METROPOLITAN SEWER DISTRICT of greater CINCINNATI

Date: October 8, 2012

To: Commissioner Greg Hartmann
Commissioner Chris Monzel
Commissioner Todd Portune

Cc: Christian Sigman, County Administrator
Jeff Aluotto, Asst. County Administrator

From: James A. Parrott, Executive Director JAP

Subject: Model and Local Data Risk Mitigation for LMCPR

MSD is confident the hydraulic and hydrologic model used to develop the recommended Lick Run sustainable projects and the larger LMCPR Sustainable Alternative is a reasonable and rational approach for decision making. Focusing on the Lick Run sustainable project, our confidence stems from several factors including:

- MSD has made a comprehensive effort to visually review every pipe, manhole, parcel, land use, & drainage pattern for all 87 sub-catchment areas directed to CSO 5.
- Existing local data provides a good understanding of the quantity of water in the existing sanitary and storm collection sewers and how they lead into the combined trunk sewers. We know what will be removed.
- The model inputs and assumptions have been fully vetted with leading industry experts including the third party County expert and the federal, state, and local Regulators.
- The LMC Partial Remedy is based upon the results of modeling software developed by USEPA. The Regulators have reviewed the local data inputs and the adjustments made to the model assumptions. They have indicated "no red flags".
- It is reasonable to assume the Lick Run section of the model is correct when the upstream and downstream sections have been validated.
- The limited risk associated with limited flow monitoring data at CSO 5 is minimized through the collective wealth of local data and sophistication of the current modeling technology that has been deemed a rational tool by the Regulators and is within industry standards.

The County monitor has suggested MSD explain how data input into the system-wide model supports the sizing and ultimately costs developed for the Sustainable Alternative. The monitor team specifically inquired about the correlation of local data and stormwater separation effectiveness. MSD understands the issues posed by the County monitor team. This memorandum highlights the key issues and explains how the data input into the model is appropriate for decision making including sewer separation vs. strategic separation; accounting of local data and system flows; industry standards and procedures for data gaps; and experiences of other cities.

Model & Local Data Risk Mitigation

1. Sewer Separation vs. Strategic Separation

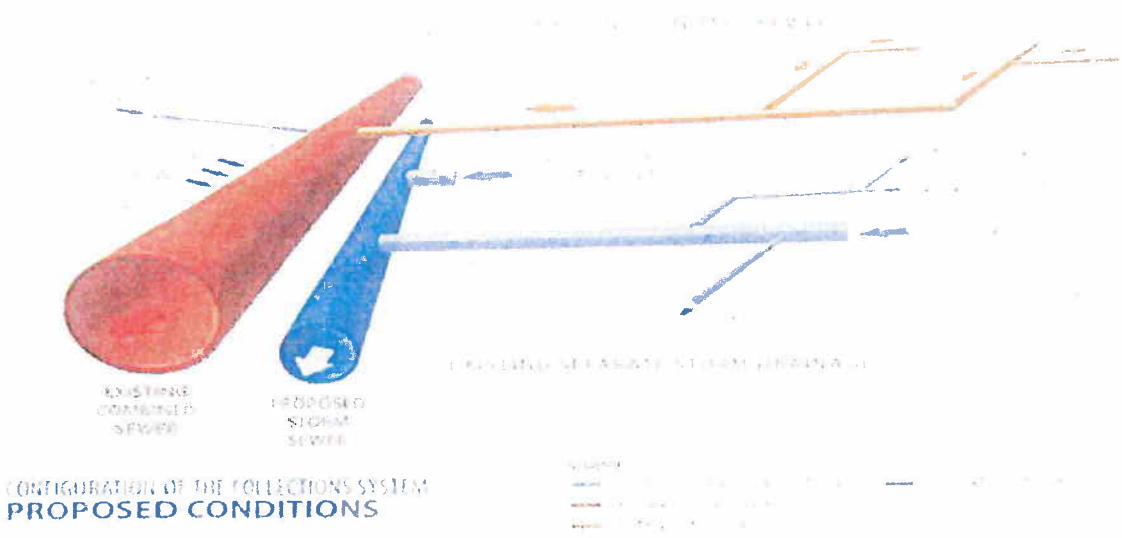
Traditional Sewer separation has been proven to be a very effective component to many CSO long term control plans. This form of separation involves constructing a new partially separated combined or storm sewer network to off-load wet weather flow from an existing combined sewer. It is typically applied to systems comprised solely of combined sewers without existing storm sewers. The legitimate criticisms of this technique include:

- House to house separation is often challenging and disruptive. There is typically a concern that sanitary connections will remain after separation, thus creating an illicit discharge.

- Historically, communities that performed separation did not provide any "treatment" to the separated stormwater and this resulted in some water quality issues from the increased stormwater discharges.

The proposed Lick Run project, an example of various projects included in the LMCPR Sustainable Alternative, addresses both of these issues. MSD is proposing "strategic separation" which focuses on street inlets and undeveloped hillsides. It generally does not involve house to house separation, except in rarte cases when cost-effective. A schematic of this concept is presented in Figure 1.

FIGURE 1 – STRATEGIC SEWER SEPARATION



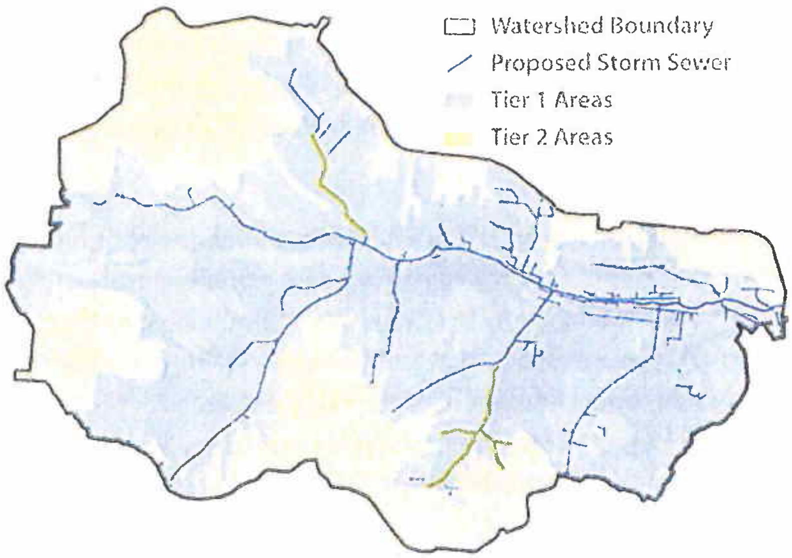
Strategic sewer separation differs from traditional separation and is not applicable to all communities. It is only viable in communities like MSD where wet weather flows are collected via existing storm sewers and sanitary flows are collected via sanitary only sewers. The existing storm and sanitary sewers are then interconnected into a large "combined sewer" network. MSD is proposing to eliminate the existing interconnection and re-route the existing separated storm sewer flow to a new storm trunk sewer –in lieu of the existing combined sewer. The sanitary flow will continue to be directed to the existing combined sewer system.

An understanding of the watershed characteristics of Lick Run and its constituent neighborhoods and the financial constraints led to the development of the strategic sewer separation approach. The limits of the proposed sewer separation within the watershed were determined with the goal of capturing as much stormwater as possible with focused investments in new infrastructure. With that goal in mind, the sewer separation approach targeted stream entry points, large undeveloped hillsides, and areas already served by separate storm and sanitary systems that eventually discharge into the combined sewer system. These targeted areas of the watershed were termed priority areas (referred to as Tier 1 areas) and represent approximately 1,800 acres.

Highly developed areas on the upper reaches of the watershed requiring extensive separation, and therefore expense, were **excluded** from the Tier 1 areas unless it was reasonably efficient to extend new separated storm trunk sewers to connect with existing separated drainage collection systems. These upland areas were termed non-priority areas (referred to as Tier 2 areas) and represent approximately 900 acres. The boundaries of the Tier 1 areas are shown in Figure 2 with the area shaded in blue representing the Tier 1 areas.

Strategic sewer separation is proposed primarily through the installation of new storm sewers or natural conveyance systems sized to convey stormwater from the Tier 1 areas only. In some isolated cases within Lick Run (approximately 10% of the Lick Run pipe to be installed), it was deemed more cost effective to install new partially separated combined sewers and utilize the existing combined sewer infrastructure for stormwater conveyance.

FIGURE 2 – TIER 1 PRIORITY AREAS OF LICK RUN WATERSHED



A summary of the fate of various flows after strategic separation has been completed in the Lick Run Watershed is as follows:

Flows to new storm sewer trunk system

- Existing storm sewers in Tier 1 areas
- Downspouts connected to existing storm sewer in Tier 1 areas
- Hillsides, ravines, and inlets in Tier 1 areas
- Overland flow from Tier 1 and 2 areas
- Stream inlets in Tier 1 areas
- Roadway inlets from 1,800 acres of Tier 1 areas

Flows to remain in existing combined sewer system

- Foundation drains
- Downspouts connected to combined sewer system
- Existing infiltration and inflow
- Stream inlets in Tier 2 areas
- Roadway inlets in 900 acres of Tier 2 areas

The situation of unknown sanitary laterals being connected to a new storm line, resulting in illicit discharges is not an issue with the approach being proposed in Lick Run. The proposed Lick Run strategy also provides for water quality treatment of all separated stormwater, thus avoiding the second issue associated with traditional storm separation projects.

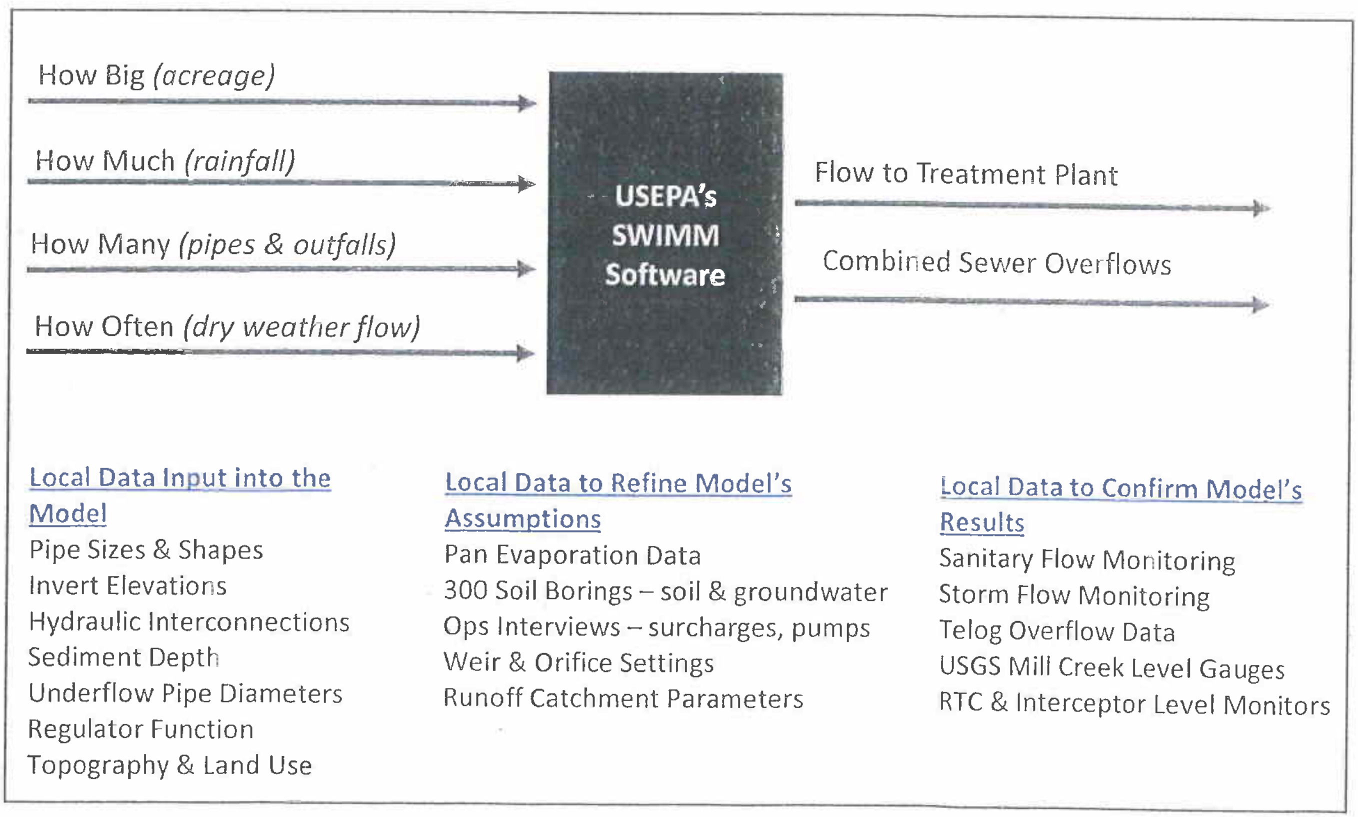
2. Accounting of Local Data and System Flows

Simply speaking, a mass balance approach is used to estimate stormwater separation effectiveness. The volume of water redirected to the storm system plus the volume of water remaining in the combined sewer system is equal to the sum of water in the combined sewer system before separation. Model inputs and results are carefully vetted to verify this volume balance.

MSD is confident the engineering and field evaluations conducted throughout the Lower Mill Creek (LMC) Study accurately accounts for capture the stormwater runoff. MSD has performed field visits and refined percent capture volumes based on actual site/drainage area conditions. Assumptions have been peer reviewed (multiple times) and deemed to be reasonable.

In order to fully understand the brevity of the mass balance approach utilized, it is important to understand the sources and impact local data has played with the LMC Study. A schematic of the hydrologic and hydraulic modeling process is shown in Figure 3.

FIGURE 3 – PROCESS OF HYDROLOGIC AND HYDRAULIC MODELING

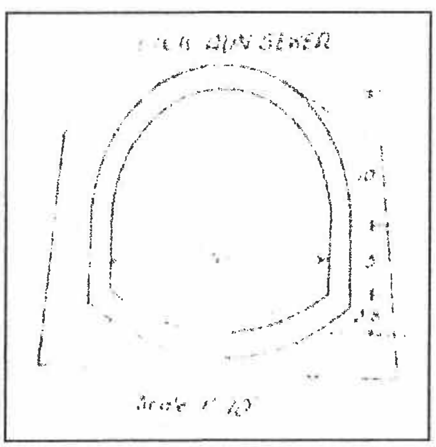


Local Data Input into the Model

The Consent Decree requires a wet weather solution that is based on USEPA's hydraulic and hydrologic modeling software developed by USEPA. During the LMC Study MSD reviewed and evaluated local data to verify information input into the model software accurately represents MSD's sewer system. Record drawings, aerial photographs, and Cincinnati Area Geographic Information System (CAGIS) were utilized extensively to quantify acreages of sub-basins, pipe sizes, local topographic conditions, impervious area, land use, topography, soil group, and hydraulic interconnections of the storm, sanitary, and combined sewer systems.

The Lick Run watershed was broken down into sub-catchment areas, as delineated in the combined sewer model. 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. The LMC Study Team conducted field investigation to develop 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. Driveways and sidewalks, parking lots, and other miscellaneous impervious areas were digitized by hand using 2011 aerial photography. This level of effort was extensive but necessary to ensure local data was utilized to reflect the existing infrastructure and land conditions input into the USEPA model.

In addition the elevations of pipe inverts, manhole rims, control gates, and weirs were verified using a combination of record drawings, CAGIS data and field surveys. Field investigations were conducted at key locations to measure and record the depth of sediment present in the existing sewers.



Local data was also gathered in the field with respect to pipe shapes. The model will assume a uniform pipe shape if different information is not input by the users. Given the age of much of the existing sewer infrastructure throughout MSD's service area ranges from 1 to 120 years, it is important to use local data to properly account for pipe shapes. The LMC Study Team had to create custom shapes for conduits for select pipes. Figure 4 shows a portion of a record drawing for a sewer segment and also lists a sampling of pipes that were customized in the hydraulic model.

Model & Local Data Risk Mitigation

FIGURE 4 – CUSTOMIZED CONDUIT SIZES

Conduit	Original Shape	Original Size	New shape	New size
28605024-28605025	HORIZ_ELLIPSE	17.83' x 20'	CUSTOM	17.8' x 20'
28605025-28605026	HORIZ_ELLIPSE	17.83' x 20'	CUSTOM	17.8' x 20'
28605026-28605029B	RECT_CLOSED	17.83' x 20.5'	CUSTOM	17.8' x 20'
28605029B-29408023	RECT_CLOSED	17.75' x 20.5'	CUSTOM	17.8' x 20.5'
29408023-29408050	CIRCULAR	14.5'	CUSTOM	17.8' x 20.5'
29408050-29408049	CIRCULAR	14.5'	CIRCULAR	19.5'

Another example of MSD's use of field investigations to improve the quality of data input into the model was confirmation of the multiple components of underflow structures. The Lick Run CSO 5 is a complex outfall structure with a myriad of interrelated pieces. MSD operations staff was instrumental in assisting the technical team with understanding the working relationship of those pieces. Figure 5 represents a profile view of the Lick Run underflow structure. The field investigation and monitoring data study resulted in tweaks to the model inputs regarding the entry loss coefficient and pipe diameter and offset measurements.

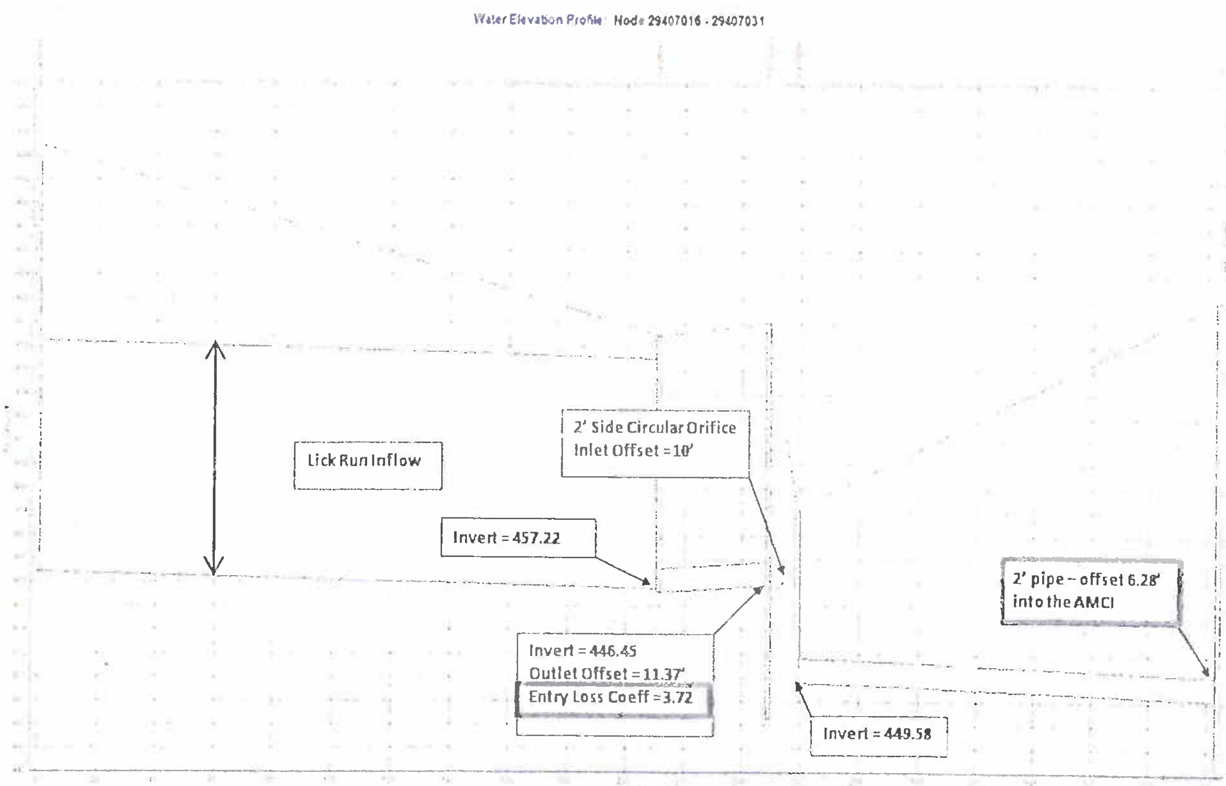


FIGURE 5 – VERIFICATION OF UNDERFLOW PIPE CHARACTERISTICS

MSD is confident this level of effort has significantly enhanced the quality of local data input into the hydraulic and hydrologic model. Earlier versions of the model used the data available at that time (before MSD's field investigation and records review) as model inputs. MSD invested time and capital into fully vetting the Sustainable Alternative and one component of that vetting process was to confirm and reaffirm local data was used to refine model inputs.

Local Data to Refine Model Assumptions for Existing System

USEPA's SWMM model software uses a complex set of engineering equations combined with logic sequences and performance assumptions to predict the flows directed to the treatment plant and the streams. The assumptions built into the model were developed by the Regulators and have been used for decades with hydraulic and hydrologic models. By improving the details of the assumptions built into the model, MSD was able to improve the accuracy of model results. Assumptions addressed by the LMC Study Team include:

- Pan evaporation data based upon local NOAA information was added into the model to account for local climatic conditions.
- 300 soil borings were advanced to confirm soil conditions and the groundwater elevation for the Lick Run area.
- Operational staff interviews were conducted to gain an accurate understanding of the locations of surcharges in the existing system and control settings for pumps, gates, and other key infrastructure.
- Weir and orifice control settings and operational logic were adjusted to match actual conditions in lieu of using typical values.
- Runoff catchment parameters were field verified to account for local data unique to each sub-catchment areas in lieu of using regional published information.

The issue of the appropriate runoff catchment parameters to utilize for the model has been an item of discussion between MSD and the County monitor team. This is an important criterion in that the model uses these parameters to simulate the volume of stormwater captured and directed to local surface waters in lieu of the combined sewer. The parameters would be more complex to develop if MSD were proposing traditional sewer separation in lieu of strategic sewer separation.

Local Data to Refine Model Assumptions for Proposed Separation Improvements

The specific details of work conducted to verify the percent capture and effectiveness for the Lick Run Watershed are presented in the *"Lick Run Percent Effectiveness Technical Memorandum" prepared by Strand and Associates, September 2012.* A brief discussion of the key issues is presented herein. It is easy to confuse the concepts of percent capture and percent effectiveness in the context of runoff catchment parameters. The definitions are as follows.

$$Percent\ Effectiveness = \frac{volume\ of\ stormwater\ removed\ from\ combined\ sewer\ system}{total\ wet\ weather\ volume\ currently\ conveyed\ to\ CSS}$$

$$Percent\ capture = \frac{volume\ of\ rainfall\ directed\ to\ storm\ sewer}{total\ rainfall\ volume}$$

Stormwater separation effectiveness is calculated as the volume of water redirected to the storm systems divided by the total wet-weather volume tributary to that location in the storm sewer. Total wet-weather volume includes both stormwater runoff and rainfall derived infiltration and inflow (RDII). Percent effectiveness is one of the primary assumptions leading to the modeled results. As such, MSD understands the importance of getting accurate local data to optimize assumptions and calculations.

The model software assumes a percent effectiveness based upon the data input into the model (impervious area, land use, etc). The LMC Study Team assessed, evaluated, and visited each of the sub-catchment areas. The results of the LMC Study indicated adjustments were made to a few sub-catchment areas to better reflect actual field conditions. The results of the evaluations for each sub-catchment area are provided in the Lick Run Percent Effectiveness Technical Memorandum.

To provide a level of understanding for the comprehensive nature of the field evaluations conducted for each sub-catchment area in the context of percent effectiveness, the following two examples are provided in Figures 6 and 7. Figure 6 presents the information for a sub-catchment area in which the assumptions were revised resulting in a higher percent effectiveness value. Figure 7 represents a sub-catchment area resulting with a lower percent effectiveness.