USEPA to work together with the understanding MSD will keep the County team updated on discussions. Subsequent to the meeting, the County expressed their desire to be involved in technical discussions between EPA and MSD from this point forward. Ms. VanTil indicated USEPA will follow-up with questions quickly to accommodate the need to make a recommendation by Labor Day. She will converse with USEPA staff and provide MSD a schedule for feedback coordination.

Mr. Pritchard had an overarching comment for discussion only regarding the 1.25 BG. He asked if the value was based upon 1) if the default grey solution was implemented, it would result with 1.25 BG of CSO reductions, or 2) when looking at the math, should the values have been lower. Mr. Lyon indicated the later. The default project, [given the original alignment and concept in Attachment 1C] achieves a CSO reduction of 1.8 BG.

Mr. Newport asked if the CSO reduction target is changed from 2 BG to 1.25 BG, would the same number of gallons be overflowed? Mr. Lyon indicated the original baseline model demonstrated 38%

watershed percent control. When an additional 2 BG is removed from the system, a total of 53% control was achieved in the watershed. The updated baseline model demonstrates a baseline of 49% control. When 1.25 BG are removed from the system, a total of 62% control is achieved in the watershed.

Mr. Lyon discussed the current system model, version 4.2. He indicated this version represents a new base condition to be applied to the alternatives and includes infrastructure improvements through 2010; this model was the version that was discussed in 2011 with USEPA as referenced earlier by Mr. Parrott. The current model is used to 1) determine reduction from projects already built and 2) as a base model for the tunnel, sustainable, and hybrid alternatives. Mr. Klingenstein asked if version 4.2 included projects 100% likely to occur. Mr. Lyon responded yes but it does not include any sustainable projects. The RTC facilities were included in model version 4.2. Mr. Lyon noted ten of the 98 CSOs had increasing volumes under the updated model, while 88 had reduced volumes. The Lick Run RTC was originally expected to remove 0.2 BG but the model indicates it reduces by 0.45 BG. The other three RTCs achieve 0.28 BG in lieu of the anticipated 0.41 BG due to a reduction of inflow in the tributary areas in the updated baseline model.

Mr. Lyon explained in detail how the individual sub-basin sustainable models were incorporated into the system-wide model. He explained the project began with 8 sub-basins and two were removed from the priority list. Detailed models were developed for the six remaining sub-basins. MSD went through an extensive review process for each sub-basin model and vetted assumptions used by the project consultants for consistency; much of this specific project and model information was presented to USEPA in December 2011 by MSD and the lead designer of the watershed project. Mr. Lyon explained the detailed analyses performed for all 98 CSOs and specifically highlighted the efforts that were performed regarding percent effectiveness of stormwater capture. The design team's work went well beyond windshield surveys. Field work included determining areas with driveway drains, roof drain leaders, and groundtruthing the specific site conditions to quantify and verify the flows entering the existing combined, which flows would be separated and what percent effective-capture would be used for all subcatchments within a prioritized Tier 1 area for sustainable infrastructure. After detailed groundtruthing of flows, the end result was a 1% reduction of the assumed percent effectiveness value (87%) from what was originally estimated for sustainable infrastructure.

Following the groundtruthing work, MSD also conducted sensitivity analysis of the stormwater capture for the six sub-basins. The analyses demonstrated that a 15% reduction in percent effectiveness resulted in reducing the average percent control from 89% to 86%. MSD stated that "independent peer review of estimated effectiveness" could vary up to 13%. MSD is confident the 87% percent effectiveness value accurately reflects the amount of capture from the proposed strategic separation system. Mr. Newport asked if MSD made adjustment in the model based on sensitivity analysis. Mr Lyon responded, no it was a "what if" exercise. Mr. Newport further asked if an alternative remedy were implemented would it be possible to verify and validate the actual percent effectiveness value. Adaptive management comes into play with respect to the confidence level in the assumptions used to develop an alternative remedy. MSD expects its post construction monitoring program will help with increased confidence in values used in the study. Mr. Klingenstein asked if additional detailed

documentation is available regarding the sub-basin investigations. Mr. Lyon indicated a May 2012 report documents the independent flow monitoring, groundtruthing exercises, and how the information was incorporated into the catchments.

Mr. Parrott asked the Regulators if the modeling information presented follows the criteria in the draft guidance document and whether sufficient detail was provided for consideration of an alternative remedy. MSD noted if 1.25 BG of CSO reductions were applied to the updated baseline model, a higher level of watershed control would be achieved than presented in the original WWIP. Additionally, a lower remaining overflow volume will be achieved because the reduced inflow volume had less to start with. Better modeling technology has resulted with better data. Ms. VanTil agreed that USEPA recognizes that is the nature of modeling.

ALTERNATIVES COMPARISON

Mr. Parrott indicated MSD used the premise of achieving a 2 BG reduction with the alternatives comparison and that additional evaluations and refinements will be performed as well. Ms. Allen asked why the grey alternative differs from the WWIP tunnel project. Due to constructability issues and the need to extend the tunnel further to achieve 2 BG reduction, the grey alterative differs from the default project in the WWIP. Mr. Lyon explained the grey alternative extends the tunnel to CSO 13 and has a shallower consolidation sewer to CSO 14 which also picks up flow from CSOs 10 and 13 on the west bank of Mill Creek. The CSO volume from CSOs on the west bank of Mill Creek was insufficient to reach the 2.0 BG goal. A deep consolidation sewer picks up flow from CSOs 9, 12, and 15 on the east bank of Mill Creek and to the east of the railroad yards. Adding the CSO volume from these three CSOs exceeded the 2.0 BG goal by approximately 0.2 BG. This increased the CSO reduction from 2 BG to 2.2 BG for the grey alternative. The remaining overflows were about equal without the extra credit achieved by the grey alternative. Two additional drop shafts were necessary for the grey alternative. Mr. Lyon explained constructability issues came into play with the CSOs along the east bank of Mill Creek located between the channelized portion of the creek and the railroad yard. There is not sufficient space to cross the rails or to site a drop shaft between the creek and rail yard. The railroad doesn't want a shallow sewer to be constructed under the rails. This requires a deep sewer and caused the tunnel not to be feasible as originally envisioned.

Mr. Parrot presented the triple bottom line approach used in the Study which considered benefits, risk, and cost of the alternatives. Lifecycle cost of each alternative was based upon 25 years. Mr. Parrott said more detailed information is available if needed and emphasized a different suite of projects may ultimately be presented.

Mr. Parrott presented the results of MSD's voluntary water quality analysis. The analysis was performed for a ¾-inch storm using the EFDC model. MSD voluntary performed this analysis to get an idea of the value added with through the capital investments required to reduce CSO overflow volumes. The existing water quality conditions in Mill Creek at the Butler-Hamilton County line exceed the current

fecal standard. There is a water quality problem in Mill Creek before it get to the first MSD CSO. Mr. Klingenstein asked what enters the system at River Mile 14. Ms. Turner explained River Mile 14 is a large stormwater inflow separated area in the vicinity of Winton Lake. Spikes in the water quality graphic represent new influences into the Mill Creek system. Ms. Buthker asked if MSD looked at anything other than total coliforms. Ms. Lodor explained other parameters were evaluated and indicated overall reductions. She also said MSD is continuing its water quality evaluation with the Midwest Biodiversity Institute for the entire Mill Creek. One primary finding to-date is that there is a lack of base flow in the creek. Mr. Newport asked what the starting point was for the water quality model effort. Ms. Tuner explained the conditions at the County line were representative wet weather concentrations input into a SWMM model to simulate runoff from separate areas. Event mean concentration (EMC) values were applied to runoff loads to generate inputs for the Mill Creek model. The EFDC model is a USEPA model used to simulate hydrodynamics and stream water quality. The model includes Mill Creek and the Ohio River. The hydraulics of the model are controlled by the downstream river stage at the Markland Dam. Mr. Newport asked if SSO inputs were applied to the separate areas. Ms. Turner said yes, the output from the hydraulic model is applied with an EMC to input that load.

Mr. Parrott asked the Regulators to let MSD know if they need specific information or have questions about the findings of the study. Mr. Newport noted the original WWIP was based upon a remaining volume of 6 BG. According to Mr. Lyon, both the grey and sustainable alternatives as presented result with about half that amount with 3 BG of remaining overflow. Mr. Pritchard asked how the original language in Attachment 1C to the WWIP was taken into account with the alternatives. Mr. Lyon responded that the tunnel option achieves 85% control and the Lick Run alternative achieves 85% control; depending upon the suite of project included in the sustainable alternative, less than 85% control may be achieved. . None of the RTC facilities by themselves will be able to achieve 85% control. MSD said additional projects will be included in Phase 2 to increase the percent control. Mr. Pritchard asked for clarification regarding what tunnel size the grey alternative needs to achieve 85% control and whether the tunnel was extended to get 85% control or to get volume reduction. Mr. Lyon responded that the revised tunnel concept is a 25-ft diameter tunnel that extends to CSO 13 for Phase 1 to be able to get the volume reduction target of 2.0 BG.

TURNING RESULTS TO REALITY

Ms. Lodor indicated MSD has been building upon information over the past two years, specifically with respect to the Lick Run Watershed. This section of the presentation will highlight the modeling and preliminary findings results that Mr. Lyon and Mr. Parrott presented and how that information can be turned into reality. Over the last 2 -2 ½ years, with the USEPA integrated planning framework, MSD has used this information with the Lick Run Watershed, one of MSD/Hamilton County's largest CSOs. Ms. Lodor stressed that this is one solution that is being considered locally and is not suggested to be a proposal to the agency. This information builds upon information previously presented to USEPA, uses the information gained from community workshops and advisory committee meetings and hopefully will specifically respond to what Asst Administrator Nancy Stoner's requested in May 2012 with her visit to

Cincinnati and her request for more information regarding the Lick Run project. Ms. Lodor explained MSD followed the plan-do-check process for develop of a sustainable watershed evaluation process. MSD provided USEPA with a draft SWEP manual last December that is currently being updated. She presented a visualized rendering of the3 segments of the Lick Run Valley Conveyance System. Mr. Newport asked if water must be lifted at the daylighting feature. Mr. Lyons said all flow is by gravity.

Ms. Lodor walked through the segments of the Valley Conveyance System, emphasizing the project would utilize curblines of existing roadways (Queen City and Westwood) but that the City Transportation and Transportation Improvement District is advancing by submitting the project to OKI for funding of the planning and design of the boulevard system, "looking favorable"; however, the base Lick Run project could proceed without a boulevard improvement within the existing curblines. Bridges will be incorporated into the project to allow the water to flow to Mill Creek. Coordination is on-going for elimination of Beekman Road and access issues associated with Westwood Avenue. Ms. Lodor also highlighted the areas of the Valley Conveyance System that are conceptualized for maintenance access, public safety and long term functionality for combined sewer overflow reduction and offloading of flow from the combined system.

Ms. Buthker asked if MSD intends to have access and maintain sustainable infrastructure like any other utility asset. Ms. Lodor responded, yes MSD will have full responsibility for maintenance. Mr. Klingenstein asked for clarification of who will own land acquired. He said a more detailed discussion of who will own property and who will be responsible for maintenance would be helpful. Ms. Lodor indicated that property acquired for sustainable projects is being acquired in the name of the County for MSD use.

Ms. Lodor presented the approach MSD has taken for acquiring properties, using state-certified appraisers and following the federal Uniform Relocation Act guidelines for reestablishment and relocation. Mr. Parrott said recent state law changes now allow MSD to use the Quick-Take process for projects related to Consent Decrees. Mr. Desai noted home values continue to decrease and asked how the appraisals will be reconciled with folks having outstanding balances. Ms. Lodor said MSD must follow state law for appraisals but has elected to use Uniform Relocation Act to maximize benefits to relocated property owners, business, and tenants. This provided more benefits than typically offered by the City and still follows federal and state guidelines while helping to close the gap.

Ms. Buthker asked if MSD interviewed all business owners in the corridor or just those impacted. Ms. Lodor explained that MSD conducted a survey of all members at a South Fairmount Business Association meeting and has been working one-on-one with affected owners and continues to be active at local business association meetings. In addition, the University of Cincinnati performed an independent evaluation of business impacts provided by the South Fairmount Business Association and found that the businesses within South Fairmount represent 1% of those that are within the City currently. Mr. Newport asked if the University's study provide information on what businesses might want to locate here after the project is completed. Mr. Lodor said the study highlighted the experience of Kalamazoo, Michigan. Based upon geography and land area and investments of daylighting, approximately $20M-

$35M of future reinvestment could occur from the Lick Run project within the immediate project area of the Valley Conveyance System.

Ms. Lodor discussed at length the public outreach efforts MSD has initiated and continues to hold with respect to the study. MSD followed-up with meeting attendees and posted reports on –line. Mr. Pritchard asked if the Sierra Club has been involved with these meetings and what was their reaction to the project. Ms. Lodor indicated the Sierra Club is a member of MSD's Communities of the Future Advisory Committee (CFAC). MSD has provided the CFAC with briefings on the Lick Run project. Sierra Club members have also participated at the Community Design Workshops. In addition, MSD had a special meeting between Workshops 2 and 3 with environmental groups, including the Sierra Club, to solicit feedback. Mr. Parrott indicated the reaction of the Sierra Club is on-going. They are seeking more information and have not shared an opinion with MSD.

Ms. Lodor briefly mentioned MSD is formulating a post-construction monitoring program and addressed the technical guidance request to identify issues inherent with a source control approach, as summarized on slide #76. MSD is developing pre-construction benchmarks within specific project areas to be able to compare future post-construction benchmarks and demonstrate compliance at CSO outfalls. Mr. Klingenstein said he would like to get a better understanding of the technologies and applications under consideration. Mr. Newport agreed the key point of compliance is at the outfall via a combination of monitoring and modeling. He asked if MSD intends to consider other monitoring locations to better validate the model results. Mr. Lyon indicated MSD is challenged to find monitoring locations at some CSOs due to existing conditions and steep hillsides. MSD is now determining sites that will enable them to perform an improved water-balance in some of the areas to be separated. Mr. Klingenstein asked if MSD intends to use the same locations used to calibrate the model. Mr. Lyon indicated yes in some areas but noted Lick Run is challenging to find suitable monitoring locations and attempting to get better definition in the upper reaches of Lick Run. Ms. Lodor also noted USGS has been collecting data from the St. Francis, Glenway Woods and other areas of the watershed; USGS and ORD have indicating that St. Francis is operating efficiently.

TIMELINE

Mr. Parrott walked through the timeline that MSD has followed and the numerous technical evaluations and analyses that have been performed over the last 3 years – slides 79-82. Mr. Parrott also walked through a potential timeline moving forward with additional design underway currently and construction to begin in 2015 to meet the 2018 timeline. Mr. Parrott highlighted the more immediate next steps with scheduled Town Hall meetings for mid-late August 2012 to gain additional public comment/feedback for incorporation into a report for Board and Council for potential action in September/October as well as the concurrent coordination needed between MSD and USEPA so that the technical issues on the targeted volume is resolved by mid-August. USEPA indicated they will be able to meet that timeline.

WRAP UP

Mr. Parrott asked if the presentation followed the draft USEPA guidance document and whether MSD needs to provide more information to answer questions posed last spring. Mr. Newport noted the guidance document was provided because evaluating a sustainable alternative is different than a tunnel project. He said USEPA wants to be sure the alternative performs as well as the default tunnel project. He advised MSD to highlight in their submittal how they will demonstrate that performance of the sustainable alternative initially and over the next 30 years will be comparable to the grey solution.

Mr. Newport indicated MSD did a good job following the criteria in the guidance document.

Mr. Klingenstein said the presentation represents, "more than a good start".

Ms. VanTil concurred that MSD had considered USEPA's criteria and appears to be on track, but noted USEPA will need to have technical and legal discussion regarding the refined model and specifically the issue of the equivalent volume/2BG target, and what additional information may be needed to inform the discussion. Early next week she will assemble staff to talk through these issues, so the Regulators can initiate dialogue with the Co-Defendants. She anticipated USEPA will want to receive a number of documents.

Mr. Parrott indicated Ms. Lodor will be the lead contact for technical questions. Legal questions will be coordinated with the County and City attorneys. He suggested and everyone agreed to hold a weekly conference call to facilitate resolution of technical issues. Mr. Parrott stated that, "MSD and the Co-Defendants cannot take any further steps to make a recommendation to the Board or Council without clarity from USEPA on these issues of the targeted reduction." Mr. Norman said the more communication the better and emphasized a need for good communication between both the technical and legal teams to avoid any disconnects.

Technical Discussion – LMCPR Modeling
August 6, 2012; 11am EST – 12:15 EST
Meeting Notes

Conference Call Attendees & Participants	
Barbara VanTil, USEPA Region 5	Carol Hufnagel, Tetra Tech
Sudhir V. Desai, USEPA Region 5	Blake Roe, Hamilton County Monitor
Mark Klingenstein, USEPA Region 5/SAIC	Mark Norman, Vorys, Sater, Seymour & Pease LLP
MaryLynn Lodor, MSDGC	Jeff Proctor, Hamilton County Monitor
Tom Lyon, MSDGC	Brandon Vatter, Hamilton County Monitor
Leisha Pica, MSDGC	Karen Ball, Hamilton County
Geoff Edwards, XCG	Colleen McCafferty, Hamilton County Prosecutor

The purpose of the meeting was to discuss USEPA questions regarding MSDGC's "Lower Mill Creek Partial Remedy System Wide Model Validation Report," February 24, 2012, and MSDGC's LMC-SA Sytstem Wide Model Restructuring Version 3.2, Version 4.1.0 and Version 4.2" June 1, 2012. Below is a summary of the discussion. A second call is planned to discuss follow-up items on August 9th at 11 am (EST).

1. **Lower Mill Creek Partial Remedy System Wide Model Validation Report**

The discussion began with questions and comments from USEPA regarding MSDGC's February 24, 2012 Validation Report, and MSD provided clarifications and responses regarding the hydraulic and hydrologic model.

Mr. Klingenstein explained that more detail would be helpful regarding the adjustments made to the hydrologic and hydraulic parameters in each catchment during the calibration process. MSD responded that the separate Lick Run report, which includes this detail, was included as Appendix C of the June 1st System Wide Model Restructuring Report. Appendix C was uploaded to the July 25th folder as a separate file on the FTP site. MSD also offered to provide an Excel spreadsheet outlining the changes made to each CSO.

Mr. Klingenstein also noted that Section 2.1 of the Validation Report made reference to the discussion of CSO 005 in a separate report. MSD explained that the referenced report was the same report included as Appendix C to the Validation Report mentioned in response to the previous comment.

Mr. Klingenstein asked whether MSD made model adjustments based on calibration adjustments in areas where flow monitoring data was available. MSD explained that all calibration model adjustments made were supported by flow monitoring data and offered to provide an expanded map of flow monitoring data to include sub-basins.

Technical Discussion – LMCPR Modeling
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Mr. Klingenstein asked for more documentation regarding why flow data for particular storms was used for calibration at some sites but not all. He stated that he understands there may be circumstances where there simply is not good data for a particular storm at some sites due to a malfunction, etc., but explained that more detail in this regard, and specifically why some storms fell off for particular sites, would be helpful to validate that there was a consistent system of choosing storms. Ms. Van Til explained that the intent of the discussion was to simply put the questions in front of MSD, and that further explanation during Thursday's call would be appropriate. Ms. Lodor stated that a detailed explanation of why particular storms were chosen would be provided, which could then be discussed during Thursday's call.

Mr. Klingenstein asked whether the Barrier Dam Pump Station collects wet well stage data while in operation, and noted that the closest USGS gauging station on the Mill Creek is 11 miles upstream of the Barrier Dam. MSD explained that Mill Creek level measurements are not recorded at the barrier dam, but that a new USGS stream/rain gauge is under discussion with USGS near the Hopple Street area.

Mr. Klingenstein noted that the Validation Report did not contain data regarding how much sediment was present in the AMCI, nor the roughness of the interiors, but that MSD had addressed this comment in the LMC-SA System Wide Restructuring Report of June 2012.

Mr. Klingenstein pointed out that Section 2.3.2 of the Report describes the Mitchell Avenue RTC as having its automatic underflow gate propped open. He asked whether the gate remains propped open and whether MSD assumed that the gate was propped open in its calibration and validation efforts. MSD responded that the underflow gate is automatically controlled by a PID control setting. MSD will confirm whether this issue has been corrected and provide an update or confirmation during Thursday's call. XCG added that the time periods used for the calibration were 2009 – prior to construction of the RTCs. CSO 482 was calibrated assuming the RTC was not in operation. Modeled future conditions include the RTC operating at this location.

Mr. Klingenstein noted that in the Validation Report, MSD states that the validation goal was to have 60% of the storms evaluated to have modeled versus measured values, but that the report also suggests that MSD is applying the 60% goal on a "lumped" basis (meaning that if 30 parameters are being measured, MSD is considering the goal met if 18 of those parameters are within the applicable range). Mr. Klingenstein noted that this method appeared in at least one place in the report, and asked from a process standpoint whether MSD is in fact looking here at all of the parameters as one and has achieved 60%, or whether MSD is instead looking for 60% achievement of each individual parameter. MSD stated that it would review this issue and provide a detailed response during Thursday's discussion.

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Mr. Klingenstein asked whether MSD has tried one of the current generation of "down-looking" meters as a way to circumvent sediment effects. MSD explained that it is looking into other monitoring options for Lick Run. XCG explained MSD had obtained some good data for the fall of 2006 from a down-looking Flodar meter for the Lick Run area. MSD's experience was these types of meters are extraordinarily labor intensive and expensive to keep operational. This type of monitoring can be very expensive with limited benefits, but MSD is evaluating options. Mr. Klingenstein noted that he was familiar with the labor intensity of this type of meter.

Mr. Klingenstein noted that MSD's discussion of its use of the TELOG overflow sensing system as a validation tool suggests limitations and notes the conclusion that TELOG data is only useful for corroborating the occurrence of overflows rather than validating peak flow, volume, and depth. Mr. Klingenstein noted that MSD's comments regarding the difficulty of using the depth data and weir orifice formulas to calculate accurate flow values are generally valid, but stated that he was interested in learning more about MSD's use of the data and wanted to know whether MSD has had any success addressing this issue since 2009. MSD responded that it has refined its use of Telog data. Tom Lyon explained that the main challenge is data drift. For example, the units track at a constant value when an overflow is not occurring, but after an event, they do not return to the original values. Mr. Klingenstein acknowledged that data drift is an issue with TELOG, noting that in his experience the drift occurs most often if the levels are plotted, but that when looking at the larger picture, most of the times the levels match up pretty well.

Mr. Klingenstein asked how MSD selected the CSOs for which detailed TELOG and modeled water level data were provided in Appendix C. MSD explained that a discussion of different runs – small, medium and large - was included in the November 2011 presentation and included an analysis of CSO 9, 12, 15, and 181. These were selected because they were the most significant locations to evaluate. They are four relatively large overflows having the most Telog monitoring data for the 2009 validation period. Other locations are smaller and have less impact on framing the alternative.

Mr. Klingenstein asked whether the start date for each CSO is the date that the TELOG system went online. MSD confirmed that when the system went online represents the "Start date".

Mr. Klingenstein noted that Appendices A&B of the SWM Validation Report present comparative hydrographs and depth plots, and asked whether the plots included are for all locations and events for which MSD carried out analyses. Subsequently in following up with XCG, MSD confirmed the analyses include all the plots for all the flow meters used for the validation, including the 4 noted above.

2. LMC-SA System Wide Model Restructuring Version 3.2, Version 4.0.10 and Version 4.2

The discussion continued with questions and comments from USEPA regarding MSDGC's June 1, 2012 Restructuring Report, and MSD provided clarifications and responses regarding the hydraulic and hydrologic model.

Mr. Klingenstein noted that the Restructuring Report states that validation was carried out using Version 3.2 of the model, but asked whether calibration was also carried out using the same version. MSD confirmed that calibration of the model was carried out in Version 3.2, with additional data added where necessary.

Mr. Klingenstein asked for clarification as to the lowest practical wet well operating range. He noted that the report references previous versions of the model having assumed wet well operation between 0 and 5.3 feet, but that the current model was revised to reflect the actual practice of 22.3 and 22.7 feet. Mr. Lyon explained that the elevations modeled for the WWTP pump operations were selected to correlate to bar screen operations. The original model was over simplified; the more detailed model reflects the actual elevations and operating conditions that exist in the field. Mr. Lyon explained that there is actually a bar screen floor, and that a specific depth of 22.5 feet must be maintained to control velocity through the bar screens. The elevations are a physical requirement. Mr. Lyon explained that when compared to the early model runs before this boundary condition was modified, approximately 3% less flow is delivered to the WWTP for the typical year.

Mr. Klingenstein commented that the discussion of sediment in sections 3.3.5 and 3.3.6 in the Restructuring Report address his earlier comments regarding sediment with regard to the Validation Report, and noted that no further response to that comment is required.

Mr. Klingenstein noted that at the Oxley Crossing Gates, the model reflects MSDs practice of diverting all flow to the AMCI. He asked whether there is any additional capacity in the WBMCI and whether the WBMCI has any RTC potential. MSD confirmed that at the Oxley Crossing Grate all flow is delivered to the AMCI instead of the WBMCI. This occurs because there is no wet weather capacity in the WBMCI because it connects to a 33-inch diameter, 2,400 foot long sewer flowing full. The WBMCI is not large enough to support a RTC.

Mr. Klingenstein noted that the Report indicates that there is a relief structure on the MCI where it crosses under the Mill Creek, and asked whether there is a CSO or SSO number associated with this relief point. MSD explained that electronic plans indicated this line was closed, but that MSD Operations staff provided physical verification of an active overflow. This

relief point has been accounted for and incorporated in the detailed model but does not have an assigned CSO number. USEPA noted this and would address it outside of this discussion.

Mr. Klingenstein noted that modifications to the West Ohio Interceptor were made to reverse flow, but that the SWM model was not capable of reflecting the actual size and slope of the modified pipe, the original model represented the status of the pipe prior to the modification. Mr. Klingenstein asked whether the updated model reflects the modified slope and size of the West Ohio Interceptor are reflected in the updated model. XCG affirmed that the changes to the slope and diameter of the West Ohio Interceptor are reflected in the updated model.

Mr. Klingenstein noted that the Report discusses the creation of a consolidated model that allows substantially shorter run times and allows multiple/iterative model runs in support of the LMC alternatives analysis. Mr. Klingenstein asked whether a detailed comparison of the results of the original full Version 3.2 and consolidated Version 3.2 are available. MSD stated that a table of those results is available and will be provided for discussion on Thursday.

Mr. Klingenstein asked whether the full version of the model Version 3.2 was used in MSD's comparison of flooded manhole and surcharge manhole predictions versus the version of the model used to complete the Capacity Assurance Program Plan in November 2005. XCG affirmed the results of comparisons of flooded manhole and surcharged manhole predictions were based upon the detailed model version. Mr. Edwards noted if the consolidated model were the basis, several manholes would not have been included in the results.

Mr. Klingenstein commented that language in Section 6.1 appears to indicate that the RTC operational rules described therein are for future operations and may not be the current versions. Mr. Klingenstein asked for confirmation that the rules used currently govern operations at the actual RTC facilities. XCG affirmed that all of the described SWM RTC operation rules are the operational rules that currently govern operations at the actual RTC facilities.

Mr. Klingenstein noted that the Report indicates that installation of the inflatable dam at CSO 125 increased overflows from the CSO, but that the total volume of overflow from CSO 125 and the West Fork Interceptor have been reduced. Mr. Klingenstein asked whether a map or schematic was available to clarify where the overflows have been reduced as well as the West Fork grates that have been modified. MSD confirmed that it will provide a schematic showing where on the interceptor overflows associated with CSO 125 have been reduced.

Mr. Klingenstein asked whether a schematic or detail drawing was available to help understand the operation of the modifications to the CSO 111 Springlawn Grate. Mr. Lyon explained the CSO 111 Springlawn Grating modifications consisted of a rubber flap bolted over the top of the

54-inch culvert. The grating has been sealed and the flap does not open. Although no further discussion is required, Mr. Lyon will provide a drawing to illustrate operation of the flap.

Mr. Klingenstein asked whether progress reports are available for incomplete projects included in model Version 4.2. MSD will provide a progress report for these projects for discussion on Thursday.

Mr. Klingenstein commented that Tables 11-17 are not presented sequentially in the report and noted that there is not a reference for the inter event period for 2009 in Table 10. MSD affirmed that In Table 10 the Inter-event Period for 2009 was 6 hours.

Mr. Klingenstein commented that he did not receive Appendices A-E in the version of the Report he received, and therefore he did not review them. MSD explained that appendices A-C of the LMC-SA System Wide Model Restructuring Report were uploaded onto the FTP as separate files in the July 25th folder. Appendices D-E were attached to the version of the report in the July 25th folder.

Technical Discussion – LMCPR Modeling
August 6, 2012; 11am EST – 12:15 EST
Meeting Notes

FOLLOW-UP TOPICS

MSD will provide the additional information to USEPA which will be discussed during the August 9h conference call.

1. A tabular summary of "before" and "final" model results based on adjustments made to the hydrologic and hydraulic parameters during calibration.

2. Revised flow monitoring locations map; illustrate both the overall boundaries of the Mill Creek sewershed, and those of the areas tributary to each flow meter.

3. Storm event/selection process to validate model

4. Underflow gate at CSO 482

5. A tabular summary comparing the consolidated and detailed model version 3.2 results.

6. A schematic showing where on the interceptor overflows associated with CSO 125 have been reduced

7. Progress reports for each project not yet completed that was included in Version 4.2 of the model.

Technical Discussion – LMCPR Modeling
August 9, 2012; 11am EST – 12:25 EST
Meeting Notes

Conference Call Attendees & Participants	
Barbara VanTil, USEPA Region 5	Geoff Edwards, XCG
Sudhir V. Desai, USEPA Region 5	Carol Hufnagel, Tetra Tech
Mark Klingenstein, USEPA Region 5/SAIC	Blake Roe, Hamilton County Monitor
Bob Newport, USEPA Region 5	Mark Norman, Vorys, Sater, Seymour & Pease LLP
Bonnie Buthker, Ohio EPA	Jeff Proctor, Hamilton County Monitor
Marianne Piekowski, Ohio EPA	Joe Graf, Hamilton County Monitor
Mike Proffitt, Ohio EPA	Brandon Vatter, Hamilton County Monitor
Jason Heath, ORSANCO	Karen Ball, Hamilton County
Tony Parrott, MSDGC	Colleen McCafferty, Hamilton County Prosecutor
MaryLynn Lodor, MSDGC	Charles Anness, Hamilton County Prosecutor
Tom Lyon, MSDGC	Lou McMahon, McMahon DeGulis
Leisha Pica, MSDGC	Erica Spitzig, MSDGC/McMahon DeGulis

The purpose of the meeting was to discuss USEPA questions regarding MSDGC's Lower Mill Creek Partial Remedy System Wide Model Validation Report, February 24, 2012, and MSDGC's LMC-SA System Wide Model Restructuring Version 3.2, Version 4.1.0 and Version 4.2, June 1, 2012. Below is a summary of the discussion.

Mr. Parrott opened the meeting reaffirming MSD's desire to focus on technical issues that need to be resolved. The primary purpose of today's meeting is to work through technical issues so MSD can move forward with finalizing public input and preparing the alternative to be submitted by the Co-Defendants.

1. **Comments on Meeting Summary from August 6th**

Ms. Lodor asked if anyone has comments regarding the meeting notes summarizing the August 6, 2012 conference call. Mr. Desai indicated EPA would provide MSD comments next week. Mr. Klingenstein said based on a quick look he has no comments, but will forward any comments to Mr. Desai. Ms. Buthker said OEPA has no comments and is looking forward to follow-up discussions today. Mr. Heath will provide any comments regarding the meeting notes to Mr. Desai.

2. **Follow-up Topics from the August 6th Meeting**

The follow-up items for discussion at this meeting were listed in the Meeting Notes from August 6th. Ms. Buthker requested MSD walk through the attachments. Mr. Proctor indicated the County does not have access to the FTP site. Ms. Lodor said she emailed everyone all attachments, except the flow monitoring location maps, which will be provided.

Technical Discussion – LMCPR Modeling
August 9, 2012; 11am EST – 12:25 EST
Meeting Notes

Agenda Item III.a.1 – A tabular summary of "before" and "final" model results based on adjustments made to the hydrologic and hydraulic parameters during calibration.

Mr. Klingenstein said the tabular summary was generally what he was seeking. He will review the model changes noted in the table in detail and request clarification as needed. Mr. Lyon clarified model version 1 is not applicable to this discussion as it represents a coordination effort between MSD and XCG and does not represent substantive changes for the updated system wide model.

Agenda Item III.a.2 – Revised flow monitoring location map; illustrate both the overall boundaries of the Mill Creek sewershed, and those of the areas tributary to each flow meter.

MSD provided maps that indicate the drainage areas that flow to each monitoring location. Approximately 30 maps have been generated to-date and 40 are expected in total. Mr. Klingenstein asked for the total acreage of the Lower Mill Creek. Ms. Lodor indicated approximately 40,000 acres and said MSD will follow-up with the acreage included in the model. Mr. Klingenstein indicated one of the maps has an error in that it references "72,800 acres".

Agenda Item III.a.3 – Storm event/selection process to validate model

Mr. Lyon explained this summary was put together in response to Mr. Klingenstein's question regarding storm selection. Mr. Lyon explained storm events comprised of at least a half-inch of rainfall were matched with time periods which MSD had good flow monitoring data. Storms occurring during time periods of high river stage, snow cover, or snow melt were excluded in that they are not simulated by the model.

Mr. Klingenstein emphasized he would like to better understand how individual storms were selected for individual meters. He indicated this response did not completely clarify this issue. Mr. Edwards referred Mr. Klingenstein to the specific details included in Appendix F of the June 2012 *LMC-SA System Wide Model Restructuring Version 3.2, Version 4.1.0 and Version 4.2 Report.* This report provides details regarding the specific storm selection criteria used as well as individual flow monitoring sites. Mr. Edwards indicated the data from 2006 through 2008 was used for the permanent flow monitors installed along the interceptors. The 2009 data was held in reserve as the validation set. The data from 2010 and 2011 was used for the flow monitors located at specific CSOs. Mr. Lyon added that the four flow monitoring locations listed in the first row of Table 1 of the response presented for this agenda item were installed in 2010 in conjunction with the default tunnel project. The flow meters for the five flow monitors listed in the second row of the table were installed in 2011 in conjunction with select sustainable infrastructure projects. Mr. Klingenstein indicated he would review the information contained in the report appendices and would access these files from the FTP site. MSD offered to email Mr. Klingenstein Appendix F following the call. Ms. Buthker confirmed the report version she received contained Appendix F.

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Mr. Klingenstein requested MSD discuss Table 2 of the response presented for this agenda item. Mr. Edwards indicated XCG is updating Table 2 to include all the flow monitoring sites to consolidate information from multiple locations and better facilitate Mr. Klingenstein's review. Mr. Klingenstein asked for clarification that the storms used at each location achieved WaPUG criteria. Mr. Lyon said the criteria were a portion of the validation and MSD also used hydrographs and average validation results to compare the data for acceptability.

Ms. Lodor asked if there were any other questions related to this important issue. She reiterated MSD wants to be in agreement with EPA as they move forward with the refined model and upcoming public meetings. She asked if the information presented appears to answer USEPA's questions. Mr. Klingenstein responded that it appears we are heading down right path but he would review the information in more detail.

Ms. Lodor asked whether anyone has any sub-topics needing more information. Mr. Klingenstein responded he was hoping to see a comparison of available storms to utilized storms. He would like to know what storms occurred during each time period having good flow monitoring data and the reasoning for excluding storm events. For example, in 2010 what were all the storm events available for the time period and why did MSD use the storms selected. Why were other storms dropped off from consideration? Mr. Edwards answered all storms were used unless flow meter data was not available. If velocity or depth dropped out from flow meter data, then those storms were not used. The model team did not look at data in light of what the model would end up predicting.

Mr. Newport asked for clarification that if the data set from one storm was incomplete, then it was excluded from consideration at the site. Mr. Edwards said yes. Mr. Klingenstein said he wanted clarification regarding specific criteria of data that eliminated storm events. For example, if five minutes of data were unusable, was entire storm eliminated? Mr. Edwards responded that storm events were only discarded when depth or velocity dropped off for longer periods of time. If data from a few five minute time steps were suspect or missing, then the storm was still used. However, if data from 1.5 hours of a two hours storm was not useable, then the storm was eliminated from consideration. Ms. Buthker stated Ohio EPA has looked at the data included in Appendix F and has no questions. Ms. Lodor indicated this item will be placed on the agenda for next week's meeting.

Agenda Item III.a.4 – Underflow gate at CSO 482

Ms. Lodor explained the ODOT contractor cut the telemetry lines serving the RTC facility at CSO 482. This action required the entire RTC to be taken out of service. Mr. Klingenstein asked for clarification regarding the last sentence in the response provided for this agenda item. Ms. Lodor explained the situation will be corrected as ODOT is finalizing the grading to get the telemetry back on line. Mr. Lyon noted MSD is not trying to simulate the temporary condition and the model reflects the way the RTC is intended to operate based on its performance when in operation and associated monitoring data

collected. Mr. Edwards verified the operating rules for RTC have been incorporated into the future conditions model (version 4.2).

Agenda Item III.a.5. – A tabular summary comparing the consolidated and detailed model version 3.2 results

Mr. Klingenstein said this summary is exactly what he wanted and he has no questions at this point. Ms. Buthker comments she is impressed with comparison of the detailed & consolidated models and how close they were in the predictions. Mr. Heath and Mr. Desai indicated they have no comments regarding this information.

Agenda Item III.a.6 – A schematic showing where on the interceptor overflow associated with CSO 125 have been reduced

Mr. Klingenstein asked Mr. Lyon to walk through the response provided for this agenda item. Mr. Lyon explained the text boxes reflect the overflow conditions before and after the grates in the West Fork Channel were raised. Before the gratings were raised, base flow from the channel would quickly fill up the interceptor and cause overflows. The grates were raised approximately one foot in order to keep base flow out of the system.

Mr. Lyon explained the Badgeley Run RTC consists of an inflatable dam that allows flow to be stored in the interceptor. After the RTC was constructed, MSD encountered situations when the dam had to be lowered prematurely because interceptor capacity was not available. This resulted with increased overflows at CSO 125. Mr. Lyon explained that by increasing the height of the grate walls previously flush to the channel floor, and sealing them in some places, the grates help reduce the volume of stream flow entering the combined system and free up interceptor capacity, and hence has resulted in much less overflow from the grates. The RTC at CSO 125 helps reduce overflow from the gratings. Mr. Lyon emphasized it is important to consider both volumes together as shown in a table at bottom of schematic.

Mr. Lyon pointed out the result of raising the gratings and constructing the RTC is an estimated 279 million gallons (MG) of overflow; which is a net reduction of 97 MG when the two improvements are considered together. Mr. Klingenstein asked how much of the reduction can be attributed to impounded flow associated with operation of an inflatable dam and how much of the benefit is from additional interceptor capacity. Mr. Lyon commented if unlimited interceptor capacity were available, significant overflow reduction would be realized due to storage behind the dam. Operation of the RTC allows more flow to be conveyed downstream of CSO 125 because the system receives less underflow originating from CSO 125.

Mr. Klingenstein asked if the dam were not installed, would the overflow reduction be a direct result of raising the grates. Mr. Lyon confirmed, yes, but the reduction would be relatively small because only one foot was added to the hydraulic grade line. Mr. Lyon noted raising the grates is more about

reserving dry weather flow capacity and reducing stream inflow to minimize overflows during small rain events. Mr. Klingenstein asked how overflow from the grates was historically reported. Mr. Lyon said previous modeling did not include those overflows and MSD does not have a means of measuring those overflows.

Mr. Newport asked Ms. Lodor to discuss the sustainable infrastructure solution for this area. Ms. Lodor explained the sustainable remedy involves sealing off the grates in the channel and disconnecting them from the sewer. A new interceptor sized for a 10-year storm event would be constructed along the side of the West Fork Channel extending from approximately CSO 130 to CSO 125. The existing interceptor downstream of CSO 125 can continue to be used in lieu of constructing a new sewer the entire length to the Auxiliary Mill Creek Interceptor. In addition to the new interceptor, separation projects in the vicinity of CSOs 130, 128, 127, 126, and 125 would reduce the volume of natural drainage entering the new sewer. She mentioned a naturalized channel could be constructed from CSO 130 to CSO 125, if funding partnership opportunities become available. Ms. Lodor stated these projects are some of the details MSD would like to discuss at next meeting. Mr. Newport indicated that it makes a lot of sense to remove clean water from the combined sewer system.

Mr. Klingenstein asked if MSD has observed changes in performance of CSOs resulting from changing the interceptor hydraulic grade line. Mr. Edwards explained the current model shows 2010 condition. The text boxes on schematic provided for this agenda item show reductions for a typical year. Mr. Klingenstein noted there are storm events now that aren't having overflows but might have overflowed before grates were raised. Mr. Edwards stated the Badgeley Run RTC does not create capacity in the interceptor but helps the system maximize capacity currently in place. He mentioned future storage will provide additional capacity. Ms. Lodor asked if the information provided helped EPA to better understand what is going on in this area. Mr. Klingenstein said yes, Ms. Buthker and Mr. Heath had no other comments to offer.

Agenda Item III.a.6B – Schematic for CSO 111

Mr. Klingenstein said the schematic made sense and is helpful.

Agenda III.a.7 – Progress reports

No additional comments were offered related to this discussion item.

Wrap-Up of discussion of Agenda Item III

Ms. Buthker asked how projects associated with the sustainable infrastructure alternative are included in the WWIP and whether the WWIP would need to be revised? She asked how this information would get captured in light of the legal agreement in place. Mr. Parrott noted this question falls in the legal realm outside the scope of this technical meeting. From a sustainable infrastructure alternative perspective, MSD will be providing a report to EPA that is focused on the projects, performance, and

volumes captured. Ms. Lodor explained the report will provide a technical summary of the components of the sustainable projects to assist with providing EPA a more detailed understanding and to facilitate dialogue for those issues.

Mr. Parrott said MSD understands based on today's conversation that Mr. Klingenstein needs to review the data provided in order to get his arms around the storm event selection issue. He explained MSD needs clarity from Mr. Klingenstein, Mr. Desai, Ms. Buthker, and Mr. Heath regarding any red-flag issues relative to the modeling that may impact MSD's ability to utilize data to develop an alternative for LMCPR. Since MSD is preparing to approach the public, quick feedback is needed on any red flag issues associated with the modeling - sooner than later. Mr. Klingenstein noted he understands MSD's position but he would caveat that he is not a Regulator and is simply an advisor to the Regulators.

Mr. Newport asked if it would it be fair to say "so far EPA hasn't seen anything to suggest values are an order of magnitude wrong". Mr. Klingenstein agreed that the issues being addressed are related to the changes contemplated by the Consent Decree and WWIP. He furthered, from due diligence standpoint; EPA wants to verify adequate documentation is in place to back-up the Co-Defendants' decision. Mr. Klingenstein said he "hasn't seen anything to suggest the ship is heading for the rocks".

Mr. Parrott requested Mr. Newport and Mr. Klingenstein share with Ms. VanTil that a public Town Hall meeting is scheduled for next Thursday. He reiterated that if there are any red flags, we need to know as soon as possible to properly prepare for the public. Mr. Newport verified no ship wreck is pending. Ms. Buthker said Ohio EPA is of the same opinion. Ms. Lodor encouraged all parties to maintain good dialogue and coordination moving forward in the process. Specifically with respect to the modeling, MSD is hopeful they are providing clarity and adequate documentation to satisfy the due diligence efforts.

Mr. Parrott noted the public feedback period will be active through Labor Day. Mr. Desai requested to be kept informed of meeting dates. Ms. Lodor indicated a court stenographer will record all feedback and comments received at the public meetings. Additionally, comments can also be submitted on-line. Ms. Lodor said a summary of all public meetings is anticipated to be available no later than September 15th.

Agenda Item IV

Ms. Lodor presented a table developed in response to a question posed by Mr. Pritchard at the July 26th Workshop regarding the default project. Mr. Klingenstein asked for a quick clarification –does the 410 MG shown on the table include the grate overflows? Mr. Lyon said the 410 MG model does not include the grate overflows, but the 282 MG model includes the combined effect of the CSO 125 RTC and raising the grates. In the previous model, the boundary conditions were different at Badgeley Run and they assumed more sewer capacity was available. Mr. Klingenstein asked if the 282 MG includes overflows from the gratings. Mr. Lyon directed him to the map provided under Agenda Item III.a.6 which indicates 91 MG overflowing from the gratings. Mr. Klingenstein noted that makes sense.

Technical Discussion – LMCPR Modeling
August 9, 2012; 11am EST – 12:25 EST
Meeting Notes

3. Next Steps

Ms. Lodor indicated the agenda for next week's meeting will including 1) finalizing the storm selection criteria discussion, 2) conclusion of issues associated with the refined model, and 3) discussion of the technical details of the sustainable alternative.

Ms. Buthker said she understands EPA is still working out the modeling details, but a discussion was initiated at the July 26th meeting regarding the 2BG CSO reduction goal vs. revised model equivalent goal. She asked at what point will this discussion move forward for resolution? Mr. Parrott said from MSD's perspective, we want to be sure everyone understands how we got to this place. That topic needs to be handled by the legal teams in lieu of the technical team. Ms. Lodor indicated the legal teams are scheduled to meet next week.

Mr. Newport noted that as we switch from model discussion to sustainable alternative discussion, he would like to have conceptual discussions regarding how issues such as downspout disconnections would be handled in the model. Ms. Lodor explained at this point, MSD does not capture reduction associated with downspout disconnections in the modeling assumptions.

All parties agreed the next conference call would be scheduled for August 16th beginning at 11:00 am. Mr. Desai noted EPA will be having internal discussions prior to the meeting on August 16th. Mr. Parrott thanked everyone for their participation and concluded the meeting.

Agenda items for August 16th

1. Wrap up the storm selection criteria discussion
2. Conclusion of issues associated with the refined model 3.2
3. Provide MSD with questions or clarifications on the technical details of the sustainable alternative

Technical Discussion – LMCPR Modeling
August 23, 2012; 11:00am EST – 12:00 EST
Meeting Notes

REISSUED

Conference Call Attendees & Participants	
Barbara VanTil, USEPA Region 5	Leisha Pica, MSDGC
Jonathan Moody, USEPA Region 5	Geoff Edwards, XCG
Mark Klingenstein, USEPA Region 5/SAIC	Carol Hufnagel, Tetra Tech
Leslie Allen, DOJ	Sue Pressman, Malcolm Pirnie
Bonnie Buthker, Ohio EPA	Gunilla Goulding, Malcolm Pirnie
Marianne Piekutowski, Ohio EPA	Blake Roe, Hamilton County Monitor
Joshua Jackson, Ohio EPA	Mark Norman, Vorys, Sater, Seymour & Pease LLP
Jason Heath, ORSANCO	Brandon Vatter, Hamilton County Monitor
Tony Parrott, MSDGC	Karen Ball, Hamilton County
MaryLynn Lodor, MSDGC	Erica Spitzig, MSDGC/McMahon DeGulis
Tom Lyon, MSDGC	

The purpose of the meeting was to discuss USEPA questions regarding MSDGC's Lower Mill Creek Partial Remedy System Wide Model Validation Report, February 24, 2012; MSDGC's LMC-SA System Wide Model Restructuring Version 3.2, Version 4.1.0 and Version 4.2, June 1, 2012; MSDGC's Working Draft Sustainable Projects Technical Memo, Lower Mill Creek Partial Remedy; and the USEPA Guidance Pertaining to Consideration of Any Proposed Revised Original Lower Mill Creek Partial Remedy Defendants May Choose to Submit in Accordance with Paragraph A.2 of the Wet Weather Improvement Program, October 11, 2011. Below is a summary of the discussion.

1. **Town Hall Meeting Wrap-up Discussion/Feedback, etc.**

Ms. Lodor indicated a Town Hall meeting was held last Thursday evening during which MSD provided a presentation of the LMCPR Preliminary Findings. She noted Ms. Piekutowski and Mr. Jackson of Ohio EPA attended the meeting. Ms. Lodor noted approximately 125 people attended the meeting, ten speakers provided comments, and 25 people submitted an exit survey. A court stenographer recorded comments as they were made. A public feedback report will be compiled to include information received during tonight's meeting and is anticipated to be complete September 15th. Mr. Vatter requested a copy of the presentation. Ms. Lodor indicated copy was provided to the County via Mr. Aluotto.

2. **Comments on Meeting Summaries from August 16th and August 9th**

Ms. VanTil asked if anyone has comments regarding the meeting notes summarizing the August 9, 2012 and August 16, 2012 conference calls. Mr. VanTil indicated USEPA has no comments. Ms. Buthker said OEPA did not have any comments.

Technical Discussion – LMCPR Modeling
August 23, 2012; 11:00am EST – 12:00 EST
Meeting Notes

REISSUED

3. Follow up on approach for Sub-basin models (uploaded to FTP August 21, 2012)

Ms. Lodor noted MSD will add clarity to the working document as indicated last week. The model reports for the mini-models have been uploaded to the FTP site. These reports may also provide some of the requested clarity. Mr. Klingenstein said he reviewed the modeling information posted to the FTP site. He said the information provided is helpful in particular for the documentation of the calibration process for the mini-models. The information varies with the documents, which is not surprising. Some reports are CSO specific. One document, West Fork Branch, provided a substantial discussion of the changes made during model development and calibration of mini-model. This report provided the information USEPA was looking for with respect to documentation of the system-wide model (SWM) and mini-model coordination. He noted little information was provided in the CSO 10 and CSO 483 reports. The Bloody Run report focused more on strategic separation and did not focus on the mini-model. Mr. Lyon pointed out the Bloody Run report included a technical memo in an Appendix that discussed model calibration. Mr. Klingenstein said Appendices A and B compare the model results and parameters; with an emphasis on model validation including sewer cross sections and degree of surcharge, hydrographs, detailed information on how strategic separation was included in the model. He did not find a technical memo in the Appendices. Mr. Lyon said MSD will verify all information was provided.

Ms. Lodor mentioned MSD did not receive a list of clarifications prior to today's meeting as discussed during last week's conference call. Mr. Klingenstein explained that rather than prepare such a list, he had reviewed the documents to determine if all his documentation needs were addressed with the recently provided reports. Ms. VanTil responded USEPA can provide comments. She asked Mr. Klingenstein to identify issues that need to be resolved.

Mr. Klingenstein indicated remaining items need to be further documented for due-diligence of the model evaluation and calibration of the mini-models. He said model version 3.2 has been sufficiently documented. However, he noted follow-up is likely to be needed for additional documentation for the mini-models. Ms. VanTil asked Mr. Klingenstein if he would create a list of items to be addressed to complete the documentation needs. For example the report regarding model version 3.2 need to have the table headings corrected. Mr. Klingenstein said the West Fork model report is well documented. Other mini-models will likely need to provide information similar, but potentially at less detail, than provided in the West Fork report.

Mr. Parrott indicated the meeting minutes from last week stated USEPA would provide any remaining questions or clarifications relative to model version 3.2 by August 20th. Since MSD has not received any additional clarification requests, he asked if the assumption was "we are ready to cross the bridge with respect to model version 3.2". Mr. Klingenstein said he has no additional clarifications for version 3.2 than what has already been discussed. He would like to develop a complete list of all items preferred. Ms. VanTil said USEPA does not have any concerns regarding the model itself. They will provide a list of

documentation to make sure the model changes are sufficiently noted. Mr. Parrott said MSD needs clarity from USEPA on what needs to be done with headers, labeling, and the specifics needed for clarity of the mini-models. Mr. Klingenstein said all issues have been discussed and at this point, all he needs to do is finalize a list of clean-up issues.

Mr. Parrott asked if as a group, we are crossing the bridge to get to specific issues of clarity needed for the mini-models. If yes, do we want to continue the discussion or would USEPA prefer to provide a request in writing to assist MSD with verifying all necessary information has been provided. Mr. Klingenstein said additional discussion is not necessary. He said was good with regard to the specifics provided on the model USEPA needs to request specifics with respect their need for full documentation. Mr. Parrott indicated MSD is here to assist USEPA and we need specifics to finalize. Mr. Klingenstein agreed and said he will make specific references to information provided to USEPA. He said MSD can expect this request to be submitted on August 24th.

Ms. VanTil asked if there is anything else that needs to be discussed today regarding the mini-models. Mr. Parrott said MSD is here to hear your comments and provide feedback. Ms. VanTil said at this point USEPA needs to provide the written request so MSD can finalize the documentation.

4. **Discussion on criteria for alternative evaluation by Regulators**

Ms. Lodor said the intent for putting this item on today's agenda was to talk about the information MSD is gathering and may submit for consideration of an alternative. MSD continues to utilize the USEPA draft guidance document as a basis for its submittal. She noted the model issues were the first item identified in the draft guidance criteria. She confirmed MSD will be receiving information on the clarity to resolve Item 1 of the draft guidance document.

Ms. VanTil said the intention of the draft guidance document was to provide MSD with clear expectations. She noted MSD has clearly been using the guidance. Mr. Parrott asked if, based upon the draft guidance provided, there are any additional items that need to be included as part of the consideration. MSD would like to get clarity now as they are working through all the technical issues which will ultimately lead to a recommendation to be made to policy makers. Ms. VanTil agreed and noted so far the discussion has focused on Item 1.

Mr. Parrott said with respect to Item 2, are any directional changes needed. Ms., Lodor noted the working draft sustainable projects technical memo, which was shared last week, includes a summary of the components included in the sub-basins. That technical memo provides some light on the technologies. She said other reports have been uploaded and provide more detailed information as compiled from the design consultants. MSD is prepared to begin providing USEPA with additional information but asks for clarity that the draft guidance document remains the appropriate benchmark.

Technical Discussion – LMCPR Modeling
August 23, 2012; 11:00am EST – 12:00 EST
Meeting Notes

REISSUED

Ms. VanTil said the draft guidance criteria are the basis for consideration. She asked if the design documents have already been uploaded or whether they are referenced/included in the working draft sustainable projects technical memo. Ms. Lodor said the technical memo provides the information. Additional information will be uploaded as we move forward with discussions. Ms. VanTil agreed and said USEPA will want to review costs and issues listed. She noted MSD is in a good position and remains on track to meet USEPA expectations. Mr. Klingenstein said with respect to Item 1, in terms of how the modeling is being utilized for a sustainable solution, the information provided to-date is more easily addressed with the sustainable projects and technologies proposed. When projects are located on private property, predicting their performance is difficult because those making the assumptions do not have control over the project. Ms. Lodor said MSD wants clarity on that issue, in particular the assumptions made for the sub-basin models.

Ms. Allen asked if the cost proposal referenced in Item 2B, refers to the estimated cost of the project, and stated DOJ will definitely need to understand the cost estimates, particularly if the costs are approaching the benchmarks for time extensions. Ms. VanTil answered the costs for implementation need to be provided. Ms. VanTil asked if MSD would be submitting project level cost information. Mr. Parrott responded MSD's intent is to provide all needed information. He noted a parallel discussion is on-going with the legal team with respect to the volume issue. He emphasized we need a coordinated effort to ensure relevant information is provided on specific projects. In the near term, MSD can provide cost information as presented at the July 26th Technical Workshop, with the caveat that this information as developed was based on the volumetric goal for the purposes of the LMC Study of 2 billion gallons. Ms. VanTil said since much of the original LMCPR revolves around the grey project, USEPA would like to see more detailed cost data. In particular information that documents the change in cost from the original concept to the current estimates is requested. She said any information that can help with determining how to get to an endpoint would be useful to USEPA. Mr. Parrott agreed that MSD will provide this information, but with the caveat that the information was developed for the LMC Study of a 2 billion gallon remedy and does not represent an offer. Ms. Van Til confirmed EPA understands of MSD's caveat and that EPA would not view the information as an offer.

Mr. Klingenstein asked if the cost values presented on page 37 of the Town Hall presentation were based upon the 2 billion gallon reduction. Mr. Parrott responded, yes those costs were based upon achieving a 2 BG reduction. Ms. VanTil asked if there are any other questions with respect to the alternative. Ms. Lodor said not from MSD. Ms. VanTil asked for the cost data and emphasized USEPA understands 2 billion gallons is not an offer.

Mr. Parrott noted MSD is hosting another Town Hall meeting tonight. As soon as preliminary feedback is available, MSD will provide it to USEPA. Any information needed from the Town Hall presentation or the July 26th presentation can be requested of MSD and they will provide a quick-turnaround.

Technical Discussion – LMCPR Modeling
August 23, 2012; 11:00am EST – 12:00 EST
Meeting Notes

REISSUED

Ms. VanTil said USEPA would like MSD to consider reaching out to the Sierra Club, given the changes that have occurred with the model. She noted statements in the press indicate the Sierra Club does not know where MSD is at with the LMCPR. She suggested MSD consider the appropriate time to approach Sierra Club. Mr. Parrott noted MSD has received information requests from Sierra Club and has provided documents and responses. Additional questions were received from Sierra Club after last week's Town Hall meeting. MSD will continue to dialogue with Sierra Club and respond to their questions. Mr. Parrott said Sierra Club has had more access to information than any other external stakeholder. Ms. VanTil was encouraged that good discussions were on-going between MSD and Sierra Club. Ms. VanTil said since model changes are foundation of decision making, MSD might want to discuss them with Sierra Club.

Ms. Buthker requested MSD copy the Regulators on responses sent to the Sierra Club. She wants to make sure everyone has the same understanding regarding questions asked.

5. **Action Items**

MSD:

1. Verify all Bloody Run model information has been provided to the Regulators for review.
2. Provide existing cost data for grey solution as presented at July 26th meeting noted for the context of a 2 BG analysis. Same cost data but different suite of projects likely to be submitted in the future.
3. Provide Regulators with responses that MSD provided to Sierra Club questions.

USEPA:

1. Submit a request for clarification of documentation via email for model Version 3.2
2. Submit a request for documentation needed for the mini-models
3. Review grey cost information from the context of understanding a 2 billion gallon CSO reduction is not an offer.

6. **Discussion Conclusion**

Ms. Buthker had one additional comment on Section 4.2 of the Working Draft Sustainable Projects Technical Memo. She noted the text is confusing as written. She understands that two sustainable alternatives were developed. Max 1 Sustainable Alternative would be pre-2018 and max sustainable plus would be post-2018. Were the references to 79% and 75% control from the model before changes were made?

Technical Discussion – LMCPR Modeling
August 23, 2012; 11:00am EST – 12:00 EST
Meeting Notes

REISSUED

Ms. Lodor indicated that understanding is not correct. Ms. Pressman clarified that the detail in Table 4-24 includes the six candidate areas and the results were from the System-Wide Model (SWM). The results are not output from the sub-basin models (mini-models). The model runs were called Max Sustainabile and Max Plus. The sub-total at bottom of the Table 4.24, notes 88% control. This is inclusive of the six watersheds only.

The Phase 1 Max includes all six basins of interest, the 75% control represents the percent control of the entire Lower Mill Creek watershed with those six candidates implemented (level of control at the WWTP). This would include the other CSOs controlled at lower levels. Ms. Buthker said this clarifies the information. Mr. Klingenstein said USEPA will include this issue on this list of comments.

Mr. Parrott requested any additional feedback from Mr. Newport be submitted in writing to MSD also.

Next Meeting will be August 30, 2012 at 11am.

Technical Discussion – LMCPR Modeling
August 30, 2012; 11:00am EST – 12:00 EST
Meeting Notes

Conference Call Attendees & Participants	
Barbara VanTil, USEPA Region 5	Geoff Edwards, XCG
Sudir Desai, USEPA Region 5	Carol Hufnagel, Tetra Tech
John Grosshans, USEPA Region 5	Sue Pressman, Malcolm Pirnie
Bob Newport, USEPA Region 5	Gunilla Goulding, Malcolm Pirnie
Gary Pritchard, USEPA Region 5	Blake Roe, Hamilton County Monitor
Mark Klingenstein, USEPA Region 5/SAIC	Ted Boggs, Vorys, Sater, Seymour & Pease LLP
Bonnie Buthker, Ohio EPA	Jeff Proctor, Hamilton County Monitor
Marianne Piekowski, Ohio EPA	Joe Graf, Hamilton County Monitor
Tony Parrott, MSDGC	Karen Ball, Hamilton County
MaryLynn Lodor, MSDGC	Erica Spitzig, MSDGC/McMahon DeGulis
Tom Lyon, MSDGC	Charles Anness, Hamilton County Prosecutor
Leisha Pica, MSDGC	Colleen McCafferty, Hamilton County Prosecutor

The purpose of the meeting was to discuss USEPA questions regarding MSDGC's Lower Mill Creek Partial Remedy System Wide Model Validation Report, February 24, 2012; MSDGC's LMC-SA System Wide Model Restructuring Version 3.2, Version 4.1.0 and Version 4.2, June 1, 2012; MSDGC's Working Draft Sustainable Projects Technical Memo, Lower Mill Creek Partial Remedy; and the USEPA Guidance Pertaining to Consideration of Any Proposed Revised Original Lower Mill Creek Partial Remedy Defendants May Choose to Submit in Accordance with Paragraph A.2 of the Wet Weather Improvement Program, October 11, 2011. Below is a summary of the discussion.

1. **Comments on Meeting Summaries from August 23rd**

Ms. VanTil asked if anyone has comments regarding the meeting notes summarizing the August 23rd conference call. Ms. VanTil indicated USEPA has no comments. Ms. Buthker said OEPA has no comments. Mr. Klingenstein had two comments for clarification. On the bottom of page 2, he noted the intent of the "no clarifications" statement was in reference to USEPA having no further additional clarifications for version 3.2 than what has already been discussed. Similarly the statement on the first paragraph on the top of page 3 regarding "MSD has a good model and USEPA needs to request specifics" he clarified, USEPA needs to request specifics with respect their need for full documentation. MSD will revise and reissue the August 23rd meeting minutes.

2. **Continued resolution on modeling discussion from Regulator questions**

Ms. VanTil said USEPA provided MSD model-related comments and questions on August 24th. She noted MSD provided responses August 29th and August 30th. Since USEPA has not had time to review the information, she asked MSD to walk-through the comments. Ms. Lodor said MSD is ready to discuss the responses.

Technical Discussion – LMCPR Modeling
August 30, 2012; 11:00am EST – 12:00 EST
Meeting Notes

Questions and Comments regarding the "Lower Mill Creek Partial Remedy System Wide Model Validation Report" & "LMC-SA System Wide Model Restructuring Version 3.2, Version 4.0.10 and Version 4.2"

1. MSD should provide detailed rainfall data. Ms. Lodor stated MSD will need several weeks to pull together the comprehensive rainfall data as requested. Ms. VanTil said that approach is fine.

2. Revise Appendix A headings. Ms. Lodor said MSD will revise the headings as noted.

3. Discussion of changes listed in Appendix A. Ms. Lodor noted that MSD provided in response a summary memo, summary table, and glossary of terms. She asked USEPA to review the information and let MSD know if this satisfies the request. Ms. VanTil agreed USEPA will review and noted she does not anticipate needing further information.

4. Confirm flow monitoring locations. Ms. VanTil asked MSD to specify which email and document includes the provided information. Ms. Lodor noted the information was provided in the August 29th 6pm email and the document is titled "SI sub-basin calibration meters table". Ms. Goulding explained the table lists the meters used for the recent changes and the meters located upstream of CSOs in the mini-models. Ms. Lodor asked USEPA to review the information and let MSD know if this satisfies the request. Ms. VanTil agreed USEPA will review and noted she does not anticipate needing further information.

Questions and Comments regarding the "Lick Run Calibration Validation Report"

1. Ms. Lodor said that MSD provided responses for the questions posed regarding the Lick Run Calibration Validation Report. She said MSD provided all information in the report and the quoted text was part of a full discussion on the Lick Run Calibration/Validation Report. She said that MSD in providing this full analysis, also provided the limitations of the data sets available for calibration and validation. In particular, MSD feels that monitoring sites have resulted in challenges that MSD is poised to address through an updated and soon to be deployed flow monitoring plan – some of the challenges encountered include the high flows and velocities as well as sediment deposition.

2. Flow Monitoring Plan. Ms. Lodor explained that MSD provided a summary of steps they intend to take to develop a more robust data set that is reflective of field conditions and addresses limitations, in a corresponding attachment "Lick Run Flow Monitoring Map" provided in the August 29th 6pm email. Mr. Edwards noted a map was provided showing the locations of flow monitoring sites. He indicated the red shapes represent the sites identified from the model with

pipes of reasonable size having velocities not exceeding 12 feet per second. MSD staff have field verified the locations of the manholes to determine if crews can safely access the sites. The green shapes represent the locations MSD staff field verified as appropriate locations for flow monitors. Mr. Edwards said MSD is making progress on the flow monitoring site selection for the Lick Run Basin. If this plan is approved, MSD will move forward with installing the units and collecting data. He noted that MSD cannot guarantee the storm events that will be available. Ms. VanTil said USEPA will review the information. She acknowledged the level of effort by MSD to assemble the information in a timely manner. Mr. Newport said the logic MSD is using based on the description provided to identify the flow monitoring locations make sense. Mr. Parrott said MSD is prepared to move forward with the monitoring plan and confident the approach makes sense from an engineering perspective. He noted that as MSD spends time and resources, we want to be sure information useful for sizing facilities is obtained. Ms. VanTil said she understands MSD's end goal and recognizes the need to resolve these issues so MSD can move forward. Ms. Lodor noted data collected will serve both the pre- and post-construction monitoring plans.

3. Debris buildup on CSO 5 underflow grate. Mr. Edwards explained when the Lick Run RTC was constructed a bar screen was installed to protect the unit. He said an average entry loss coefficient of 3.2 was developed to simulate how flow would get from the RTC into the interceptor. Mr. Edwards discussed how XCG performed sensitivity testing to verify an average coefficient of 3.2 was appropriate. The testing resulted with similar results and verified the value was appropriate to use. Mr. Klingenstein asked if the underflow is metered. Mr. Edwards said MSD tried to meter the underflow, but pooling of water makes it difficult to collect data. He noted water can stack up rather high with the 20-foot pipe for longer periods of time. Mr. Klingenstein asked if direct data was used or whether various storms were used to calibrate the model. Mr. Edwards responded some direct data and level data were available.

5. Comments 4 & 5. Ms. Lodor said additional information was provided to respond to these clarifications which should be fairly straight forward. She asked USEPA to review the response and let MSD know if this satisfies the request. Ms. VanTil agreed USEPA will review and but noted the holiday weekend may not provide adequate time for review of all information before the next conference call. Mr. Newport said USEPA would provide some feedback on responses provided by MSD on August 30th during next week's call.

Questions and Comments regarding the "Working Draft: Sustainable Projects Technical Memorandum – Lower Mill Creek Partial Remedy Study"

Ms. Lodor said MSD will incorporate responses to USEPA and Ohio EPA comments into the next version of the document.

4. Burnet Woods Park. Ms. Lodor said MSD provided a response to Comment 4 regarding Burnet Woods Park in the August 30th 10 am email in a document called "Working Draft Sustainable Tech Memo Questions, Clarifications & Responses." She explained the Burnet Woods Project is a potential Enabled Impact Project being coordinated with the City of Cincinnati Parks Board. The project includes daylighting and detention components to reduce or detain flow from entering the combined sewer. She said this project is an opportunity to integrate a larger scale green infrastructure project into a sustainable infrastructure solution. She emphasized that this project could provide benefits of CSO reduction, it is not included in the "max sustainable alternative" presented in the reports and technical memorandum previously provided. If constructed, the project could provide additional benefits beyond those presented in the SI Tech Memo.
5. Detailed mini-model calibration information. Ms. Lodor said MSD's response to this comment provided specific page numbers to refer USEPA and Ohio EPA to documents previously provided. Ms. VanTil appreciated the references given the volume of information to review.

Questions and Comments regarding the Mini-Model reports – "West Fork Branch Model Update – Calibration and Characterization – Final Report"

Ms. Lodor said MSD needs several weeks to assemble the information. She clarified the information is available but resides in different locations. MSD will work with the sub-basin design teams to pull the information together. Ms. VanTil said that approach is fine.

Ms. Lodor said these items will be put on the agenda for a future meeting. Mr. Newport expressed appreciation for the homework and MSD's level of effort to provide the responses prior to this meeting.

3. **Sierra Club Responses Forwarded – confirm receipt**

Ms. Lodor said MSD forwarded the Regulators its responses to questions received from the Sierra Club on August 16th and 17th. The information was provided via email the morning of August 30th. She noted these responses were provided in full to USEPA. All information was consolidated into one email which included several emails and follow-up responses. She noted MSD has a meeting scheduled with the Sierra Club on Friday, September 7th. Mr. Newport said the Regulators will notify MSD of clarifications or comments prior to next week's conference call. Mr. Newport clarified the intent is for the Regulators and MSD to have a shared understanding of each party's position with respect to the Sierra Club's questions. Ms. VanTil said comments regarding the Sierra Club's questions and MSD's responses are a higher priority for USEPA since a meeting is scheduled for next week. Ms. Buthker said OEPA would indicate their response to the questions also. Ms. VanTil clarified any comments are provided will be in context of consistent messaging. She furthered that USEPA does not have objection – but is not endorsing MSD's responses. Ms. VanTil said comments from USEPA and Ohio EPA will be consolidated

into one document and provided to MSD preferably by the close of business, September 5th to allow this topic to be on the agenda of next Thursday's call. She noted that this way, USEPA and OEPA would try to provide MSD with feedback prior to Friday's meeting.

Ms. Ball requested the County be copied on exchanges of information between USEPA and MSD. Ms. VanTil asked if items transmitted from USEPA need to be sent to everyone at the same time. Ms. Ball replied, yes. Ms. Ball said the County needs to be present at the meeting with the Sierra Club.

4. **Discussion Topics for September 6th Meeting**

Ms. VanTil reviewed the action item list from the August 23rd meeting. Given the holiday weekend, she noted USEPA may not be prepared to discuss all information next week. She said at next week's call, USEPA will let MSD know when they expect comments from the Regulators. Some items will likely need to be carried forward over time.

5. **Action Items**

MSD:

1. Provide a summary of the grey alternative cost history by close of business August 31st.
2. Continue preparing response to Regulatory comments which require more time (detailed rainfall data and mini model documentation)

USEPA:

1. Review and comment on MSD responses provided to the Sierra Club (agenda item for Sept 6).
2. Review and comment on MSD responses for model calibration and documentation questions (agenda item for Sept 6).
3. Review and comment on MSD responses for working draft technical memorandum (agenda item for Sept 6).
4. Provide MSD time frame to receive comments regarding grey alternative cost history (agenda item for Sept 6).

6. **Discussion Conclusion**

Public Comments. Ms. Lodor said Mr. Desai was able to attend the August 23rd Town Hall meeting. She said MSD continues to compile comments received from the public. All comments will be consolidated and summarized into a report by mid-September.

USEPA Draft Guidance Document. Ms. Lodor informed Mr. Newport the draft guidance document was discussed during last week's call. She asked if any further discussion or dialogue regarding the draft guidance document is necessary. Mr. Newport said USEPA is still looking to the guidance document for

evaluation criteria. He said the guidance document represents USEPA's criteria for assessing the sustainable alternative. One of the themes of the guidance document is to provide direction to ensure the projects perform as conventional infrastructure, be well maintained, and ensure a useful life in the future is feasible. He said as MSD continues to work on formal December submittal, topics listed in the draft guidance document will be added to the agenda for discussion. He emphasized the importance of demonstrating the feasibility of the sustainable alternative and that it will continue to perform in the future.

Ms. Lodor said MSD understands these are long term solutions that must provide sustained, assured CSO reduction. She said MSD anticipates providing cost information regarding the sustainable projects similarly to the information provided on the grey cost history and that MSD is considering the project components and features that will help to address the Regulator intentions outlined in the guidance. Ms. VanTil agreed conversations of the weekly conference calls are essentially moving through the criteria provided in the draft guidance document.

Technical Discussion – LMCPR Modeling
September 6, 2012; 11:00am EST – 11:50 EST
Meeting Notes

Conference Call Attendees & Participants	
Barbara VanTil, USEPA Region 5	Geoff Edwards, XCG
Sudhir V. Desai, USEPA Region 5	Carol Hufnagel, Tetra Tech
Bob Newport, USEPA Region 5	Sue Pressman, Malcolm Pirnie
Gary Pritchard, USEPA Region 5	Gunilla Goulding, Malcolm Pirnie
Mark Klingenstein, USEPA Region 5/SAIC	Ted Boggs, Vorys, Sater, Seymour & Pease LLP
Marianne Piekutowski, Ohio EPA	Jeff Proctor, Hamilton County Monitor
Joshua Jackson, Ohio EPA	Brandon Vatter, Hamilton County Monitor
Jason Heath, ORSANCO	Joe Graf, Hamilton County Monitor
Tony Parrott, MSDGC	Karen Ball, Hamilton County
MaryLynn Lodor, MSDGC	Erica Spitzig, MSDGC/McMahon DeGulis
Tom Lyon, MSDGC	Charles Anness, Hamilton County Prosecutor
Leisha Pica, MSDGC	Colleen McCafferty, Hamilton County Prosecutor

The purpose of the meeting was to discuss USEPA questions regarding MSDGC's Lower Mill Creek Partial Remedy System Wide Model Validation Report, February 24, 2012; MSDGC's LMC-SA System Wide Model Restructuring Version 3.2, Version 4.1.0 and Version 4.2, June 1, 2012; MSDGC's Working Draft Sustainable Projects Technical Memo, Lower Mill Creek Partial Remedy; USEPA Guidance Pertaining to Consideration of Any Proposed Revised Original Lower Mill Creek Partial Remedy Defendants May Choose to Submit in Accordance with Paragraph A.2 of the Wet Weather Improvement Program, October 11, 2011; and the Draft Default Plan and Modified Default Plan Costs. Below is a summary of the discussion.

I. Regulator Comments on Meeting Summary from August 30th

Ms. VanTil asked if anyone has comments regarding the meeting notes summarizing the August 30th conference call. Ms. VanTil indicated USEPA has no comments. Ms. Piekutowski said OEPA has no comments. Mr. Heath indicated ORSANCO has no comments.

II. Follow-Up Topics

a. Sierra Club Responses and Meeting

Ms. Lodor acknowledged feedback was received from USEPA and Ohio EPA regarding MSD's responses to Sierra Club's questions. She noted MSD will be meeting with the Sierra Club tomorrow to bring them up-to-date on the LMC Study. Ms. VanTil said USEPA would appreciate receiving the minutes from the meeting with the Sierra Club.

b. **USEPA review feedback from the MSD clarifications on modeling**

Ms. Lodor said MSD would like to follow-up with the responses previously provided to USEPA and potentially close-out some of the items regarding model documentation. Ms. VanTil said given the short work week, the Regulators prioritized their efforts and focused on the grey alternative cost report. She said in general with respect to the modeling, MSD is on a good track. Mr. Newport said USEPA has not received any information that makes them think the numbers produced from the updated model are wrong, and that remaining questions are really just about documentation. He said this Technical Working Group will continue to discuss the documentation needs.

Ms. VanTil said USEPA understands MSD is continuing to update the working draft document regarding the mini-models. Ms. Goulding noted the information pertaining to the mini-models was included in *MSDGC's LMC-SA System Wide Model Restructuring Version 3.2, Version 4.1.0 and Version 4.2, June 1, 2012* report and Appendix A. She requested clarity on the type of information the Regulators are seeking. In particular, Ms. Goulding asked USEPA to specify the information requested in Question 2 of the *Mini-Model Comments, "In addition, for each mini-model (including West Fork Branch) we are looking for tabular summaries of the initial and final calibration hydrologic and hydraulic parameters"*.

Mr. Klingenstein responded that USEPA is seeking the same kind of documentation that was provided for the system-wide model (SWM) version 3.2 and was also included in the West Fork Branch Update Model report. He said USEPA assumed model version 3.2 represented the initial parameters used for developing the mini-models. Ms. Goulding clarified version 3.2 represented the final parameters and the mini-models were incorporated into version 3.2. Mr. Edwards also confirmed that understanding. He noted MSD previously provided a tabular format describing the initial and final parameters.

Mr. Klingenstein asked which SWM model version was used to craft the mini-models. Ms. Goulding responded that "it depends" because some projects were started using model version 1 while others started using interim version 3 models (precursor to version 3.2). She said MSD will note which SWM model versions were used to develop the initial mini-models. Mr. Edwards noted several mini-models were being developed in parallel to the SWM model update. However, when the mini-models were folded into the SWM, anyadjustments made to the mini-models were also reflected in 3.2 Mr. Edwards stated this was an important step to ensure an apples-to-apples comparison was performed. Mr. Klingenstein will review his notes from previous discussions as he did not recollect version 3.2 included all the details. Mr. Edwards noted each mini-model started from a common point to accurately describe and determine the reductions modeled for the sustainable projects. Ms. Lodor referred Mr. Klingenstein to the August 16th meeting minutes where Mr. Edwards explained the interaction of the SWM and mini-models. Mr. Klingenstein suggested USEPA staff regroup early next week to confirm everyone has the same understanding and whether any follow-up questions need to be issued.

Ms. VanTil noted similarly to the *MSDGC's Working Draft Sustainable Projects Technical Memo, Lower Mill Creek Partial Remedy*, and USEPA is working to review this item and requests it be added to the agenda next week for a substantive discussion.

c. USEPA review feedback from SI Working Draft Document

This topic will be discussed during the next meeting.

III. **New Topics**

a. **LMC Grey Cost and Revised Default Cost Draft Document**

Mr. Newport walked through the document and asked MSD discuss the changes and impacts noted in draft document, *Draft Default Plan and Modified Default Plan Costs,* provided to the Regulators August 31st. He commented the report was easy to follow and the presentation of the information clearly explained the evolution of the default project. His overall conclusion was the 2009 estimate was a planning level estimate and enhancements were needed for the alternative to properly function.

Mr. Newport noted changes to the default project cost focused primarily on 1) unit price increases, 2) increased thickness of the walls of the drop shafts, 3) longer and more complicated consolidation sewers, and 4) changes to outfall locations. He asked if these summarize the initial changes causing the default project cost to increase from $244 million to $313 million. He also asked if the unit costs for the tunnel were higher. Mr. Lyon said the unit costs for the main stem of the tunnel were reduced. Mr. Lyon added that reconfiguration of the tunnel pump station was also a main factor of the increased costs. If the pump station were constructed inside the shaft as originally planned, the Phase 1 2018 schedule for construction completion could not have been achieved. The depth of the pumps within the vertical shaft installation also raised safety concerns and made maintenance difficult because of the need to raise and lower the pumps.

Unit Prices. Mr. Klingenstein recalled the original project information was used to develop the 2006 costs included in the original WWIP; in 2008 the technical team revised the project cost; and since 2008 the project has been well defined resulting with significant changes to unit costs. He asked if the majority of the cost changes were a result of changes in the project itself or changes to unit prices. Mr. Lyon confirmed most of the changes was attributed to changes in the project, but noted there were also some fairly significant changes in unit costs. Mr. Klingenstein asked MSD to highlight these so the Regulators can understand the relevance of the two types of changes. He also noted changes in unit prices need to be documented.

Tunnel Pump Station. Mr. Newport commented the enhancements to the submersible pump system appeared to be comparable to the cavern type station in cost. Mr. Lyon explained a two-stage system was required for the pump station to work. Two sets of pumps were included in the original estimate; but costs for the upper portion of the wet well and screening structure were not included. Mr. Newport

asked if those enhancements were functional or gold plated changes. He noted the report indicated the cavern type pump station offers considerable safety improvements. Mr. Lyon verified the changes were functional, and that safety improvements are highly recommended. Mr. Newport concluded the tunnel pump station changes were necessary for the project to function as intended.

Mr. Klingenstein asked if the project schedule were to offer flexibility, what would be MSD's preferred approach for the pump station. Mr. Lyon said the project would still be constructed using the cavern type pump station, regardless of the schedule. He said the cavern-style is a far superior type of a facility. Mr. Klingenstein advised MSD to clarify in the draft report language that schedule would not necessarily be the main driver for pump station selection. He recommends modifying the language to emphasize technical and safety needs take precedence over the schedule compliance date.

Starter Tunnel and Tunnel Extension. Mr. Newport noted the report mentioned an enhancement starter tunnel for operability and future connection. He asked why an extension is needed on each end of the tunnel. Mr. Lyon explained the original concept assumed a tunnel boring machine (TBM) would be used. If that were the method of construction, a starter shaft would be required to assemble the TBM and install conveyer belts required for tunneling operations. The starter shaft was not included in the original price. The TBM would need to be retrieved at the end of construction. The LMCFR proposes a Phase 2 tunnel. To allow construction to proceed in Phase 2 without affecting operation of the Phase 1 portion, a tunnel extension would be required. Another factor contributing to the need for a tunnel extension was finding a suitable site for a TBM retrieval shaft. The location needs to be sited north of CSO 5. Mr. Klingenstein presumed the tail end tunnel would be 300 feet because of the issue with siting a drop shaft. Mr. Lyon replied, yes to facilitate future construction and not impact operation of lower section of the tunnel.

Mr. Newport asked if MSD would consider using a different tunnel construction method if the TBM language was not included in the WWIP. He also asked if the drill and blast method would be less expensive than the TBM method. Mr. Lyon responded, yes, and MSD intends to bid the project both ways (drill and blast and TBM) to quantify the potential savings. He said a starter tunnel would not be required for the drill and blast method since it begins inside the shaft. Typically the tunnel industry prefers to use the drill and blast method for shorter tunnels and TBMs for longer tunnels. The length of the LMCPR tunnel is on the borderline for deciding which tunnel construction method to use.

Consolidation Sewers. Mr. Newport noted the report indicates consolidation sewers changes were necessary because of the difficulty working in the limited space between the rail yard and Mill Creek. A longer consolidation sewer is required to shift the tunnel further east. Hence the length of sewers increased a lot from the original 2006 estimate as did the cost for the diversion structures. Mr. Lyon discussed the challenge of constructing the consolidation sewers in rock to comply with requirements of the railroad. Mr. Klingenstein asked is the tunnel for the consolidation sewer would be constructed in rock. Mr. Lyon responded, yes, the tunnel acts a carrier pipe with a sewer inside for the rail yard crossing. Mr. Klingenstein asked if this was a technical requirement or cost issue. Mr. Lyon replied the

costs are comparable but MSD is more comfortable with working in rock given the active rail yard operations. Mr. Newport asked if MSD would encounter an easement issue with CSX for the tunnel construction under rail yard. Mr. Lyon responded this approach would result with minimal easement coordination requirements.

Diversion Structures. Mr. Lyon noted the diversion structures were not given much thought in the February 2009 white paper. The 2009 project cost estimate included large manhole type structures with the diversion dams. The design has advanced for the diversion structures primarily to address floatables control. He pointed out the project is particularly more difficult around CSO 666. Although that location has a suitable diameter pipe, it needs to connect to the tunnel on other side of the creek. This requires a bridge to cross the creek because the railroad has stated they will prohibit access to a construction site in that vicinity. Mr. Newport noted the geography requires this change. Mr. Klingenstein asked if this location would require vehicular access. Mr. Lyon responded yes, during construction and for maintenance of the diversion structure after construction is completed.

Mr. Lyon also stated some of the diversion structures located between Mill Creek and rail yards require a flag man to be present from the railroad during all cleaning events. He explained access to the structures could take hours to coordinate because up to 40 railroad tracks would require crossing. He said moving them to east side of rail yards will greatly improve MSD's access to the structures.

Soft Costs. Mr. Newport said the discussion of soft costs provided a good explanation of the assumptions utilized. He concluded the detailed accounting method did not result in much of a net change in soft costs. He asked if MSD was going to build the original list of project components, would the list of enhancements to the work result in a total project cost of $414 million. Mr. Lyon confirmed the $414 million updated cost estimate was based on the detailed design for the original project components.

Mr. Newport said the last section of the report discusses a 25-foot diameter tunnel that is twice as long as the original project concept in order to pick up enough flow to achieve 2 billion gallon CSO reduction in accordance with the updated baseline model results at total project cost of $537 million.

Mr. Newport said USEPA has a good understanding of the information included in the draft document. The details provided help them understand that the changes are necessary for the project to effectively operate. He noted the complex story is difficult to precisely communicate in a newspaper story.

Mr. Klingenstein asked if the unit costs presented in Tables 4 and 7 should be identical. Mr. Lyon responded that some of the costs are identical, such as the diversion structures, tunnel pump station and EHRT facility. Others costs were based upon detailed estimates. He noted some of the consolidation sewer sizes changes. Mr. Klingenstein noted it would be helpful to have schematics showing the changes in the project from the original concept to the modified Phase 1 project presented as the grey alternative. He said the schematic would help show how this is apples-to-oranges-to-peaches with respect to the scope of the project. Mr. Lyon replied the schematics have been developed

and will be incorporated into the report. Mr. Klingenstein said any follow-up questions or comments will be emailed to MSD.

Ms. Piekutowski said Ohio EPA has no questions or comments on the Draft Default Plan & Modified Default Plan Costs Report. Mr. Heath said ORSANCO has no questions or comments on the report.

IV. Other Items

Mr. Parrott said after review of the grey costs has been completed, this Technical Working Group needs to walk through the sustainable infrastructure costs in a similar fashion. MSD will finalize the sustainable infrastructure cost information after comments have been received from the Regulators on *MSDGC's Working Draft Sustainable Projects Technical Memo, Lower Mill Creek Partial Remedy*. Ms. VanTil agreed with this approach.

V. Next Steps

MSD:

1. Update grey cost report to incorporate items discussed today.
2. Provide meeting minutes from September 7th Sierra Club meeting.

USEPA:

1. Finalize model documentation information needs.
2. Review and comment on MSD's Working Draft Sustainable Projects Technical Memo, specifically noting which items need to be revisited. Ms. VanTil said the Regulators will target providing this information to MSD by September 11th.
3. Provide MSD with any follow-up questions regarding the grey alternative cost history report.

VI. Next Meeting Date: September 13th @11am EST

Ms. VanTil said next week's call will use the same call-in number used for today's call.

APPENDIX C

PROJECT GROUNDWORK
your pipeline to clean water

Metropolitan Sewer District of Greater Cincinnati

Preliminary Enabled Impact Program: Interim Summary Report – September 2012

Update from Interim Summary Report – December 2011

1. Introduction

The Metropolitan Sewer District (MSD) is among the top 5 Combined Sewer Overflow (CSO) dischargers in the country, discharging approximately 11-billion gallons of overflow during a typical year of rainfall. MSD is implementing an integrated, watershed based approach to reducing CSO volume. This approach, titled Project Groundwork, is an effort to improve the quality of our lives — through cleaner streams, improved protection of public health, and enhancements to the communities where we work, live, and play. The program is designed to assess whether sustainable stormwater infrastructure, either alone or integrated with more traditional stormwater management approaches, can have a meaningful impact on the reduction of CSOs in the MSD service area, particularly in the Lower Mill Creek. The program is comprised of individual projects which range widely in size, scope, complexity, location, and surrounding land use. These projects are categorized in two primary categories: Direct Impact and Enabled Impact Projects.

As a lead role in the watershed based approach, Direct Impact Projects provide source control through strategic separation, detention, stream separation and other sustainable infrastructure techniques. Direct Impact Projects are projects and assets that MSD owns and operates to reduce flow entering the system through strategic separation of stormwater and natural drainage.

Enabled Impact Projects rely on partnerships with public and private entities to implement source control solutions to reduce stormwater from entering the combined sewer system (CSS). Through these partnerships, Enabled Impact Projects provide additional value and benefits which lead to greater understanding of sustainable infrastructure. This greater understanding can be leveraged and shared within local service area communities. Early in MSD's implementation of Project Groundwork, the Enabled Impact Program was subdivided into two parts: the Green Demonstration Program and Early Success Projects. Through evolution, and in an effort to build on the base of projects constructed, MSD now implements Enabled Impact Projects under the program title only. Sections 2, 3, and 4 present each type of Enabled Impact Project in greater detail.

2. Green Demonstration Program Summary

Between 2009 and 2011 MSD provided resources for project partners to install sustainable storm water infrastructure on their property; in exchange, the project partners agreed to assure long-term maintenance of the improvement was performed, and agreed to provide access to MSD and the surrounding communities for purposes of inspection and educational activities. In whole, MSD and the Green Demonstration Program partnered with 13 public and private partners on 22 projects, providing resources to construct approximately 290,000 square feet of bioinfiltration practices; 168,000 square feet of vegetated (green) roofs; 155,000 square feet of porous/pervious paving; 125,000 gallons of rainwater storage for reuse; 2,040 linear feet of storm sewer separation; and five large capacity stormwater dry wells.

Figure 1 is an example of a completed project showing large rain gardens installed at Cincinnati State Technical and Community College.

Table 1 provides a list of the approved projects, associated green infrastructure practices, and projected annual stormwater runoff capture volumes.[1]

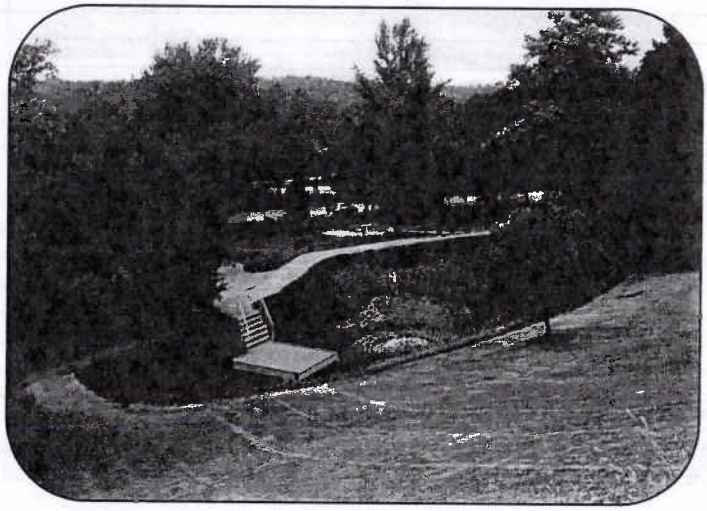


Figure 1 project example: Cincinnati State rain gardens

[1] Capture volume estimate are based on the 1971 typical year rainfall of 41 inches.

Table 1 Green Demonstration Program Project Summary

Project Partner	Project Name	Estim. Annual Capture Volume (gal)	Green Infrastructure Type	Quantity	Estimated Total Size of Control(s)
American Red Cross	Red Cross Building	978,000	Green Roof: Extensive Sloped	1	2000 sf
			Bioinfiltration Trench	1	500 sf
			Bioswale	1	12,000 sf
Christ Hospital	Christ Hospital Bioswales	243,000	Bioinfiltration Basin	3	1450 sf
Cincinnati DOTE	Comer Alley	150,000	Pervious Pavement: Pavers	1	2,660 sf
	Oakley Square	220,000	Pervious Pavement: Concrete	10	1,927 sf
			Rain Garden: Urban Planter	8	760 sf
			Rain Garden: Natural	1	132 sf
	Osborn Alley	228,000	Pervious Pavement: Pavers	1	2,660 sf
Cincinnati Museum Center	Museum Center Green Roof	95,000	Green Roof: Extensive (shallow)	1	6,490 sf
Cincinnati Parks/3CDC	Washington Park	3,864,000	Dry Wells	5	3 @ 35 ft, 2 @ 40 ft
		3,864,000	Green Roof: Extensive (shallow)	5	110,000 sf
Cincinnati Public Schools	CPS Clark Montessori	1,875,000	Rain Garden: Urban Planter	3	750 sf
			Green Roof: Intensive (deep)	1	9,200 sf
			Green Roof: Extensive (shallow)	1	5,500 sf
			Bioswale	1	2,800 sf
			Pervious Pavement: Pavers	1	2,000 sf
			Pervious Pavement: Concrete	1	13,000 sf
	CPS Hartwell	614,000	Pervious Pavement: Concrete	1	8078 sf
	CPS North Avondale	10,000	Green Roof: Modular	1	1,200 sf
	CPS Taft IT	610,000	Bioinfiltration Basin	1	1,070 sf
			Green Roof: Modular Extensive	1	32,000 sf
Cincinnati Recreation Commission	Evanston Aquatic Center	1,230,000	Pervious Pavement: Concrete	1	2724 sf
			Bioinfiltration Basin	2	5420 sf
Cincinnati State Technical College	Phase 2	8,000,000	Bioswale	1	972 sf
			Level Spreader	1	420 sf
			Rainwater Harvesting: Cistern	1	4,000 gal
			Bioinfiltration Basins	4	42,050 sf
			Rainwater Harvesting & Reuse	2	20,000 gal
			Pervious Pavement: Pavers	4	29,328 sf
			Bioinfiltration Trench	1	1,540 sf
Cincinnati State Technical College	Phase 1	4,620,000	Rain Garden: Natural	3	2700 sf
			Bioswale	2	10,000 sf
			Pervious Pavement: Concrete	1	1645 sf
			Pervious Pavement: Pavers	6	10,710 sf
			Bioswale	1	500 sf
			Pervious Pavement: Asphalt	1	2002 sf
Cincinnati Zoo	African Savannah Phase 1	3,100,000	Pervious Pavement: Pavers	1	42,207 sf
			Enhanced Turf System	1	20,000 sy
			Other - Tree Wells	2	TBD
	African Savannah Phase 2	12,500,000	Storm Sewer Separation	1	2040 lf
			Rainwater Harvesting	1	55,000 gal
	Zoo Main Entry	1,107,000	Pervious Pavement: Pavers	1	30,000 sf
			Rainwater Harvesting: Cistern	1	10,000 gal
Civic Garden Center	Green Learning Station	40,000	Rainwater Harvesting: Cistern	1	3000 gal
			Pervious Pavement: Asphalt	1	1200 sf
			Bioswale	3	1502 sf
			Pervious Pavement: Concrete	1	1200 sf
			Pervious Pavement: Pavers	3	3600 sf
MSD and City of Wyoming	Pilot Rain Barrel Program	TBD	Rainwater Harvesting: Barrels	250	55 gal
Rain Garden Alliance	RGA Rain Garden	140,000	Rain Garden: Natural	2	2950 sf
Wyoming Board of Education	Wyoming High School	100,000	Bioinfiltration Basin Retrofit	1	1,500 sf

3. Early Success Program Summary

Beginning in 2010, MSD began constructing Early Success Projects (ESPs) throughout priority watersheds within the Lower Mill Creek. These ESPs are site-specific stormwater management strategies that may provide both water quantity and quality benefits, and which built support and trust within the community and watershed stakeholders. ESPs implement best management practices such as bioinfiltration features, reforestation, and porous pavement systems. ESPs are implemented and monitored under a memorandum of understanding between MSD and Cincinnati Park Board. Long term maintenance of the ESP is the responsibility of the property owner. Table 2 provides a list of these ESPs, and a short explanation of the project status.

Table 2 Early Success Projects

ESP Project Name (Watershed)	Construction Date	Status	Green Infrastructure Type
Beekman (Lick Run - LR)	2013	Grant Agreement accepted by Hamilton County, design scheduled for 1st Quarter 2013.	Bioretention/infiltration, conversion of impervious to pervious landcover
Denham/Carll Ravine & Future CRC Improvements (Denham)	2014	MSD has been awarded an Ohio EPA Surface Water Improvement Fund Grant for $72,000. Project design is scheduled for 4th Quarter 2012.	Storm separation, bioinfiltration/bioswale features, open space improvement
Former Habig's Parking Lot (Muddy)	2011	Construction completed 4th Quarter2011.	Porous pavers and bioinfiltration area
Harrison Ave Phase A - CDOTE (LR)	2013	100% design drawings are under review within MSD. Project construction planned for 2nd Quarter 2013, and will coordinate with CDOTE construction project in area.	Vegetated bioinfiltration curb bumpout
Immanuel Church (LR)	2010	Installation complete. Lawn reestablished 2nd Quarter 2012.	Downspout redirection to street-level, lined biodetention basin area
Queen City Avenue Reforestation (LR)	Ongoing	Parks continues to plan and implement additional reforestation efforts along Queen City Ave. and throughout MSDs priority areas (utilizing volunteers when possible.)	Reforestation
Rapid Run Park (LR)	2013	100% design drawings expected 4th Quarter 2012, construction scheduled for 3rd Quarter 2013.	Bioswales, reforestation, contour infiltration planting, step pools, bioinfiltration
Roselawn Park (Bloody)	2013	Supplemental design underway to accommodate CRC proposed ball field retrofit and indoor baseball practice facility. 100% design drawings expected 4th Quarter 2012, construction scheduled for 3rd Quarter 2013.	Bioinfiltration basins, separate storm sewer connection, contour reforestation
San Antonio Church (LR)	2012	William Court property transferred to the property owner, construction completed 3rd Quarter 2012.	Porous pavers, parking lot bioinfiltration areas, parking lot entrance reconfiguration
St. Francis Court Apartments (LR)	2010	Installation complete. USGS and USEPA are monitoring the quality and quantity of flow. Clay dike at upper basin outlet installed November 2011.	Biodetention basins, landscape improvements, community gardens

4. Enabled Impact Projects

In 2011, as part of the Enabled Impact Program, MSD began developing strategies to support a comprehensive monitoring program aimed at collecting combined sewer and sustainable stormwater infrastructure performance (flow) data, confirming effectiveness of the stormwater sewer separation projects, and synthesize this data for application on future Direct and Enabled Impact Projects. A detailed description of these strategies is included in Section 5 of this report.

In 2012, following the successful implementation of over 30 Green Demonstration and Early Success Projects, MSD began phasing out these programs in favor of Enabled Impact Projects which capitalize on the strengths of its experience (e.g. effective best management practices, public outreach and education,) but which encourage MSD partners to identify additional funding mechanisms to implement the projects beyond sole sponsorship by MSD. As the Enabled Impact Program moves forward, MSD will continue to identify project opportunities, explore alternative funding sources (e.g. grants, project partnering, and community organizations.)

ESP Project Name (Watershed)	Construction Date	Status	Green Infrastructure Type
University of Cincinnati Campus Green SW Improvements	TBD	100% Design complete; project is seeking additional partners beyond MSD to supplement construction funding.	Storm Sewer Separation, Permeable Pavements, Bioinfiltration Basins, rainwater harvesting and reuse.
Cincinnati Zoo Cat Canyon	TBD	100% Design complete; project will be encouraged to seek additional partners beyond MSD to supplement construction funding.	Rainwater Harvesting and Reuse
Cincinnati Public Schools – Oyler School	TBD	Project concept has been recommended to MSD Office of Director for consideration.	Vegetated Green Roof
Mercer Commons	2013	Project concept has been approved for design funding, design expected to commence 1st Quarter 2013.	Dry wells, permeable pavement
St. Francis Court Apartments Phase II (Lick Run - LR)	2013	Installation complete. USGS and USEPA are monitoring the quality and quantity of flow. Clay dike at upper basin outlet installed November 2011. 30% design of secondary capture area underway.	Biodetention basins, landscape improvements, community gardens

5. Project Monitoring

Early in implementation of the Enabled Impact Program, MSD recognized that the assessment of sustainable stormwater infrastructure performance was critical in order to optimize future Enabled Impact Projcts, and ultimately maximize MSD's investment in Direct Impact Projects. MSD developed a comprehensive monitoring approach which encompasses a variety of objectives including the identification of design lessons-learned, constructability constraints, stormwater runoff volume reduction, vegetative success, operational/functional issues, maintenance needs, and long-term viability. These objectives lend themselves to both quantitative and qualitative monitoring approaches, depending on the nature of a specific project.

Currently MSD has implemented preconstruction quantitative flow monitoring on select projects (typically larger scale, more complex projects) to establish a baseline of preexisting stormwater flow rates within the combined sewer system. In 2011, with the assistance of Dr. Robert Pitt of the University of Alabama, MSD began developing strategies to incorporate qualitative monitoring provisions into selected Enabled Impact Projects during the design phase. Dr. Pitt made design modification recommendations during the design of three projects, with the overall goal of meeting MSD's previously mentioned objectives. These recommendations were incorporated into the construction of the Cincinnati State project, and have been incorporated into the construction documents for the Cat Canyon and University of Cincinnati projects (construction of these projects is to be determined.)

To ensure that overall long-term performance will be assessed at all locations, each completed project will be subjected to qualitative monitoring efforts. This will include seasonal and wet weather site inspections to assess the conditions of the controls and to identify any operation and maintenance issues. **Table 3** illustrates the qualitative and quantitative monitoring effort for the each Enabled Impact Project. Additional details regarding MSD's monitoring efforts are outlined in Sections 5.a through 5.d

Table 3 Monitoring Types

Project	Quantitative		Qualitative (post-con)	Monitoring Partners (in addition to MSD)
	Pre-con	Post-con		
Red Cross Building			YES	Cincinnati Park Board (CPB)
Christ Hospital Bioswales			YES	CPB
Comer Alley			YES	CPB
Oakley Square			YES	
Osborn Alley			YES	
Museum Center Green Roof		YES	YES	Urban Alta, CPB
Washington Park	YES	YES	YES	CPB
CPS Clark Montessori	YES	YES	YES	USEPA, CPB
CPS Hartwell			YES	
CPS North Avondale			YES	
CPS Taft IT			YES	
Evanston Aquatic Center			YES	
Cincinnati State	YES	YES	YES	USEPA, University of Alabama, University of Cincinnati, CPB
African Savannah	YES	YES	YES	USGS, CPB
Zoo Main Entry	YES	YES	YES	USGS, CPB
Green Learning Station		YES	YES	Civic Garden Center, Urban Alta, CPB
Pilot Rain Barrel Program				CPB
RGA Rain Garden			YES	CPB

Project	Quantitative		Qualitative (post-con)	Monitoring Partners (in addition to MSD)
	Pre-con	Post-con		
Wyoming High School			YES	CPB
Beekman			YES	CPB
Denham/Carll Ravine			YES	CPB
Former Habig's Parking Lot			YES	CPB
Harrison Ave Phase A - CDOTE			YES	CPB
Immanuel Church			YES	CPB
Queen City Avenue Reforestation			YES	CPB
Rapid Run Park			YES	CPB
Roselawn Park			YES	CPB
San Antonio Church			YES	CPB
St. Francis Court Apartments Phase I	YES	YES	YES	USEPA, USGS
University of Cincinnati Campus Green SW Improvements	YES	YES	YES	USEPA, University of Alabama, University of Cincinnati, CPB
Cincinnati Zoo Cat Canyon	YES	YES	YES	University of Alabama, University of Cincinnati,
Cincinnati Public Schools – Oyler			YES	CPB
Mercer Commons			YES	CPB
St. Francis Court Apartments Phase II	YES	YES	YES	USEPA, USGS, CPB

a. Quantitative Flow Monitoring – Large Scale

Direct measurement of potential reductions in runoff volume to the combined system is being performed by MSD through the use of in-system flow monitors placed in combined or storm sewers on or adjacent to several of the larger demonstration projects. These flow monitors were installed early in the demonstration program to provide pre-construction baseline flow data and will be used to collect post-construction data once construction is complete and the sites have stabilized. Flow monitors are currently in place at three locations surrounding the Cincinnati State facility, the Cincinnati Zoo site, and the Clark Montessori High School site.

MSD collects this raw data and subjects it to standard industry reviews; this results in preliminary monitoring data which represents pre-construction and construction-related conditions, as well as post-construction conditions (currently only at Cincinnati State.) Because this data is preliminary, and primarily untended to form a baseline of existing and changed conditions, the database of monitoring information is insufficient to accurately characterize the performance of the sustainable stormwater infrastructure performance. Rather, the data has been collected, reviewed, and organized for future use once sufficient post-construction data has been collected. It is expected that the post-construction flow monitoring will allow evaluation of the sustainable stormwater infrastructure performance once the database has two years of post-construction data logged. At

that point, MSD will initiate an engineering and scientific review of the data, and will report on installed performance.

b. Quantitative Monitoring – Project Practice Scale

Quantitative monitoring of selected sustainable stormwater infrastructure is being planned at the Cincinnati State Technical and Community College project, the University of Cincinnati project, and the Cincinnati Zoo Main Entry, African Savannah, and Cat Canyon projects. MSD is currently performing post-construction monitoring at the Cincinnati Public School (CPS) Clark Montessori and Civic Garden Center Green Learning Station projects. These efforts are joint ventures between MSD and key monitoring partners and are described below:

i. United States Environmental Protection Agency Research

The United States Environmental Protection Agency (USEPA) Cincinnati, Ohio and Edison, New Jersey research labs are conducting research efforts to assess the effectiveness of green infrastructure in managing stormwater runoff at two sites within the demonstration program. They have selected specific controls at St. Francis Court Apartments, Clark Montessori, and Cincinnati State for monitoring moisture and temperature within individual controls. As of September 2011, USEPA has installed all sensors and flow meters during construction process. More information on the study sites and the specific instrumentation used is found in the project monitoring descriptions presented later in this plan.

Data recorded to date for these sites has been summarized to date, and can be made available upon request of MSD.

ii. University of Alabama/University of Cincinnati

The University of Alabama (UA), through Dr. Robert Pitt, has assisted MSD in the development of quantitative monitoring strategies for the Cincinnati State, Zoo and University of Cincinnati demonstration projects. Specific green infrastructure or groups of green infrastructure in series have been selected for monitoring based on the size of the control (with larger controls preferred), the likelihood of obtaining measureable (versus modeled) data, and the ease of access for installation and maintenance of monitoring equipment. Not all controls at each site will be monitored.

The priorities for this effort are:

- Quantifying the overall runoff reduction volume actually achieved at the demonstration locations. The primary parameters include total runoff volume, peak runoff rate and rain intensity at several locations within the monitoring area.
- Collecting data that enables these results to be used in other locations in order to quantify runoff volume reductions at the demonstration sites. The secondary parameters for monitoring will include total recoverable iron, copper, lead and zinc; and indicator bacteria.
- Collecting water quality data to assess the performance of green infrastructure in reducing specific water quality parameters. The parameters for this objective include SAR (calcium, magnesium and sodium) of runoff water and conductivity; TSS and psd; SAR of backfilled media in biofilters and bioretention devices; and soil moisture in back-filled media.

The University of Cincinnati (UC) will implement these monitoring programs. Trained UC graduate students will be collecting samples and data as each monitoring program is

brought on line. Water quality samples will be analyzed by MSD Division of Industrial Waste. Data will be stored at UC and available to MSD.

The first phase of this monitoring effort is planned for implementation 4th Quarter 2012. Flow monitors and associated equipment will be installed in the first phase.

iii. United States Geological Survey

The US Geological Survey (USGS) is interested in the impact of green infrastructure on groundwater levels and quality. The USGS has been monitoring the Cincinnati Zoo African Savannah project from four wells it installed in fall 2009. These shallow monitoring wells are installed geographically above, within and below green infrastructure. African Savannah construction started in 2010 and is on-going. The USGS is also monitoring performance of the installed green controls at the St. Francis Court Apartment ESP site by monitoring groundwater levers throughout the upper and lower basins on the project. Groundwater level and basic water quality parameters are collected continuously using onsite dataloggers. These are downloaded manually by USGS personnel on a routine basis. USGS stores the collected data. Real-time USGS provisional data is available on line. Annual summary reports for monitoring wells are available upon request of MSD.

iv. Detailed Assessment

A partnership between the Civic Garden Center, University of Cincinnati and USEPA has resulted in installation of an elaborate monitoring network that will assess performance of different types of green stormwater controls. These controls were constructed to allow detailed analysis of the behavior of stormwater runoff over and through the site. Sensors located throughout the site and within installed controls continuously monitor the site conditions. A sophisticated system of nodes/routers, servers and cloud-based analyses will deliver data to a web-based interface. A preliminary report of the data has been prepared and is available upon request of MSD.

c. Qualitative Monitoring

Beginning in 2011, through the support of Cincinnati Park Board, MSD began implementing qualitative monitoring on constructed Enabled Impact projects the use of seasonal site inspections and wet weather inspections. All data collected during qualitative monitoring is first entered into field inspection report (**Attachment A**) and then into a Microsoft® Access-based database accessible to both the Park Board and MSD, which can generate site summaries, maintenance reports, and maintenance follow-up reports transmitted to the entities responsible for maintenance of the project.

i. Seasonal Site Inspections

These scheduled quarterly inspections document site conditions and identify potential issues related to functional operation, maintenance, and vegetational success (where appropriate) of the installed green infrastructure. Seasonal site inspection reports from 2nd Quarter 2012 have been prepared and distributed to the propery owners 3rd Quarter 2012.

ii. Wet Weather Site Inspections

Site visits are also conducted at select locations after high intensity wet weather events to assess performance of the green infrastructure and, where appropriate, overflow structures. Wet weather inspections are comprised of two separate visits one during or immediately after the rain event and another follow-up visit within a day to assess how

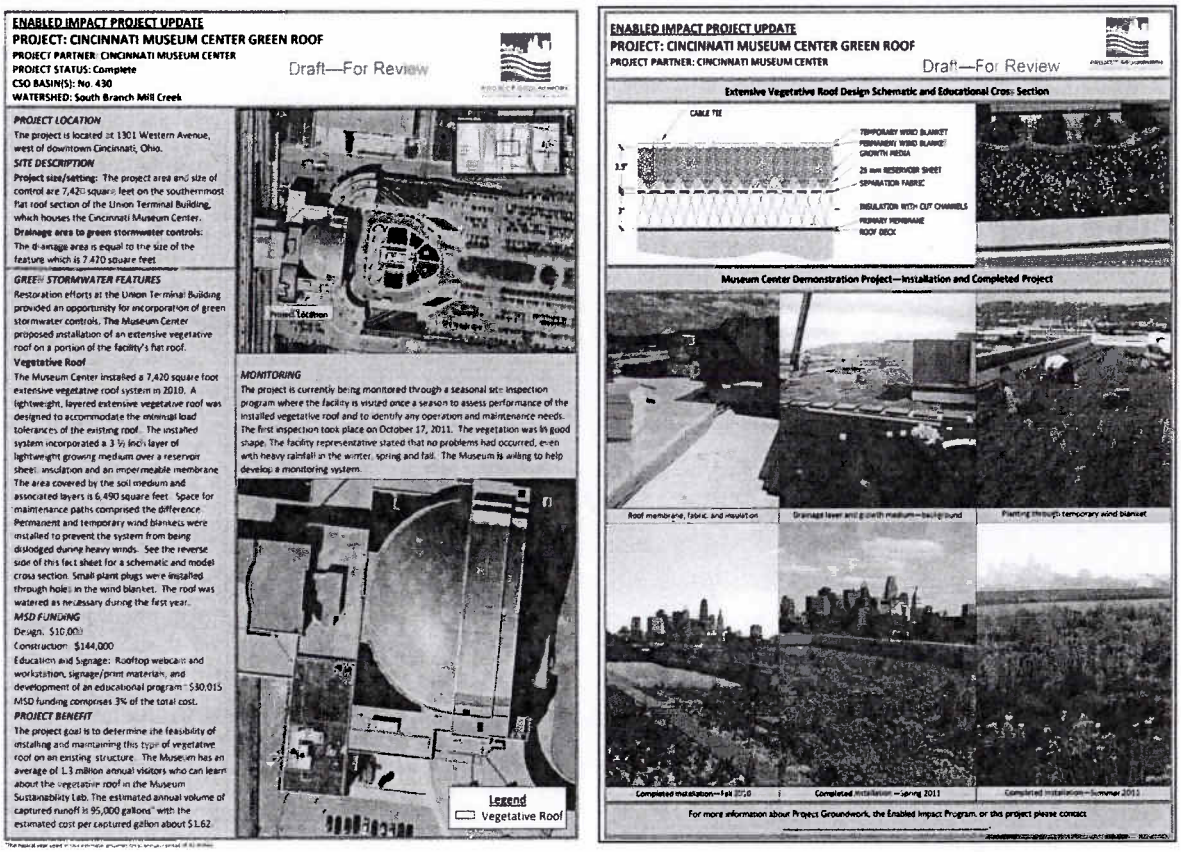
well the green infrastructure handled the large runoff events. Wet weather site inspections are planned on all constructed projects for 4th Quarter 2012.

6. Active Project Summaries

A project summary has been created for each of the projects that have been completed or are under construction. These summaries are presented as stand-alone summary sheets that can be modified as necessary to incorporate new information. The sheets for each project are included as **Attachment B** to this document. An example of a summary sheet is presented in Figure 2.

The summary sheets are intended to provide the reader with a basic understanding of the project, its status, location, setting, green infrastructure, project benefits, MSD funding levels, and current monitoring. "Lessons learned" are indicated where appropriate. The summaries also include a project location map, a graphic showing the location and types of green infrastructure, design and layout schematics, and relevant photographs.

Figure 2 Sample project summary sheet



Lessons Learned

Since a variety of factors (such as soil type, climate, slope, surrounding land use, and maintenance) impact the effectiveness of green infrastructure technologies, details relating to the best design, construction methods, and ultimately the performance of these features is not fully understood in the Midwestern United States. Implementation of the Enabled Impact Project Program allows green infrastructures to be installed as pilot projects throughout the Cincinnati area. MSD plans to use these projects as means to monitor performance and learn about green infrastructure practices throughout Cincinnati. Therefore, lessons learned from this program are important for modifying future designs and methods of construction for improved functionality and effectiveness.

Monitoring project implementation before and during construction has yielded some immediate observations that impact project performance and, ultimately, design. Project-specific issues and their resolution are presented as part of the project fact sheets that are attached to this report. However, a brief summary of many of the lessons learned is provided in **Figure 3**.

Figure 3 Enabled Impact Program - Lessons Learned

- *Consider weekly project team meetings before and during construction to keep issues from getting to a critical stage*
- *Consider operation and maintenance provisions during design (i.e. access, irrigation source)*
- *Conduct adequate soil testing to determine functionality and detailed designs*
- *Ensure that proper erosion protection and sediment control practices are in place to prevent unnecessary clogging of green infrastructure during construction.*
- *Heavy construction equipment driven by those unfamiliar with infiltration practices can result in compaction and reduced native infiltration rates (and cost money to fix)*
- *Non-traditional designs require educating the contractor – otherwise conventional construction practices prevail*
- *Improper drainage planning can result in ponding, stagnation, and mosquito breeding conditions – this can be costly to retrofit.*
- *Incorporate construction materials that serve multiple intents (Integrating root barriers into chosen roof material (under green roof))*
- *Plan to experience field-based retrofits and plan on soliciting specialty trades for field retrofit solutions*
- *Consideration of quantities ordered for non-traditional materials*
- *Consideration of lead time on non-traditional materials (i.e. growing time for green roof trays)*
- *Approach BMP design with a comprehensive site assessment*
- *Standard construction details may not always apply*
- *Anticipate traditional contractor means and methods*
- *Protect sites from sedimentation – before, during, and post-construction*
- *Prepare a maintenance plan, and secure sustainable means to implement*
- *Work with material suppliers/product manufacturers to identify effective installation methods*
- *Specify maximum equipment loading on infiltration subgrades*

Stream Daylighting and Restoration Case Studies

Hamilton County Planning and Development Department

Prepared September 2012

Domestic Daylighted Streams and Natural Conveyance Channels

State	Location	Waterbody	Year Daylighted	Length	Size of Watershed	Cost	Sponsors	Narrative and Notes	Notable Features	Links or Sources
California	Berkeley	**Codornices Creek**	Started 1992- Finished 1995	400 feet	1.5 square miles, urban	$33,000 plus in-kind donations and considerable volunteer labor	Urban Creeks Council, Ecocity Builders, Friends of the Five Creeks	Saved from a former parking lot.	Successful low budget project.	• EcoCity Builders • Pinkham, Richard (2000)
California	Berkeley	**Strawberry Creek**	1984	200 feet	2.0 square miles, urban and university campus	$50,000 for daylighting, (of total $580,000 total park costs		Create a park and an urban creek amenity		Pinkham, Richard (2000)
California	Berkeley	**Blackberry Creek**	1995	250 feet	0.3 square miles, urban	$144,000 plus donations and additional park related cost		Create educational site, improve community park, relieve flooding		Pinkham, Richard (2000)
California	Berkeley	**Derby Creek**	--	450 feet (proposed)	.25 square mile, urban	$500,000 (estimate)	Wolfe Mason Assoc. Waterways Restoration Institute	Derby Creek runs under People's Park -- famed as site of many 1960s protests. History and culture associated with park means any proposed project generates enormous controversy. Daylighting the creek, while much-desired, will not happen in the foreseeable future.	Culturally significant location in community.	www.peoplespark.org Pinkham, Richard (2000) Appendix B
California	San Francisco	**Islais Creek**	Study phase	--	--	--		Part of proposed CSS projects for City and County of San Francisco - 2030 Sewer System Master Plan	--	• http://www.sfwater.org/modules/showdocument.aspx?documentid=561 • Cheng, Paul (2010)
California	San Francisco	**Glen Park**	Study phase	--	--	--		Part of proposed CSS projects for City and County of San Francisco - 2030 Sewer System Master Plan	--	• http://www.sfwater.org/modules/showdocument.aspx?documentid=561 • Cheng, Paul (2010) •
California	Arcata	**Jolly Giant Creek**	1991, 1995, 1997	160 feet of new channel daylighted, plus 580 feet of surface channel restored	1.7 square miles, rural and urban	$120,000 plus considerable donated materials, in-kind services, and volunteer labor		Tied to educational programing, stream restoration, and park development	Links multiple daylighting and restoration projects	Pinkham, Richard (2000)
California	El Cerrito	**Baxter Creek**	1996	250 feet of new channel	0.25 square miles; residential	N/A		Storm drain renovation; create open stream in neighborhood park	Repair of a poorly engineered projects; daylighting on a steep slope	Pinkham, Richard (2000)
California	San Luis Obispo	**San Luis Obispo Creek**	Project initiated 1963	600 feet	84 square miles	$100,000		Integrated into larger redevelopment plans for Mission Plaza area. Creek and plaza work together to create unique community amenity and economic development driver. Integrates flood control measures.	Initially opposed by business community, now embraced as heart of the city	Hoobayar, Paul (2002)
California	San Diego	**Cottonwood Creek**	2004	700 feet	3.4 square miles (part of Tijuana River Watershed)	$4 million for overall flood control and 7.5 acre Cottonwood Creek Park project	County of San Diego Public Works Watershed Protection Program	Creek receives lots of urban runoff and pollution. Improving water quality a goal of daylighting—incorporates bio-filtration, aeration over rocks and falls, and channel vegetation selected for filtering qualities	Creek dedicated as California State point of historic significance in 1991	www.SDDT.com North County Times, 4/4/04
Colorado	Denver	**Westerly Creek**	--	1.2 miles	1,900 acres, 4,500 acres	--		Establish an ecological and recreational corridor at old air force base		Buchholz & Younos (2007)
Connecticut	Meriden	**Harbor Brook**	--	2,000 feet	10 sq. mi.	$30,000,000		Address flood threats to several hundred commercial buildings and industrial buildings	Build a new floodplain at lower elevation than natural one	Buchholz & Younos (2007)

State	Location	Waterbody	Year Daylighted	Length	Size of Watershed	Cost	Sponsors	Narrative and Notes	Notable Features	Links or Sources
Connecticut	Bridgeport	**Pequonnock River**	Assessment stage (2011)	unknown	unknown	unknown	Pequonnock River Initiative	"A significant amount of stream channel modification was observed throughout the watershed. Segments of some streams in the watershed are buried in underground conduits, resulting from historical development and past storm drainage practices and flood control practices... The possibility of daylighting these sections is low since roadways and shopping centers have been built above the culverts."	Seven different sub-watersheds included in comprehensive analysis	*Watershed Field Assessment Report* *Pequonnock River Watershed* City of Bridgeport February 2011
Connecticut	Bristol and surrounding areas	**Pequabuck River**	Planning stage (2005)	Unknown	58 square miles	unknown	Pequabuck River Watershed Coalition	"There are stretches of the Pequabuck River and North Brook that are piped through underground culverts. In some areas there is the potential to "daylight" sections of the river, i.e., allowing the public to enjoy the beauty of a flowing, aboveground river once again. Daylighting can be expensive, but in places such as Brackett Park in Bristol, it makes great sense to celebrate the natural attributes of the river rather than have them hidden from view."	Report states that 70% of watershed is forested. Pollution problems from very early industrial development	*The Pequabuck River Watershed Management Plan* June 2005 The Central Connecticut Regional Planning Agency Pequabuck River Watershed Association Farmington River Watershed Association
Georgia	DeKalb County	**Shoal Creek Tributary**	1994	200 feet of culvert removed	-0.15 square miles; medium density residential	$14,500 plus unallocated staff time		Remove hazardous collapsed culvert; restore stream		Pinkham, Richard (2000)
Idaho	Boise	**Cottonwood Creek/Julia Creek**	2007	300 feet	12.5 square miles	unknown	Trout Unlimited Embrace a Stream Program Boise River Management and Master Plan Ada County Highway Department	Began as Cottonwood Creek project, shifted to creating entirely new Julia Creek within existing park. Original project may be completed at future time. New creek provides fish spawning/maturation habitat alongside Boise River. Associated riparian wetlands satisfy mitigation requirements for nearby roadway project.	Initial project goal to provide needed trout habitat along Boise River	Trout Unlimited www.tedtruebloodtu.org
Idaho	Caldwell	**Indian Creek**	--	5 City blocks to be daylighted	N/A	$9 million		Catalyst for downtown revitalization in the historic district	Restore creek for community trail system and annual creek festival	Buchholz & Younos (2007)
Illinois	Barrington	**Kilgoblin Wetland**	1995	300 feet of culvert removed	1.2 square miles; urban and suburban	$55,000, excluding land acquisition		Daylighting storm sewer to create a wetland		Pinkham, Richard (2000)
Illinois	Barrington	**Flint Creek**	1999	250 feet of culvert removed	4 square miles; semi-rural	$60,000		Stream bank restoration; reduced municipal maintenance costs	Special-use zoning permit used to require daylighting on private property	Pinkham, Richard (2000)
Illinois	Urbana	**Embarrass Creek**	Early 1970's	4,000 feet of new channel	Less than 1 square mile, suburban	N/A		Create storm amenity for new park		• Pinkham, Richard (2000)
Illinois	Waukegan	**South Branch Waukegan River**	--		2.5 sq. mi.			Reduce water quality impacts of culvert	Remove fish passage barriers	• Buchholz & Younos (2007)
Indiana	Indiana Dunes State Park	**Dunes Creek**						A creek daylighting project is being implemented as part of stormwater management upgrades after a 20,000 square-foot portion of a parking lot collapsed after a four-day deluge in 2008.		• OutdoorHub
Kansas	Hutchinson	**Cow Creek**	1997	800 feet of new channel	1.5 square miles, plus 6.8 square miles divertible to a levy in storm events	$1.25 million for stream and new park; $4 million total		Speed a large bridge replacement project; create a downtown park	Use of confined channel through an urban park	• Pinkham, Richard (2000)
Maryland	Belair	**Plumtree Park Stream**								
Massachusetts	Littleton									
Massachusetts	Rowley	**West Ox Pasture Brook**	1999	85 feet of culvert removed	0.35 square miles; low density suburban	$1,200 plus donated materials and time		Stream restoration and riparian habitat creation	Backyard daylighting; cost savings on a home septic system replacement	• Pinkham, Richard (2000)

State	Location	Waterbody	Year Daylighted	Length	Size of Watershed	Cost	Sponsors	Narrative and Notes	Notable Features	Links or Sources
Massachusetts	Boston	**Muddy River**	Proposed but built ?????					Culverts at 3 sites in Boston's "Emerald Necklace" park system must be enlarged or removed		• Buchholz & Younos (2007)
Massachusetts	Boston	**Stony Brook**								• Novotny, Vladimir (n.d.)
Massachusetts	Hylyoke	**Wyckoff Country Club**	Proposed but built ?????	350 feet				Golf course to turn culvert into water feature hazard with additional benefits	Ponds and wetland to improve water quality	• Buchholz & Younos (2007)
Massachusetts	Cambridge									
Massachusetts	Foxboro									
Massachusetts	Worcester									
Massachusetts	Lincoln		2007							
Michigan	Kalamazoo	**Arcadia Creek**	1995	1,550 feet	7.4 square miles; urban	$7.5 million		Flood relief; creation of downtown amenity	Daylighting in a central business district; use of a confined channel; part of a major redevelopment project	• Pinkham, Richard (2000)
Michigan	Detroit (Jackson)	**Grand River**	1998	300 feet of capped culvert was removed; riverbanks were stabilized	163 sq. mi.	$1,100,000	Michigan Dept. of Environmental Quality	To remediate safety hazard to drowning; to promote waterfront development	Contaminated soils led to daylighted stream design consisting of concrete canal	• Buchholz & Younos (2007)
Michigan	Detroit	**Bloody Run Creek**								
Michigan	Flint	**Gilkey Creek**	2007-2008	1200 feet	16 acres; greyfield institutional land uses	$1.1 million		Stream stabilization and habitat recreation	Includes wetlands, pools, rapids, native plantings, bank stabilization and more.	• Reclaiming Gilkey Creek • Landscape Architecture Foundation • Michigan Live
Minnesota	St. Paul	**Phalen Creek**	1987	Approx. 2,100 feet of surface channel and ponds created	2.4 square miles; high density residential and industrial			Create stream amenity for park	Partial-flow daylighting	• Pinkham, Richard (2000) • Jones S. 2001,
Minnesota	Minneapolis	**Bassett Creek**	Proposed but built?????					Remove damaged buildings from poor soil area and allow some flow from water tunnels to flow again on the surface	Create a central stream corridor and new park	• Buchholz & Younos (2007)
Missouri	Springfield	**Jordan Creek**	2005-2007			$2.5 million plus additional grants	• Public Works Stormwater Engineering • Ozark Greenways, Inc. • Springfield-Greene County Parks Department • Public Works Operations • City Utilities	Flood and stormwater management		• Jordan Creek Project Fact Sheet • KY3 Article • Miller, R. et al. (2007)
New Hampshire	Dover	**Berry Brook**	2012 - ongoing	1,960 feet	164 acre watershed, includes urban and institutional land uses	$198,100 from USACE	City of Dover, the University of New Hampshire Stormwater Center, the Cocheco River Watershed Coalition, the New Hampshire Fish and Game Department, American Rivers, and funding by New Hampshire Department of Environmental Services.		Wetlands, streambank and riparian corridor restoration, and other BMPs	• Berry Brook Watershed Management Plan (2008) • USACE Aquatic Fund Distribution Report (2012) • University of New Hampshire Stormwater Center
New Jersey	West Milford	**Greenwood Lake**								
New Jersey	Trenton	**Assunpink Creek**	2011	500 feet	91 square miles	$4 million		Improve fish migration, community development catalyst,		• USACE Philadelphia (2011)

State	Location	Waterbody	Year Daylighted	Length	Size of Watershed	Cost	Sponsors	Narrative and Notes	Notable Features	Links or Sources
New York	Yonkers	**Saw Mill River**	2012	800 feet		$18 million	Scenic Hudson, Groundwork Hudson Valley, City of Yonkers	"The daylighting project already has offered some economic relief via 200 construction jobs; projections suggest that's just the tip of the iceberg. Eventually the park is expected to generate 1,000 permanent new jobs and a $5- to $6-million-dollar jump in revenues of local restaurants and businesses."		• http://www.thedailygreen.com/living-green/blogs/easy-tips/daylighting-saw-mill-river-1207
New York	Roscoe	**Darbee Brook**	1996	330 feet of culvert removed, 160 feet of new channel	Approx. 1.5 square miles, agricultural and residential	$9,000 plus earthmoving costs, and donated services, materials and labor.		Replace deteriorating culvert; improve school playing fields; allow fish passage	Trade-offs to achieve a win-win project for school, state regulators, and fishing groups; less costly than culvert replacement	• Pinkham, Richard (2000)
North Carolina	Raleigh	**Rocky Branch**	2002 - 2009	Daylighted 253 feet – also includes 6,100 feet of restored stream geometry, banks....	N/A	$5,000,000		Campus greenway and stream restoration project (connect to city greenway system)	Replace 3 culverts under roads with bridges for sub-grade crossing for people and wildfire	• Buchholz & Younos (2007)
North Carolina	Charlotte	**Little Sugar Creek**	Several phases from 2002 - 2012	950 feet				Unearthed from a parking lot	Includes floodplain restoration and wetlands	• Sea Grant North Carolina • Charlotte Mecklenburg Storm Water Services
Oregon	Salem	**Pringle Creek**	Permitting Phase		84 acres			Part of "Boise Cascade" site's proposed mixed-use redevelopment.	Tight urban corridor means some water will be mechanically treated instead of bio-engineered	• StatesmanJournal.com • STORMWATER Journal • Pringle Creek Watershed Management Plan
Oregon	Portland	**Tryon Creek**	2006-2008	@ 450 feet	3 acre site			The "Headwaters Project"	Wetland enhancement, and full stormwater management of neighboring development	• Tryon Creek • http://en.wikipedia.org/wiki/Tryon_Creek • http://www.tryonfriends.org/index.php • http://www.tryoncreekreport.com/WorkingFirstDocument_001-038.pdf • http://www.portlandonline.com/bes/index.cfm?c=32200&a=238755 • http://www.portlandonline.com/bes/index.cfm?c=32200
Oregon	Portland	**Tanner Creek**	2004				"Tanner Springs Park"	Part of CSS control project and park redevelopment plan	Wetland enhancement, flowing runnels	• City of Portland Environmental Services (2011)
Pennsylvania	Philadelphia	**Tacony Creek**	2011-2012	2,200 feet		$1.8 million from U.S. Army grant		Stream restoration	Streambank stabilization, in-stream rock vanes, native plantings	• Tookany/Tacony-Frankford • Ecological Restoration Inc.
Utah	Salt Lake City	**City Creek**	Study Phase	8,900 feet	650 acres	Study funded by U.S. EPA		Stream restoration, community catalyst, riparian corridor enhancement.		• Love, Ron (2010) • EPA Land Revitalization
Virginia	University of Virginia	**Meadow Creek "The Dell"**	2004	1,200 feet	150 acre; suburban	~$700,000		Create campus amenity; allow new stream to deposit sediment on site, slow major flows	Use site as floodplain	
Virginia	McLean	**Pimmit Run Tributary**	Mid-1990s	50-100 feet	0.03 sq. mi.; forested	N/A		Storm runoff control; create amenity	Ephemeral stream; Residential-scale "micro-daylighting"; partial flow daylighting	• Pinkham, Richard (2000)
Washington	Seattle	**Madrona Park Creek**	2007-2009	.25 mile		$805,000; The total creek daylighting project was accomplished with grants, donations and volunteer time/labor. Approximate dollar amount shown represents only cash/grants.	Friends of the Madrona Woods;	This community-initiated project took Madrona Creek out of pipes and put it back on the surface of the ground to provide multiple benefits including habitat, environmental education and scenic beauty in Madrona Park.	Includes waterfalls, cascades, wetlands, creek stabilization and more	• http://www.cityofseattle.net/parks/maintenance/MadronaCreek.htm • http://www.madronawoods.org/projects/current-projects/ • http://www.wasla.org/wp-content/uploads/2012/07/wasla_award_summary_2010_fnl.pdf
Washington	Seattle	**Ravenna Creek**	1996	600 feet		2 million				

State	Location	Waterbody	Year Daylighted	Length	Size of Watershed	Cost	Sponsors	Narrative and Notes	Notable Features	Links or Sources
Washington	Seattle	**Pipers Creek**	Mid-2000's		1,835 acre; urban			Improve fish passage and salmonid habitat, upstream includes 110th SEA Street Natural Drainage System	Includes cascading pools	• SPU – 110th Cascade Project • Seattle's Natural Drainage Systems
Washington	Seattle	**Taylor Creek**	Several segments - 1971 to present					Volunteers have planted thousands of indigenous trees and plants, removed tons of garbage, removed invasive plants, and had city help removing fish-blocking culverts and improving trails.		• City of Seattle – Restore our Waters • Seattle's Natural Drainage Systems
Washington	Seattle	**Thorton Creek**	2009	Approx. 300 feet long by 30 feet wide	680 acres; urban & suburban	$14,700,000		Catalyst for economic development, provides water quality benefits;		• http://www.seattle.gov/util/groups/public/documents/webcontent/spu01_006146.pdf • Seattle's Natural Drainage Systems
Washington	Port Angeles	**Valley Creek**	1997	490 feet of culvert removed	4.2 square miles; forested and urban	$1 million; including park amenities; includes value of considerable donated time and materials		Reduce costs for an important local business, retain jobs, create habitat and recreational amenity	Restored coastal estuary; high return on investment for a business	• Pinkham, Richard (2000) • Jones S. 2001.
Washington	Maple Valley	**Jenkins Creek**	Phase 1: 1994 Phase 2: 1996	Phase 1: 800 feet of new channel Phase 2: 700 feet of new channel	Phase 1: 1.6 sq. mi. Phase 2: 0.6 sq. mi.	Phase 1: $645,000, including purchase of an easement Phase 2: $400,000		Improve upstream salmonid passage and spawning/rearing habitat	Daylighting on golf course and daylighting of a parking lot; design for fish passage and habitat	• Pinkham, Richard (2000)
Washington	Omak	**Omak Creek**	1998	1,500 feet of culvert removed	140 sq. mi.; range land and commercial forestry	$780,000 including special arch culvert logging deck		Improve fish passage and stream function; repair flood damage and reopen lumber mill	Fast-track design and permitting; adaptive construction management; incremental introduction of flows	• Pinkham, Richard (2000)
Washington	Bellingham	**Padden Creek**	Engineering Planning	2,200 feet				Converts brick tunnel to natural stream channel to allow fish passage, improve habitat and reduce flooding		City of Bellingham
Washington D.C.	D.C.	**Tributary to Anacostia River**								
Wisconsin	Janesville									

International Daylighted Streams and Natural Conveyance Channels

State	Location	Waterbody	Year Daylighted	Length	Size of Watershed	Cost	Sponsors	Narrative and Notes	Notable Features	Hyperlinks or Sources
British Columbia	Vancouver	**Burnaby Mountain and/or Still Creek**	Still Creek: 2005-2009	Still Creek: 75 meters				Combines sustainable community design with innovative stormwater features. The project is called "UniverCity".		• http://www.waterbucket.ca/gi/sites/wbcgi/documents/media/150.pdf • Developer's website: http://liveorigin.com/
Switzerland	City of Zurich	**40 different creeks**	1988 to present (several segments)	40 creeks that total around 12 miles				CSS control projects – have reduced nearly 4.5 million gallons per day from entering city's two wastewater treatment plants		• SFPUC 2030 Sewer System Master Plan • Jones S. 2001. •
Sweden	Malmo									
British Columbia	Vancouver	**Spanish Bank Creek**	1999 - 2001	58 meters	17 hectacres,	$80,000		Habitat improvement was primary objective	Stream riparian corridor improvement, surrounded by green open space, connects waterway to waterway.	• Jones S. 2001.
British Columbia	Vancouver	**Hastings Creek**	1999	800 meters	7.1 km^2, 20 hectares, dense mixed use area	$10 – 12 million		PNE Park renovation project; aka "The Sanctuary", aka Creekway Park Plan	Waterway to culvert connection	• http://vancouver.ca/pnepark/ • Jones S. 2001.
British Columbia	North Vancouver	**Thain Creek**	1998	200 meters	0.3 hectares; residential area	$1.5 million		Stormwater management was primary objective	Culvert to waterway	• Jones S. 2001.
New Zealand	Christchurch	**Corsers Stream**	1988-1990			$1.8 to $2 million – a third of the alternative plan – a pipe – which would have cost $5.4 million		Stormwater management was primary objective	Culvert to waterway	• 2010 Stormwater Conference "Lessons from New Zealand" • Watts and Greenaway (n.d.) • Watts. R.H. (2011)
New Zealand	Christchurch	**Papanui Stream**	2002				Retirement Village and various City depts.	Stormwater management was primary objective but creating a new community amenity was a significant objective	Culvert to waterway combines landscaped stormwater treatment trains with naturalized waterway	• Watts. R.H. (2011) • Waterways. Wetlands and Drainage Guide (2003)
New Zealand	Auckland	**Meola Creek**	2009-2010	Approx.. 600 meters		"several hundred thousand dollars" (p.6)	Metrowater and "STEPS" community group	Primary goal was flood relief	Daylighted culvert with rock cascading weir	• 2010 Stormwater Conference "Lessons from New Zealand" • Auckland Environmental Court minutes (March 2011)
Ontario	Toronto	**Garrison Creek**	Proposed							• Lost River Walks • Jones S. 2001.
Ontario	Toronto	**Taddle Creek**	Proposed							• Jones S. 2001.
Ontario	Toronto	**Humber Creek**	2002							
Singapore	Kolam Ayer	**Kallang River**	2009-2012	2.7 kilometers	62 hectare park in highly dense urban area	$2.5 million	Singapore Government	Part of larger Bishan Park restoration. Primary goals – community amenity, ecological restoration, stormwater management		• Kallang River • Bishan Park • TreeHugger
Nova Scotia	Halilfax									
Korea	Seoul	**Cheong-Gye-Cheon**	2002-2005	4 miles		$380 million	Seoul Mayor Lee Myung-bak	Buried stream beneath roadway and elevated highway in slum of Seoul was turned into beautiful new creek.	Some parts of stream are very urban and publicly interactive will other parts of stream are more naturalistic, secluded and quiet.	• L.A. Creek Freak Online Blog
China	Beijing	**Zhuanhe River**	2002		Stream length: 3,700 meters					• China Daily

APPENDIX D

APPENDIX E

The Importance of Base Flow to the Restoration and Attainment of WQS Designated Uses in Cincinnati Area Streams

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The attainment of designated uses as described in the Ohio WQS for aquatic life and recreation in urban streams can be problematic. The U.S. EPA and Department of Justice (DOJ) have recently focused on enforcement of Clean Water Act (CWA) provisions related to the impairment of designated uses caused by sanitary sewer overflows (SSOs) and combined sewer overflows (CSOs) common to many large urban areas of the U.S. As a result many U.S. cities have signed "Consent Decrees" with EPA and DOJ to initiate addressing these challenging water quality issues. The Metropolitan Sewer District of Greater Cincinnati (MSDGC) developed a remediation plan that would be effective, but still affordable for local ratepayers. It includes the consideration of alternatives to classic "grey" engineering alternatives and coupled with the knowledge being generated by the watershed assessment program it provides the opportunity to seek solutions that are more environmentally and cost-effective.

Impacts to aquatic life uses in urban areas are so prevalent that it has been termed the "Urban Stream Syndrome" (Walsh et al. 2005). The causes of these impacts include "flashy" flows (high and low extremes), elevated concentrations of nutrients and chemical contaminants, and altered channel morphology. Even though altered flows and physical habitat impacts are important agents of aquatic life impairment, the assessment of SSO and CSO control effectiveness has largely focused on surrogate measures that focus on water chemistry (e.g., total suspended solids, oxygen demanding wastes, etc.). However, based on what is known about the impairments this narrow focus may not result in the real restoration of the aquatic life uses to which they are linked in state WQS. This is even more explicit in Ohio where designated uses are expressed in measurable biological attributes, i.e., compliance is measured by biological criteria. These more holistic and direct measures of aquatic life use attainment, via the assessment of the condition of biological assemblages (e.g., fish and macroinvertebrates) provides the most accurate and complete overall measure of condition and status. Biological condition integrates the effects of all stressors that can impair the aquatic life designated uses including habitat and flow. Environmental flows are of particular concern in urban watersheds because of the substantial and historical alterations that have taken place relative to more natural conditions, and these are revealed in greater extremes between peak and low flows. The importance of base summer flows to aquatic life is critical and it has been termed the "master" variable in a seminal paper on the "Natural Flow Regime" by Poff et al. (1999). Flow is one of the five factors included by Karr et al. (1986) in the model that demonstrates the relationship of chemical, physical, and biological variables to meeting the biological integrity goal of the Clean Water Act (CWA). In Midwestern streams, base flow provides a number of critical functions that affect the eventual attainment of designated uses.

The Linkage From Stressor Effects to Ecosystem Response

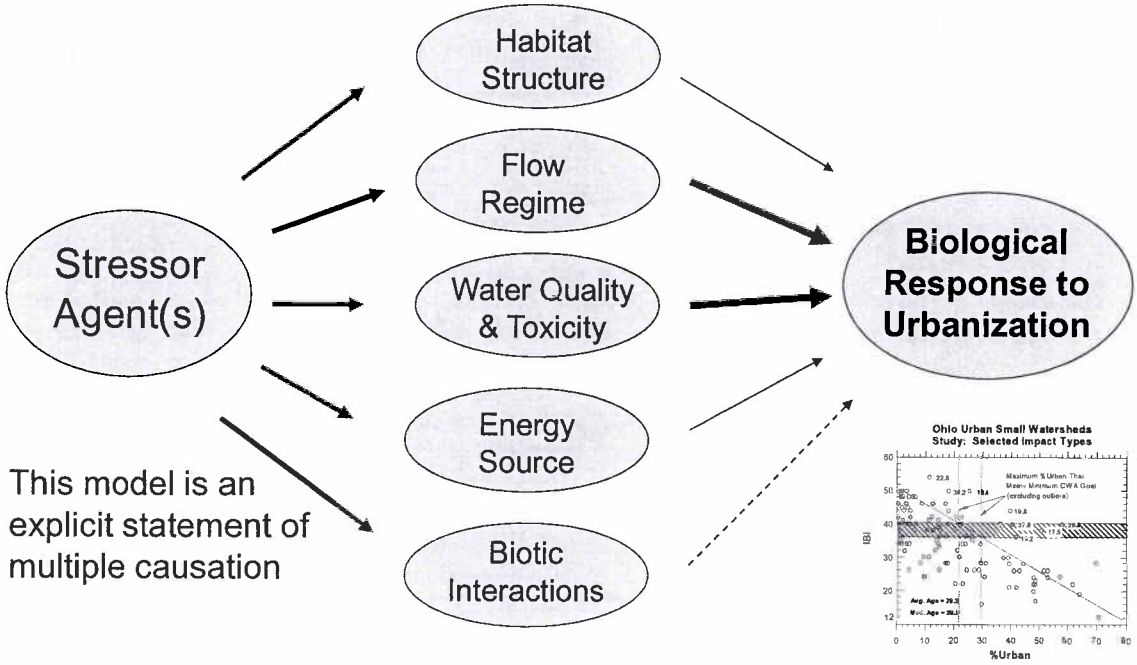

Figure 1. The biological response to urbanization as it is affected by the five factors that determine the integrity of a water resources.

Without sufficient summer-fall base flows these WQS goals simply cannot be met. Figure 1 illustrates the role of flow with these other factors and I tis based on observations from the major urban areas of Ohio. Unfortunately, traditional and "grey" approaches to pollution abatement frequently ignore the importance of base flow and at times recommend practices that degrade the base flow regime in the interest of achieving a "zero discharge" of pollutants. This has already happened to some extent in Hamilton County via the issuance of NPDES permits that attempt to "regionalize" sewage flows by diverting them away from headwater streams towards the largest rivers in the area. When this "sweeps up" and diverts storm flows from smaller streams, impairment of aquatic life results simply from the lack of sufficient water and habitat. Shifting this thinking toward the augmentation of low flows even with treated effluent would be a positive for use attainment.

An issue with conventional responses to CSO and SSO flow reductions can result in a worsening of the base flow problem particularly in smaller tributaries of impacted watersheds. Diverting combined flows to sequestration places (e.g., tunnels or oversized interceptor sewers) may appear to address the overall pollution problem, but it can ignore the need to keep the non-sanitary flows distributed within a watershed. Criticisms of holistic and innovative approaches

to urban stormwater management reflect a lack of awareness about the mechanisms of aquatic life use impairments. An over-reliance on more traditional "grey" infrastructure solutions can become disconnected from the overall goals of water quality restoration efforts particularly when the underlying assumptions are focused on administrative measures or surrogate water quality targets rather than on direct and more complete measures of designated use attainment (e.g., aquatic life). Innovative approaches that are "green" or a mix of "green" and "grey" approaches can be more cost-effective compared to "grey" approaches alone and more broadly address the actual designated use goals of water quality restoration (U.S. EPA 2007). Recent studies are documenting that "green" infrastructure and the restoration of natural functions and features can be important drivers of economic re-development in urban areas (Adelaja et al. 2012).

Ohio offers an advanced setting in having tiered aquatic life designated uses in their WQS which provides an impetus to consider all of the factors that drive quality in rivers and streams. Neither does it does not hold all waters to a single uniform standard, but rather recognizes that restoration potentials can vary from biologically and physically limited waters to biological unique and diverse waters thus allowing restoration projects to take these differences in potential into account. The potential costs and benefits of properly restoring ecosystem services in urban areas can be complex and a sound scientific basis for guiding water quality management is imperative. Such an ecologically-focused approach allows a broader consideration of ecosystem services that are produced by watersheds including nutrient and waste assimilation, water conservation, recreational attributes, maintenance and protection of biodiversity, as well as more global and diffuse benefits such as carbon and nutrient control and climate change benefits.

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