Water Quality Modeling Study

Ivy Falls Creek, Interstate Valley Creek and Highway 13 Watersheds

Prepared for
Lower Mississippi River Watershed Management Organization

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Executive Summary

The Ivy Falls Creek, Interstate Valley Creek, and West, Central, and East Highway 13 watersheds are located in the northwestern part of the Lower Mississippi River Water Management Organization (LMRWMO). This area encompasses a large portion of the city of Mendota Heights, most of the cities of Lilydale and Sunfish Lake, and small portions of the cities of St. Paul, West St. Paul and Inver Grove Heights. These watersheds generally drain to the northwest, by means of Interstate Valley and Ivy Falls Creeks.

In accordance with the LMRWMO *Watershed Management Plan* (Plan) (Barr, 2001), the LMRWMO Board of Managers initiated a water quality modeling study for the five watersheds named above, with the intent of "identifying hot spots for nutrient loading to the Mississippi River and to identify if the water quality improvement measures (or other measures) identified in Table 5-3 of the Plan are appropriate and feasible" (from Section 5.3A, Policy 4 of the Plan). This is consistent with the LMRWMO's overall initiative of improving the quality of stormwater runoff to the Mississippi River by reducing nonpoint source pollution transported by stormwater runoff. This Water Quality Modeling Study (Study) was completed in response to the LMRWMO's goals.

The goals of the Study were twofold: (1) to assess the existing and future conditions expected in the Ivy Falls Creek, Interstate Valley Creek, and West/Central/East Highway 13 watersheds and (2) determine the relative benefit of completing the improvement projects identified in Table 6-1 of the Plan.

The Modeling was intended to evaluate relative water quality improvement options, and not to determine absolute runoff quantities. This concept-level evaluation of the potential benefits of the improvement options was not intended for detailed design and assessment of their feasibility and cost-effectiveness. According to the Plan, an engineering feasibility study was intended to follow this Study to focus on issues involving detailed design and cost estimates.

The approach for this project was to compile existing information and data from other sources to determine subwatershed and drainage system inputs for the water quality model used in this study. The water quality model was then used to estimate hydrologic and nutrient loadings to the Mississippi River under existing and future land use development conditions, as well as loading estimates following implementation of various best management practices (BMPs).

For improving water quality in urban water bodies, both structural (involving construction of detention basins, outlets, flow diverting structures, etc.) and non-structural (involving behavioral change: increased street sweeping, reduced fertilizer use, changes in landscaping practices, etc.) BMPs should be considered. Using the P8 water quality model, five types of BMPs for improving the water quality entering the Mississippi River from the Ivy Falls Creek, Interstate Valley Creek, and West/Central/East Highway 13 drainage districts were evaluated. These BMPs included:

- **Detention Ponds** – Three different detention pond improvements were applied. Selected wet detention ponds were deepened, some existing dry detention ponds were deepened and converted to wet detention ponds, and new wet detention ponds were created in some subwatersheds. Three of the proposed improvements involving deeper wet detention ponds were intended for water quality improvement in Sunfish, Rogers and Hornbeam Lakes, respectively.

- **Combination of Detention Pond Improvements** – Some of the detention pond alterations described above were grouped together to increase the reduction of nutrients entering the Mississippi River.

- **Infiltration/Rainwater Gardens** – After receiving knowledge of locations in the study area where they might be feasible, infiltration practices, or rainwater gardens, were modeled at each site using typical dimensions and construction practices. In addition, another scenario was modeled, based on the assumption that infiltration practices would be implemented throughout the study area.

- **Phosphorous Fertilizer Ban** – An ordinance prohibiting the use of phosphorous fertilizers was modeled across the study area. Depending on conformity, this would help to curb a significant source of phosphorous in stormwater runoff.

- **Street Sweeping** – Used primarily in the spring to remove accumulation of sand and grit applied to streets during winter months and leaves in the fall, a ramped-up street sweeping program during summer months could also intercept phosphorous and solids before entering ponds, wetlands, streams, and eventually, the Mississippi River.

Based on the P8 water quality modeling results of the five types of BMPs, the following conclusions can be made about improving the water quality entering the Mississippi River from the Ivy Falls Creek, Interstate Valley Creek, and West/Central/East Highway 13 drainage districts:

- The expected water quality improvement from implementing a combination of detention pond options is almost the same as the total phosphorus load reduction predicted for the diversion of both creeks into the wetland southwest of Pickerel Lake, without the combination of upstream wet detention pond options.

- Implementing infiltration practices (such as rainwater gardens) watershed-wide would result in significant total phosphorus load reductions – approximately 66 percent of the total phosphorus load from the entire study area during an average year.

- An optimistic modeling scenario of the effects of a phosphorus-free fertilizer ordinance indicates a significant total phosphorus load reduction could be expected (approximately 9 percent of the total total phosphorus load from the study area). This scenario may predict more benefit than what might realistically be expected given the fact that pervious areas do not contribute significant runoff volumes during typical rainfall runoff events and limited data is available regarding the dependence on citizen (and commercial applicator) education, conformity and actual mobilization of phosphorus from fertilizer applied under current practices in the watershed areas.

- Additional mechanical street sweeping (beyond passes in the spring and fall) will not result in significant total phosphorus load reductions and provide very little water quality improvement benefits.

Based on the goals and conclusions of this study, the following recommendations can be made:

- **Complete Feasibility Study of the Study Area** – The LMRWMO *Watershed Management Plan* (Barr, 2001) recommends that a feasibility study be conducted following the completion of this water quality modeling study. The intent of the feasibility study is to take the conceptual evaluation of the potential benefits of the improvement options discussed in this study, consider their detailed design issues, and assess them for their feasibility and cost-effectiveness after making any necessary refinements to the water quality modeling.

- **Initiate Monitoring Program for the Study Area** – As previously mentioned, limited water quantity and quality data was available from the watersheds in the study area. As a result, the water quality modeling was largely completed using default model parameters associated with watershed land use or detention pond characteristics. Monitoring data from the watersheds in this study area can be used to calibrate the water quality modeling and verify the initial conclusions and recommendations that have subsequently been made about implementing watershed BMPs. In addition, some of the BMP scenarios that were evaluated during this study were intended to improve the water quality of Sunfish, Rogers and Hornbeam Lakes. Other BMPs may also have a positive effect on flooding, streambank stabilization and the water quality of streams or wetlands. Additional monitoring of these water resources will enable us to evaluate their overall health, and provide for future refinements of the water quantity and quality goals, as well as the modeling completed for this study.

- **Refine Water Quality Goals for Lakes, Streams and Wetlands in the Study Area** – The results of the engineering feasibility study and additional monitoring data should be used to evaluate whether refinements should be made to the LMRWMO goals for the lakes, streams and wetlands in this study area. For example, total phosphorus and other monitoring data collected from the lakes in the study area could be used to set quantitative goals for controlling eutrophication. Likewise, the engineering feasibility study may identify the need to further consider streambank stabilization measures.

- **Continue to Identify Opportunities for Implementation of Water Quality Improvements** – As more monitoring data becomes available and each of the cities complete Storm Water Pollution Prevention Plans, as part of Phase II of the MPCA's NPDES permit program, new water quality improvement opportunities may become apparent. The LMRWMO should continue to take advantage of opportunities involving pollution prevention, such as public education and participation, new ordinances and revisions to existing ordinances, future development and redevelopment, and education of municipal employees.

1.0 Introduction

The Ivy Falls Creek, Interstate Valley Creek, and the West, Central, and East Highway 13 watersheds are located in the northwestern part of the Lower Mississippi River Watershed Management Organization (LMRWMO), as shown on Figure 1. This study area encompasses a large portion of the city of Mendota Heights, most of the cities of Lilydale and Sunfish Lake, and small portions of the cities of St. Paul, West St. Paul and Inver Grove Heights. These watersheds generally drain to the northwest, by means of local storm sewer systems, Interstate Valley and Ivy Falls Creeks.

1.1 Project Purpose

The October 2001 LMRWMO Plan established a number of water quality management goals for the WMO, including the following: "Improve the quality of stormwater runoff reaching the Mississippi River by reducing nonpoint source pollution (including sediment) carried as stormwater runoff." To further this goal, the Plan includes a policy that calls for the LMRWMO to perform water quality modeling to identify "hot spots" for nutrient loading to the Mississippi River and appropriate water quality improvement measures. This water quality modeling study is the first in a series of projects listed in the implementation table of the Plan that address the LMRWMO's goals and policies.

In accordance with the LMRWMO *Watershed Management Plan* (Plan), the LMRWMO Board of Managers initiated a water quality modeling study for the five watersheds named above, with the intent of locating nutrient loading "hot spots". These are subwatersheds with an excessive amount of sediment and nutrients, such as total phosphorous (TP), in the stormwater runoff. Most of this runoff passes through ponds, lakes and streams, before flowing into the Mississippi River. These "hot spots" can be identified by their relatively low percentage of cumulative TP removal. A detailed explanation of this concept can be found in Appendix A.

1.2 Previous Studies

Barr prepared the water resources management plans for the cities of Inver Grove Heights, Lilydale, Mendota Heights, Sunfish Lake (with Price and Associates) and West St. Paul. As part of plan development, Barr completed hydrologic modeling for these cities. All of the hydrologic modeling was completed using the Barr Watershed Model, and yielded peak discharge rates, storage retention volumes, and high water elevations for the 10-and 100-year frequency storms for each subwatershed.

Barr also completed Pondnet water quality modeling for the city of Mendota Heights, as part of their water resource management plan. This spreadsheet program calculates the nutrient loading from a watershed, taking into account nutrient (total phosphorus) removals from wet detention ponds. Unlike the P8 model (used for this water quality modeling study), Pondnet cannot:

- Model runoff quantity, quality and treatment efficiency for individual storm events
- Account for affects of pond outlet characteristics
- Model other types of Best Management Practices (BMPs)

Barr also completed hydrologic modeling of other smaller areas within the study area. These modeling efforts used either the Barr Watershed Model (e.g. Mendakota Golf Course) or the XP-SWMM hydrologic/hydraulic model (e.g. Town Centre).

Barr used the pond information from these past studies for this water quality modeling study. The pond information included normal water elevation (NWL, which is the elevation of the pond outlet's control), the 100-year high water elevation, storage detention volume for a 100-year storm, downstream subwatershed, outlet type and size, mean pond depth, pond water surface area at the normal water level, and the wet pond volume (or "dead storage") for the pond in each subwatershed.

The methods, results, and recommendations of this Study are presented in the following sections.

2.0 Project Approach and Methodology

The approach for this project was to compile existing information and data from other sources to determine subwatershed and drainage system inputs for the water quality model used in this study. The water quality model was then used to estimate hydrologic and nutrient loadings to the Mississippi River under existing and future land use development conditions, as well as loading estimates following implementation of various best management practices (BMPs).

To determine the location of the nutrient loading hot spots, subwatershed divides, soils data, existing and future land use information, and model input data from previous studies in the area (as described in Section 1.2) were collected. Much of the additional data collected in order to proceed with the modeling effort was in electronic ArcView geographic information system (GIS) mapping format. These maps and ArcView coverages included existing and projected land use maps from the municipalities and the Metropolitan Council (Met Council), parcel, watershed, pond, and roadway maps. Also imported into GIS were graphical coverages such as aerial photos taken in the spring of 2000 and USGS topographic maps. Finally, all available water quality and lake level monitoring data was collected for the water bodies in the study area.

After collection of existing data and mapping, the drainage basin characteristics for each subwatershed were determined. This involved identifying the existing and future land use type for each parcel in the entire study area with the aid of the land use mapping from various sources. Assumptions about the total and directly-connected impervious percentages were made in conjunction with assigning each land use type throughout the study area. Directly-connected impervious surfaces are the fraction of the overall impervious areas that drain directly to storm water conveyances without first passing over pervious surfaces. The data collection and model input determination process in more explained in detail in Section A.1.1 of Appendix A.

The next task involved collecting and entering pond data into the existing conditions water quality model, and running the model for continuous water years (October 1 through September 30) with varying climatic conditions. Pond information required by the water quality model includes water surface area, dead storage volume, flood storage volume and surface area, and outlet type, size and configuration.

A model was then constructed and run for fully developed land use conditions, before additional BMPs were added to the model for evaluation. Finally, each watershed BMP was modeled individually to determine its impact on water quality and all of the results were summarized, tabulated, and recommendations were formulated.

2.1 Modeling Watershed Stormwater and Total Phosphorus Loads

2.1.1 P8 Model Background

The computer model P8 (Program for Predicting Polluting Particle Passage through Pits, Puddles and Ponds; IEP, Inc., 1990) was used to estimate both the runoff and total phosphorus (TP) loads to the Mississippi River from the entire watershed. P8 is a runoff water quality model capable of accurate predictions of phosphorus loads. The model tracks the movement of particulate matter (sand, dust, soil particles, etc.) as they are carried along by rainwater as it travels over land and pavement. Particle deposition in ponds along the way is also tracked, so that the model can estimate the amount of pollutants – carried by the particles – that eventually reach a particular water body. P8 is a useful diagnostic tool for evaluating and designing watershed improvements and best management practices (BMPs).

When evaluating the results of the modeling, it is important to consider that the results provided are more accurate in terms of relative differences than in absolute results. The model will predict the percent difference in phosphorus reduction between various BMP options in the watershed fairly accurately. It also provides a realistic estimate of the relative differences in phosphorus and water loadings from the various subwatersheds and major inflow points to the Mississippi River or pond of interest. However, since runoff quality is highly variable with time and location, the phosphorus loadings estimated by the model for a specific watershed may not necessarily reflect the actual loadings, in absolute terms. Various site-specific factors, such as lawn care practices, illicit point discharges and erosion due to construction are not accounted for in the model. The model provides values that are considered to be typical of the region, given the watershed's respective land uses. Additionally, no calibration data was available for this modeling effort, which would allow Barr to analyze actual conditions and adjust model inputs accordingly. This enables the development of a concept-level evaluation of the potential benefits of the improvement options and is not intended for detailed design and assessment of their feasibility and cost-effectiveness. It is intended that an engineering feasibility study will follow this modeling study to focus on detailed design and cost estimation.

2.1.2 P8 Model Inputs

The model requires hourly precipitation data and daily average temperature data from a data file for a continuous simulation of watershed hydrology and the buildup/washoff of particles. The precipitation data file for this study was obtained from historical daily precipitation records at the Minneapolis-St. Paul International Airport. This file contains hourly precipitation amounts on a daily basis. The average temperature file was also taken from the Minneapolis-St. Paul airport.

Long-term climatic data was used so that watersheds and BMPs could be evaluated for varying hydrologic conditions. This is a good approach to hydrologic and water quality modeling because the best solution to this type of engineering problem is obtained when all scenarios are analyzed. For this modeling effort, three different climate years were modeled: average, wet, and dry. Based on the 52 years of data, the year with the cumulative precipitation distribution (total precipitation = 28.15 inches) closest to the long-term average was October 1, 1956 to September 30, 1957, or, the 1956-57 water year. The wet water year used was 1982-83 (total precipitation = 40.99 inches) and the dry water year used was 1987-88 (total precipitation = 18.67 inches).

To properly set up the model, it is also required to have an accurate assessment of land use and impervious percentages, pond system morphology, flow routing, and pond water quality treatment efficiency. These assessments are discussed in the following sections and in Appendix A.

2.2 Determination of Drainage Basin Characteristics

Examination of the watershed characteristics for the study area involved assessments of soil types, land use and residential development density, and the impervious fraction of the land in the watershed. ArcView GIS software was used extensively in assessing the watershed characteristics. The software also allowed mapping of the drainage network for the area.

Land use coverages were created for the existing and expected future conditions from electronic versions of land use plans for each city and the Met Council. Since each city had a different method of classifying similar land use types, a normalization process was completed to accurately represent all parcels within all of the cities of the study area under one set of land use categories.

As a starting point, Barr used the Met Council's recently released full-development land use coverage, representing projected land use in the year 2020. The residential land use types were reclassified into more appropriate categories, based on the housing density classification field provided in the Met Council's 2020 land use GIS theme. This reclassification resulted in four residential groups in which the roof area, paved area, and total impervious percentages were representative of all of the included properties for each residential land use type. This improved the accuracy and legitimacy of how runoff parameters are determined for the water quality model.

Adjustments and combinations were made to some of the land use categories. For example, the land use categories entitled "Mixed Use" and "Multiple Use" used in some of the coverages each had a small sample size in the study area, so they were re-classified into a commercial, industrial, institutional, or a residential category after each of these parcels had been analyzed visually.

To ensure accuracy and quality control, the Met Council future land use data was cross-referenced with the future land use plans of the cities within the study area. Appropriate changes were made where discrepancies existed, most often resulting in the use of the city's interpretation of a parcel's future land use. Copies of each of the completed land use coverages were sent to the LMRWMO board members from each city in the study for review and comment. Adjustments were made in instances where the board member had a differing opinion on future developments or specialized knowledge about an existing parcel's land use. Figure 2 shows the map of existing land uses in the study area, while Figure 3 shows the future projected land use conditions. The primary difference between the two land use coverages is that the existing land use within the study area currently contains some small areas of vacant land in Mendota Heights and Sunfish Lake that would be expected to develop into low density and rural residential, respectively. In addition, there is vacant land in Inver Grove Heights that will be developed into commercial property under future land use conditions.

Pervious curve numbers, used to represent infiltration rates and compute direct runoff from various soil types, were determined. GIS data from the Dakota County Soil Survey (SCS, 1993), as well as a small portion of the Ramsey County Soil Survey, were imported into ArcView. This data included soil name and the Soil Conservation Service hydrologic soil group (HSG). The overwhelming majority of subwatersheds in the study area contained HSG Type B soils (sandy loam).

Using the table for runoff curve numbers in TR-55 (NRCS, 1986), a pervious curve number was computed by Barr's P8 Model pre-processor for each subwatershed, based on the land use type, soil type, and cover conditions (e.g., if the soil is Type B and pervious areas are composed of grassy areas with greater than 75% cover, then a curve number of 61 would be selected). A composite pervious curve number was determined by weighting the areas for the given soil groups within the subwatershed. This composite pervious curve number was then weighted with indirect (i.e., unconnected) impervious areas in each subwatershed to determine the overall weighted pervious curve number as follows:

$$WCN = \frac{[(Indirect\ Impervious\ Area] * (98)] + [(Pervious\ Area) * (Pervious\ Curve\ Number)]}{Total\ Area}$$

For the future conditions land use coverage, changes were manually made where differences existed between this layer and the aerial photos, the 1997 Met Council land use layer, and the cities' existing land use layers. Most of these differences were for land that is currently vacant but will most likely be developed in the future. Additionally, some select institutional and residential properties were upgraded from low density to high density in the future plan if there was currently space and a possibility of expansion and thus a decrease in total pervious area. The existing land use plans from the cities in the study area were also consulted, primarily to reinforce the Met Council's assignments for non-residential land use types.

For each land use category, a group of representative properties was selected from the completed land use coverage in GIS for estimation of impervious percentages. An impervious area is a surface area in which rainfall or snowmelt cannot infiltrate into the ground and drains from the area by surface runoff. The roof and paved areas from representative properties were digitized in GIS with the aid of aerial photography. The sum of these two areas equals the total impervious area. To determine the total impervious percentage, this total impervious area was divided by the total sample area. An average was then calculated for each land use category.

The next step after calculating the assumed percent impervious values for the land use categories was to compute the assumed directly-connected percentages for each land use type. This is the fraction of land area on a parcel of land in which runoff drains directly into a storm sewer system without first crossing a pervious surface. Except for the Very High Density Residential land use type, approximately half of the total impervious surface area within the representative residential areas, was directly-connected. The following table presents the total and directly-connected impervious percentages that were determined for each of the land uses:

Land Use	Total Impervious Percentage	Directly-connected Impervious Percentage
Commercial	70	65
Industrial	55	50
Highway	35	35
Low Density Institutional	25	16
High Density Institutional	55	45
Rural Residential	8	4
Low Density Residential	35	16
Medium Density Residential	45	20
Very High Density Residential	60	50
Park and Recreational	4	4
Vacant	5	5
Railway	8	0

Another map coverage needed for the study was the subwatershed divides for the study area. The subwatershed coverage used in GIS was a combination of the digitally-represented hard copy versions of subwatershed boundaries, as shown in the water management plans of the five municipalities within the study area.

The water quality model input files were created with Barr's P8 Model pre-processor using the land use, soils, and subwatershed coverages in ArcView, and were then loaded into the P8 model. The remaining input needed for the water quality modeling was the routing and pond input data.

2.3 Determination of Pond Data

As a basis for choosing which ponds and wetlands should be included in the water quality model, two pond and wetland coverages were evaluated in ArcView. The first and more complete coverage was from the National Wetland Inventory (NWI). The other was the protected waters layer from the

Minnesota Department of Natural Resources (MN DNR) Division of Waters. Aerial imagery was also consulted in determining the location and extent of water bodies.

A landlocked pond is defined as a depression or low point in the terrain that holds water some or all of the time, has no outlet, or only has a high-level outlet, in which water flows out of the pond during extreme events. Landlocked ponds were not modeled in P8 because landlocked ponds are largely independent and will only affect downstream ponds (and ultimately the Mississippi River) if there is a large storm, or extended wet period, that increases the pond's water level a significant amount. A review of the Sunfish Lake historical lake level data indicates that the lake is essentially landlocked. For the purposes of this study, it was assumed that Sunfish Lake did not contribute flow and was not included in the P8 models developed for the Interstate Valley Creek watershed. A separate P8 model was developed to evaluate the Sunfish Lake watershed.

Most of the existing pond data was taken from the water resource management plans of the municipalities within the study area. These plans, in part, summarized the results of hydrologic modeling done with the Barr Watershed Model in the early 1990's. Some other types of data obtained from the management plans includes landlocked ponds, MN DNR Protected Waters identification number, drainage area, and sites previously identified by Barr or the city as possible locations for drainage system improvements. Additionally, data was obtained from Pondnet models previously done for many of the ponds in the City of Mendota Heights.

Table A-1, in Appendix A, summarizes the pond input parameters, including normal water elevation, 100-year high water elevation, storage detention volume for a 100-year storm, downstream subwatershed, outlet type and size, mean pond depth, pond water surface area at the normal water level, and the wet pond volume or dead storage for the pond in each subwatershed.

For development of a future conditions model, necessary revisions were made to the existing conditions pond coverage to account for modifications that were anticipated in the near future. The revised data for these modified ponds was obtained from the members of the Lower Mississippi River Watershed Management Organization, or Barr staff associated with the project design and their project files. The location of these pond modifications and a brief description of the changes made are described below.

2.3.1 Pond Modifications

Realizing that the some of the pond data was outdated, adjustments were made to ensure accurate modeling of existing and future conditions. These changes fall into three categories: those that are due to past installation of new ponds or modifications of old ponds, the addition of existing ponds that were not previously modeled, and ponds that are planned for new construction or will be modified in the near future. These three types of pond modifications require the adjustment of P8 Model input parameters (such as dead storage volume, water surface area, and pond outlet size and configuration). A detailed explanation of the modifications made to the ponds that were modeled is contained in Section A.1.2.3 of Appendix A.

2.3.2 Other Sources of Pond Data

Some data was not available for the ponds that were not previously modeled in Pondnet, such as average pond depth and dead storage volume. For these ponds, average depth was determined using an indirect method facilitated by the wetland type designation contained in the NWI GIS coverage. A detailed explanation of this method is described in Section A.1.2.4 of Appendix A. Another study from this watershed, which included observed average pond depths, was consulted to correlate modeled average pond depths with a table of results from a Purple Loosestrife Field Wetland Investigation (Barr, 1993).

By combining a variety of maps in GIS, and associating pond dimensions and other parameters with the pond's location in GIS, a comprehensive representation of the study area was created. This was then used to assess present conditions, set up the P8 model, and ultimately present the results of the water quality model for improvement options around the study area.

After the list of ponds to be modeled was complete, the data for these ponds was entered into the P8 modeling program, and subwatershed data was imported from the P8 pre-processor previously described. The existing conditions model and future conditions model (without additional BMPs) were then run for the three climate years and results were summarized with the help of the P8 Processor. The P8 Processor not only helps with getting input into the P8 model, but also simplifies the transfer of output from P8 into GIS for easy manipulation, and for producing meaningful maps to summarize and display the results.

3.0 Options for Water Quality Improvement

For improving water quality in urban water bodies, both structural (involving construction of detention basins, outlets, flow diverting structures, etc.) and non-structural (involving behavioral change: increased street sweeping, reduced fertilizer use, changes in landscaping practices, etc.) measures should be considered. Typical non-structural measures are described in detail in Table 5-5 in the LMRWMO Plan. Such efforts will reduce the amount of phosphorus reaching water bodies in the study area and the Mississippi River, while educating and motivating local residents so that they are more likely to take an active interest in water quality issues.

Using the P8 water quality model, five types of BMPs for improving the water quality entering the Mississippi River from the Ivy Falls Creek, Interstate Valley Creek, and West/Central/East Highway 13 drainage districts were evaluated. Figure 4 shows the proposed BMP locations within the study area. These BMPs included:

- **Detention Ponds** – Three different detention pond improvements were applied. Selected wet detention ponds were deepened, some existing dry detention ponds were deepened and converted to wet detention ponds, and new wet detention ponds were created in some subwatersheds. Three of the proposed improvements involving deeper wet detention ponds were intended for water quality improvement in Sunfish, Rogers and Hornbeam Lakes, respectively.

- **Combination of Detention Pond Improvements** – Some of the detention pond alterations described above were grouped together to increase the reduction of nutrients entering the Mississippi River.

- **Infiltration/Rainwater Gardens** – After receiving knowledge of locations in the study area where they might be feasible, infiltration practices, or rainwater gardens, were modeled at each site using typical dimensions and construction practices. In addition, another scenario was modeled, based on the assumption that infiltration practices would be implemented throughout the study area.

- **Phosphorous Fertilizer Ban** – An ordinance prohibiting the use of phosphorous fertilizers was modeled across the study area. Depending on conformity, this would help to curb a significant source of phosphorous in stormwater runoff.

- **Street Sweeping** – Used primarily in the spring to remove accumulation of sand and grit applied to streets during winter months and leaves in the fall, a ramped-up street sweeping program during summer months could also intercept phosphorous and solids before entering ponds, wetlands, streams, and eventually, the Mississippi River.

After the model was set up for existing and future land use conditions, with corresponding pond data, the modeling of possible runoff water quality improvement projects was completed for the five types of BMP scenarios. First, additional BMPs were modeled individually to determine their incremental benefit on water quality. Next, the most beneficial and feasible BMPs were combined in a way that might be realistic for implementation. These multiple BMPs were reflected in the model and the cumulative benefit was determined from the model output. Another option was constructing rainwater gardens at strategic locations around the study area.

There are two other water quality improvement possibilities that were explored and modeled that are more widespread, non-localized improvements. The first was enacting a phosphorous fertilizer ban in the cities making up the study area. This scenario can effectively be used as a representation of what was expected when the State of Minnesota recently passed the law restricting the use of phosphorus fertilizer in urban areas, assuming a high level of compliance and effectiveness. The other watershed-wide water quality improvement that was investigated was implementing a street sweeping program to remove built-up sediment and phosphorous from road surfaces and curb-and-gutter, by means of a mechanical street sweeper.

Section 4.2 provides a more detailed discussion of the assumptions made and expected water quality improvements following implementation of each of the above BMP options.

4.0 Results and Discussion

The results of the water quality modeling conducted for this study point to several conclusions regarding the present and possible future condition of the watershed areas. These conclusions are discussed in the sections that follow.

4.1 Water Quality Modeling Results for Existing & Future Land Use

As previously mentioned, P8 water quality models were developed for both existing and future (ultimate planned development) land use conditions in the study area, and run for wet, dry and average climatic conditions. As a way to compare the results of these six P8 model runs, which assume existing drainage conditions, the total phosphorous from the study area entering the Mississippi River was noted for each model at three locations: near the outlet of the Interstate Valley Creek to the river, near the outfall of Ivy Falls Creek, and the remaining riverbank areas not draining to either of the aforementioned watersheds. The results of this can be seen in the following table.

Study Area Outfall	Total Phosphorous Load with Existing Conditions Land Use			Total Phosphorous Load with Future Conditions Land Use		
	Dry[1]	Average[2]	Wet[3]	Dry[1]	Average[2]	Wet[3]
Interstate Valley Creek[4]	470	691	1250	486	716	1274
Ivy Falls Creek[5]	147	220	372	178	215	360
Remaining Local Areas (including Pickerel Lake subwatersheds)	180	272	444	144	261	433
Total	797	1183	2066	808	1192	2067

[1] Modeled using 1987-88 total precipitation of 18.67"
[2] Modeled using 1956-57 total precipitation of 28.15"
[3] Modeled using 1982-83 total precipitation of 40.99"
[4] Loading computed for all flows tributary to Subwatesheds IV-139
[5] Loading computed for all flows tributary to Subwatersheds IF-8, IF-10, IF-22, and IF-24

Comparing the existing and future land use conditions TP loading for the same climate years reveals only a small increase in the expected TP loading as a result of future development. This is due to some development of land with a low impervious fraction to a higher one, as well as the adjustments made to reflect specific knowledge of future developments. In contrast, a comparison of the total phosphorous loadings between different climate years within the same land use condition shows the significant impacts that climatic conditions can have on nutrient loadings. The modeling results, from above, also show that Interstate Valley Creek, alone, typically accounts for about 60% of the phosphorus loading from this study area under the various climatic conditions. When Interstate Valley Creek and Ivy Falls Creek are considered together, they account for approximately 80% of the total phosphorus loading from the study area. As a result, BMP options that can significantly reduce nutrient loadings should be considered for both watersheds.

Generally, implementation of various conventional BMPs is more successful at reducing nutrient loadings from a watershed when the unit areal loading rate from the watershed (expressed as pounds of phosphorus in runoff per acre of watershed area per year) is higher. Therefore, the P8 modeling results were used to express the phosphorus loadings on this basis and compared (in the following table) to monitoring that has been done in the Twin Cities metropolitan area.

Comparison of Areal Phosphorus Loadings
Lower Mississippi WMO Watershed

Watershed	Location	Watershed Area (acres)	Areal Loading lbs/acre/yr	Source
Twin Lake/Site 37	Minneapolis Chain of Lakes	1,714	0.21[1]	Barr Engineering Co., 1992
Bass Lake/Site 17	Minneapolis Chain of Lakes	1,385	0.31[1]	Barr Engineering Co., 1992
Ramsey County Ditch 16	Lake Gervais/Little Canada	1,900	0.34[1]	Ramsey County, 1988
Ramsey County Ditch 18	Kohlman Lake/Maplewood	6,500	0.36[1]	Ramsey County, 1988
	Twin Cities Metro Urban Storm Sewers	--	1.06[1]	Mulcahy, 1991
Interstate Valley Creek, Ivy Falls Creek, East, Central and West Hwy. 13 Drainage Districts	**Mendota Heights, Lilydale, West St. Paul, St. Paul and Inver Grove Heights**	**5,157**	**0.23[2]**	**This Study**

[1] Phosphorus loads are based on water quality monitoring results.
[2] Phosphorus loads are based on P8 model simulations for average precipitation and fully developed watershed conditions.

The P8 model predictions shown in this table indicate that areal phosphorus loading from this watershed is at the low end of what has been observed in other studies involving monitoring data from the Twin Cities area. As a result, portions of the watersheds in this study area may not lend themselves to significantly better treatment of stormwater runoff.

After the future land use condition scenario had been run in P8, the results were tabulated in ArcView, and the watershed locations with little or no total phosphorus treatment efficiency were identified. Figure 5 shows the estimated range of cumulative total phosphorus removal for each of the subwatersheds modeled in P8. This "hot spots" map identifies the subwatersheds that had the lowest percentage of TP removal, based on the cumulative loadings from their respective tributary areas. For instance, the darkest red color indicates that the cumulative TP removal, or the total TP removal in the treatment device in that subwatershed and all upstream devices as a percentage of the total TP entering the device located in the subwatershed, is under 10%.

4.2 Water Quality Modeling Results for BMP Scenarios

This section provides a detailed discussion of the assumptions and expected water quality improvements following implementation of each of the BMP scenarios discussed in Section 3.

4.2.1 Detention Ponds

The "hotspots" from Figure 5 are good locations for new or improved detention ponds, so several subwatersheds were chosen as locations for modeling each of three different detention pond improvement: wet detention ponds with average depth increased to 4 ft (increased dead storage), dry detention ponds converted to wet detention ponds with an average depth of 4 ft and at least 0.3 ac of water surface area, and new wet detention ponds with an average depth of 4 ft and at least 0.3 ac of water surface area. A fourth option investigated was diverting the lower flows (up to 30 cfs) from the outlets of Interstate Valley and Ivy Falls Creeks into the wetland southwest of Pickerel Lake. This fourth option was included in the list of possible water quality improvement projects from Table 5-3 of the LMRWMO Plan. The locations of the modeled detention pond BMPs are in presented in the table below.

Wet Detention Ponds with Increased Dead Storage Capacity	Dry Detention Ponds Converted to Wet Detention Ponds	New Wet Detention Ponds	Diversion of Lower Flows
IV-57	IV-64	MB-SP1	IV-140 / L-10L
IF-21	IV-106	MB-2	IF-28 / L-10L
IV-126	IV-100	L-8	IV-140 / IF-28 / L-10L
IF-1	IV-119	IV-123	
SFL-11	IF-10	L-5	
IV-30	MB-10	L-3B	
HB-2	IV-TC_EP, IV-TC_NW, IV-TC_NP, IV-TC_SP,		

After the models were modified to include each of these proposed detention ponds, the model was run and the total TP load reduction entering the river was noted as the quantifiable benefit for each individual pond. The modeling results for each of these BMP scenarios are shown in Table 1. The scenario/BMP IDs shown in Table 1 correspond with the potential BMP location labels shown in Figure 4.

Table 1 shows that the three types of wet detention pond scenarios result in modest total phosphorus load reductions, when considered individually, while the three diversion options provide approximately 9 to 12 percent reductions in the total phosphorus loadings from the entire study area. As a result, there appears to be some potential for treatment of total phosphorus in the runoff from both Interstate Valley and Ivy Falls Creeks in the wetland southwest of Pickerel Lake.

Three of these pond options presented in Table 1 were evaluated as devices to increase the quality of runoff entering a lake, rather than the Mississippi River. They were SFL-11, IV-30, and HB-2, tributary to Sunfish Lake, North Rogers Lake, and Hornbeam Lake, respectively. All three existing wet detention ponds would be dredged to an average depth of 4 ft in this proposal. Table 1 shows that the proposed detention ponds for North Rogers and Hornbeam Lake are particularly beneficial with total phosphorus load reductions of estimated to be 30 and 41 percent, respectively.

4.2.2 Combination of Detention Ponds

As previously mentioned, Table 1 revealed the expected TP load reduction for each of the wet detention pond options and the diversion of both Ivy Falls and Interstate Valley Creek to the wetland southwest of Pickerel Lake. Table 1 also shows another scenario involving the combination of all 20 detention pond and diversion options to ascertain the combined effect on reducing the TP load entering the Mississippi River. New P8 models were developed for this scenario because if more than one of the examined BMPs are considered for the same watershed, one cannot simply sum the TP load reduction from the two individual detention pond modeling scenarios. The ponds in each watershed are not always independent; if one altered pond is upstream of another, the upstream device directly affects the events occurring at the downstream pond. This can explain why detention ponds at the downstream end of a system with several ponds or wetlands do not function with substantial treatment efficiency. This effect is present with the scenario involving this combination of detention ponds with the diversion, based on a closer examination of Table 1. The TP load reduction of 148 pounds is almost the same as the TP load reduction predicted for the diversion of both creeks without the combination of upstream wet detention pond options. This is likely due to the fact that the combination of detention pond options are generally particulate phosphorus that would otherwise be removed by the wetland southwest of Pickerel Lake following the diversion of both creeks without implementation of the upstream BMPs.

4.2.3 Infiltration/Rainwater Gardens

The City of Mendota Heights identified individual areas as possible locations for future implementation of rainwater gardens or other infiltration practices. The size of the rainwater gardens proposed for each location was based on the directly-connected impervious area within the region to be treated by the corresponding rainwater garden. The total volume required for the rainwater gardens in each area was equivalent to ½" of rainfall over the respective directly-connected impervious area, and a 1.5 ft average depth was used to determine the storage pool surface area of the infiltration basin (or rainwater garden).

After the infiltration basin volume and area was determined, the tributary area was split off from the existing study area subwatersheds containing the proposed rainwater gardens. New directly-connected impervious percentages and pervious CN's were calculated, based on the revised subwatershed areas and the change in the distribution of land use areas. In some instances, the area to be routed to the rainwater gardens was previously routed to a pond in the original (future conditions land use) P8 model. In this case, the area was routed to the rainwater garden first, with the overflow routed to the pond. Any runoff that was not infiltrated into the rainwater garden would be treated in the pond. The revised model was then run and the TP load reduction was noted at the outlet of the system into the river.

Other inputs for the infiltration basin were assumed. A void volume percentage of 100% was used, illustrating that the rainwater gardens will not be lined with riprap or other material. Since the majority of the study area is composed of Type B soils, an infiltration rate of 0.26 in/hr was used (McCuen, 1982).

For the implementation of rainwater gardens to the entire study area, a rainwater garden device was placed at the outlet of each of the five P8 modeling areas. These devices were sized for the directly connected impervious areas from the tributary watershed areas. The TP load reduction was then noted at the outlet of the model area and summed to obtain a total reduction of TP entering the Mississippi River. The same approach was used for the Sunfish Lake watershed.

Table 1 shows that the three rainwater gardens proposed for Mendota Heights result in total phosphorus load reductions ranging from approximately 4 to 9 pounds during an average year. All three projects, considered together, would result in a TP load reduction of approximately 1.5 percent, from the entire study area. Table 1 also shows that implementing infiltration practices watershed-wide would result in a TP load reduction of approximately 780 pounds per average year, or 66 percent of the TP load from the entire study area.

4.2.4 Phosphorous Fertilizer Ban

An ordinance prohibiting the use of phosphorous fertilizers was modeled across the study area. Depending on conformity, this would help to curb a significant source of phosphorous in stormwater runoff. Since this BMP has a significant dependence on citizen education and implementation, it is hard to predict what percentage of homeowners (and commercial applicators) would fully comply with the intent of this ordinance. In addition, few studies have been completed to demonstrate exactly how much benefit can be realized in the TP load reductions, as a result of the implementation of this ordinance.

The preliminary results of one study (Hennepin Parks, 2002) show a TP loading reduction of up to 50% from residential areas, based on the difference between loading rates from a residential area with a phosphorus ordinance compared to another area without the ordinance. Since this study does not involve monitoring of paired watersheds, the preliminary results should be used with caution. Nonetheless, this TP load reduction appears to represent an optimistic estimate of what could be attainable throughout the study area. This TP load reduction translates to the use of a "Scale Factor for Pervious Area Loads" of 0.5 in the P8 Model, rather than the default value of 1.0. After this adjustment was made for all subwatersheds in the model, P8 was run again and the results were tabulated.

The modeled results for this BMP option, shown in Table 1, indicates that a TP load reduction of 111 pounds could be expected, excluding the Sunfish Lake watershed. This represents approximately 9 percent of the total TP load from the study area, and may be optimistically higher than what might be expected given the fact that pervious areas do not contribute significant runoff volumes during typical rainfall runoff events.

4.2.5 Street Sweeping

Since the P8 Urban Catchment Model has the ability to model street sweeping, a few simple assumptions were made to determine the relative effect. A sweeping frequency of once every two weeks, from April 1 to October 30, was assumed. It was also assumed was that half of the study area's directly-connected impervious surfaces would be swept. Even in the unlikely event that all road surfaces are swept in a city, this assumption is still valid because some driveways that are directly-connected would not be swept; and certainly all roofs of high density buildings that are connected to storm sewer by either direct piping or surface flow across pavement would not be swept by a street sweeper.

The P8 Model has default street sweeping removal efficiencies for each of the particle sizes that are simulated by the model. These removal efficiencies range from 4 to 16 percent, with the lower efficiencies corresponding with the smaller particle sizes, which is consistent with the NURP study results. It was also intended to model this BMP option with the use a high-efficiency vacuum-type sweeper, but the most current research on the effectiveness of these machines does not provide removal efficiencies for the various particles sizes simulated by the P8 Model. As a result, the only BMP option evaluated, and presented in Table 1, involves the use of a mechanical street sweeper and the corresponding default values in the P8 Model. Table 1 shows that mechanical street sweeping every two weeks between April and October would only be expected to reduce the overall TP loading by 3.5 pounds, or less than 0.5 percent of the total TP load from the study area.

5.0 Conclusions and Recommendations

Based on the results presented in the previous section, the P8 water quality modeling of the five types of BMPs indicates that the following conclusions can be made about improving the water quality entering the Mississippi River from the Ivy Falls Creek, Interstate Valley Creek, and West/Central/East Highway 13 drainage districts:

- The expected water quality improvement from implementing a combination of detention pond options is almost the same as the TP load reduction predicted for the diversion of both creeks into the wetland southwest of Pickerel Lake, without the combination of upstream wet detention pond options. This is likely due to the fact that the combination of detention pond options are generally particulate phosphorus that would otherwise be removed by the wetland southwest of Pickerel Lake following the diversion of both creeks without implementation of the upstream BMPs.

- Implementing infiltration practices (such as rainwater gardens) watershed-wide would result in significant TP load reductions, approximately 66 percent of the TP load from the entire study area during an average year.

- An optimistic modeling scenario of the effects of a phosphorus-free fertilizer ordinance indicates a significant TP load reduction could be expected (approximately 9 percent of the total TP load from the study area). This scenario may predict more benefit than what might realistically be expected given the fact that pervious areas do not contribute significant runoff volumes during typical rainfall runoff events and limited data is available regarding the dependence on citizen (and commercial applicator) education, conformity and actual mobilization of phosphorus from fertilizer applied under current practices in the watershed areas.

- While recent studies indicate that the newest generation of high-efficiency, vacuum-type sweepers have the potential to provide water quality benefits, limited data is available for accurately modeling the effects. Additional mechanical street sweeping (beyond passes in the spring and fall) will not result in significant TP load reductions and provide very little water quality improvement benefits.

Based on the goals and conclusions of this study, the following recommendations can be made:

- **Complete Feasibility Study of the Study Area** – The LMRWMO *Watershed Management Plan* (Barr, 2001) recommends that a feasibility study be conducted following the completion of this water quality modeling study. The intent of the feasibility study is to take the conceptual evaluation of the potential benefits of the improvement options discussed in this study, consider their detailed design issues, and assess them for their feasibility and cost-effectiveness after making any necessary refinements to the water quality modeling.

- **Initiate Monitoring Program for the Study Area** – As previously mentioned, limited water quantity and quality data was available from the watersheds in the study area. As a result, the water quality modeling was largely completed using default model parameters associated with watershed land use or detention pond characteristics. Monitoring data from the watersheds in this study area can be used to calibrate the water quality modeling and verify the initial conclusions and recommendations that have subsequently been made about implementing watershed BMPs. In addition, some of the BMP scenarios that were evaluated during this study were intended to improve the water quality of Sunfish, Rogers and Hornbeam Lakes. Other BMPs may also have a positive effect on flooding, streambank stabilization and the water quality of streams or wetlands. Additional monitoring of these water resources will enable us to evaluate their overall health, and provide for future refinements of the water quantity and quality goals, as well as the modeling completed for this study.

- **Refine Water Quality Goals for Lakes, Streams and Wetlands in the Study Area** – The results of the engineering feasibility study and additional monitoring data should be used to evaluate whether refinements should be made to the LMRWMO goals for the lakes, streams and wetlands in this study area. For example, total phosphorus and other monitoring data collected from the lakes in the study area could be used to set quantitative goals for controlling eutrophication. Likewise, the engineering feasibility study may identify the need to further consider streambank stabilization measures.

- **Continue to Identify Opportunities for Implementation of Water Quality Improvements** – As more monitoring data becomes available and each of the cities complete Storm Water Pollution Prevention Plans, as part of Phase II of the MPCA's NPDES permit program, new water quality improvement opportunities may become apparent. The LMRWMO should continue to take advantage of opportunities involving pollution prevention, such as public education and participation, new ordinances and revisions to existing ordinances, future development and redevelopment, and education of municipal employees.

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Tables

TABLE 1

Effects of Possible BMPs on Total TP Loading into Mississippi River, Pickerel Lake, and Nearby Wetland

Ultimate Land Use, Average Climate Year

Lower Mississippi River WMO - Interstate Valley Creek, Ivy Falls, Creek, and East/Central/West Highway 13 Drainage Districts

BMP Type	BMP Location	Subwatershed	Scenario / BMP ID	TP Load Reduction (lb)	TP Load Reduction Percentage	Overall TP Loading for Tributary Watershed
Existing Conditions	***None***	***All***	-			***1,185***
Diversion of Low Flows	Interstate Valley Creek Diversion to wetland near Pickerel Lake	IV-140 / L-10L	1A	109	9.2%	1,076
	Ivy Falls Creek Diversion to wetland near Pickerel Lake	IF-28 / L-10L	1B	103	8.7%	1,082
	Interstate Valley Creek and Ivy Falls Creek Diversion to wetland near Pickerel Lake	IV-140 / IF-28 / L-10L	1C	147	12%	1,038
Wet Detention Ponds With Increased Dead Storage Capacity	Dodge Nature Center Pond	IV-57	2	33.3	2.8%	1,152
	Ivy Hills Pond	IF-21	3	19.0	1.6%	1,166
	Cherry Hills Pond	IV-126	4	4.0	0.3%	1,181
	Somerset G.C. Pond #1	IF-1	5	21.1	1.8%	1,164
	East of 273 Salem Church Rd.	SFL-11	18	0.5[1]	3.5%[1]	14.4[1]
	Mendakota Golf Course west pond	IV-30	19	12.9[2]	30%[2]	29.7[2]
	NE corner of I-494 & Delaware Ave.	HB-2	20	25.8[3]	41%[3]	63.4[3]
Dry Detention Ponds Converted to Wet Detention Ponds	McDonald's Pond	IV-64	6	10.6	0.9%	1,175
	NE corner of Valley Curve Rd. & Trail Rd., S. of Marie Ave. W.	IV-106	7	16.6	1.4%	1,169
	NE corner of Dodd Rd. & Marie Ave. W.	IV-100	8	10.0	0.8%	1,175
	NE corner of Wachtler Ave. & Wentworth Ave. W.	IV-119	9	5.8	0.5%	1,180
	Between Sylvandale Rd. and Laura St.	IF-10	10	17.5	1.5%	1,168
	Mayfield Heights Pond	MB-10	11	8.1	0.7%	1,177
	Highway 110 and Dodd Road (Mendota Heights Town Center)	IV-TC_EP, IV-TC_NW, IV-TC_NP, IV-TC_SP	Incorporated into Future Conditions (TC)	8.9	0.8%	NA
New Wet Detention Ponds	NE corner of Cherokee Heights Blvd. & Annapolis St. W.	MB-SP1	12	12.3	1.0%	1,173
	West of Highway 13 near Garden Lane	MB-2	13	4.3	0.4%	1,181
	Between I-35E and ramp to Highway 13	L-8	14	12.1	1.0%	1,173
	West of Wachtler Ave. and Deer Trail Court cul-de-sac near Interstate Valley Creek	IV-123	15	8.4	0.7%	1,177
	Riverwood Apartments	L-5	16	5.0	0.4%	1,180
	North of Highway 13/Lexington Ave. intersection	L-3B	17	6.3	0.5%	1,179
All 20 Detention Pond Improvements and Diversion Scenario 1C	See Above	See Above	ALL	148	12%	1,037
Infiltration Practices/Rainwater Gardens	Location #1 - South of Dodd Rd. and Delaware Ave. Intersection	IF-18, IF-5	RW1	3.8	0.3%	1,182
	Location #2 - South of Hwy. 13, West of Ivy Hills Park	IF-23, IF-24, IF-27, IF-28, MB-20	RW2	9.4	0.8%	1,176
	Location #3 - West of Dodd Rd., North of Wentworth Ave.	IV-115, IV-118, IF-4, IF-6, IF-7, IF-8	RW3	5.0	0.4%	1,180
	Entire Study Area[4]	All	RW0	779[4]	66%[4]	407[4]
Bi-Weekly Street Sweeping	Entire Study Area[4]	All[4]	FB	3.5[4]	0.3%[4]	1,182[4]
Phosphorous Fertilizer Ban	Entire Study Area[4]	All[4]	SS	111[4]	9.4%[4]	1,074[4]

[1] TP load reduction to Sunfish Lake

[2] TP load reduction to N. Rogers Lake

[3] TP load reduction to Hornbeam Lake

[4] Excluding area and subwatersheds tributary to Sunfish Lake

Figures

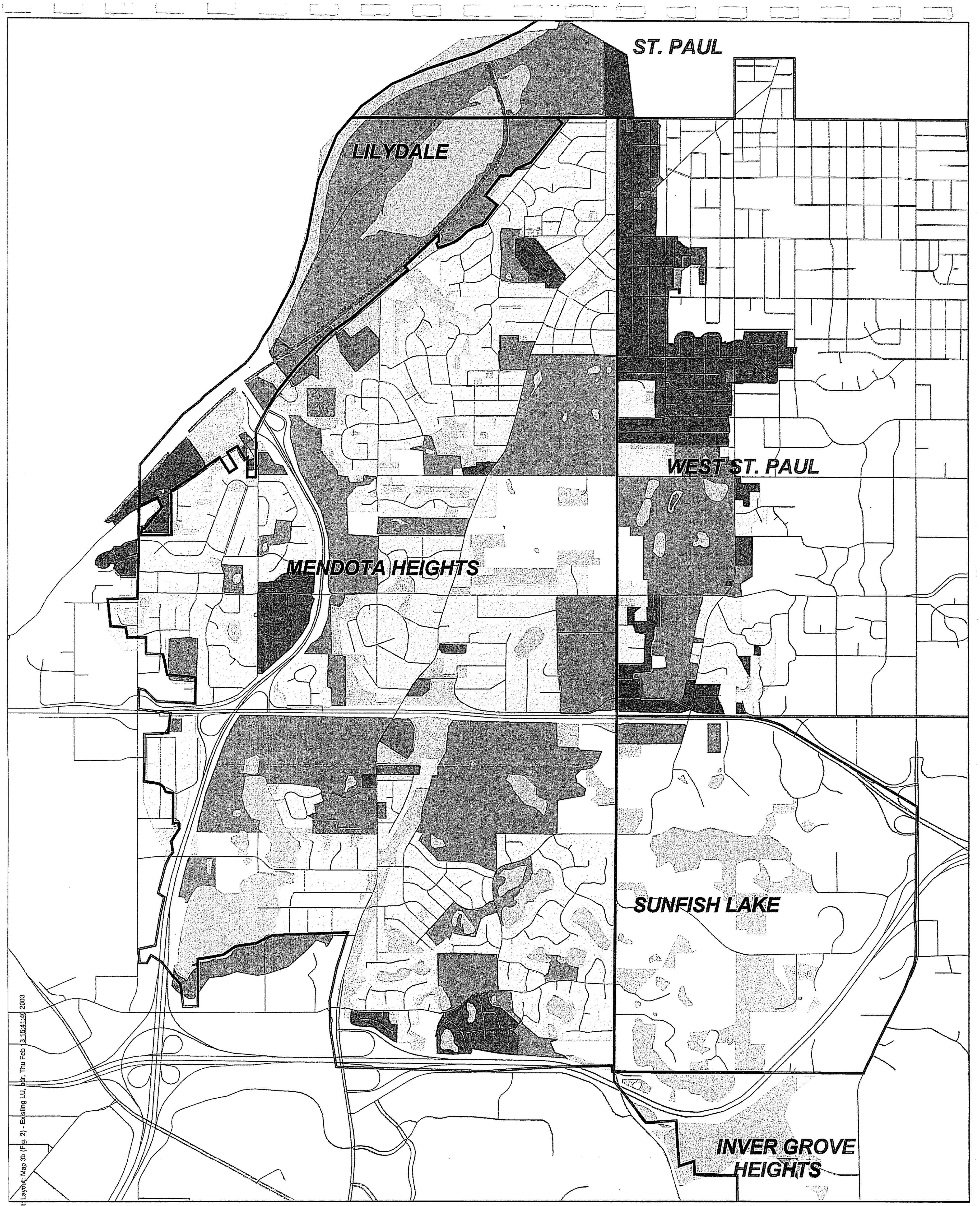

Figure 2

EXISTING CONDITIONS LAND USE

Lower Mississippi River WMO

Interstate Valley Creek, Ivy Falls Creek,
East Highway 13, Central Highway 13,
and West Highway 13

Barr: Arcview 3.1,OPT201, i:\client\lowermiss\district\project\23198003\p8_modeling_preproc.apr, Layout:Layout: Map 3b (Fig. 2) - Existing LU, bdr, Thu Feb 13 15:41:40 2003

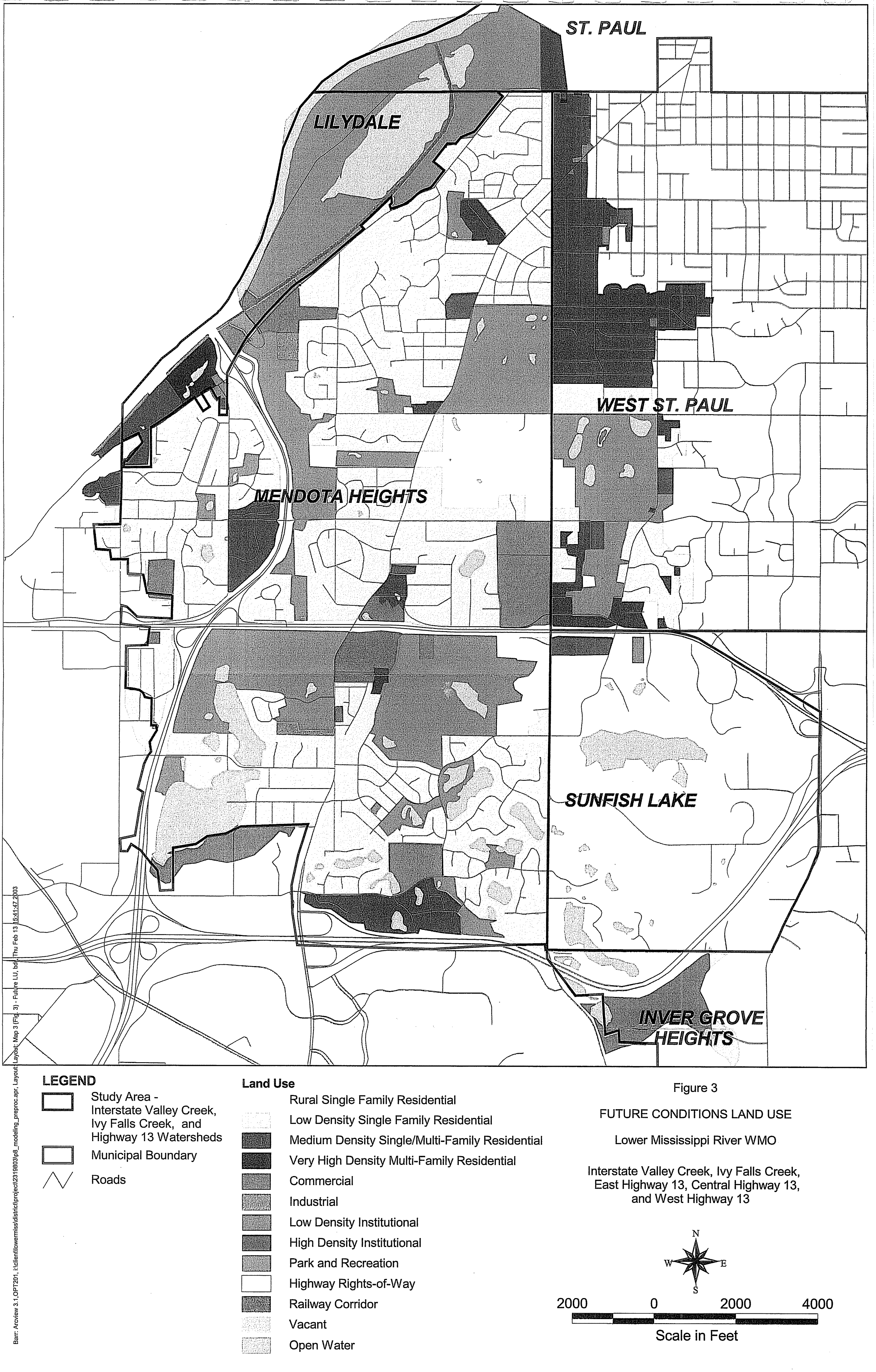

Figure 3

FUTURE CONDITIONS LAND USE

Lower Mississippi River WMO

Interstate Valley Creek, Ivy Falls Creek,
East Highway 13, Central Highway 13,
and West Highway 13

Barr: Arcview 3.1,OPT201, i:\client\lowermiss\district\project\2319803\p8_modeling_preproc.apr, Layout: Layout: Map 3 (Fig. 3) - Future LU, bdx, Thu Feb 13 15:41:47 2003

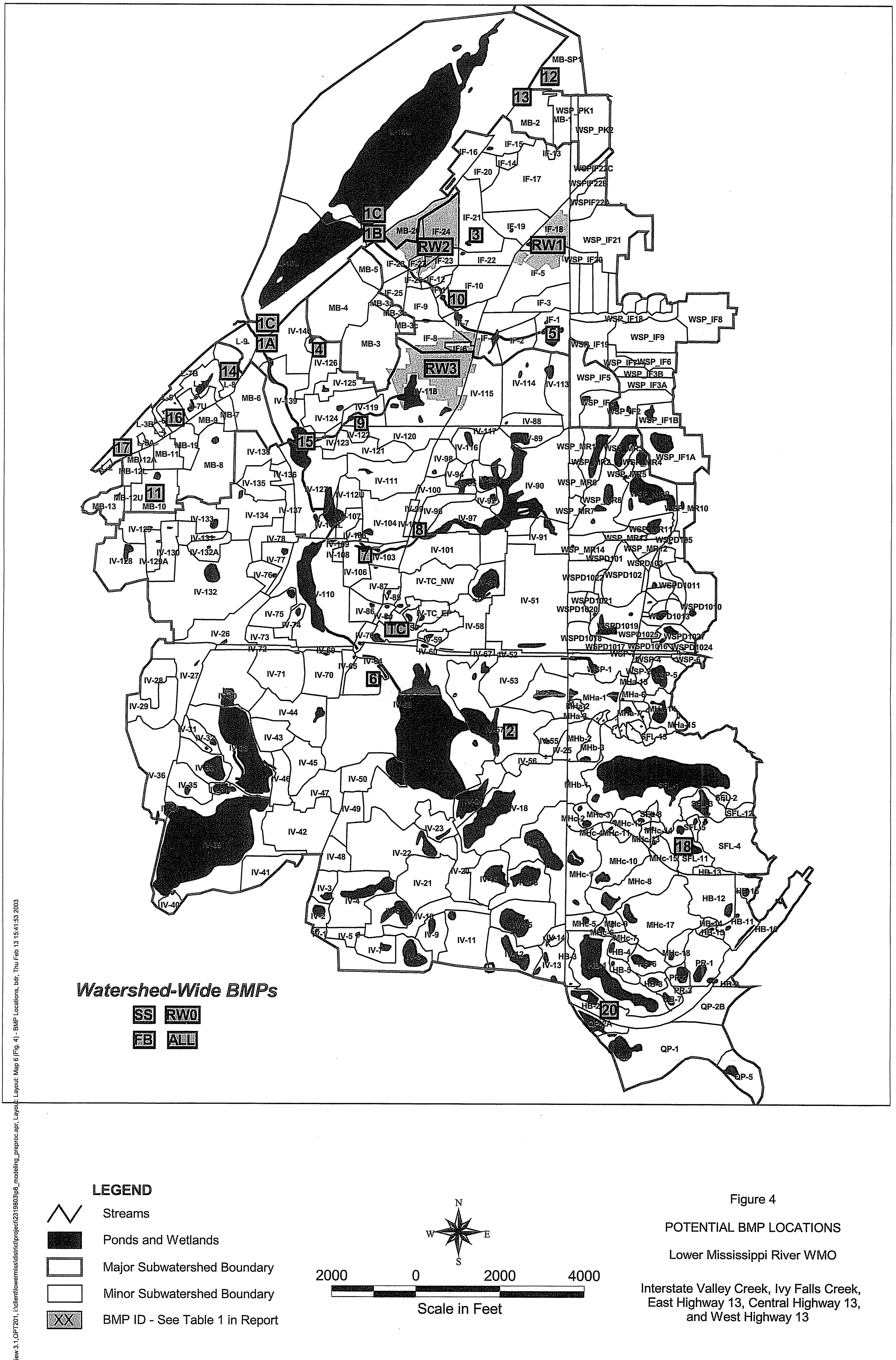

Figure 4

POTENTIAL BMP LOCATIONS

Lower Mississippi River WMO

Interstate Valley Creek, Ivy Falls Creek,
East Highway 13, Central Highway 13,
and West Highway 13

Barr: Arcview 3.1,OPT201, i:\client\lowermiss\district\project\2319803\p8_modeling_preproc.apr, Layout: Layout: Map 6 (Fig. 4) - BMP Locations, bdr, Thu Feb 13 15:41:53 2003

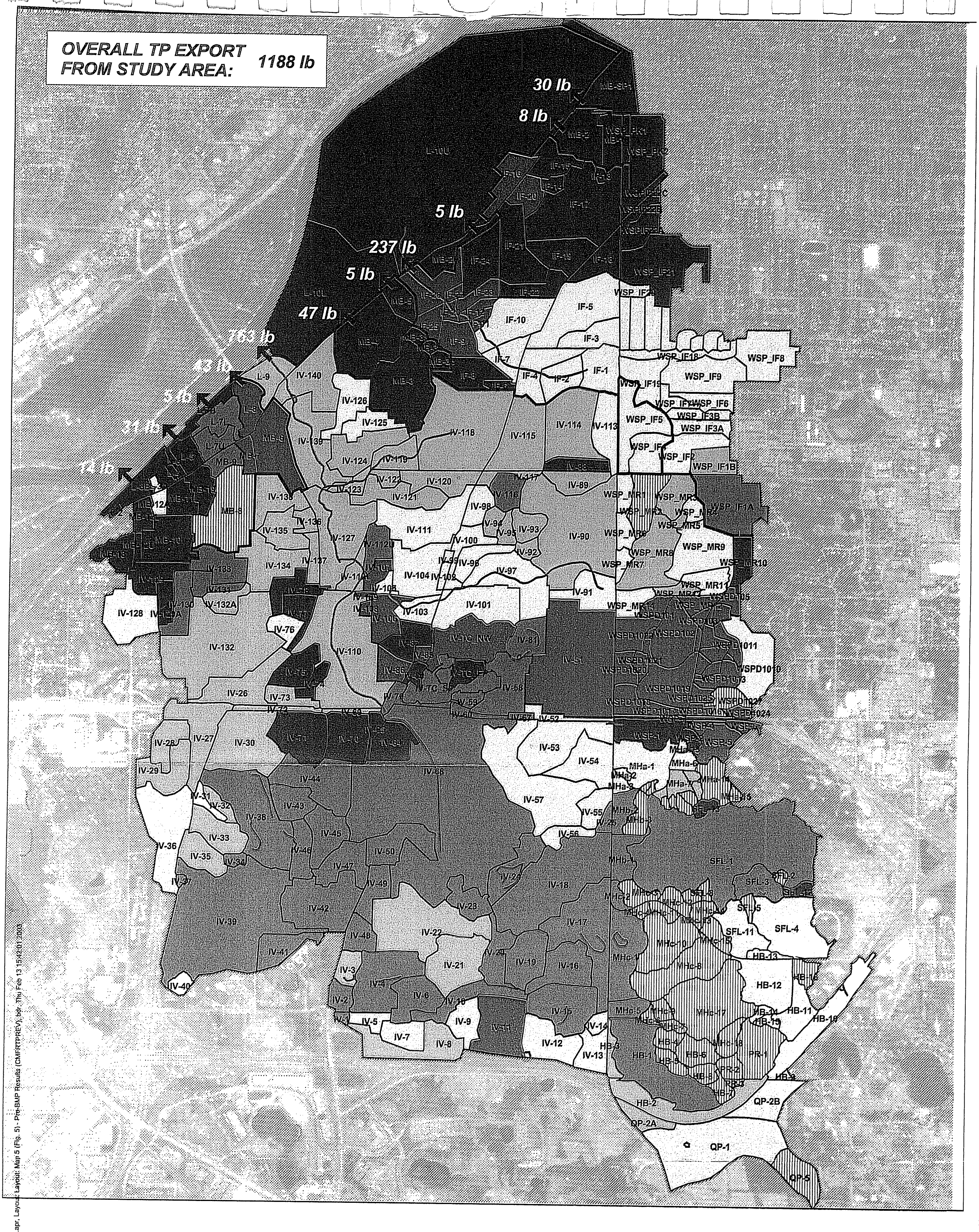

Figure 5

HOT SPOTS MAP
BEFORE BMP APPLICATION
FUTURE LAND USE, AVERAGE CLIMATE YEAR

Lower Mississippi River WMO

Interstate Valley Creek, Ivy Falls Creek,
East Highway 13, Central Highway 13,
and West Highway 13

Barr: Arcview 3.1,OPT201, i:\client\lowermiss\district\project\2319803\p8_modeling_preproc.apr, Layout: Layout: Map 5 (Fig. 5) - Pre-BMP Results (CMFRTPREV), bdr, Thu Feb 13 15:42:01 2003

Appendix A

Technical Supplement

Appendix A—Technical Supplement: Detailed Modeling Methodology and Assumptions

A.1 Methodology

A.1.1 Determination of Drainage Basin Characteristics

After the existing data and maps were collected from the municipalities within the study area, an ArcView GIS project was set up that combined the collected data with other in-house sources of data, both in hard copy and electronic format. Along with the existing and projected land use maps from the municipalities and the Metropolitan Council, Barr incorporated parcel, watershed, pond, and roadway maps into GIS. In addition, graphical coverages were utilized, such as aerial photos taken in the spring of 2000, and USGS topographic maps. Both of these resources served as valuable references for orientation and quality control.

A.1.1.1 Future Conditions Model

As a starting point, Barr used the Met Council's recently released full-development land use coverage, representing projected land use in the year 2020. This was used because it covered the entire area so multiple themes wouldn't have to be merged together. Another reason for this is because this data was supplied by the cities, and should be consistent with their own land use plans for the most part.

The first step in producing comprehensive land use maps was completing a procedure to absorb the minor rights-of-way (ROW) into the surrounding land uses. Major ROW, the main highways that have four or more lanes, was kept as a separate land use. This absorption process involved using a Barr-written procedure that used a "nearest neighbor" algorithm to fill in the gaps where the Met Council previously designated the minor ROW. Before the absorption process, the major highways were preserved as a separate land use by digitizing the ROW surrounding them, using a highway GIS layer, the 1997 Met Council land use plan, and year 2000 aerial photos.

The next step in preparing the future land use map was to reclassify the properties into more appropriate categories in which the percent roof area, percent paved area, and total impervious percentage would be representative of all of the included properties. This improves the accuracy and the legitimacy of these runoff parameters implemented in the model. For residential land uses, Barr took the housing density classification (units per acre) supplied in the Met Council's planned land use layer and grouped these into four residential groups: Rural Single Family Residential, Low Density Single Family Residential, Medium Density Single/Multi-Family Residential, and Very High Density Multi-Family Residential. These groupings were made in part with the aid of regional density ranges used by MetroGIS, a Twin Cities coalition of GIS users and developers. For residential properties that did not have a housing density entry, the density was computed manually based on parcel data and aerial imagery.

The land use categories entitled "Mixed Use" and "Multiple Use" each had a small sample size in the study area, so they were re-classified as commercial, industrial, institutional, or a residential category after each of these parcels was analyzed individually.

Since the institutional properties such as schools, churches, and hospitals had a very high variance in the percent impervious values, they were split into two land uses: High Density Institutional and Low Density Institutional. This adjustment allows for two sets of assumed percent impervious values, decreasing the range.

To ensure accuracy and control quality, the Met Council future land use data was cross-referenced with the future land use plans of the cities within the study area. Appropriate changes were made where discrepancies existed.

A.1.1.2 Existing Conditions Model

Once the future land use plan was completed, a copy was made and used as the initial land use plan for existing conditions. Then changes were made manually where differences existed between this layer and the aerial photos, the 1997 Met Council land use layer, and the cities' existing land use layers. Most of these differences were for land that is currently vacant but will most likely be developed in the future. Additionally, some select institutional and residential properties were upgraded from low density to high density in the future plan if there was currently space and a possibility of expansion and thus a decrease in total pervious area.

After the existing land use layer was complete, about five properties were selected from each land use type that were representative of the entire set of parcels of that land use classification. For each property, the percent roof area and percent paved area of the total property area was calculated, with the aid of the aerial imagery in georeferenced GIS. The sum of these two percentages is the impervious percentage, the percentage of a parcel's surface area in which rainfall or snowmelt cannot infiltrate into the ground and has to leave the area by runoff. An average was then calculated for each land use category. These calculations were done using the existing land use classification of developed properties, since the future land use type of a given property would not match up with the aerial imagery if there were redevelopment expected.

The next step after calculating the assumed percent impervious values for the land use categories was to compute the assumed directly connected percentages for each land use type. This is the fraction of land area on a parcel of land in which runoff drains directly into a storm sewer system without first crossing a pervious surface. All paved road surfaces were assumed to be directly connected. Parking lots were assumed to be directly connected also, either to an immediate storm sewer inlet in the parking lot, or to an adjacent street with the grade of the pavement. Driveways were usually not directly connected. For Commercial, Industrial, Very High Density Residential, Low Density Institutional, and High Density Institutional land uses, at least a portion of the roof drainage was assumed to be directly-connected to the storm sewer system, depending on the proximity and location of surrounding pavement. If a building is surrounded by impervious pavement on half of its perimeter (i.e. two sides of a square building), then one-half of the roof area was assumed to be directly connected, as long as the pavement is directly connected and there is not more than 20 feet of a pervious surface between the pavement and the building. All impervious surfaces in the Vacant land use group were assumed to be directly connected since these areas are paved roadways in all cases.

Due to a large variation in the parcel sizes among the included properties, the assumed percent impervious and percent directly-connected values for the Park and Recreation and High Density Institutional land use groups were not calculated using a simple arithmetic mean. Instead, a weighted average was used based on area. This gave more importance to the larger properties to better represent the trends of the land use category.

After the land use coverages were completed and an average assumed percent impervious and percent directly connected value was determined for each land use, the next step was to import coverage for the Dakota County Soil Survey into GIS. A hydrologic group designation, which describes the drainage characteristics of a particular soil type, was provided for each soil type, which was then associated with a pervious Curve Number (CN), depending on the land use at the site. The CN was used by the model to compute the expected infiltration rates for the soil. For cases in which a soil's hydrologic group had a dual classification, such as "A/D", engineering judgment was used to convert this to a single classification. The four hydrologic groups are A, B, C, and D. For portions of the study area in which a hydrologic group was not given, a hard copy of the Dakota County Soil Survey was used to determine a suitable hydrologic group for the area.

Another coverage needed for the project was a layer containing the subwatershed in the study area. The subwatershed layer is a combination of the electronic or digitally represented hard copy versions of subwatershed boundaries, as shown in the water management plans of the five municipalities within the study area. Where needed, minor adjustments were made to make this coverage seamless and non-coincidental, and to adjust for differing nomenclature used for the subwatershed ID's among the cities and Barr staff.

The completed subwatershed coverage was then intersected with the land use layer and soils layer. This was the first step of the Barr-developed P8 Processor, created to generate an ASCII text input file that could be directly imported into the P8 Urban Catchment Model. This input file contains watershed data, such as drainage area, impervious fraction, percent directly-connected, curve number, depression storage, device number the watershed runoff flows to, as well as some coefficients and scale factors. After the intersections, there were inconsistencies between the land use and soils coverages in what was classified as open water. These differences needed to be rectified manually, most often towards the land use coverage standpoint, since many times these open water bodies were digitized manually.

Once the P8 input files were created, they were loaded into the model. The next input needed for the modeling was the pond data and pond routing.

A.1.2 Determination of Pond Data

Since the P8 Urban Catchment Model has a limitation of 48 water quality control "Devices", such as detention ponds or infiltration basins, Barr had to selectively choose the existing ponds and wetlands that would most significantly affect the quality of storm water for inclusion in the model. As a base for choosing these most critical devices, two pond and wetland coverages were analyzed in GIS. The first and more complete coverage was from the National Wetland Institute (NWI). The other was the protected waters layer from the Minnesota Department of Natural Resources (MN DNR) Division of Waters. Not all ponds and wetlands, especially dry detention ponds (depressions that would hold runoff in large storms), were represented in one or both of these layers. Therefore, some devices were added to the coverage manually to show the location of additional devices that were modeled in the Barr Watershed Model. Aerial imagery also was consulted in determining the location and extent of water bodies.

A.1.2.1 Existing Conditions Model

Most of the existing pond data was taken from the water resource management plans of the municipalities within the study area. These plans in part summarized the results of Barr Watershed Model runs, completed in the early 1990's. The Barr Watershed Model data contained normal water elevation, the 100-year high water elevation, storage detention volume for a 100-year storm, downstream subwatershed, and outlet type and size for the pond in each subwatershed. Some other types of data obtained from the management plans includes landlocked ponds, MN DNR Protected Waters identification number, drainage area, and possible locations previously identified by Barr or the city as possible locations for drainage system improvements. Additionally, Barr had previously run another water quality model, Pondnet, for a large number of ponds located in Mendota Heights. The input and output data for these Pondnet models was also utilized in gathering pond data. This data set included mean pond depth, pond water surface area at the normal water level, and the wet pond volume or dead storage. This pond data was combined in a spreadsheet.

A.1.2.2 Future Conditions Model

For the future conditions model, additions and deletions were made to a copy of the completed existing conditions pond coverage, as needed, to indicate modifications that Barr knew would be completed in the near future. The revised data for these modified ponds was obtained from the members of the Lower Mississippi River Watershed Management Organization Board of Managers, or Barr staff associated with the project design and their project files. The location of these pond modifications and a brief description of the changes made will be described in Section A.2.3.3.

A.1.2.3 Pond Modifications

Realizing that the main source of the pond data was outdated, many adjustments were made to ensure accurate modeling of existing and future conditions. These changes can be split into three categories: those that are due to past installation of new ponds or modifications of old ponds, the addition of existing ponds that were not previously modeled, and ponds that will be newly constructed or modified in the near future. These three pond modification types require the adjustment of P8 input parameters, such as dead storage volume, water surface area, and pond outlet, etc.

Changes to Ponds in Existing and Future Conditions Models - Alterations were made to the P8 input parameters for ponds that had been modified since the Barr Watershed or Pondnet models were run for the water management plans. These changes were reflected in both the existing and future P8 models.

As recommended in the 1991 Sunfish Lake Water Resources Management Plan, an outlet was built between subwatersheds MHc-5 and MHc-1 to prevent water from flowing into Hornbeam Lake. This was assumed in the previous Barr Watershed Model runs. After verifying that this project was indeed completed, this data for the pond in subwatershed MHc-5 was used in the P8 model.

Another modification is in Mendakota Country Club. In 1997, the dead storage capacity of the pond in subwatershed IV-44 was increased, and a new outlet was installed. Information about the pond modifications was obtained from Barr project files.

A last update that was made to both existing and future conditions models was the outlet of Sunfish Lake. Previously landlocked, a 12" HDPE outlet with an invert elevation of 937.0 was installed in 1995, which now routes water from Sunfish Lake to Friendly Marsh in Mendota Heights.

Although an outlet was constructed for the Caren Court/Lilac Lane pond (MB-8) in Mendota Heights, this outlet is a high level outlet in which there is only outflow for a very large storm. A previous modeling effort by Barr showed that there is no outflow through this two-way outlet even in a 10-year event. Except during an extreme event with a return period longer than 10 years, the normal water level is below the outlet invert elevation, the usual definition of normal water level. Therefore this pond acts as a landlocked pond for much of the time, and was assumed to be landlocked for this study.

Addition of Ponds Not Previously Modeled - One pond, located in Lilydale at the Lexington Riverside Apartments (L-3A, previously, L-3), was not previously modeled since it was considered a decorative pond. However, this pond was considered by Barr to be a detention pond since it has significant storage during the 100-year storm event. Therefore it was included in both the existing and future P8 models. Data for this pond was obtained from a 2' contour map in GIS, Barr Engineering staff familiar with the pond, and Barr project files.

Known Future Pond Improvements - One change made very recently to the study area's stormwater drainage system was the addition of two new detention ponds in the Stonebridge development. This is located in Lilydale on Highway 13. Before the redevelopment, there was one existing pond on the site, previously identified as the Shiely property pond in the Lilydale stormwater management plan. However, no information was obtained on the pond and it was not modeled in either the Barr Watershed Model or Pondnet. With the redevelopment of Stonebridge, the existing pond (L-7U) was expanded and connected to the newly constructed lower pond (L-7L) by an 8' weir. Since this construction was just completed, these new ponds will be modeled in the future conditions P8 model only, using pond data obtained from Barr staff and project files.

The other change made to the future conditions pond coverage was the addition of two wet detention ponds and the modification of a dry pond and wetland in the (future) Mendota Heights Town Center. Barr completed an XP-SWMM model for this stormwater system. This will begin construction in 2003, so it is only modeled in the future conditions model. Located just north of Highway 110 and east of Dodd Road, this new residential and commercial development includes a medium-sized North Pond and a large South Pond that drains into Valley Marsh to the west, both replacing existing dry ponds in a vacant lot. An existing wetland near Dodd Road was expanded and received a new cap skimmer outlet. In addition, a small depression on the east side of the site, named the East Pond, will have a new outlet installed. Networked together, these ponds incorporate a new local drainage system that maintains the overall existing stormwater routing in the area.

A.1.2.4 Other Sources of Pond Data

For some non-Pondnet modeled ponds, not all data was available, such as normal water surface area, average pond depth, and dead storage volume. For these ponds, average depth was determined using an indirect method facilitated by the NWI coverage wetland type designation. As previously discussed, the NWI has a GIS layer for wetlands, ponds, and lakes. One of the attribute fields associated with this layer is titled "NEW_COW", which is the updated version of a mapped wetland code from NWI published maps. It is a hierarchical classification system that has five major systems and many subsystems, along with modifiers concerning human interaction with the natural water bodies. Using these classifications for ponds of unknown average depth, a reference table was used to find an accepted average depth value. This reference table was developed by the Ramsey-Washington Metro Watershed District. These reference values were also compared to the average depth values for ponds that were Pondnet modeled, which yielded an average depth value as a model output, to verify the validity of the lookup table. Also consulted for authentication of average pond depths was a table of results from a Barr-performed Purple Loosestrife Field Wetland Investigation, which included observed average pond depths.

By combining the variety of maps in GIS, such as land use maps, and associating pond dimensions and other parameters with the pond's location in GIS, a comprehensive representation of the study area was created. This was then used to assess present conditions, set up the P8 model, and ultimately present the results of the water quality model as improvement options around the study area.

A.1.3 P8 Model Setup

As described in section A.1.2., the P8 Urban Catchment Model has a limitation of 48 water quality control "Devices", (ie. BMPs). Since there are a lot more than 48 ponds in the study area, Barr split up the study area into five groups, each to be modeled separately in P8. This way, most of the ponds and wetlands affecting the water quality in the study area could be modeled. The study area was divided into the five models by trying to spread out the ponds so that they where equally distributed throughout the model areas. A more limiting factor, however, was the geographical layout and routing of the subwatersheds. To minimize the number of adjustments to the results that are needed after the models are run, it was necessary to have one outlet for each of the P8 model groupings, except for the Ivy Falls/Highway 13 area, in which there are many outlets into the Mississippi River. These adjustments will be described in detail later in this section.

The smallest P8 model area is around Sunfish Lake and is composed of ten subwatersheds, all draining into Sunfish Lake. This area is appropriately called the "Sunfish Lake P8 Model". Since Sunfish Lake is for all intents and purposes landlocked, the loads from this area were not accounted for in downstream devices. However, BMPs were investigated to increase the water quality of runoff draining into Sunfish Lake. A large part of Mendota heights and Interstate Valley Creek drainage district composes the P8 model area called the "Friendly Marsh P8 Model". This model area encompasses the entire southern portion of the study area (except the Sunfish Lake area) and contains Hornbeam and Rogers Lakes. The Friendly Marsh is also in this area, and serves as the effective outlet point of the model area. This drains into the next downstream area called the "IV DS Friendly West P8 Model". The downstream point of this model area is the Mississippi at the outlet of Interstate Valley Creek in Lilydale. Also draining into IV DS Friendly West P8 Model is a model area called "IV DS Friendly East P8 Model". The last P8 model area is a portion of Wet St. Paul, part of northern Mendota Heights, and most of Lilydale. This model area is entitled the "Ivy Falls Highway 13 P8 Model". The downstream "device" for this area is the river at various points along the riverbank.

Although it helped to divide the ponds among five P8 model areas, Barr still had to narrow down the number of ponds in some of the models, in particular the large area tributary to Friendly Marsh in Mendota Heights. There are many small ponds upstream of the marsh and some could not be modeled.

To choose the 45 or so ponds that would most significantly affect the quality of storm water, (leaving a few slots open for modeling proposed BMPs) a few things were considered. First, if a pond was landlocked, it was not modeled. This is because the pond is largely independent and will only affect downstream ponds (and ultimately the Mississippi River) if there is a large storm to bounce the pond's water level a significant amount. Next, if a pond was Pondnet modeled, it was automatically included in the set of ponds to be P8 modeled since there was already adequate data for this pond. Also, most of these ponds had some dead storage. If a pond was modeled in the Barr Watershed Model, but not modeled in Pondnet, it was still in consideration for modeling. The rest of the ponds and wetlands not previously modeled by the Barr Watershed or Pondnet models were thrown out, for the most part. Of the remaining ponds, Barr selected those with the largest water surface areas with the aid of aerial photos.

The storm file needed for model was taken from historical daily precipitation records at the Minneapolis-St. Paul International Airport and supplemented by data from the Eden Prairie, MN and Hopkins, MN rain gages in the Nine Mile Creek Watershed District. This file contained hourly precipitation amounts for every day from 1949 to 2001. For this modeling effort, three different climate years were modeled: average, wet, and dry. Based on the 52 years of data, the rain year with the total amount of precipitation closest to the average was October 1, 1956 to September 30, 1957, or, the 1957 rain year, which had 28.15 inches of total precipitation. The wet climate year used was 1983 (40.99") and the dry climate year used was 1988 (18.67").

After the list of ponds to be modeled was complete, the data for these ponds was entered into the P8 modeling program, and subwatershed data was imported from the P8 Processor previously described. The existing conditions model and future conditions model (without additional BMPs) were then run for the three climate years and results were summarized with the help of the P8 Processor. The P8 Processor not only helps with getting input into the P8 model, but also simplifies the transfer of output from P8 into GIS for easy manipulation, and for producing meaningful maps to summarize and display the results.

There are some drawbacks to splitting the study area up into five different P8 models to accommodate more devices. One of these drawbacks is that adjustments have to be made to the model output (as mentioned earlier in this section) to reflect the fact that a one of the P8 model areas is downstream of two other models. They were modeled separately, but to remain accurate, the total phosphorous (TP) and total suspended solids (TSS) loads in the outflow of the last downstream device of the two upstream models must be added to the devices through which these additional loads flow in the downstream P8 model. There are two modeled devices affected in line with Interstate Valley Creek, the wetland in subwatershed IV-110 and the dry pond in subwatershed IV-139. Since these both have an average depth of zero, they were given a Particle Removal Scale Factor of zero. This means that there will be no treatment in these devices and the inflow loads will equal the outflow loads. Another disadvantage of this modeling configuration is that BMPs can't be modeled in Interstate Valley Creek downstream of Friendly Marsh (in subwatershed IV-68) because the loads from the upstream P8 model cannot simply be added to the inflows and outflows. However, by this point in the system, there is a large contributory area such that an in-line BMP would not be practical.

A.1.4 Evaluation of Possible Water Quality Improvements Projects

Once the model was set up for existing and future conditions land use and pond data, the modeling of possible runoff water quality improvement projects was split into five components. First, additional BMPs were modeled individually to determine their incremental benefit on water quality. Next, the most beneficial and feasible BMPs were combined in a way that might be realistic for implementation. These multiple BMPs were reflected in the model and the cumulative benefit was determined from the model output. Another option was constructing rainwater gardens at strategic locations around the study area.

There are two other water quality improvement possibilities that were explored and modeled that are more widespread, non-localized improvement "devices". The first was enacting a phosphorous fertilizer ban in the cities making up the study area. This is becoming quite common in urban cities, with various levels of compliance and effectiveness. The other universal water quality improvement plan that was investigated was implementing a street sweeping program to remove built-up sediment and phosphorous from road surfaces and curbing, by means of a mechanical street sweeper.

A.1.4.1 Detention Ponds

Once the future conditions scenarios were run through P8 and the results were tabulated, locations were pinpointed based on a "hot spots" map that identified the subwatersheds that had the lowest percentage of cumulative TP removal. These are highlighted in dark red in Figure 5. For example, take a subwatershed that shows up in red on the map. The red color indicates that the cumulative TP removal is less than 10%, or, the total TP removal in the device in that subwatershed and all upstream devices as a percentage of the total TP entering the device located in the subwatershed in question. These "hot spots" are good locations for new or improved detention ponds, so select subwatersheds were chosen as locations for modeling the three detention pond improvement types: wet detention ponds with average depth increased to 4 ft (increased dead storage), dry detention ponds converted to wet detention ponds with an average depth of 4 ft and at least 0.3 ac of water surface area, and lastly, new wet detention ponds with an average depth of 4 ft and at least 0.3 ac of water surface area. A fourth option investigated was diverting the low flows and the first flush of large storms at the outlets of Interstate Valley and Ivy Falls Creeks into the Mississippi River. This option was listed as a possible water quality improvement project in Table 5-3 of the LMRWMO Plan (Barr Engineering Co, October 2001). The locations of the modeled detention pond BMPs are in the table below.

Wet Detention Ponds with Increased Dead Storage Capacity	Dry Detention Ponds Converted to Wet Detention Ponds	New Wet Detention Ponds	Diversion of Low Flows / First Flush
IV-57	IV-64	MB-SP1	IV-140 / L-10L
IF-21	IV-106	MB-2	IF-28 / L-10L
IV-126	IV-100	L-8	IV-140 / IF-28 / L-10L
IF-1	IV-119	IV-123	
SFL-11	IF-10	L-5	
IV-30	MB-10	L-3B	
HB-2	IV-TC_EP, IV-TC_NW, IV-TC_NP, IV-TC_SP,		

After the models were modified to include one of these proposed detention ponds, the model was run and the total TP load reduction entering the river was noted as the quantifiable benefit for that pond. Three of these ponds were evaluated as devices to increase the quality of runoff entering a lake, rather than the Mississippi River. They were SFL-11, IV-30, and HB-2, tributary to Sunfish Lake, North Rogers Lake, and Hornbeam Lake, respectively. All are existing wet detention ponds that would be dredged to an average depth of 4 ft in this proposal.

A.1.4.2 Combination of Detention Ponds

After some of the individually modeled detention pond BMPs were eliminated from consideration due to their inappropriate location or other factors, the most beneficial and feasible detention ponds were combined in a new model to ascertain their combined effect on reducing the TP entering the Mississippi River. It was necessary to run a new model because if more than one of the examined BMPs are to be considered, one cannot simply sum the TP load reduction from the two detention pond scenarios model runs. The ponds are not always independent; if one altered pond is upstream of another, the upstream device directly affects the events occurring at the downstream pond. These multiple detention pond scenarios being considered needed to be modeled together to obtain the overall TP load reduction.

A.1.4.3 Rainwater Gardens

For the individual areas identified by the city of Mendota Heights as possible locations for future rainwater garden implementation, the rainwater gardens were sized according to the directly connected area within the region to be treated by the rainwater garden. A ½" storm was used as the model storm to determine the total volume required for the rainwater gardens in the area, and a 1.5 ft average depth was used to determine the infiltration basin (P8 terminology for a rainwater garden) storage pool surface area. After the infiltration basin was sized, the tributary area was split off from the subwatersheds containing the rainwater gardens. New directly connected impervious percentages and pervious CN's were calculated, based on the revised subwatershed areas and the change in the distribution of land use areas. Some instances occurred where the area to be routed to the rainwater gardens was previously routed to a pond in the original (future conditions land use) model. In this case, the area was routed to the rainwater garden first, and then to the pond. Any runoff that was not infiltrated into the rainwater garden would be treated in the pond. The infiltrated runoff was assumed to not continue downstream as groundwater flow (no routing of exfiltration). The revised model was then run and the TP load reduction was noted at the outlet of the system into the river.

Other inputs for the infiltration basin were assumed. A void volume percentage of 100% was used, illustrating that the rainwater gardens will not be lined with riprap or other material. Since the majority of the study area is composed of Type B soils, an infiltration rate of 0.26 in/hr was used (McCuen 1982).

by a street sweeper. The P8 models were rerun after these assumptions were applied to all subwatersheds in the model. The results were then tabulated and compared to other runoff water quality improvement projects.

A.2 Assumptions

Some assumptions had to be made where certain information was not known, or where the amount of effort and cost to obtain such information was deemed too high in relation to its relative importance to the outcome of the project. These assumptions and the reasoning for using them are described in the following section.

The major subwatershed boundary between Ivy Falls Creek and Interstate Valley Creek will change slightly for the future conditions model. For the future model, WSP_IF-5 and WSP_IF-4 will be routed to the Interstate Valley Creek major subwatershed, instead of the to the Ivy Falls Creek major sub. This is based on the assumption that the Thompson Avenue Diversion project will go ahead as planned in the near future.

There are three dry ponds located on the property of Riverwood Apartments on Highway 13 in the City of Lilydale (subwatershed L-5). These were ignored and not included in the model due to their anticipated insignificant effect on stormwater drainage and water quality. These three dry ponds were also not included in the previous Barr Watershed Modeling efforts.

Pickerel Lake (L-10U) and the Mississippi River floodplain to the south (L-10L) are within the LMRWMO boundary, but were not modeled as BMPs. This is due to the fact that Barr has no data on these such as dead storage, 100-year flood storage, outlet information, etc. Without this information, they couldn't be modeling in the P8 Urban Catchment Model. However, their contribution to the water quality was taken into account. This was done by modeling the floodplain area south of Pickerel Lake as a subwatershed routed to a subwatershed comprised of Pickerel Lake and it's immediately tributary area. This watershed was then routed to the Mississippi River.

In determining the land use of the study area, an entire parcel was generally kept as the same land use, unless doing this would make the percent impervious and percent directly-connected much different (lower) than the assumed values set for its land use type. In this case, a portion of the parcel was changed to vacant to bring the impervious and directly connected percentages up to a value to represent the all of the land for that particular land use.

Another assumption made pertaining to land use had to with the "vacant" land use. It was generally assumed that in urban areas, land designated as "vacant" in existing conditions would be developed in the future conditions coverage, and would have the same land use classification as the surrounding parcels. This is consistent with the Metropolitan Council land use coverage. The exception to this assumption was in instances where Barr had specific knowledge of the area.

Some assumptions were made in the P8 model itself. These include setting the depression storage to 0.03 inches for all subwatersheds, using an impervious runoff coefficient of 0.95, and employing the NURP 50 particle file. This file sets the accumulation and washoff rates, settling velocities, decay rates, and other parameters, in an attempt to represent the median site of the National Urban Runoff Program (NURP). Also, Barr assumed no infiltration through ponds into groundwater to slightly simplify the model.

In an attempt to best represent the ponds and their ability to treat runoff, different Particle Removal Scale Factors were used for different ponds, based on their average depth below the normal water surface elevation. If a pond was a dry pond, it was given a Particle Removal Scale Factor of zero. In essence, this is saying that there is no water quality treatment at this device because there is no dead storage, which is the portion of a pond where the particle settling occurs. If a pond or wetland has an average depth of less than 2 ft, it was given a Particle Removal Scale Factor of 0.01. A pond or wetland with an average depth between 2 ft and 3 ft was given a Particle Removal Scale Factor of 0.02. This is an effort to tell the model that since these are shallow ponds or wetlands, their ability to remove particles is greatly diminished. Only 1 to 2% of the load settled out of a pond with a Particle Removal Scale Factor of 1.0 would settle out of a pond with a Particle Removal Scale Factor of 0.01 or 0.02, respectively. For the remaining ponds and wetlands with average depths greater than 3 ft, the Particle Removal Scale Factor was set to 1.0, reflecting the fact that most likely there are ideal conditions in this pond for the removal of particles.

All paved road surfaces were assumed to be directly connected. Parking lots were assumed to be directly connected also, either to an immediate storm sewer inlet in the parking lot, or to an adjacent street with the grade of the pavement. Driveways were usually not directly connected. For Commercial, Industrial, Very High Density Residential, Low Density Institutional, and High Density Institutional land uses, at least a portion of the roof drainage was assumed to be directly-connected to the storm sewer system, depending on the proximity and location of surrounding pavement. If a building is surrounded by impervious pavement on half of its perimeter (i.e. two sides of a square building), then one-half of the roof area was assumed to be directly connected, as long as the pavement is directly connected and there is not more than 20 feet of a pervious surface between the pavement and the building. All impervious surfaces in the Vacant land use group were assumed to be directly connected since these areas are paved roadways in all cases.

P8 parameters not discussed in the following paragraphs were left at the default setting. Version 2.4 of the P8 Model was used for the modeling.

A.2.1 Time Step, Snowmelt, & Runoff Parameters

- Time Steps Per Hour (Integer)— Varies. Selection was based upon the number of time steps required to eliminate continuity errors greater than two percent.

- Growing Season AMC—II = 0 and AMC—III = 100. Selection of this factor was based upon the observation that the model accurately predicted runoff water volumes from monitored watersheds when the Antecedent Moisture Condition II was selected (i.e., curve numbers selected by the model are based upon antecedent moisture conditions). Modeled water volumes from pervious areas were less than observed volumes when Antecedent Moisture Condition I was selected, and modeled water volumes exceeded observed volumes when Antecedent Moisture Condition III was selected. The selected parameters tell the model to only use Antecedent Moisture Condition I when less than 0 inches of rainfall occur during the five days prior to a rainfall event and to only use Antecedent Moisture Condition III if more than 100 inches of rainfall occur within five days prior to a rainfall event.

A.2.2 Particle File Selection

- NURP50.PAR. This particle file is the default file developed for the median runoff site from the NURP monitoring.

A.2.3 Precipitation File Selection

- MSP4999.PCP. The precipitation file MSP4999.PCP is comprised of hourly precipitation measured at the Minneapolis–St. Paul International Airport were used for the period between 1949 and the end of September 1999.

A.2.4 Air Temperature File Selection

- MSP4999.tmp. The temperature file was comprised of temperature data from the Minneapolis–St. Paul International Airport during the period from 1949 through 1999.

A.2.5 Devices Parameter Selection

- Detention Pond— Permanent Pool— Area and Volume— The surface area and dead storage volume of each detention pond was determined and entered here. Where available, Barr used outlet stage-discharge relationships or other rating information and pond volume information developed for the hydrologic/hydraulic modeling. If limited information was supplied, Barr made assumptions about the average depth (as outlined above) and estimated the surface area information (based on USGS quad maps or aerial photos) to determine the pond permanent pool volume.

- Detention Pond— Flood Pool— Area and Volume— The surface area and storage volume under flood conditions (i.e., the storage volume between the normal level and flood elevation) was determined and entered here. The areas and volumes were estimated based on information developed for the hydrologic/hydraulic modeling.

- Detention Pond— Infiltration Rate (in/hr)— Infiltration rates were only entered for basins that were known to experience water levels below the normal water level. An infiltration rate was determined based on observed water levels during dry periods.

- Detention Pond— Orifice Diameter and Weir Length— The orifice diameter or weir length was determined from field surveys or development plans of the area for each detention pond and entered here.

- Detention Pond or Generalized Device— Particle Removal Scale Factor— Particle Removal Scale Factor— 0 for all dry ponds, 0.01 for wet ponds with average depths less than two feet, 0.02 for wet ponds with average depths between two and three feet, and 1.0 for all ponds with average depths of three feet or greater.

- Detention Pond or Generalized Device— Outflow Device Nos.— The number of the downstream device receiving water from the detention pond outflow was entered.

- Pipe/Manhole— Time of Concentration— Because detailed topographic information was not available for the entire District the time of concentration for each pipe/manhole device was entered as 0 hrs. A "dummy" pipe/manhole was installed in the network to enable the model to sum up water and pollutant loads at specific watershed runoff inflow and outflow locations. This forced the model to total all loads (i.e., water, nutrients, etc.) entering the lake. Failure to enter the "dummy" pipe requires the modeler to manually tabulate the loads entering the lake.

A.2.6 Watersheds Parameter Selection

- Outflow Device Number— The Device Number of the device receiving runoff from the watersheds was selected to match the pond or manhole node ID used for the hydrologic/hydraulic modeling.

- Pervious Curve Number— An overall composite pervious curve number was determined by weighting the areas for the given soil groups within the subwatershed. This composite pervious curve number was then weighted with indirect (i.e., unconnected) impervious areas in each subwatershed as outlined above.

- Swept/Not Swept—An "Unswept" assumption was made for the entire impervious watershed area. A Sweeping Frequency of 0 was selected. Selected parameters were placed in the "Unswept" column since a sweeping frequency of 0 was selected.

- Impervious Fraction—The direct or connected impervious fraction for each subwatershed was determined and entered here. Connectivity estimation of the various impervious surface types was accomplished by associating each surface type with a land use category.

- Depression Storage— 0.03 (Assumed, based on average watershed slope)

- Impervious Runoff Coefficient— 0.95 (Assumed)

A.2.7 Passes Through the Storm File

- Passes Through Storm File— The number of passes through the storm file was determined after the model had been set up and a preliminary run completed. The selection of the number of passes through the storm file was based upon the number required to achieve model stability. Multiple passes through the storm file were required because the model assumes that dead storage waters contain no pollutants. Consequently, the first pass through the storm file results in lower pollutant loading than occurs with subsequent passes. Stability occurs when subsequent passes do not result in a change in pollutant concentration in the pond waters. To determine the number of passes to select, the model was run with five passes and ten passes. A comparison of pollutant predictions for all devices was evaluated to determine whether changes occurred between the two scenarios. If there is no difference between five and ten passes, five passes is sufficient to achieve model stability. This parameter was determined for all of the P8 model areas and no differences were noted between five and ten passes. Therefore, it was determined that five (5) passes through the storm file resulted in model stability for these models.

Table A-1
Pond and Wetland Summary Sheets

Mendota Heights

Subwatershed ID	Pond ID	Pond Name	DNR ID	Normal Pond Elevation	100-yr Pond Elevation	Average Pond Depth (ft)	Normal Pond Surface Area (acres)	100-yr Pond Surface Area (acres)	Pond Dead Storage (ac-ft)	100-yr Detention Storage (ac-ft)	Outlet Type	Comment
IV-26	IV-26-1	35-E Basin		888.00	890.30			-		2.80	33" RCP	Depression at interstate interchange
IV-27	IV-27-1	35-E Basin		889.00	893.80			-		1.40	65" RCP Span	Depression at interstate interchange
IV-28	IV-28-1	-		-	-			-		-	30" CMP	
IV-29	IV-29-1	-		-	-			-		-	36" RCP	
IV-30	IV-30-1	Golf Course Pond	19-80P	872.00	875.20	3.00	3.20	4.92	9.60	13.00	18" CMP	
Scenario 19	IV-30-1	Golf Course Pond	19-80P	872.00	875.20	4.00	3.20	4.92	12.80	13.00	18" CMP	
IV-31	IV-31-1	-	-	876.00	876.03	0.50	0.10	2.57	0.05	0.04	Ditch	
IV-32	IV-32-1	-	-	874.50	874.60	0.75	0.40	1.60	0.30	0.10	Ditch	
IV-33	IV-33-1	N. Wagon Wheel Pond	19-108W	875.00	875.40	1.50	0.90	5.40	1.35	1.20	Ditch	
IV-34	IV-34-1	S. Wagon Wheel Pond	19-108W	874.00	874.30	1.00	0.60	2.07	0.60	0.40	15" RCP	
IV-35	IV-35-1	Rogers Park Pond	-	874.00	874.80	2.50	0.40	1.85	1.00	0.90	Ditch	
IV-36	IV-36-1	35-E Pond	-	872.90	876.30	2.00	0.50	2.38	1.00	4.90	24" RCP	
IV-37	IV-37-1	Rogers Lake Marsh	19-80P	874.50	874.53	0.00	0.00		0.00	0.04	Ditch	
IV-38	IV-38-1	N. Rogers Lake	19-80P	872.20	873.20	3.40	30.06	31.36	110.70	30.71	36" CMP	Equalizes with IV-39
IV-39	IV-39-1	S. Rogers Lake	19-80P	872.20	873.20	6.50	78.15	79.92	507.98	79.04	30" RCP	
IV-40	IV-40-1	I.O.S. Pond	-	871.00	873.60	1.00	0.30	0.39	0.30	0.90	18" Riser	
IV-41	IV-41-1	-		-	-			-		-	24" CMP	Silt basin at outlet
IV-42	IV-42-1	-		-	-			-		-	15", 24" RCP	Silt basin at outlet
IV-1	IV-1-1	-		908.00	908.50			-		0.20	15" RCP	
IV-2	IV-2-1	Westview Pond	-	892.80	893.70	2.17	0.80	1.87	1.74	1.20	12" RCP	
IV-3	IV-3-1	Hazel Pond	-	891.00	892.10	1.50	0.80	1.56	1.20	1.30	12" RCP	
IV-4	IV-4-1	Upper Bridgeview Pond	19-227W	872.90	874.10	5.76	4.10	9.90	23.62	8.40	15" RCP	
IV-5	IV-5-1	-		890.00	891.40	1.00	0.38	0.48	0.38	0.60	18" RCP	
IV-6	IV-6-1	Lower Bridgeview Pond	19-228W	871.80	872.80	1.50	4.60	5.00	6.90	5.00	24" RCP	
IV-7	IV-7-1	Arbor Pond	-	877.00	878.00	0.50	0.41	1.60	0.20	1.50	18" RCP	
IV-8	IV-8-1	Brookfield Pond	19-229W	875.00	875.80	1.50	2.50	4.00	3.75	2.60	21" RCP	
IV-9	IV-9-1	Lockwood Pond	-	878.80	879.80	1.50	0.60	2.80	0.90	1.70	18" RCP	
IV-10	IV-10-1	-		-	-			-		-	33" RCP	
IV-11	IV-11-1	Kensington Park	-	864.20	867.30	1.00	0.30	2.02	0.30	3.60	30" RCP	
IV-12	IV-12-1	Southeast Ponds	19-235W	872.00	872.70	1.50	0.60	18.54	0.90	6.70	12" RCP	Proposed Outlet; Existing - Natural Overflow
IV-13	IV-13-1	Southeast Ponds	-	878.00	878.70	1.00	0.20	5.23	0.20	1.90	12" RCP	Proposed Outlet; Existing - Natural Overflow
IV-14	IV-14-1	Southeast Ponds	-	886.00	886.50	1.00	0.20	1.80	0.20	0.50	12" RCP	Proposed Outlet; Existing - Natural Overflow
IV-15	IV-15-1	Owens Pond	19-234W	854.50	855.90	5.90	2.10	8.33	12.39	7.30	18" RCP	
IV-16	IV-16-1	King Pond	19-232W	854.00	855.30	4.10	5.20	5.72	21.32	7.10	18" RCP	
IV-17	IV-17-1	Delaware Pond 1	19-233W	850.70	853.30	4.00	6.90	11.56	27.60	24.00	24" RCP	
IV-18	IV-18-1	Copperfield Pond	19-103P	839.00	841.10	3.10	13.40	20.50	41.50	67.00	Ditch	
IV-19	IV-19-1	Hagstrom Pond	19-231W	854.00	854.90	3.70	1.80	5.09	6.66	3.10	18" RCP	
IV-20	IV-20-1	-		-	-			-		-	48" RCP	
IV-21	IV-21-1	I.D.S. #197		-	-			-		-	-	
IV-22	IV-22-1	Friendly Hills Pond	-	845.00	846.90	3.00	1.90	8.42	5.70	9.80	Ditch	
IV-23	IV-23-1	-		840.10	844.30			-		0.10	48" RCP	
IV-24	IV-24-1	Darsow Pond	19-103P	837.00	839.10	2.68	5.50	20.70	14.90	27.50	2-36"x58" Arches	
IV-25	IV-25-1	-		-	921.30			-		0.30	18" RCP	
IV-43	IV-43-1	-		-	-			-		-	-	
IV-44	IV-44-1	Mendakota Pond	-	883.00	886.70	4.74	1.60	1.91	7.58	6.50	12" RCP	1997 Mendakota Pond Modification
IV-45	IV-45-1	-		-	-			-		-	-	
IV-46	IV-46-1	-		-	-			-		-	-	
IV-47	IV-47-1	-		-	-			-		-	-	
IV-48	IV-48-1	-		-	-			-		-	-	
IV-49	IV-49-1	-		-	-			-		-	-	
IV-50	IV-50-1	F.M. Pond	19-103P	832.00	834.60	2.50	1.00	1.31	2.50	3.00	Wood Weir	Beaver problem at this location
IV-51	IV-51-1	Sibley H.S. Pond	-	900.00	907.20	0.50	0.80	0.98	0.40	6.40	42" RCP	Pond filled by sediment; Overflows frontage road during 100 year event

				Normal	100yr	Depth	(acres) Normal S.A.	(acres) 100yr S.A.	acre-ft Dead Storage	acre-ft 100yr Storage	outlet	
IV-52	IV-52-1	-		902.00	902.80			-		0.02	Weir Structure	
IV-53	IV-53-1	-		-	-			-		-	-	
IV-54	IV-54-1	Delaware Pond 2	-	-	-	0.00	0.00		0.00	-	-	
IV-55	IV-55-1	-	-	-	-	0.00	0.00		0.00	-	-	
IV-56	IV-56-1	-		-	-			-		-	-	
IV-57	IV-57-1	Dodge N.C. Pond	19-102W	850.00	851.70	3.00	5.30	11.17	15.90	14.00	Ditch	
Scenario 2	IV-57-1	Dodge N.C. Pond	19-102W	850.00	851.70	4.00	5.30	11.17	21.20	14.00	Ditch	
IV-58	IV-58-1	-		885.00	888.10			-		0.10	24" RCP	Overflows frontage road during 10 year event
IV-59	IV-59-1	-		870.00	872.60			-		0.10	18" RCP	
IV-60	IV-60-1	-		867.00	870.80			-		0.10	24" RCP	Overflows ditch block to IV-63: Additional 30 cfs to IV-63 (10 year event), Additional 70 cfs to IV-63 (100 year event)
IV-TC_EP	IV-TC_EP-1	-		872.00	876.50	0.20	0.05	0.58	0.01	1.00	24" RCP	EXISTING. Dry pond
IV-TC_EP	IV-TC_EP-2			870.70	875.00	0.00	0.00	0.20	0.00	1.00	18"x29" ellip	FUTURE. New pipe construction for Mendota Heights Town Center - lowered invert from 872.0 to 870.7
IV-TC_NP	IV-TC_NP-1	-		866.00	868.20	0.00	0.00	0.05	0.00	0.10	24" RCP	EXISTING
IV-TC_NP	IV-TC_NP-2	Mendota Heights Town Center North Pond		868.00	868.90	3.06	0.33	0.36	1.01	0.33	15" HDPE	FUTURE. Newly-constructed pond/pipe for Mendota Heights Town Center
IV-TC_SP	IV-TC_SP-1	-		845.00	855.60	0.00	0.00	0.70	0.00	3.10	24" RCP	EXISTING. Additional 60 cfs overflows to IV-79 during 100 year event
IV-TC_SP	IV-TC_SP-2	Mendota Heights Town Center South Pond		854.00	857.70	5.10	0.58	0.82	2.96	2.64	Skimmer/MH - see HydroCAD printout from manual rating curve	FUTURE. Newly-constructed pipe/pond for Mendota Heights Town Center
IV-64	IV-64-1	McDonalds Pond	-	828.60	837.50	0.00	0.00	0.76	0.00	3.23	6" CMP	Pond overflows during 10 year event
Scenario 6	IV-64-1	McDonalds Pond	-	828.60	837.50	4.00	0.30	0.76	1.20	3.23	6" CMP	
IV-65	IV-65-1	-		847.00	849.20	0.00	0.00	0.21	0.00	0.30	24" CMP	
IV-67	IV-67-1	-		-	-			-		-	-	
IV-68	IV-68-1	Friendly Marsh	19-103P	824.80	836.60	0.50	0.10	62.23	0.05	121.00	36" Orifice	Proposed Outlet; Existing - 72" RCP
IV-128	IV-128-1	Lex./Marie Ave.	-	879.20	885.20	2.30	0.40	1.87	0.92	6.80	24" RCP	
IV-129	IV-129-1			877.80	888.70	0.00	0.00	0.06	0.00	0.30	24" RCP	Peak discharge of 21 cfs flows to IV-128 (10 year event), Peak discharge of 28 cfs flows to IV-128 (100 year event)
IV-129A	IV-129A-1			877.00	888.70	0.00	0.00	0.24	0.00	1.40	12" RCP	
IV-130	IV-130-1	Faro Lane	-	873.00	888.40	0.00	0.00		0.00	0.10	24" RCP	
IV-131	IV-131-1			858.40	863.90			-		0.00	36" RCP	Peak discharge of 21 cfs flows to IV-132a (100 year event)
IV-132	IV-132-1	Burrows Pond	-	859.20	863.70	2.45	2.90	7.68	7.11	23.80	36" RCP	
IV-132A	IV-132A-1			858.50	863.80	0.50	0.02	0.02	0.03	0.10	Drop Inlet to 36" RCP	Peak discharge of 36 cfs flows to IV-132 (100 year event)
IV-133	IV-133-1	Marie Pond	-	858.90	863.60	4.00	0.60	1.19	2.40	4.20	24" RCP	
IV-134	IV-134-1	Victoria Pond	-	855.00	861.00	2.50	0.40	2.27	1.00	8.00	15" RCP	
IV-81	IV-81-1	Warrior Pond	19-93W	926.40	927.00	3.00	4.00	5.00	12.00	2.70	12" RCP	
IV-TC_NW	IV-TC_NW-1			861.00	866.90	0.00	0.00	0.92	0.00	3.20	24" RCP	EXISTING.
IV-TC_NW	IV-TC_NW-2	Mendota Heights Town Center North Wetland		867.00	869.00	0.50	0.21	0.51	0.10	0.70	30" pipe and weir (weir controls - see HydroCAD printout for manual rating curve)	FUTURE. New pipe with construction of Mendota Heights Town Center
IV-84	IV-84-1	-		857.50	859.10	0.00	0.00	0.10	0.00	0.10	15" RCP	Additional 12 cfs flows to IV-86 (100 year event), Additional 6 cfs flows to IV-86 (10 year event)
IV-85	IV-85-1	-		856.00	858.00	0.50	0.10	0.21	0.05	0.30	15" RCP	Overflows pond during 100 year event
IV-86	IV-86-1	-		852.00	855.70	0.50	0.10	0.49	0.05	1.10	12" RCP	Overflows Hilltop Road during 100 year event
IV-87	IV-87-1	-		848.50	849.10	0.00	0.00	0.04	0.00	0.04	15" RCP	Overflows Valley Willow Lane during 10 year event
IV-88	IV-88-1	-		943.00	945.40	0.00	0.00	0.57	0.00	0.70	15" RCP	
IV-89	IV-89-1	Marie Marsh	-	941.00	942.90	0.50	0.83	1.54	0.42	2.50	12" RCP	Proposed Outlet; Existing - Natural Overflow
IV-90	IV-90-1	Marie Marsh	-	932.00	934.30	0.50	4.43	6.76	2.22	12.80	3-24" RCP	Proposed Outlet; Existing - Natural Overflow
IV-91	IV-91-1	Marie Marsh		933.00	935.80	0.50	0.71	1.54	0.36	3.10	3-24" RCP	Proposed Outlet; Existing - Natural Overflow
IV-92	IV-92-1	Marie Marsh	-	933.00	933.70	0.50	0.30	1.41	0.15	0.60	12" RCP	Proposed Outlet; Existing - Natural Overflow
IV-93	IV-93-1	Marie Marsh	-	931.00	931.70	0.50	0.80	4.34	0.40	1.80	12" RCP	Proposed Outlet; Existing - Natural Overflow
IV-94	IV-94-1	-	-	-	-			-		-	-	
IV-95	IV-95-1	Marie Marsh		922.00	923.30	0.50	0.60	1.09	0.30	1.10	24" CMP	
IV-96	IV-96-1	-		-	-			-		-	-	
IV-97	IV-97-1	Marie Marsh	-	-	-	0.00	0.00		0.00	-	-	
IV-98	IV-98-1	-	-	911.00	912.50	0.50	0.50	0.97	0.25	1.10	15" RCP	Proposed Outlet; Existing - Natural Overflow
IV-99	IV-99-1	-		-	-			-		-	-	
IV-100	IV-100-1	Marie Ave. Creek	-	869.80	875.50	0.00	0.00	0.20	0.00	0.37	2-36" RCP	Overtops Dodd/Marie Intersection during 100 year event (proposed); Overtops Dodd/Marie Intersection during 10 year event (existing)
Scenario 8	IV-100-1	Marie Ave. Creek	-	869.80	875.50	4.00	0.30	0.38	1.20	0.37	2-36" RCP	
IV-101	IV-101-1	-		-	-			-		-	-	

IV-102	IV-102-1	-		-	-			-		4.00	-	
IV-103	IV-103-1	-		829.00	832.90	0.50	0.04	0.24	0.02	0.50	48" RCP	Overtops driveway (10 year event)
IV-104	IV-104-1	Sutton/Marie Pond	-	824.70	827.70	2.45	0.40	1.13	0.98	2.30	3-12" RCP	Overtops control structure (100 year event)
IV-105	IV-105-1	Sutton/Marie Pond	-	819.40	823.70	0.00	0.00	0.20	0.00	0.46	36" RCP	
IV-106	IV-106-1	-		812.40	820.00	0.00	0.00	0.08	0.00	0.30	45"x73" CMPA	Overtops Wachtler Road (10 year event)
Scenario 7	IV-106-1	-		812.40	820.00	4.00	0.30	0.38	1.20	0.30	45"x73" CMPA	
IV-107	IV-107-1	-		-	-			-		-	-	
IV-108	IV-108-1	-		-	-			-		-	-	
IV-109	IV-109-1	-		810.10	816.30	0.00	0.00	0.10	0.00	0.40	45"x73" CMPA	Additional 240 cfs overflows to IV-110 (10 year event); Additional 50 cfs overflows to IV-110 (10 year event)
IV-69	IV-69-1	-		-	-			-		-	-	
IV-70	IV-70-1	-		839.00	843.00	0.00	0.00	0.38	0.00	0.80	30" RCP	
IV-71	IV-71-1	-		865.00	871.40	0.00	0.00	0.16	0.00	0.30	33" RCP	
IV-72	IV-72-1	-		-	-			-		-	-	
IV-73	IV-73-1	-		-	-			-		-	-	
IV-74	IV-74-1	Lower Crown Point	-	820.50	826.10	0.00	0.00	0.17	0.00	0.54	12" CMP	Pond overflows during 100 year event
IV-75	IV-75-1	Upper Crown Point	-	820.50	826.60	0.00	0.00	0.31	0.00	1.22	12" CMP	Pond overflows during 100 year event
IV-76	IV-76-1	-		868.00	872.50	0.00	0.00	0.03	0.00	0.10	30" RCP	
IV-77	IV-77-1	-		840.00	846.00	0.00	0.00	0.02	0.00	0.10	36" RCP	
IV-78	IV-78-1	-		815.00	818.80	0.00	0.00	0.09	0.00	0.20	36" RCP	
IV-79	IV-79-1	-		850.00	852.80	0.00	0.00	0.30	0.00	0.50	18" CMP	Pond overflows Dodd road during 100 year event
IV-110	IV-110-1	Valley Marsh	-	809.60	817.50	0.00	0.00	10.45	0.00	24.85	1-55"x88" RCPA	Proposed Outlet; Existing - 2-55"x88" RCPA
IV-111	IV-111-1	Bachelor Ave. Pond	-	857.40	860.90	2.00	0.50	2.01	1.00	4.40	12" RCP	
IV-112U	IV-112U-1	Valley Park Pond	19-104W	806.00	809.00	3.30	0.60	1.60	1.98	3.30	Wood Weir	Beaver problem at this location
IV-112L	IV-112L-1		19-104W	-	-							subdivided out from IV-112U (originally IV-112) since stream does not enter pond
IV-113	IV-113-1	-	-	954.20	959.60	2.00	0.50	2.24	1.00	7.40	Drop Inlet into 36" CMP	Assumes pond storage expanded
IV-114	IV-114-1	-	-	938.20	941.40	2.00	0.90	1.54	1.80	3.90	Drop Inlet into 36" CMP	Assumes pond storage expanded
IV-115	IV-115-1	-		914.00	>918.0			-		0.00	30" pipe	Overflows Dodd Road during 10 and 100 year events
IV-116	IV-116-1	Wentworth Pond	-	926.00	926.80	2.00	1.30	2.20	2.60	1.40	12" RCP	Proposed Outlet; Existing - Natural Overflow
IV-117	IV-117-1	-		-	-			-		-	-	
IV-118	IV-118-1	Wentworth Pond	-	876.50	881.20	4.00	0.40	6.71	1.60	16.70	48" RCP with Beam Top @ 100 yr level	Existing Outlet: Gabion beam with 3-8" steel pipes
IV-119	IV-119-1	-		852.00	855.80	0.00	0.00	0.17	0.00	0.40	60" RCP	
Scenario 9	IV-119-1	-		852.00	855.80	4.00	0.30	0.38	1.20	0.40	60" RCP	
IV-120	IV-120-1	-		-	-			-		-	-	
IV-121	IV-121-1	-		-	-			-		-	-	
IV-122	IV-122-1	-		-	-			-		-	-	
IV-123	IV-123-1	-		-	-			-		-	-	
Scenario 15		-		0.00	3.00	4.00	0.30	0.38	1.20	1.00	12"	
IV-124	IV-124-1	-		-	-			-		-	-	
IV-125	IV-125-1	Park Place Pond	-	845.00	848.00	2.00	0.40	0.60	0.80	1.50	15" RCP	
IV-126	IV-126-1	Cherry Hills Pond	-	804.00	809.20	0.50	0.60	1.17	0.30	4.60	8" CMP	
Scenario 4	IV-126-1	Cherry Hills Pond	-	804.00	809.20	4.00	0.60	1.17	2.40	4.60	8" CMP	
IV-127	IV-127-1	-		-	-	0.00	0.00		0.00	-	-	MH Pondnet: IV-127a and IV-127b
IV-135	IV-135-1	-		-	-			-		-	-	
IV-136	IV-136-1	-		-	-			-		-	-	
IV-137	IV-137-1	-		-	-			-		-	-	
IV-138	IV-138-1	-		-	-			-		-	-	
IV-139	IV-139-1	Lilydale Road Embankment		722.90	743.40	0.00	0.00	1.37	0.00	12.50	60" RCP	Lilydale Road Embankment
IV-140	IV-140-1	-		-	-			-		-	Creek	Railroad Bridge
IF-1	IF-1-1	Sommerset G.C. Pond #1	-	957.35	964.60	2.00	2.00	2.80	4.00	17.40	42" CMP	
Scenario 5	IF-1-1	Sommerset G.C. Pond #1	-	957.35	964.60	4.00	2.00	2.80	8.00	17.40	42" CMP	
IF-2	IF-2-1	-		-	-			-		-	-	
IF-3	IF-3-1	-		-	-			-		-	-	
IF-4	IF-4-1	Sommerset G.C. Pond #2	-	917.00	922.20	2.00	1.15	1.97	2.30	8.10	48" RCP	Pond Overflows during 10 year event
IF-5	IF-5-1	-		-	-			-		-	-	
IF-6	IF-6-1	-		-	-			-		-	-	
IF-7	IF-7-1	-		860.70	866.30	0.00	0.00	0.21	0.00	0.60	2-48" RCP	
IF-8	IF-8-1	Brookside Pond		862.00	863.50	0.10	0.10	4.83	0.01	3.70	15" RCP	Proposed pipe

IF-9	IF-9-1	-		-	-			-		-	-	
IF-10	IF-10-1	-		848.10	850.90	0.00	0.00	0.21	0.00	0.30	72" RCP	
Scenario 10	IF-10-1	-		848.10	850.90	4.00	0.30	0.38	1.20	0.30	72" RCP	
IF-11	IF-11-1	-		-	-			-		-	-	
IF-12	IF-12-1	-		-	-			-		-	-	
IF-13	IF-13-1	-		-	-			-		-	-	
IF-14	IF-14-1	-		-	-			-		-	-	
IF-15	IF-15-1	Sutcliff Pond	-	942.00	947.60	0.00	0.00	0.31	0.00	1.16	12" RCP	
IF-16	IF-16-1	MnDOT T.H. 13 Pond	-	925.00	929.10	0.50	0.42	0.67	0.21	2.26	12" RCP	
IF-17	IF-17-1	-		-	-			-		-	-	
IF-18	IF-18-1	-		968.10	971.30	0.20	0.06	1.50	0.01	2.50	18" RCP	
IF-19	IF-19-1	-		-	-			-		-	-	
IF-20	IF-20-1	-		-	-			-		-	-	
IF-21	IF-21-1	Ivy Hills Park Pond	-	892.00	898.80	2.00	0.30	2.46	0.60	9.40	48" RCP	Pond assumed to be enlarged per feasibility study
Scenario 3	IF-21-1	Ivy Hills Park Pond	-	892.00	898.80	4.00	0.30	2.46	1.20	9.40	48" RCP	
IF-22	IF-22-1	-		879.20	885.30	0.00	0.00	0.07	0.00	0.20	48" RCP	
IF-23	IF-23-1	-						-			-	
IF-24	IF-24-1	-		851.60	857.30	0.20	0.06	0.08	0.01	0.40	24" RCP	Pond overflows during 10 year event
IF-25	IF-25-1	-						-				Gabion Check Dams
IF-26	IF-26-1	-		-	-			-		-	-	
IF-27	IF-27-1	-		-	-			-		-	-	
IF-28	IF-28-1	-		-	-			-		-	Creek	
MB-6	MB-6-1	-		-	-			-		-	-	
MB-7	MB-7-1	Cliff Side parking area stormwater detention		857.00	857.80			-		-	-	Parking area stormwater detention (dry)
MB-8	MB-8-1	Lilac Lane Pond	-	835.40	845.10	0.00	0.00		0.00	7.10	15" CMP	high level overflow
MB-9	MB-9-1	-		-	-			-		-	12" CMP	1997 storm sewer construction at Caren Road and Caren Court
MB-11	MB-11-1	Sibley Memorial Dr. Ditch		803.50	805.80			-		-	30" RCP	Highway Ditch (dry)
MB-12U	MB-12U-1	-		-	-			-		-	30" RCP	Flow diverted to Mayfield Heights Pond
MB-12L	MB-12L-1	-		-	-			-		-	24" CMP	
MB-12A	MB-12A-1	-		-	-			-		-	21" & 18" CMP	Proposed Outlet; Existing - 18" & 15" CMP
MB-13	MB-13-1	Lexington Avenue		879.00	883.00	0.00	0.00	0.10	0.00	0.20	36" RCP	Proposed Outlet; Flow diverted to Mayfield Heights Pond (dry) - Pond no longer there?
MB-19	MB-19-1	-		-	-			-		-	24" CMP	
MB-3	MB-3-1	-		-	-			-		-	-	
MB-3a	MB-3a-1	-		-	-			-		-	-	Additional 11 cfs overflows to IF-25
MB-3b	MB-3b-1	-		-	-			-		-	-	Additional 9 cfs overflows to IF-25
MB-3c	MB-3c-1	-		-	-			-		-	-	Additional 9 cfs overflows to IF-9
MB-4	MB-4-1	-		-	-			-		-	24" CMP	
MB-5	MB-5-1	-		-	-			-		-	-	
MB-1	MB-1-1	-		-	-			-		-	-	
MB-2	MB-2-1	-		-	-			-		-	-	
Scenario 13	MB-2-1	-		0.00	3.00	4.00	0.30	0.38	1.20	1.00	12"	
MB-20	MB-20-1							-		-	24" CMP	

West St. Paul

*Elevations converted from West St. Paul Datum: 694.18 ft above MSL

Subwatershed ID	Pond ID	Pond Name	DNR ID	Normal Pond Elevation	100-yr Pond Elevation	Average Pond Depth (ft)	Normal Pond Surface Area (acres)	100-yr Pond Surface Area (acres)	Pond Dead Storage (ac-ft)	100-yr Detention Storage (ac-ft)	Outlet Type	Comment
WSP_IF1A	WSP_IF1A-1	Dodge Center Pond	19-87P	1017.00	1018.80	3.00	3.81	4.70	11.43	5.40	24" CMP	Deep Marsh
WSP_IF1B	WSP_IF1B-1			1011.30	1015.00	1.00	0.32	0.82	0.32	2.10	18" RCP	
WSP_IF2	WSP_IF2-1			-	-			-		-		
WSP_IF3A	WSP_IF3A-1			-	-			-		-		
WSP_IF3B	WSP_IF3B-1			-	-			-		-		
WSP_IF4	WSP_IF4-1			-	-			-		-		
WSP_IF5	WSP_IF5-1			-	-			-		-		
WSP_IF6	WSP_IF6-1			-	-			-		-		
WSP_IF7	WSP_IF7-1			-	-			-		-		
WSP_IF8	WSP_IF8-1			-	-			-		-		
WSP_IF9	WSP_IF9-1			-	-			-		-		
WSP_IF10	WSP_IF10-1			-	-			-		-		
WSP_IF11	WSP_IF11-1			-	-			-		-		
WSP_IF12	WSP_IF12-1			-	-			-		-		
WSP_IF13	WSP_IF13-1			-	-			-		-		
WSP_IF14	WSP_IF14-1			-	-			-		-		
WSP_IF15	WSP_IF15-1			-	-			-		-	WSP Thompson Ave. Diversion	
WSP_IF16	WSP_IF16-1			-	-			-		-		
WSP_IF17	WSP_IF17-1			-	-			-		-		
WSP_IF18	WSP_IF18-1			-	-			-		-		
WSP_IF19	WSP_IF19-1			-	-			-		-		
WSP_IF20	WSP_IF20-1			-	-			-		-		
WSP_IF21	WSP_IF21-1			-	-			-		-	33" RCP	
WSPIF22A	WSPIF22A-1							-			33" RCP	
WSPIF22B	WSPIF22B-1			-	-			-		-	-	
WSPIF22C	WSPIF22C-1			-	-			-		-	-	
WSPD101	WSPD101-1			-	-			-		-		
WSPD102	WSPD102-1			-	-			-		-		
WSPD103	WSPD103-1			-	-			-		-		
WSPD104	WSPD104-1			-	-			-		-		
WSPD105	WSPD105-1			1038.18	1040.78			-		0.70		
WSPD106	WSPD106-1							-		-		
WSPD107	WSPD107-1			1002.38	1003.28			-		0.70		
WSPD108	WSPD108-1							-		-		
WSPD109	WSPD109-1							-		-		
WSPD1010	WSPD1010-1			1034.20	1040.80	2.50	0.35	0.50	1.25	2.30		
WSPD1011	WSPD1011-1							-		-		
WSPD1012	WSPD1012-1							-		-		
WSPD1013	WSPD1013-1			980.18	985.08			-		1.60		
WSPD1014	WSPD1014-1			980.18	984.18			-		1.00		
WSPD1015	WSPD1015-1							-		-		
WSPD1016	WSPD1016-1							-		-		
WSPD1017	WSPD1017-1							-		-		
WSPD1018	WSPD1018-1							-		-	42" RCP (MH plan)	
WSPD1019	WSPD1019-1	21WSP		924.80	928.98	0.75	1.34	5.93	1.00	15.20	Assume 36" pipe	
WSPD1020	WSPD1020-1							-		-		
WSPD1021	WSPD1021-1			960.18	967.48			-		2.20		
WSPD1022	WSPD1022-1							-		-		
WSPD1024	WSPD1024-1			1000.18	1002.18			-		0.20	18" CMP	
WSPD1025	WSPD1025-1							-		-		
WSPD1027	WSPD1027-1	20WSP		993.18	997.18			-		6.20		
WSP_MR1	WSP_MR1-1							-		-		
WSP_MR2	WSP_MR2-1	Dodge Center Pond	19-86P	1026.38	1028.78			-		12.20		Deep Marsh
WSP_MR3	WSP_MR3-1	15WSP, 14WSP		1018.48	1018.98	1.00	1.31	4.29	1.31	1.40		
WSP_MR4	WSP_MR4-1			1017.88	1018.68	0.50	0.19	1.81	0.10	0.80		
WSP_MR5	WSP_MR5-1	13WSP						-		-		

WSP_MR6	WSP_MR6-1							-		-		
WSP_MR7	WSP_MR7-1							-		-		
WSP_MR8	WSP_MR8-1	Dodge Center Pond	19-89P	1005.48	1008.08	2.00	2.54	6.00	5.08	11.10	12" RCP	Deep Marsh
WSP_MR9	WSP_MR9-1	11WSP		1016.18	1017.58	0.50	1.76	2.24	0.88	2.80		
WSP_MR10	WSP_MR10-1	12WSP		1034.08	1035.08	0.00	0.00	1.20	0.00	0.60		
WSP_MR11	WSP_MR11-1			1022.18	1026.38	0.50	0.14	2.10	0.07	4.70		
WSP_MR12	WSP_MR12-1			-	-			-		-		
WSP_MR13	WSP_MR13-1			-	-			-		-		
WSP_MR14	WSP_MR14-1			-	-			-		-	24" RCP	
WSP_PK1	WSP_PK1-1			-	-			-		-		
WSP_PK2	WSP_PK2-1			-	-			-		-		

Lilydale

Subwatershed ID	Pond ID	Pond Name	DNR ID	Normal Pond Elevation	100-yr Pond Elevation	Average Pond Depth (ft)	Normal Pond Surface Area (acres)	100-yr Pond Surface Area (acres)	Pond Dead Storage (ac-ft)	100-yr Detention Storage (ac-ft)	Outlet Type	Comment
L-1	L-1-1											Out of Study Area
L-2	L-2-1							-			12" RCP	
L-3A	L-3A-1	Lexington Riverside Decorative Pond		799.80	803.00	2.00	0.17	0.49	0.34	1.06	6" Steel Pipe with stop logs (see diagram)	Decorative Pond - model this pond
L-3B	L-3B-1											
Scenario 17	L-3B-1			0.00	3.00	4.00	0.30	0.38	1.20	1.00	12"	
L-4	L-4-1	Lilywood Estates		800.00	-			-		-	12" RCP	Max depth is 1.5 ft (dry)
L-5	L-5-1	Riverwood Ponds						-			3-12" RCP, 1-24" RCP from driveway catch basins	3 dry ponds not modeled
Scenario 16	L-5-1			0.00	3.00	4.00	0.30	0.38	1.20	1.00	12"	
L-6	L-6-1							-			36" PEP	
L-7U	L-7U-1	Stonebridge upper pond		787.00	789.00	4.00	0.60	0.78	2.40	1.38	10' weir with 6' notch	This pond will be modeled only in the future conditions case
L-7L	L-7L-1	Stonebridge lower pond		783.00	785.00	4.00	1.50	2.35	6.00	3.85	24" RCP with 2' notched weir	This pond will be modeled only in the future conditions case
L-7B	L-7B-1											Bluffs - Dakota County Trail drainage system
L-8	L-8-1	I-35E		777.00	778.20			-		-	Open Channel	Approximate data from Mn/DOT plan sheets; 2 proposed ponds ignored for now
Scenario 14	L-8-1	I-35E		0.00	3.00	4.00	0.30	0.38	1.20	1.00	12"	
L-9	L-9-1	Lilydale Gardens		791.00	794.00			0.08		0.11	8" PVC	dry pond
L-10U	L-10U-1	Pickerel Lake	19-5P					-				Pickerel Lake. No information obtained. Show this as pipe in model
L-10L	L-10L-1	Mississippi River Floodplain	19-5P					-				Mississippi River Floodplain. No information obtained. Show this as pipe in model
MB-10	MB-10-1	Mayfield Heights Pond	-	847.93	856.80	0.00	0.00	1.50	0.00	5.50	6" CMP & 15" RCP Two Stage Outlet	
Scenario 11	MB-10-1	Mayfield Heights Pond	-	847.93	856.80	4.00	0.30	1.50	1.20	5.50	6" CMP & 15" RCP Two Stage Outlet	

Inver Grove Heights

Subwatershed ID	Pond ID	Pond Name	DNR ID	Normal Pond Elevation	100-yr Pond Elevation	Average Pond Depth (ft)	Normal Pond Surface Area (acres)	100-yr Pond Surface Area (acres)	Pond Dead Storage (ac-ft)	100-yr Detention Storage (ac-ft)	Outlet Type	Comment
QP-1	QP-1-1		19-248W	881.00	884.40	2.00	2.98	5.26	5.96	14.00	24" RCP	Class IV Deep Marsh
QP-2A	QP-2A-1		19-249W	881.50	884.40	2.00	3.96	5.01	7.92	13.00	36" RCP	Shallow Marsh
QP-2B	QP-2B-1											
QP-5	QP-5-1		-	924.00	929.00	1.00		-		10.00	No Outlet	Class III Shallow Marsh

St. Paul

Subwatershed ID	Pond ID	Pond Name	DNR ID	Normal Pond Elevation	100-yr Pond Elevation	Average Pond Depth (ft)	Normal Pond Surface Area (acres)	100-yr Pond Surface Area (acres)	Pond Dead Storage (ac-ft)	100-yr Detention Storage (ac-ft)	Outlet Type	Comment
MB-SP1	MB-SP1-1							-				No Pond
Scenario 12	MB-SP1-1			0.00	3.00	4.00	0.30	0.38	1.20	1.01	12"	

Sunfish Lake

Subwatershed ID	Pond ID	Pond Name	DNR ID	Normal Pond Elevation	100-yr Pond Elevation	Average Pond Depth (ft)	Normal Pond Surface Area (acres)	100-yr Pond Surface Area (acres)	Pond Dead Storage (ac-ft)	100-yr Detention Storage (ac-ft)	Outlet Type	Comment
MHa-1	MHa-1-1			921.60	930.70	0.00	0.00	1.11	0.00	3.58	12" CMP	
MHa-2	MHa-2-1			934.10	936.60	0.00	0.00	0.06	0.00	0.10	10" CMP	
MHa-3	MHa-3-1			936.00	937.70	0.00	0.00	0.01	0.00	0.05	10" CMP	Overflows driveway during 10 year event
MHa-4	MHa-4-1			984.30	987.00	0.00	0.00	0.43	0.00	0.50	Natural Overflow	
MHa-5	MHa-5-1			985.50	986.30	0.00	0.00	0.06	0.00	0.10	Natural Overflow	Overflows driveway during 10 year event
MHa-6	MHa-6-1			963.20	965.40	0.00	0.00	0.30	0.00	0.40	18" CMP	Overflows Charlton Road during 100 year event
MHa-7	MHa-7-1			967.80	969.50	0.50	0.83	1.60	0.42	2.07	12" CMP	Assumes regrading of Mulrooney property
MHa-8	MHa-8-1			980.80	982.10		0.00	0.04		0.10	15" CMP	Overflows driveway during 100 year event
MHa-9	MHa-9-1			991.00	993.50		0.00	0.16		0.20	Natural Overflow	
MHa-10	MHa-10-1			992.20	994.20		0.00	0.30		0.20	Natural Overflow	
MHa-11	MHa-11-1			971.00	973.30		0.00	0.68		0.20	12" CMP	Assumes regrading of Mulrooney property
MHa-12	MHa-12-1			983.50	985.10		0.00	0.15		0.10	10" CMP	Overflows driveway during 100 year event
MHa-13	MHa-13-1			969.50	971.10			-		0.10	18" CMP	Missing data sheet
MHa-14	MHa-14-1		19-101W	982.60	983.30		3.00	3.57		2.30	Natural Overflow	
MHa-15	MHa-15-1			993.00	995.60		0.00	0.01		0.10	12" CMP	Overflows driveway during 10 year event
MHa-16	MHa-16-1			980.00	982.10		0.00	0.01		0.10	15" CMP	
MHa-17	MHa-17-1			980.40	982.10		0.00	0.11		0.10	10" CMP	
MHb-1	MHb-1-1			911.00	917.60		0.00	0.16		0.37	24" CMP	Overflows Delaware Avenue during 100-yr event with existing outlet. Proposed Outlet: 36" CMP
MHb-2	MHb-2-1			920.20	923.90		0.00	0.10		0.19	12" CMP	Overflows Charlton Road during 10-yr event with existing outlet. Proposed Outlet: 2-18" CMP
MHb-3	MHb-3-1			926.20	927.40		0.23	0.40		0.43	Natural Overflow	
MHc-1	MHc-1-1			854.40	862.70	1.50	0.90	2.35	1.35	13.50	15" CMP	
MHc-2	MHc-2-1			910.20	912.50		0.00	0.08		0.10	18" CMP	Overflows Salem Church Road during 100-yr event
MHc-3	MHc-3-1			929.80	934.30		0.00	0.95		2.60	Natural Overflow	
MHc-4	MHc-4-1			933.20	934.60		0.00	0.12		0.10	22" Arch	
MHc-5	MHc-5-1			870.30	872.80	1.00	0.64	1.20	0.64	2.30	12" RCP	
MHc-6	MHc-6-1			869.50	873.40		0.41	0.82		2.40	Natural Overflow	
MHc-7	MHc-7-1			880.60	882.40		0.00	0.07		0.10	Natural Overflow	
MHc-8	MHc-8-1		19-236W	873.50	879.30		1.92	5.15		20.50	Natural Overflow	
MHc-9	MHc-9-1			872.10	879.30		0.00	1.35		4.20	Natural Overflow	
MHc-10	MHc-10-1			877.80	882.80		0.36	2.56		7.30	Natural Overflow	
MHc-11	MHc-11-1			935.00	937.00		0.00	0.76		0.90	Natural Overflow	
MHc-12	MHc-12-1			942.70	944.60		0.00	0.12		0.10	2-18" CMP	Overflows Salem Church Road during 10-yr event with existing outlet. Proposed Outlet: 3-18" CMP
MHc-13	MHc-13-1			949.00	953.20		0.00	0.34		1.00	Natural Overflow	
MHc-14	MHc-14-1			951.00	955.80		0.00	0.18		0.50	12" CMP	Overflows road during 100-yr event
MHc-15	MHc-15-1			967.60	968.90		0.00	0.13		1.00	12" CMP	Overflows road during 10-yr event
MHc-17	MHc-17-1			874.70	880.40		0.00	3.65		15.00	Natural Overflow	
MHc-18	MHc-18-1	Pagoda Pond		895.60	899.40		0.83	1.17		3.80	Natural Overflow	
HB-1	HB-1-1	Hornbean Lake	19-47P	870.60	872.80	9.00	21.50	22.95	193.50	49.10	15" RCP	
HB-2	HB-2-1			877.10	880.80	3.00	2.50	4.53	7.50	13.00	24" CMP	Inflow enters from Inver Grove Heights
Scenario 20	HB-2-1	MN DOT I-494 pond		877.10	880.80	4.00	2.50	4.53	10.00	13.00	24" CMP	
HB-3	HB-3-1			879.80	882.00		0.00	0.17		0.27	18" RCP	
HB-4	HB-4-1			872.00	875.60		0.62	1.03		2.96	Natural Overflow	
HB-5	HB-5-1			876.00	883.60		0.00	0.81		2.97	Natural Overflow	
HB-6	HB-6-1	Wood Duck Pond	19-238W	889.70	892.30		2.38	2.75		6.71	Natural Overflow	
HB-7	HB-7-1			882.20	887.50		0.00	1.09		3.16	Natural Overflow	
HB-8	HB-8-1			889.30	891.30		0.00	1.02		1.61	Natural Overflow	
HB-9	HB-9-1			934.00	935.50		0.00	0.06		0.06	18" CMP	
HB-10	HB-10-1			-	-			-			Natural Overflow	I-494. HB-10a,b,c,d are small sed. basins
HB-11	HB-11-1			939.00	948.20		0.00	1.07		3.38	12" RCP	
HB-12	HB-12-1			953.20	957.10		0.00	1.06		2.12	24" CMP	Overflows road during 100-yr event
HB-13	HB-13-1			1007.40	1009.60		0.00	0.10		0.11	24" CMP	
HB-14	HB-14-1			967.80	970.60		0.00	0.24		0.33	15" CMP	This pond overflows and acts as one with the next downstream pond: HB-15
HB-15	HB-15-1			964.20	970.60		0.00	0.67		2.13	12" CMP	

HB-16	HB-16-1			978.80	982.60		0.00	1.09		3.14	Natural Overflow	
WSP-1	WSP-1-1			928.00	931.40	0.75	0.08	0.52	0.06	1.18	36" RCP	
WSP-2	WSP-2-1			975.80	977.20		0.00	0.14		0.14	18" CMP	
WSP-3	WSP-3-1			974.40	975.20		0.00	0.05		0.02	15" RCP	
WSP-4	WSP-4-1			974.00	976.60		0.00	0.05		0.06	36" RCP	
WSP-5	WSP-5-1			975.80	976.60		0.00	2.25		1.78	5-10" Steel Pipes	5-10" Steel Pipes placed by property owner
WSP-6	WSP-6-1			998.70	1001.60		0.00	0.12		0.18	24" CMP	Overflows Sunfish Lane during 100-yr event. Inflow enters from West St. Paul.
WSP-7	WSP-7-1			932.00	933.40		0.00	0.80		0.56	18" CMP	
WSP-8	WSP-8-1			1006.80	1008.00			-		0.00	18" CMP	
PR-1	PR-1-1			876.20	882.80		0.00	3.05		12.05	Natural Overflow	Permanently Landlocked
PR-2	PR-2-1			886.20	892.10		0.00	1.24		4.75	Natural Overflow	
PR-3	PR-3-1			908.00	910.00		0.00	0.02		0.02	18" CMP	
SFL-1	SFL-1-1	Sunfish Lake	19-50P	937.00	939.90	9.10	44.00	53.59	401.00	141.34	12" HDPE	No longer landlocked after construction of outlet
SFL-2	SFL-2-1			950.20	952.50		0.00	0.47		0.61	Natural Overflow	
SFL-3	SFL-3-1	-	19-237W	936.60	939.90	3.00	3.51	4.38	10.53	13.10	12" CMP	This pond overflows and acts as one with the next downstream pond: SFL-1
SFL-4	SFL-4-1			937.40	939.90	0.50	0.51	0.84	0.26	1.71	12" CMP	Overflows driveway during 10-yr event; This pond overflows and acts as one with the next downstream pond: SFL-3
SFL-5	SFL-5-1			947.20	949.70		0.00	0.48		0.87	Natural Overflow	
SFL-8	SFL-8-1			950.10	953.40		0.00	1.07		1.78	Natural Overflow	
SFL-10	SFL-10-1			952.50	956.00		0.00	0.63		1.05	Natural Overflow	
SFL-11	SFL-11-1			960.60	962.20	0.75	0.64	1.16	0.48	1.44	Natural Overflow	
Scenario 18	SFL-11-1			960.60	962.20	4.00	0.64	1.16	2.56	1.44	12"	
SFL-12	SFL-12-1			967.10	970.20	0.00	0.00	0.20	0.00	0.31	12" CMP	Overflows driveway during 100-yr event
SFL-13	SFL-13-1			980.50	981.50	0.00	0.00	0.27	0.00	0.10	2 catch basins	assumed 12" outlet in BWM

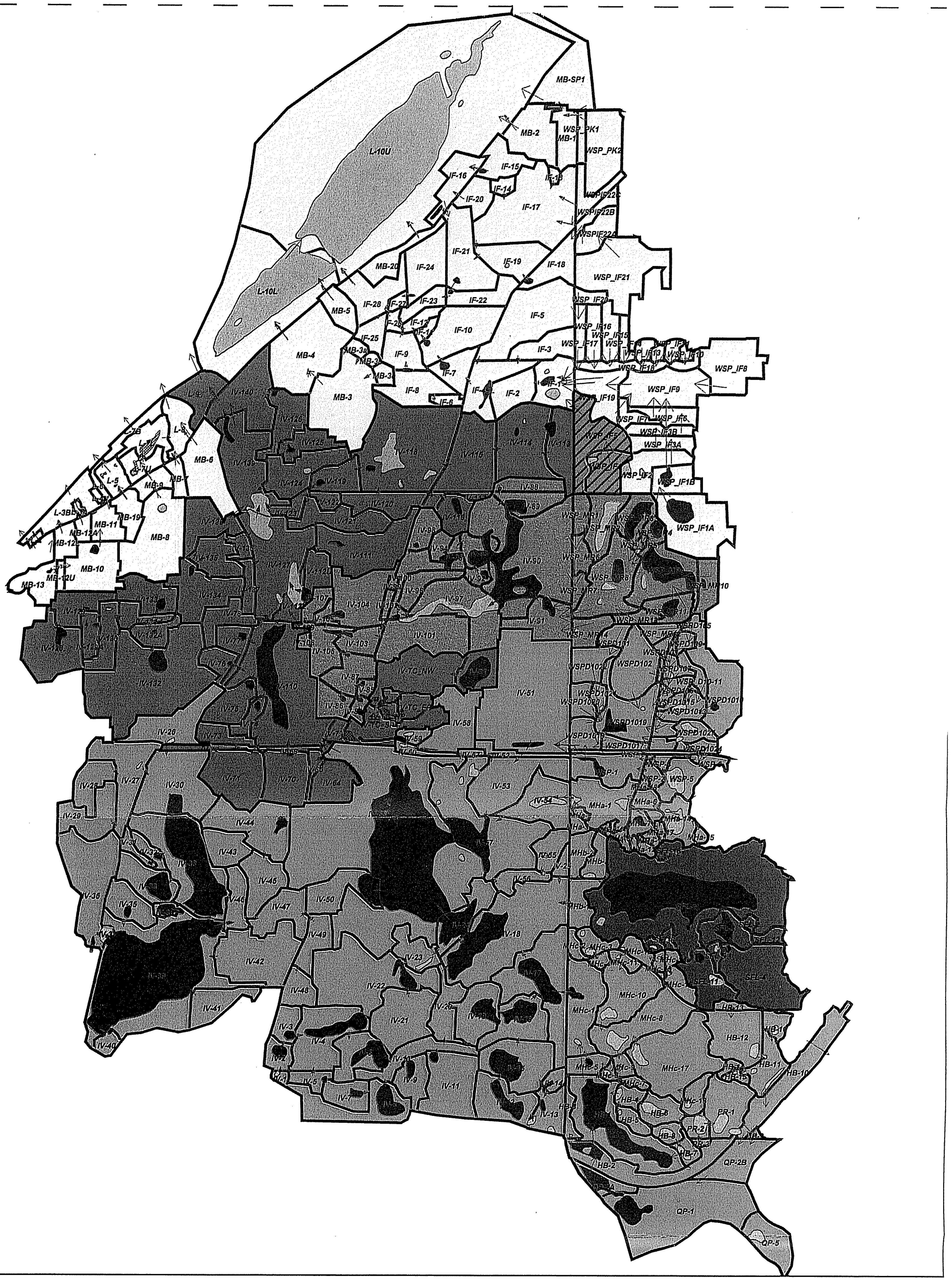

Figure A-1

P8 MODEL GROUPINGS
AND MODELED PONDS

Lower Mississippi River WMO

Interstate Valley Creek, Ivy Falls Creek,
East Highway 13, Central Highway 13,
and West Highway 13

Barr: Arcview 3.1,OPT201, i:\client\lowermiss\district\project\2319803\p8_modeling_preproc.apr, Layout: Figure A-1 P8 Model Groupings and Modeled Ponds, bdr, Thu Feb 13 15:42:31 2003