Phalen Chain of Lakes
Study of Untreated Tributary Drainage and Other Improvement Areas

Prepared for
Ramsey-Washington Metro Watershed District

October 2005

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BARR

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Executive Summary

The draft *Strategic Lake Management Plan for the Phalen Chain of Lakes* (Barr, October 2004) (SLMP) identified areas of water quality concern for further study, including a more detailed evaluation of the drainage patterns of stormwater in the untreated drainage areas surrounding each lake. The stormwater running off of these drainage areas flows directly to one of the lakes in the Phalen Chain, without flowing through ponds, wetlands, or treatment devices, and is considered "untreated" in terms of total phosphorus (TP), removed.

Three different categories of recommended treatment measures are identified in order of cost effectiveness:

1. Eight capital improvement projects that treat most of the runoff leaving the sub-drainage area.
2. Four hot spot areas that would be targeted for further treatment in the future as opportunities arise,
3. Eleven residential measure areas that would target runoff at its source across the sub-drainage area.

The total estimated first cost of the eight capital improvement projects, if all were implemented, is about $1.2 million and would annually remove approximately 182 pounds of phosphorus prior to entering the Phalen Chain of Lakes.

The annual total amount of phosphorus entering the lakes from the four identified hot spot areas and an area identified for a cooperative agreement is 1,058 pounds. Funding for any treatment in these areas would be at least partially subject to payment by others and the cost would be subject to the type and level of treatment selected.

The suggested investment in the residential measures is $121,500, with an additional 26 pounds of phosphorus trapped annually before entering the lakes. Some of the residential measures could be considered hot spot areas to be pursued when redevelopment occurs or when a cooperative arrangement for cost sharing can be arranged.

The recommended treatment measures can be considered preliminary recommendations that represent the best options in terms of managing untreated drainage areas. Any treatment recommendations will not be considered final until the entire suite of 2005 Phalen Chain of Lakes feasibility studies are

completed later this year. At that time, the preliminary recommendations from all of the feasibility studies will be compiled and evaluated in reference to the new lake goals that will be established based on the lake user survey results currently being compiled. In this manner, big picture, meaningful lake management decisions can be made for the Phalen Chain of Lakes based on all of the detailed studies that have been conducted this year.

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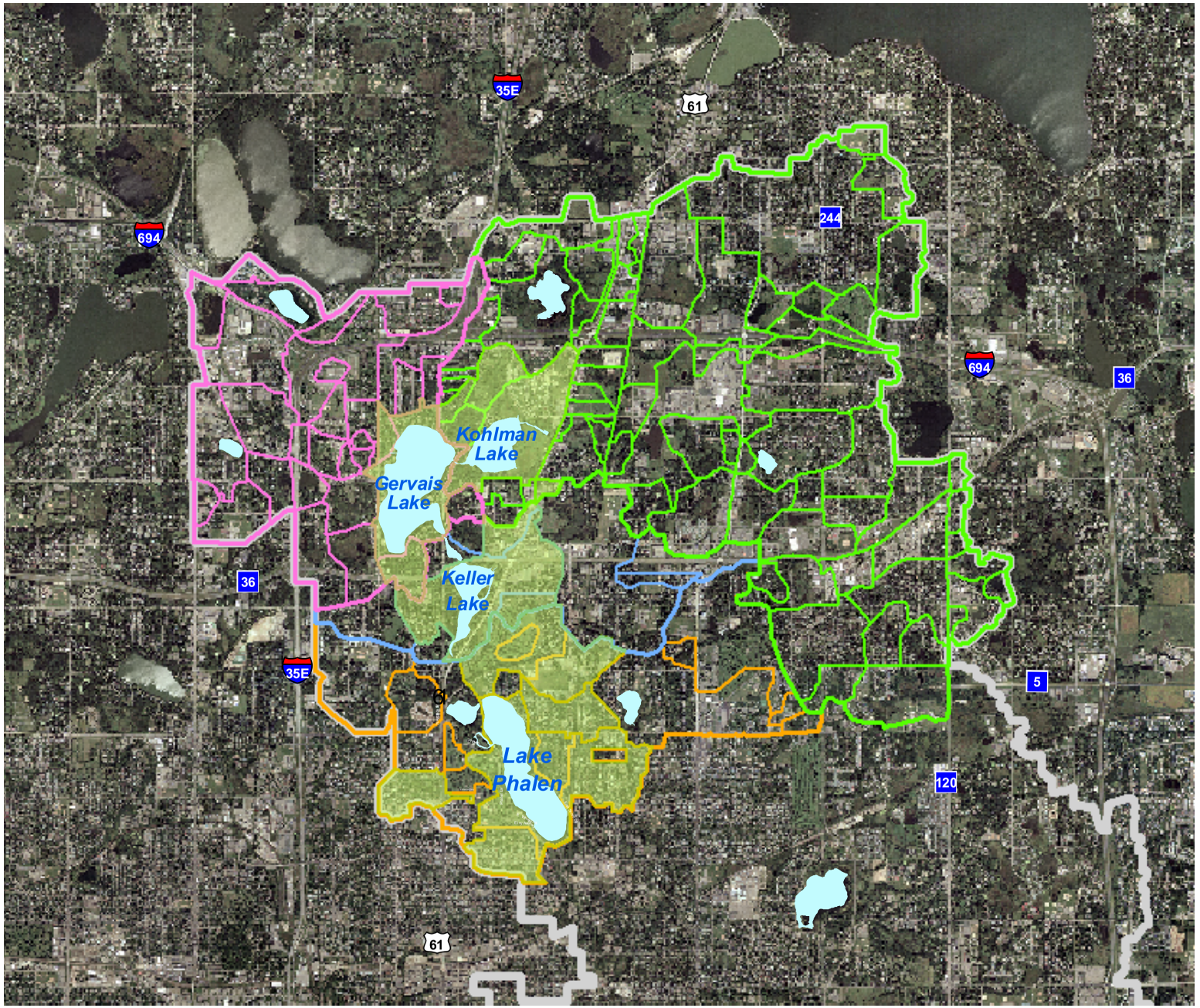
1.0 Introduction

Some of the stormwater reaching the Phalen Chain of Lakes comes from drainage areas that provide no treatment in terms of ponds, wetlands, or other stormwater treatment devices. The stormwater running off of these drainage areas flows directly to one of the lakes in the Phalen Chain and is considered "untreated". The draft *Strategic Lake Management Plan for the Phalen Chain of Lakes* (Barr, October 2004) (SLMP) identified areas of concern for further study, including a more detailed evaluation of the drainage patterns of stormwater in the untreated drainage areas surrounding each lake. Three other currently treated sites were also evaluated in the Keller Lake and Lake Phalen sub-watersheds. KELL-03, PHAL-08 and PHAL-16 were studied to determine whether additional treatment could be achieved. Figure 1 shows the watersheds tributary to the Phalen Chain of Lakes (Kohlman, Gervais, Keller, and Phalen). The areas of primary concern for this report, the untreated drainage areas and the other three treated areas, are highlighted in this figure.

For this study, the 17 drainage areas of concern were further subdivided into 61 new sub-drainage areas, as shown in Figures 2 through 5 (hereafter referred to as sub-drainage areas). These new sub-drainage area boundaries are primarily determined by the location of the stormwater outlets into the lake. The areas were studied to determine exactly where localized treatment systems, such as self-contained treatment manholes or catch basins, sand filters, buffer strips, rainwater or first flush gardens, pervious pavements, ponds, alternative Best Management Practices (BMPs), and/or infiltration systems could be used to provide treatment. Combinations of treatment techniques in series were also explored.

The results of this study will spin off into two other areas that will seek to encourage the use of prescriptive practices and innovative treatment techniques in the untreated drainage areas described here. First, a "hot spot" handout (recommendation ST-14 in the SLMP) will be created and distributed to cities in the untreated drainage areas. This handout will encourage the construction of stormwater treatment technologies as new sites are being constructed, as roads are redone, etc. These projects would come out of cost-sharing and cooperative planning between the District and developers. Second, maps showing the businesses and organizations that reside within the untreated drainage areas will be created. This information will be later used in looking for cooperative arrangements to provide treatment and/or to increase the use of prescriptive practices in these areas (ST-16 in the SLMP).



LEGEND

- Drainage Areas Evaluated
- Gervais Subwatershed
- Kohlman Subwatershed
- Keller Subwatershed
- Phalen Subwatershed
- RWMWD Hydrologic Boundary

N
W E
S

4,000 2,000 0 4,000
Feet

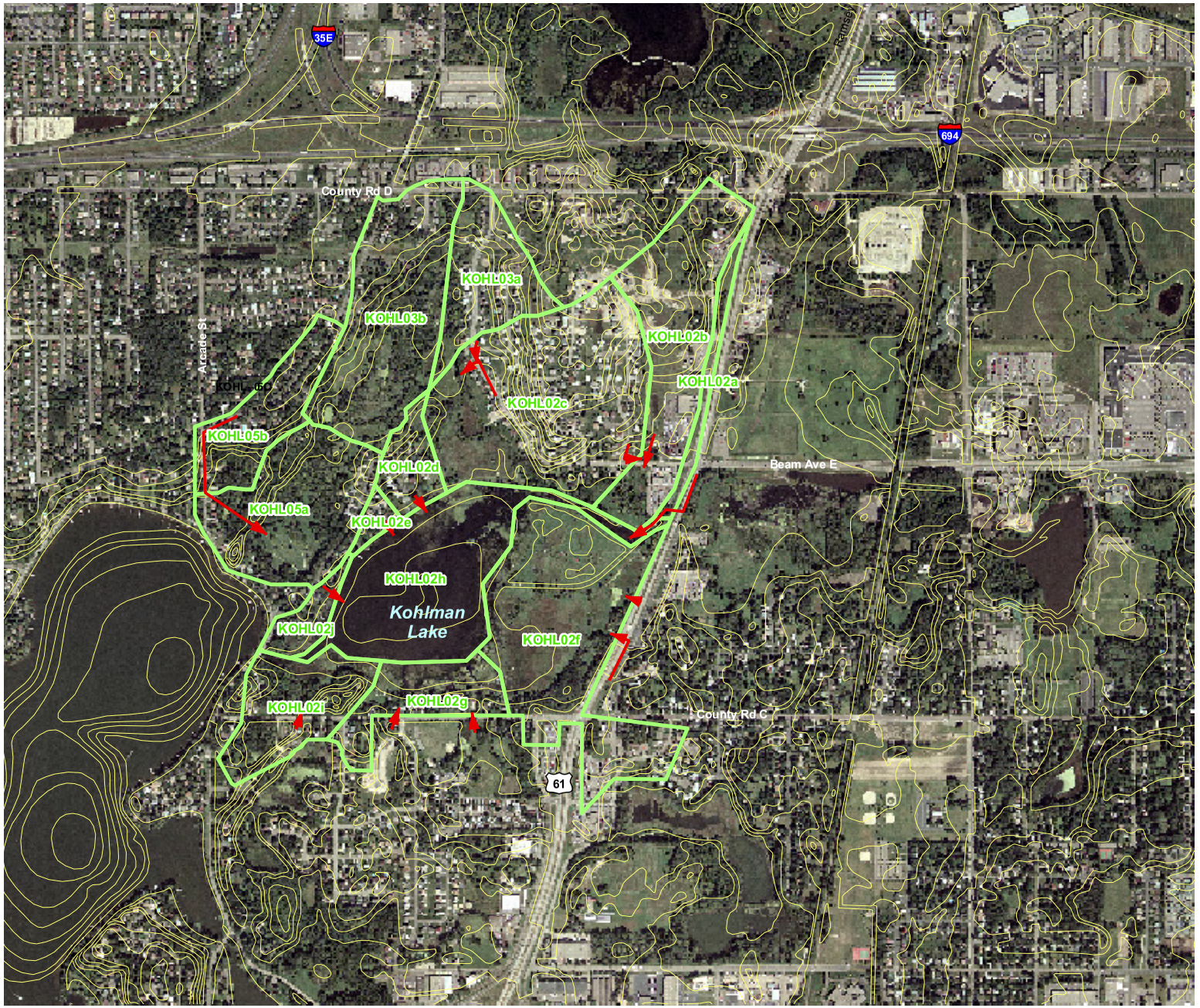
Ramsey-Washington Metro Watershed District

BARR

Figure 1

SITE LOCATION MAP
SUBWATERSHEDS AND
DRAINAGE AREAS
EVALUATED FOR FURTHER TREATMENT

Phalen Chain of Lakes
Ramsey-Washington Metro Watershed District



LEGEND

Kohlman Sub-Drainage Areas

Key Storm Water Outlets

1,000 500 0 1,000 2,000

Feet

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Figure 2

KOHLMAN LAKE SUBWATERSHED
SUB-DRAINAGE AREAS
EVALUATED FOR FURTHER TREATMENT

Phalen Chain of Lakes
Ramsey-Washington Metro Watershed District

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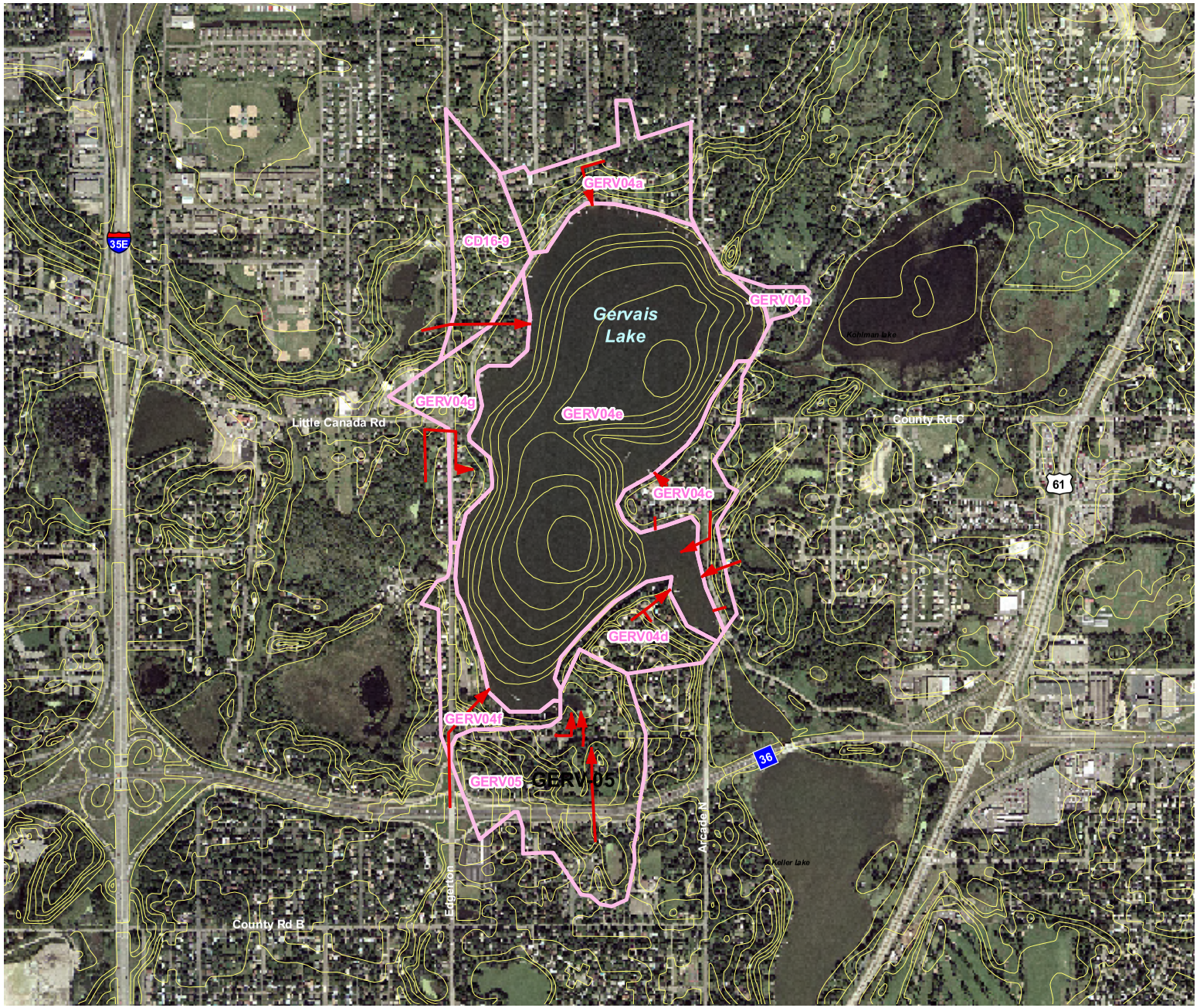

LEGEND

Gervais Sub_Drainage Areas

Key Storm Water Outlets

1,000 500 0 1,000

Feet

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Figure 3

GERVAIS LAKE SUBWATERSHED
SUB-DRAINAGE AREAS
EVALUATED FOR FURTHER TREATMENT

Phalen Chain of Lakes
Ramsey-Washington Metro Watershed District

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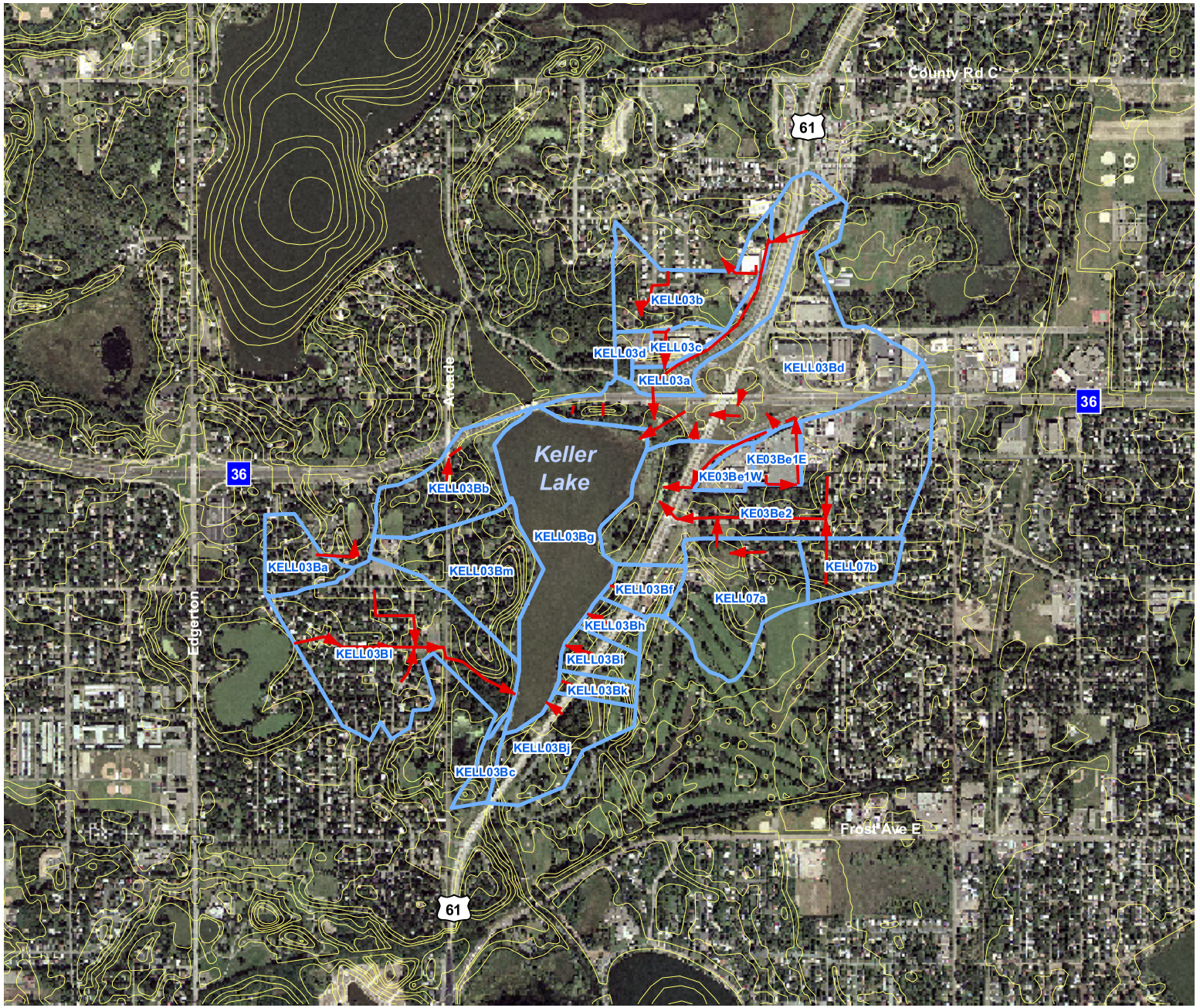

LEGEND

Keller Sub-Drainage Areas

Key Storm Water Outlets

1,000 500 0 1,000

Feet

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Figure 4

KELLER LAKE SUBWATERSHED
SUB-DRAINAGE AREAS
EVALUATED FOR FURTHER TREATMENT

Phalen Chain of Lakes
Ramsey-Washington Metro Watershed District

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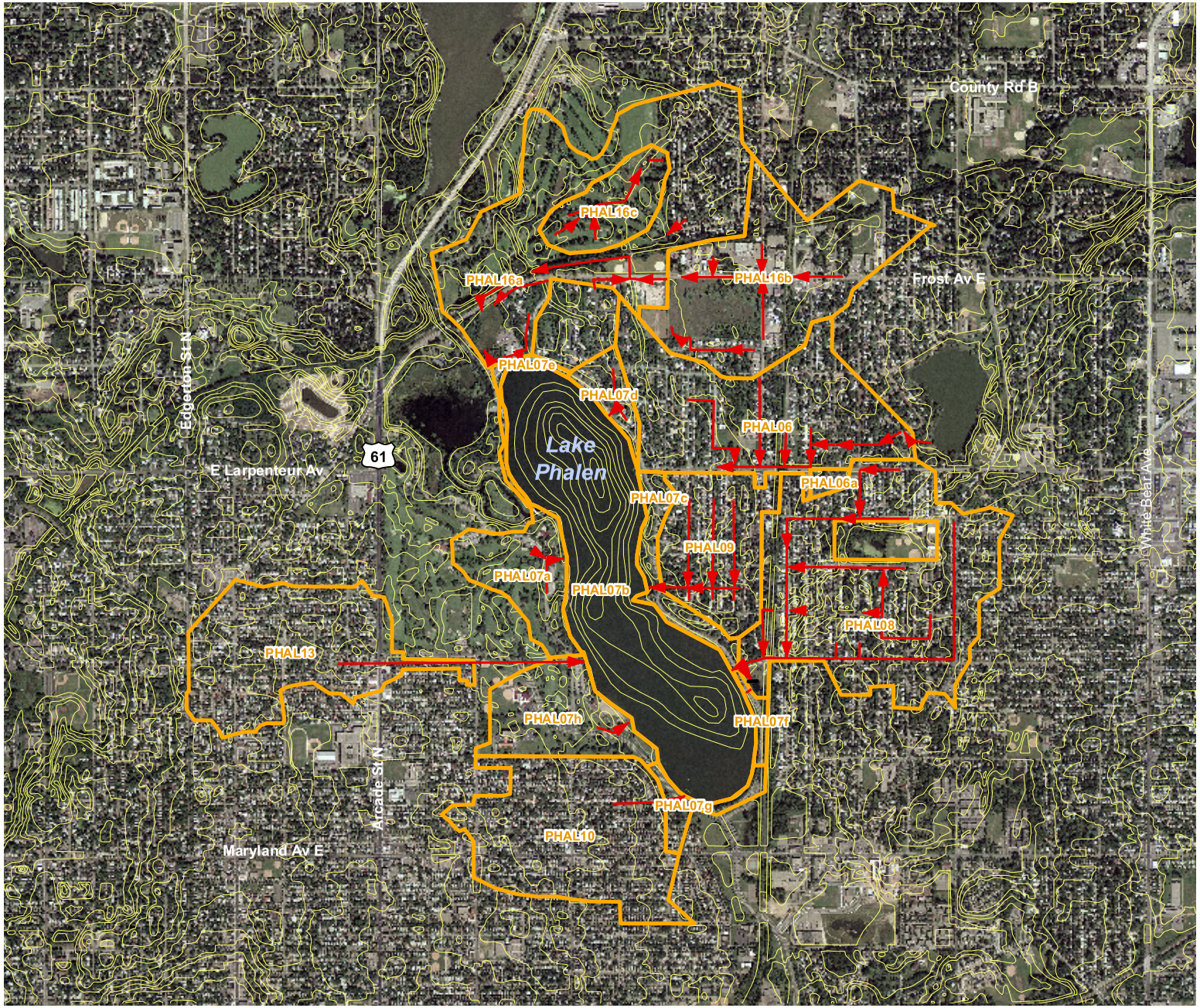

LEGEND

Phalen Sub-Drainage Areas

Key Storm Water Outlets

0.25 0.125 0 0.25

Miles

Ramsey-Washington Metro Watershed District

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Figure 5

LAKE PHALEN SUBWATERSHED
SUB-DRAINAGE AREAS
EVALUATED FOR FURTHER TREATMENT

Phalen Chain of Lakes
Ramsey-Washington Metro Watershed District

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The treatment measures highlighted in Section 4.0 "Conclusions and Recommendations" of this report can be considered preliminary recommendations that represent the best options in terms of managing untreated drainage areas. Any treatment recommendations will not be considered final until the entire suite of 2005 Phalen Chain of Lakes feasibility studies are completed later this year. At that time, the preliminary recommendations from all of the feasibility studies will be compiled and evaluated in reference to the new lake goals that will be established based on the lake user survey results currently being compiled. In this manner, big picture, meaningful lake management decisions can be made for the Phalen Chain of Lakes based on all of the detailed studies that have been conducted this year, which include:

- Phalen Chain of Lakes Untreated Tributary Drainage Area Study
- Phalen Chain of Lakes Carp Population Study
- Phalen Chain of Lakes Wetland Enhancement Study
- Internal Phosphorus Load Study: Kohlman and Keller Lakes
- Ramsey-Washington Metro Watershed District Phosphorus Sources Assessment Study

2.0 Methods

For this study, the untreated areas discussed in the *Phalen Chain of Lakes SLMP* were further subdivided in order to perform a more detailed evaluation of treatment options. Untreated areas are defined as sub-drainage areas that currently provide little or no water quality treatment of their stormwater runoff before the runoff reaches the Phalen Chain of Lakes. Some of the sub-drainage areas in this study, although termed "untreated", actually do provide some removal of total phosphorus (TP). This treatment was only noted when this more detailed study of the area was undertaken.

Maps of the storm sewers and utilities information were obtained from the Cities of St. Paul, Maplewood, and Little Canada. In addition, field visits were conducted in order to determine physical site constraints that would affect the viability of different treatment designs. In some cases, topographic maps were studied to aid in the subdivision of the untreated drainage areas; but in most cases, the new drainage area divides were primarily determined by the location of storm sewer networks. After all of the sub-drainage areas were identified, the number of untreated drainage areas increased from 17 to 61, thus enabling a more fine-tuned look at the drainage patterns in these areas. In some cases, areas that were formerly considered untreated were found to receive some treatment through wetlands or ponds that were not included in the original modeling effort for the SLMP (the size of the pond or wetland was not large enough to be included in the original pond/wetland survey.)

The P8 (Program for Predicting Polluting Particle Passage through Pits, Puddles, and Ponds; IEP, Inc. 1990) Urban Catchment (computer) Model (version 2.4) was used to remodel the stormwater runoff in the new untreated drainage areas, incorporating any wetlands or ponds that had been discovered. Model results indicated how much phosphorus (in terms of TP) was coming from each of the sub-drainage areas during an average climatological year (October 2000 to September 2001 precipitation).

Each sub-drainage area was individually evaluated to determine its TP treatment potential. Key factors considered in this initial screening were: the amount of TP running off of the sub-drainage area (based on P8 modeling results), the opportunity to treat runoff at a collection point, the amount of treatment that runoff has already received prior to the collection point, the space available for a treatment device, the location of the runoff's entrance into the lake relative to the lake's outlet (relevant in the Lake Phalen watershed), and a preliminary estimate of the proposed treatment

measure's cost-effectiveness (based on an annualized capital and maintenance cost per pound of TP removed.)

Following the initial screening of potential treatment measures, those sub-drainage areas that appeared to have greatest opportunity for treatment were further evaluated and prioritized in terms of estimated cost-effectiveness.

The type of treatment measure that was considered for each sub-drainage area depended largely on whether or not runoff could be collected at a single point. Where water could be treated at a collection point, options such as settlement ponds, rainwater gardens, underground infiltration systems, and catch basin filters were considered. In areas where stormwater drains overland directly into the lake, the most cost-effective treatment opportunities are limited to measures such as buffer strips along the lake shore and landowners' commitments to follow appropriate best management practices on his or her lot. Providing information and possibly incentives to those landowners in key drainage areas could be effective in some reduction of nutrient runoff. In fact, public education activities, conducted during the implementation of all of the projects recommended in this report, is considered an essential element of this process.

To be considered for additional treatment potential, untreated sub-drainage areas must contribute greater than 10 lbs. of TP and have less than 50 percent removal of TP under current site conditions[1]. In order for a treatment project to be a recommended action in this report, the project had to deemed relatively feasible, that is, comparable on a $ per lb of TP removal basis when compared to other projects that have been pursued by the District in the past.

[1]50 percent TP removal was chosen as a somewhat arbitrary threshold- it is close to the District's original TP removal goal of 60 percent, but recognizes the fact that projects that would increase the overall TP removal by an additional 10 percent would rarely be cost-effective. Instead, projects that would provide greater levels of additional treatment were pursued in other, less treated sub-drainage areas.

3.0 Initial Screening Results

Figures 6 through 9 show the relative amounts of TP being contributed to each of the lakes from the treated (including the lake immediately upstream) and untreated drainage areas. In the Kohlman and Gervais Lake tributary watersheds, TP from the untreated drainage areas represents only 8 and 5 percent, respectively, of the total TP load from their entire watersheds. In the Keller and Phalen Lake tributary watersheds, TP from the untreated drainage areas represents approximately 23 and 42 percent, respectively, of the total TP load from the their entire watersheds and upstream lakes combined. It should be noted that these percentages, in some cases, differ from those presented in the SLMP for the direct drainage districts (shown on Figures J-2, J-8, J-14 and J-18 of the SLMP). These differences can be attributed to the fact that some of the untreated drainage areas actually do receive some treatment through ponds and wetlands, a fact noticed only when looking at these areas in finer detail under the scope of this study.

Table 1 provides a summary of the initial screening results for each of the 61 sub-drainage areas, including the amount of TP estimated to be generated and trapped by existing features (such as ponds and wetlands), and a list of potential measures that warrant further study. Besides the potential treatment measures shown on the table, there may be opportunity for storm filter treatment with catch basin inserts at a number of stormwater outfall locations. However, the long-term effectiveness, given the need to regularly clean and maintain the inserts, is uncertain and is not being considered among the alternatives for initial screening. The alternatives that appear to be the most cost effective are highlighted in yellow in the table.

A detailed description of the characteristics and treatment potential of each of the sub-drainage areas is provided below. Bold text indicates evaluations that were conducted in greater detail in the next phase of study.

Table 1

Phalen Chain of Lakes - Sub-Drainage Areas Evaluated for Further Treatment

(Initial screening of potential treatment measures)

	Sub-Drainage Area	Area (Acres)	TP w/o Trtmt.(lbs.)	Trapped TP (lbs.)	Remaining TP (lbs.)	Potential Treatment Measure
	Kolhman Lake					
	KOHL-02a	8.0	17.6		17.5	?
	KOHL-02b	55.7	69.3	56.9	12.3	
	KOHL-02c	89.6	87.9	50.1	37.9	Detention Pond?
	KOHL-02d	12.2	9.1		9.1	
	KOHL-02e	3.6	3.6		3.5	
	KOHL-02f	81.8	56.6	42.9	13.7	
	KOHL-02g	22.7	14		14.0	Residential Measures?
	KOHL-02h	64.2	16.2		16.2	No Action - Lake Area
	KOHL-02i	30.1	33.1	11.8	21.3	Detention Pond/Residential Measures?
	KOHL-02j	8.6	10.9		10.8	Residential Measures?
	KOHL-03a	29.0	27.5	20.4	7.2	
	KOHL-03b	60.5	70.5	38	32.6	Detention Pond?
	KOHL-05A	48.9	94.4	55.5	38.6	Detention Pond?
	KOHL-05B	26.1	20.9	16.6	4.2	
	Totals	541.1	531.6	292.2	238.9	
	Gervais Lake					
	GERV-04a	33.4	16.2		16.2	Residential Measures?
	GERV-04b	3.7	2.1		2.1	
	GERV-04c	27.5	18.1		18.1	Residential Measures?
	GERV-04d	20.7	10.9		10.9	Residential Measures?
	GERV-04e	227.4	1.7		1.7	
	GERV-04f	19.8	7.6		7.5	
	GERV-04g	27.0	9.6		9.6	Residential Measures?
	GERV-05	71.3	50.5	17.2	33.2	Improve efficiency of pond?
	CD16-19	29.1	14.6		14.6	Residential Measures?
	Totals	460.0	131.3	17.2	113.9	
	Keller Lake					
*	KELL-03a	19.7	34.8		34.8	Detention Pond? (also treats KELL-03a, 03b, & 06)
*	KELL-03b	24.7	24.6	17.7	6.9	Flows to KELL-03a
*	KELL-03c	5.8	12.5		12.5	Flows to KELL-03a
*	KELL-03d	3.0	6.0		0.0	Drains to land locked pond
	KELL-03Ba	11.1	8.0		0.0	Drains to land locked pond
	KELL-03Bb	23.3	19.6		19.6	Residential Measures?
	KELL-03Bc	4.5	0.4		0.4	
	KELL-03Bd	72.5	125.4		125.4	Detention Pond (also treats KELL-03Be1E)
	KELL-03Be1E	6.4	17.5		17.5	Flows to KELL-03Bd
	KELL-03Be1W	4.4	12.1	3.4	8.7	Detention Pond?
	KELL-03Be2	80.2	100.7	28.7	72.0	Detention Pond (also treats KELL-07a & 07b)
	KELL-03Bf	8.0	1.5		1.5	
	KELL-03Bg	61.5	2.2		2.1	
	KELL-03Bh	5.2	1		1.0	
	KELL-03Bi	7.2	1.3		1.3	
	KELL-03Bj	22.0	4.8	2.4	2.3	
	KELL-03Bk	4.6	0.8		0.8	
	KELL-03Bl	63.8	48.5		48.5	Rain Water Garden?
	KELL-03Bm	30.2	23		23.0	Residential Measures?
	KELL-07a	33.2	12.4	3.5	8.9	Flows to KELL-03Be2
	KELL-07b	12.7	9.9	2.8	7.1	Flows to KELL-03Be2
	Totals	450.8	389.1	40.8	340.1	
	Lake Phalen					
	PHAL-06	133.4	504.3		504.3	Residential Measures?
	PHAL-06a	3.0	12.0		12.0	Rain Water Garden?
	PHAL-07a	41.6	4.6		4.6	
	PHAL-07b	194.9	1.1		1.0	
	PHAL-07c	21.7	19.7		19.7	Buffer Strip?
	PHAL-07d	14.1	19		19.0	Residential Measures?
	PHAL-07e	5.9	5.9		5.9	Residential Measures?
	PHAL-07f	4.8	2.2		2.2	
	PHAL-07g	11.7	8.5		8.5	
	PHAL-07h	51.9	63.8		63.8	Sediment Trap (24") S. of beach
*	PHAL-08	184.9	352.4	80.3	272.1	Expand Detention Pond?
	PHAL-09	64.5	105.3		105.2	Rain Garden?
	PHAL-10	120.5	210.1		210.0	Detention Pond?
	PHAL-13	107.1	181.7		181.6	Divert1st Flush to pond? (72")
*	PHAL-16a	175.4	182.2	75.8	106.4	Detention Pond?
*	PHAL-16b	133.7	274.3	114.1	160.2	Detention Pond?
*	PHAL-16c	34.2	10.0		0.0	Drains to land locked pond
	Totals	1132.8	1440.8	80.3	1160.2	

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Notes:

Yellow highlighted items indicate measures that will be further considered in more detailed evaluation

* Drainage Areas that have some existing treatment that have been added to this study

Figure 6
KOHLMAN LAKE

Subwatershed Sources of TP (lbs) from Treated and Untreated Drainage Areas

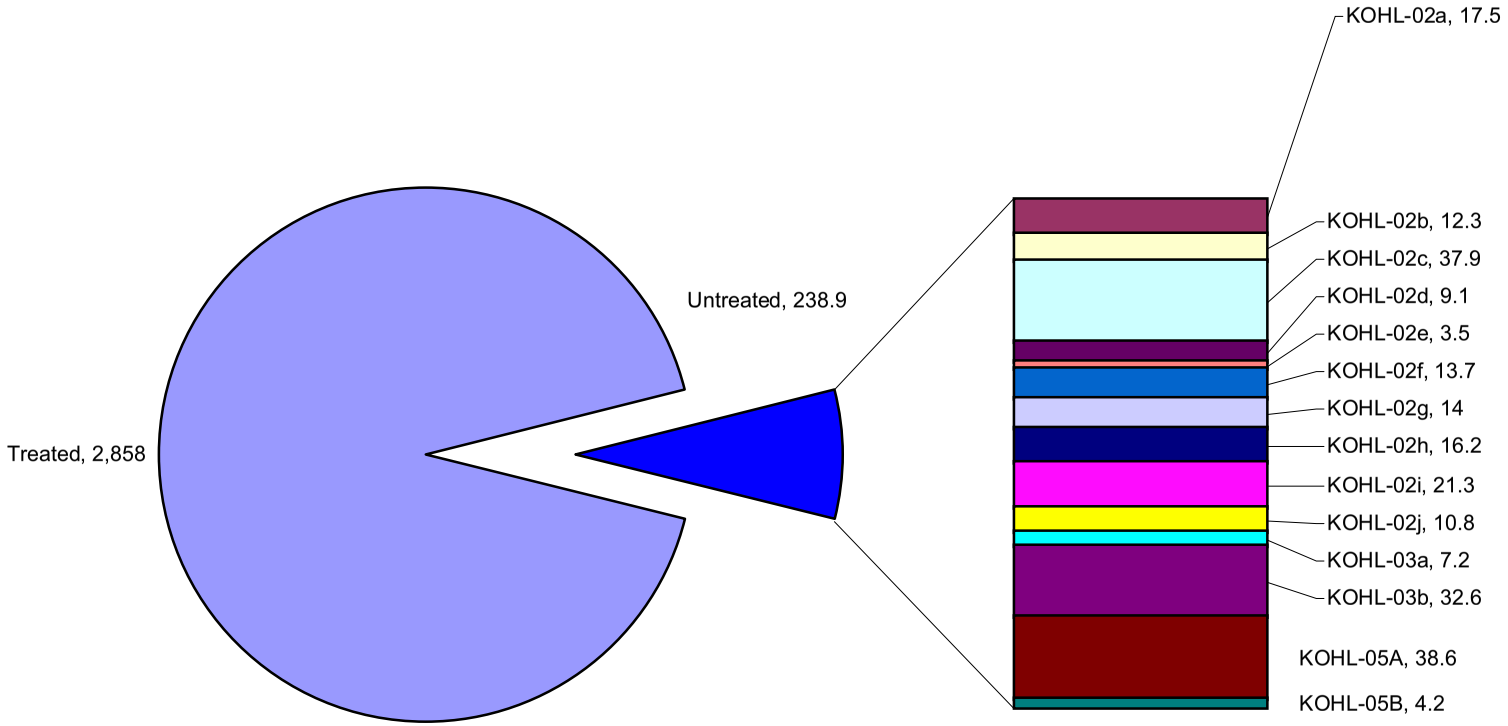

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Figure 7
Gervais Lake
Subwatershed Sources of TP (lbs) from
Treated and Untreated Drainage Areas

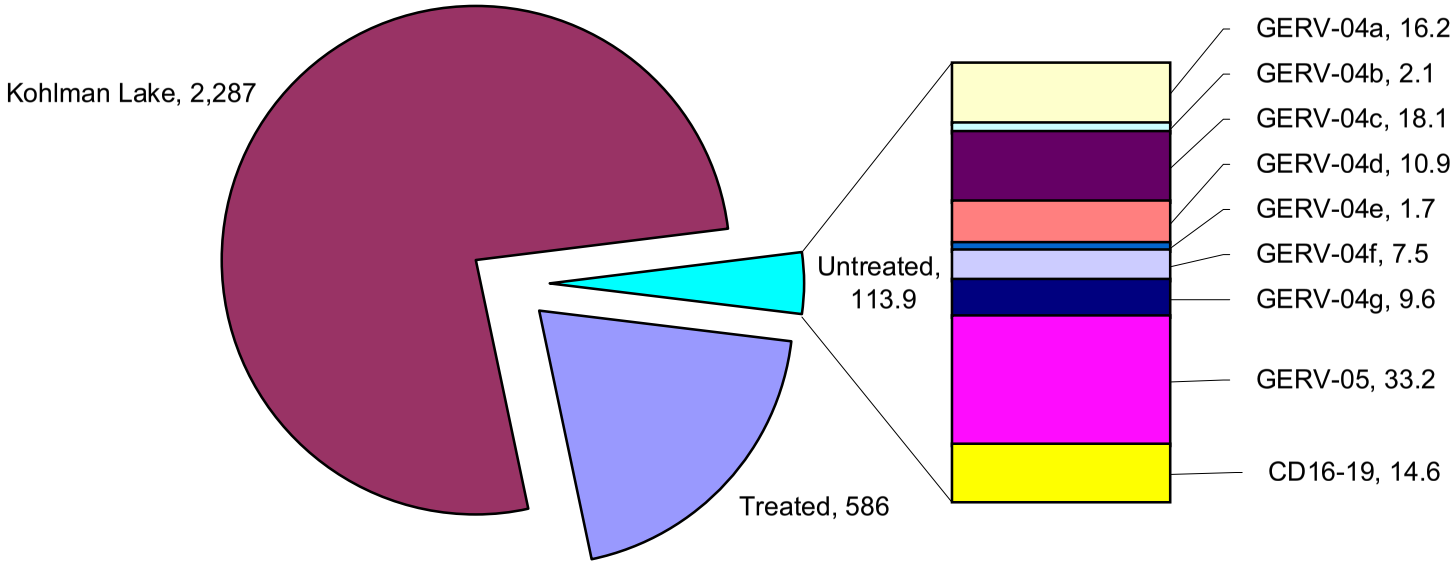


Figure 8
Keller Lake
Subwatershed Sources of TP (lbs) from
Treated and Untreated Drainage Areas

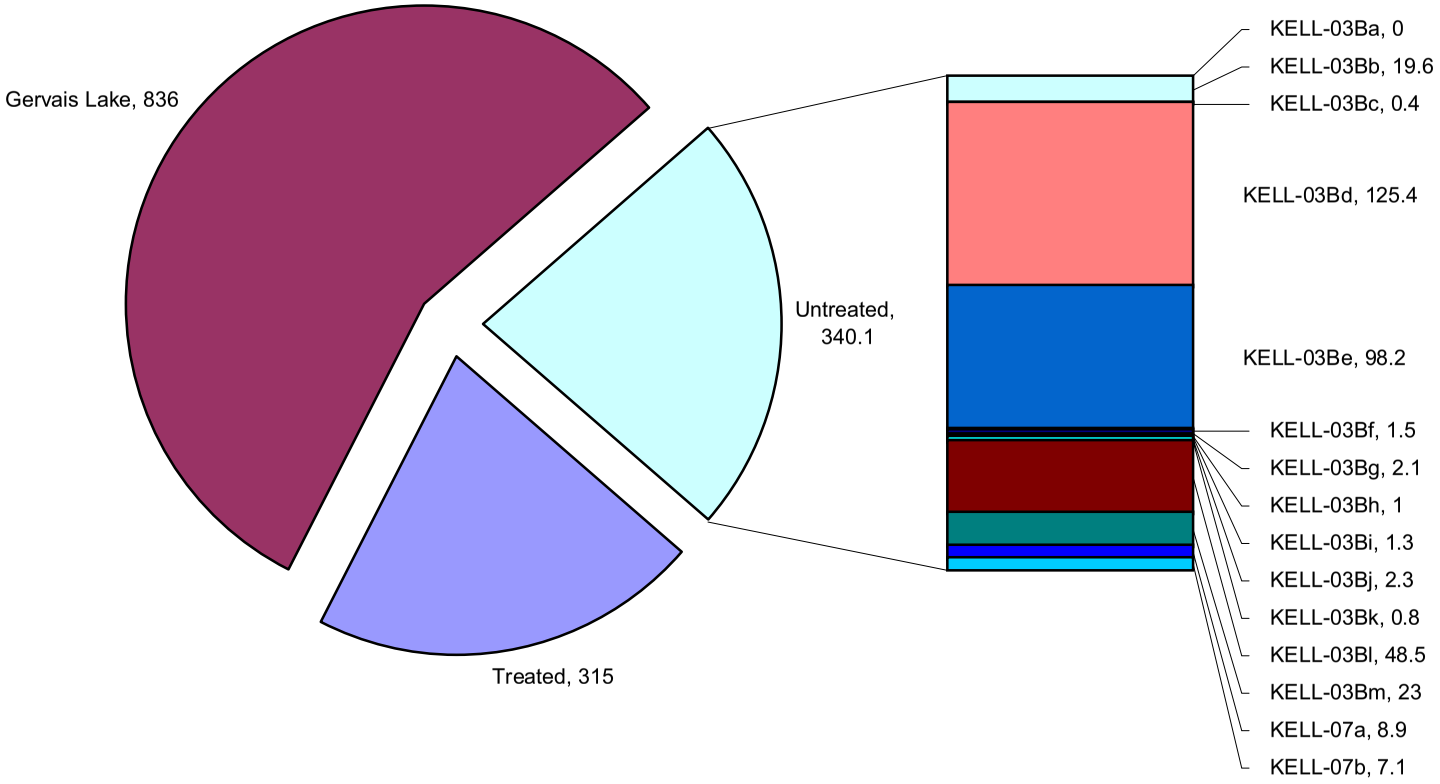
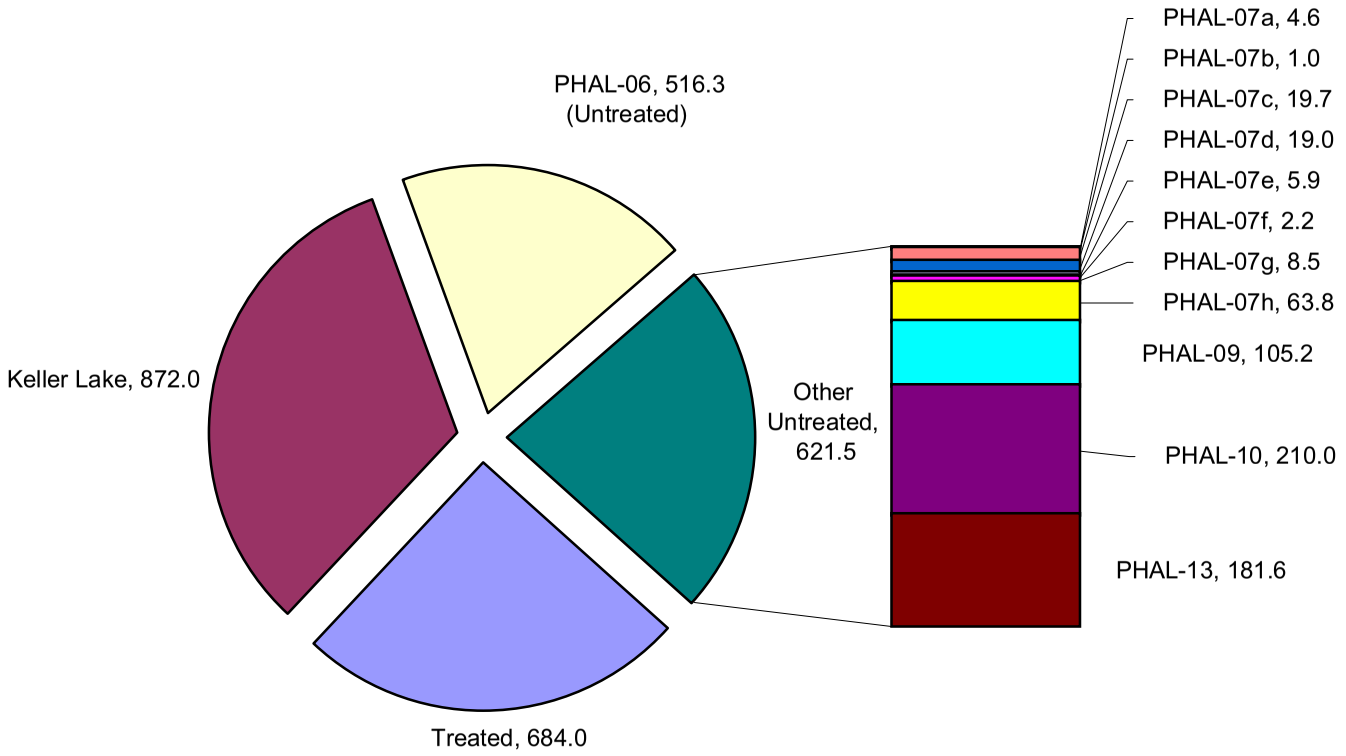


Figure 9
Lake Phalen
Subwatershed Sources of TP (lbs) from
Treated and Untreated Drainage Areas



3.1 Kohlman Lake—Description of Sub-Drainage Areas

Each of Kohlman Lake's 14 sub-drainage areas evaluated for treatment and its treatment potential is described in detail below.

KOHL-02a - This 8-acre sub-drainage area is a narrow strip of land on the west side of Highway 61. The drainage is conveyed to the lake through a ditch that passes through a 24-inch culvert under Beam Avenue and into County Ditch 18. There may be some treatment of this inflow at the overflow structure at the end of County Ditch 18, but any treatment here was considered insignificant for the purposes of this study. No practical treatment measure has been identified to remove the 17.5 lbs of TP estimated for this sub-drainage area. **No treatment action was identified in the initial screening, however, with the study criteria for remaining TP exceeding 10 pounds, this sub-drainage area will be further evaluated.**

KOHL-02b - This elongated 56-acre sub-drainage area, which is being developed for commercial establishments, has a steep slope toward the lake. The runoff from this area flows through a series of detention ponds before entering the lake and further treatment is not considered necessary.

KOHL-02c - A relatively large (90-acre) sub-drainage area, this area has a steep slope toward the lake and is mostly residential. There are a number of detention ponds among the homes and most of the stormwater appears to be collected in a stormwater system that outlets into a wetland on the north side of the lake. The P8 model identified 57 percent of the TP being collected. **There may be opportunity to more effectively treat the remaining 38 pounds of TP to further reduce the amount reaching the lake.**

KOHL-02d - Although this area does not appear to receive any treatment before the 15-inch stormwater outlets to the lake, no cost effective means of treating the estimated 9 pounds of TP that it generates is apparent.

KOHL-02e - Although this area does not appear to receive any treatment before the 12-inch stormwater outlets to the lake, no cost effective means of treating the estimated 4 pounds of TP is apparent.

KOHL-02f - Although this sub-drainage area is relatively large (82 acres), it is entirely wetland and no further treatment is needed.

KOHL-02g - This 23-acre sub-drainage area on the south side of the lake is primarily direct drainage into the lake. There is a 24-inch and 36-inch culvert carrying flow toward the lake under County Road C, however, both are outflows from detention ponds, where some treatment has already occurred (which has not been accounted for in the P8 modeling). No practical

means for treating these outflows is apparent. **However, encouragement and incentives for individual property owners in this area to undertake phosphorus reduction measures appear to be warranted.**

KOHL-02h - This area is primarily the lake itself, with some protruding land masses. No treatment is being considered.

KOHL-02i - A 24-inch stormwater outlet collects the runoff from this drainage area on the south side of County Road C and allows that plus local runoff to pass through a wetland area before entering the lake. With an estimated 35 percent removal of TP, **there may be opportunity to make the wetland more effective. Also, encouragement and incentives for individual property owners in this area to undertake phosphorus reduction measures appear to be warranted.**

KOHL-02j - The stormwater runoff for this area is primarily captured by a catch basin in a 24-inch stormwater outlet, which passes through this area from KOHL-05a. There is not an evident means of cost effectively capturing the 10.8 pounds of TP estimated for this area. **Encouragement and incentives for individual property owners in this area to undertake phosphorus reduction measures appear to be warranted.**

KOHL-03a - The runoff from this sub-drainage area is primarily captured by the same 48-inch outlet that flows into the wetland in KOHL-02c. With only an estimated 7 pounds of TP generated in this area, further measures treatment measures are not recommended.

KOHL-03b - This 61-acre sub-drainage area primarily collects runoff in a wetland area. The P8 modeling showed 54 percent efficiency in removal of phosphorus. **This area has been identified for potential further study to consider development of a pond to remove a portion of the remaining 33 pounds of phosphorus.** However, initial estimates indicate that such measures are not cost effective.

KOHL-05A - This 49-acre sub-drainage area primarily collects runoff in a wetland area. P8 modeling showed 59 percent efficiency in removal of phosphorus. **This area has been identified for potential further study to consider development of a pond to remove a portion of the remaining 38 pounds of TP**. However, initial estimates indicate that such measures are not cost effective.

KOHL-05B - Stormwater is either collected in a 24-inch storm sewer and routed through the wetland in KOHL-05a or flows directly into the wetland area. No further treatment is considered necessary.

3.2 Gervais Lake- Description of Sub-Drainage Areas

Each of Gervais Lake's 9 sub-drainage areas considered for further treatment and its treatment potential is described in detail below.

GERV-04a - The stormwater runoff from this 33-acre sub-drainage area on the north end of Gervais Lake is primarily captured in a 30-inch storm sewer, which is not treated before entry into the lake. Treatment of this flow does not appear to be cost effective. **However, encouragement and incentives for individual property owners in this area to undertake phosphorus reduction measures appear to be warranted.**

GERV-04b - This small sub-drainage area contributes a small amount of phosphorus . No further action is recommended.

GERV-04c - There are several contributing stormwater outfalls in this mostly residential area. No specific treatment measure appears to be cost effective for the 18 pounds of TP estimated for this area. **However, encouragement and incentives for individual property owners in this area to undertake phosphorus reduction measures appear to be warranted.**

GERV-04d - Most of the runoff from this area is collected in a single outfall, but no specific treatment measure appears to be cost effective for the estimated 10.9 pounds of TP. **However, encouragement and incentives for individual property owners in this area to undertake phosphorus reduction measures appear to be warranted.**

GERV-04e - This area is primarily the lake itself, with some protruding land masses. No treatment is being considered.

GERV-04f - The runoff from this area is primarily captured in a catch basin which is part of a storm sewer passing through from the intersection of Highway 36 and Edgerton Street. With only 7.5 pounds of TP untreated, this sub-drainage area will not be studied for further treatment in the next phase of the study.

GERV-04g - This residential area either drains overland directly into the lake or is captured and directed toward a pond on the west side of Edgerton Street. **Encouragement and incentives for individual property owners in this area to undertake phosphorus reduction measures appear to be warranted.**

GERV-05 - Much of the runoff in this area flows through a pond prior to entering the lake. The P8 model estimated a 34 percent efficiency of TP removal.. **This area has been identified for further study, since it appears that it may be cost effective to remove some of the remaining 33 pounds of TP.**

CD16-19 - This residential area is estimated to contribute 15 pounds of TP, but no specific treatment measure is considered to be cost effective. **However, encouragement and incentives for individual property owners in this area to undertake phosphorus reduction measures appear to be warranted.**

3.3 Keller Lake- Description of Sub-Drainage Areas

Each of Keller Lake's 21 sub-drainage areas evaluated for further treatment and its treatment potential is described in detail below.

KELL-03a - The runoff from this 20-acre sub-drainage area's immediate watershed contributes 34.8 pounds of phosphorus to Keller Lake. Flows from KELL-06, which receive significant treatment in Gerten Pond, also travel through this sub-drainage area via 24-inch storm sewer, carrying 212 pounds of phosphorus annually. Flows from KELL-03b (6.9 pounds of phosphorus, which has been partially treated) and KELL-03c (12.5 pounds of phosphorus, which has not been treated) also enter this sub-drainage area. **Further treatment with a detention pond is considered a likely option.**

KELL-03b - This 25-acre sub-drainage area is primarily residential, with runoff partially treated in a pond prior to flowing into KELL-03a. Based on P8 modeling results, the pond removes over 60 percent of the total TP, with 6.9 pounds passing through KELL-03c, and into KELL-03a.

KELL-03c - This 6-acre sub-drainage area is primarily commercial, with almost entirely impervious surfaces. The 12.5 pounds of TP flow into KELL-03a.

KELL-03d : This 3-acre area drains into an existing NURP (Nationwide Urban Runoff Program) detention pond and typically does not contribute to phosphorus loading in Keller Lake.

KELL-03Ba - The runoff from this sub-drainage area is primarily collected in a storm sewer with an 18-inch outlet into a pond, which does not appear to drain toward Keller Lake. With only an identified 8 pounds of TP, no further action is being taken with this area.

KELL-03Bb - Although there is some stormwater collection on the north end of the area, much of this drainage area's 23 acres appears to drain overland directly into the lake. **Encouragement and incentives for individual property owners in this area to undertake phosphorus reduction measures appear to be warranted.**

KELL-03Bc - This small sub-drainage area contributes a small amount of phosphorus. No further action is recommended.

KELL-03Bd - This 73-acre area is mostly commercial developments and highway right-of-way, including the cloverleaf for the Highways 36 and 61 interchange. The runoff appears to flow into County Ditch No. 6 prior to entering the lake**.** Although there may be some treatment already occurring within the highway right-of-way, none has been accounted for with the P8 modeling performed to date. **With 125 pounds of TP identified for this sub-drainage area, further evaluation to investigate the feasibility of holding some of this runoff in a pond prior to entering the lake is justified.**

KELL-03Be - Most of the runoff from this sub-drainage area (as well as runoff from areas KELL-07a and KELL-07b) is collected in a pond on the east side of the lake prior to entering the lake. P8 modeling estimated 30 percent TP removal through the pond. Since stormwater runoff in KELL-03Be has several collection points before reaching the existing pond, this area was further sub-divided into KELL-03Be1E, KELL-03Be1W, and KELL-03Be2. **With 90 pounds of TP remaining, an evaluation of additional detention pond storage for each of these sub-drainage areas appears warranted.**

KELL-03Bf - This small sub-drainage area contributes a small amount of phosphorus . No further action is recommended.

KELL-03Bg - This area is primarily the lake itself, with some protruding land masses. No treatment is being considered.

KELL-03Bh - This small sub-drainage area contributes a small amount of phosphorus . No further action is recommended.

KELL-03Bi - This small sub-drainage area contributes a small amount of phosphorus . No further action is recommended.

KELL-03Bj - This small sub-drainage area contributes a small amount of phosphorus . No further action is recommended.

KELL-03Bk - This small sub-drainage area contributes a small amount of phosphorus . No further action is recommended.

KELL-03Bl - This 64-acre sub-drainage area currently has no treatment and the runoff is collected in a 30-inch storm sewer into a ditch before entering the lake. An estimated 49 pounds of TP is generated from this area and some form of treatment appears to be justified. **A rainwater garden appears to be an option, but initial indications are that it would not be very cost effective.**

KELL-03Bm - The runoff from this sub-drainage area is entirely with overland flow to the lake. A buffer strip may be an option, however, there is no other apparent cost effective means of treating the 23 pounds of TP. **However, encouragement and incentives for individual property owners in this area to undertake phosphorus reduction measures appear to be warranted.**

KELL-07a - A major portion of this sub-drainage area is on the Keller Golf Course. The remaining land use is primarily residential. A storm sewer collects some of the runoff from this sub-drainage area and diverts it to the same pond as identified in KELL-03Be above. **Additional detention pond storage, together with KELL-03Be should be considered.**

KELL-07b - A storm sewer collects some of the runoff from this sub-drainage area and diverts it to the same pond as identified in KELL-03Be above. **Additional detention pond storage, together with KELL-03Be should be considered.**

3.4 Lake Phalen- Description of Sub-Drainage Areas

Each of Lake Phalen's 17 sub-drainage areas evaluated for further treatment and its treatment potential is described in detail below.

PHAL-06 - The inflow into Lake Phalen from this drainage area is estimated to contribute 516 pounds of TP each year through a single 84-inch stormwater outlet. Of this amount, 310 pounds are simply passing through from the Wakefield Lake outlet in PHAL-03. A separate sub-drainage area on property owned by the Our Redeemer Lutheran Church was created as PHAL-06a since it appeared to provide a good opportunity for implementation of a rainwater garden. **With the drainage area regarded as having a high potential for rainwater gardens, it is considered appropriate, as a minimum, to provide encouragement and incentives for individual property owners in this area to undertake phosphorus reduction measures appear to be warranted.**

PHAL-07a - This 42-acre sub-drainage area consists primarily of golf course and park land, yielding only low levels of TP. No treatment action is recommended.

PHAL-07b - This area is primarily the lake itself, with some protruding land masses. No treatment is being considered.

PHAL-07c - This sub-drainage area is a narrow strip of land on the east side of the lake whose runoff travels overland to the lake. **Although the watershed district has already implemented shoreline restoration measures in some of this area, which will assist in capturing some of the TP, the study criteria would suggest that we review it in the next phase of the study.**

PHAL-07d - There is a stormwater collection system in this sub-drainage area, with a primary 30-inch outlet and two smaller outlets. P8 estimates that 19 pounds of TP are generated in this area. But no cost effective means of reducing this load is apparent. **However, encouragement and incentives for individual property owners in this area to undertake phosphorus reduction measures appear to be warranted.**

PHAL-07e - This sub-drainage area is a narrow strip of land on the northeast portion of the lake whose runoff travels overland to the lake. No further action is recommended.

PHAL-07f - This small sub-drainage area contributes a small amount of phosphorus. No further action is recommended.

PHAL-07g - This sub-drainage area is a narrow strip of land on the southern end of the lake whose runoff travels overland to the lake. With only 8.5 pounds of TP estimated for this area, no action is recommended. Also, Lake Phalen's outlet is very close to this sub-drainage area. Any flows into the lake from this area are not likely to affect the water quality of Lake Phalen significantly. For these reasons, no further action is recommended.

PHAL-07h - Most of this sub-drainage area is golf course, however, there are a number of streets, parking lots, and buildings, which increase the portion of impervious area. P8 estimates that this area generates approximately 63.8 pounds of TP. There is some open space in this sub-drainage area that may be potentially be used for some treatment measure. **Further investigation of treatment options in this area is recommended.**

PHAL-08 - The drainage area was not subdivided since the storm sewer system for the area delivers all flows to the vicinity of an existing pond, the Arlington English Storm Pond, which treats a portion of the stormwater runoff prior to entering Lake Phalen. A rectangular area within PHAL-08, which includes the Frost Lake School and Frost Lake, is land locked and does not contribute to the runoff. Based on P8 modeling results, the pond removes approximately 80 pounds of TP annually, which is 22.8 percent of the estimated 352 pounds of TP from the drainage area. **Expanding the size of the detention pond to treat a larger portion of the runoff warrants further investigation.**

PHAL-09 - Runoff from this sub-drainage area is collected in a storm sewer system with a 42-inch outlet on the west side of the lake. The P8 model estimates that 105 pounds of TP are generated in this sub-drainage area. **There is an open private yard on the east side of East Shore Drive, where a rain garden may be an acceptable alternative. Further investigation of this is recommended.**

PHAL-10 - The P8 model estimates that 210 pounds of TP are generated in this sub-drainage area. Runoff from this sub-drainage area is collected in a storm sewer system with an outlet consisting

of two 42-inch outlets. **Although Lake Phalen's outlet is very close to these outlets- any flows into the lake from this area are not likely to affect the water quality of Lake Phalen significantly, the study criteria would suggest that we review it in the next phase of the study.**

PHAL-13 - This sub-drainage area is not immediately adjacent to Lake Phalen, however, a 72-inch storm sewer carries the runoff to the lake, crossing the golf course en route. P8 estimates that **181.6 pounds of TP area generated in this sub-drainage area. It is recommended that some treatment be considered, such as diverting some of this area's initial flow from a storm into an existing pond on the golf course.**

PHAL-16a - A major portion of this sub-drainage area consists of the Keller Golf Course, although a portion of the golf course is land locked and does not contribute to the runoff (PHAL-16c). The eastern quarter of the sub-drainage area is residential and flows from PHAL-16b flow through this sub-drainage area. Most of the stormwater flows through two separate ponds prior to entering Lake Phalen. Including stormwater from PHAL-16b, the estimated total TP from this sub-drainage area is 456 pounds annually. Based on P8 modeling results, the ponds remove approximately 190 pounds of TP, or 41.6 percent of the total. **With the large amount of TP from this drainage area, further evaluation of opportunities for treatment appears to be warranted.**

PHAL-16b - As mentioned above, the stormwater runoff from this sub-drainage area flows though PHAL-16a prior to entering Lake Phalen. The estimated annually produced TP from this drainage area is 274 pounds. This may receive some treatment in a leveed area on the western end of the Gladstone Savanna Neighborhood Preserve, however, the P8 modeling did not consider this treatment. Potential opportunities for further treatment depend on future use of neighborhood preserve and the lands surrounding it. **With the large amount of TP from this drainage area, further evaluation of opportunities for treatment appears to be warranted.**

PHAL-16c - Since this is a 34.2-acre landlocked area within the Keller Golf Course, no action is recommended.

4.0 Conclusions and Recommendations

The treatment measures identified for further study were investigated in greater depth for implementation, considering the volume of stormwater storage needed, various treatment measures for each sub-drainage area, reviewing any constraints that might prevent implementation, such as wetland classifications, general soil conditions, storm sewer depths and configurations, adequate space, utility interference, etc.

Table 2 summarizes the results of this more detailed evaluation of the treatment measures that appeared to be the most viable. Three different categories of treatment measures are identified:

1. Capital improvement projects that treat most of the runoff leaving the sub-drainage area.
2. Hot spot areas that would be targeted for further treatment in the future as opportunities arise.
3. Residential measures that would target runoff at its source across the sub-drainage area, described in more detail below.

Table 2 lists the treatment measures in order of cost effectiveness and highlights 23 of those measures, which are considered most appropriate for potential implementation. The locations of these 23 measures are also shown on Figure 10. Figures 11 through 15 show these proposed project locations in greater detail.

A project was deemed generally cost effective if its cost per lb of TP removed fell within the range of values of actual treatment projects pursued by the District in the past. The estimated annual cost per pound of TP removed for the treatment measures considered for implementation in this study varies from $368 to $2,762. Table 3 indicates that the annual cost per pound of TP removed of actual past projects throughout the District varies from $45 to $2,040.

Table 2

Detailed Evaluation of Treatment Measures

(Reordered in order of most cost effective)

No.	Sub-Drainage Areas	Treatment Measure Evaluated	Revised cost estimates and amounts of TP removed							Cumulative First Cost	Cumulative TP Removed
			Total First Cost	Annual O&M Cost	Est. Annual Cost	Remaining TP (lbs.)	Addit. % Removed	Addit.TP Removed	Annual Cost/ lb. TP removed		
1	KELL-03Bd	Detention Ponds	$230,000	$1,000	$21,052	142.9	40	57.2	$368	$230,000	57.2
2	KELL-03Be2	Detention Pond [1]	$105,000	$800	$9,954	88.0	25	22.0	$452	$335,000	79.2
3	PHAL-08	Detention Pond	$311,000	$3,000	$30,114	272.1	20	54.4	$553	$646,000	133.6
4	KELL-03BI	Infiltration Swale and Pond	$145,000	$1,500	$14,142	48.5	40	19.4	$729	$791,000	153.0
5	KELL-03a	Detention Pond [2]	$238,000	$1,500	$22,250	54.2	40	21.7	$1,026	$1,029,000	174.7
6	PHAL-06a	Demonstration/Education Project	$72,000	$1,000	$7,277	12.0	35	4.2	$1,733	$1,101,000	178.9
7	KELL-03Be1W	Demonstration/Education Project	$85,000	$1,000	$8,411	8.7	35	3.0	$2,762	$1,186,000	181.9
8	PHAL-16b	Cooperative Agreement?	[11]			160.2					
9	PHAL-06	Hot Spot Area	[11]			504.3					
10	PHAL-09	Hot Spot Area	[11]			105.2					
11	PHAL-13	Hot Spot Area	[11]			181.6					
12	PHAL-16a	Hot Spot Area	[11]			106.4					
13	KELL-03Bm	Residential Measures [3]	$10,000	$100	$972	23.0	15	3.5	$282	$10,000	3.5
14	KOHL-02i	Residential Measures [3]	$10,000	$100	$972	21.3	15	3.2	$304	$20,000	6.6
15	KELL-03Bb	Residential Measures [3]	$10,000	$100	$972	19.6	15	2.9	$331	$30,000	9.6
16	PHAL-07d	Residential Measures [3]	$12,000	$100	$1,146	19.0	15	2.9	$402	$42,000	12.4
17	KOHL-02g	Residential Measures [3]	$10,000	$100	$972	14.0	15	2.1	$463	$52,000	14.5
18	KOHL-02j	Residential Measures [3]	$7,500	$100	$754	10.8	15	1.6	$465	$59,500	16.2
19	GERV-04c	Residential Measures [3]	$15,000	$150	$1,458	18.1	15	2.7	$537	$74,500	18.9
20	GERV-04d	Residential Measures [3]	$10,000	$100	$972	10.9	15	1.6	$594	$84,500	20.5
21	GERV-04a	Residential Measures [3]	$15,000	$150	$1,458	16.2	15	2.4	$600	$99,500	22.9
22	GERV-04g	Residential Measures [3]	$10,000	$100	$972	9.6	15	1.4	$675	$109,500	24.4
23	CD16-19	Residential Measures [3]	$12,000	$100	$1,146	14.6	10	1.5	$785	$121,500	25.8
24	KOHL-02a	[4]				17.5					
25	KOHL-02c	[5]				37.9					
26	KOHL-03b	[6]				32.6					
27	KOHL-05A	[6]				38.6					
28	GERV-05	[7]				20±					
29	PHAL-07c	[8]				19.7					
30	PHAL-07h	[9]				10±					
31	PHAL-10	[10]				210.0					

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Notes:

[1] Also treats flows from KELL-07a & 7b.

[2] Also treats flows from KELL-03b & 03c.

[3] Estimated cost of Residential Measures is based on number of homes, size of area, and approximate level of cost effectiveness (in terms of how much may be reasonably be spent in this area), but could be adjusted for individual sub-drainage areas depending on level of acceptance, etc.

[4] No practical treatment measure was identified.

[5] Although detention pond could be placed in a Utilize wetland classification area, remaining TP for treatment is relatively small and not cost effective.

[6] Proposed pond would be in a P wetland classification area and opportunity to trap TP upstream of wetland is unlikely.

[7] Pond is in an M1 wetland classification area and additional ponding has recently been provided with new subdivision development.

[8] Previous buffer strip work by the watershed district is considered to treat this area to the extent practical.

[9] Upon further investigation determined that portion of DA actually handled by 24-inch drain into lake is less than first estimated. Treatment not cost effective.

[10] Although amount of untreated TP is high, the inlet to lake is immediately adjacent to the lake's outlet. Any treatment would result in little impact to the lake's water quality.

[11] Funding is at least partially subject to payment by others, cost would be subject to type and level of treatment selected.

Capital Improvement Project Recommendations
Hot Spot Areas
Residential Measures
Drainage Areas with No Specific Recommended Actions

Table 3

Estimated Cost Effectiveness for Other Treatment Projects

(Relative to the amount of estimated Total Phosphorus removed)

	Primary Treatment Feature	Total Year	Capital Cost ($)	WQ Features ($)	2005 Prices ($)	Annual Life Span	Annual O&M Costs	Total Annual Costs 6%	Annual TP Removed (lbs.)	Cost/lb
Gervais Mill Pond	Pond	1993	$877,034	$700,000	$969,761	20	$4,000	$65,000	203	$320
(23/62-230)									[2]	
Owasso Basin	Pond	1990	$1,037,392	$900,000	$1,374,723	20	$3,000	$81,500	136	$599
(23/62-031 & 201)				[1]					[2]	
North St. Paul Urban	Pond	1998	$122,355	$122,000	$148,801	20	$3,000	$13,600	150	$91
(Sod Farm) (23/62-414)									[2]	
Kohlman Basin (&Pipeline)	Pond	2001	$1,461,867	$1,400,000	$1,597,005	20	$8,000	$130,100	239	$544
(23/62-207 & 269)									[2]	
Tanners Lake WQ Impr.	Alum	1995	$1,073,545	$676,000	$895,617	20	$49,000	$107,900	308	$350
(23/62-291)	Treatment								[3]	
East Tamarack Swamp	Ponds/	2000	$216,000	$216,000	$252,057	20	$3,000	$21,800	25	$872
Trtmt. Basins (PFS)	Polymer								[4]	
(23/82-310)										
Carver Lake Porous	Porous	2005	$228,000	$228,000	$228,000	20	$500	$20,400	10	$2,040
Pavement (23/82-359)	Pavement								[4]	

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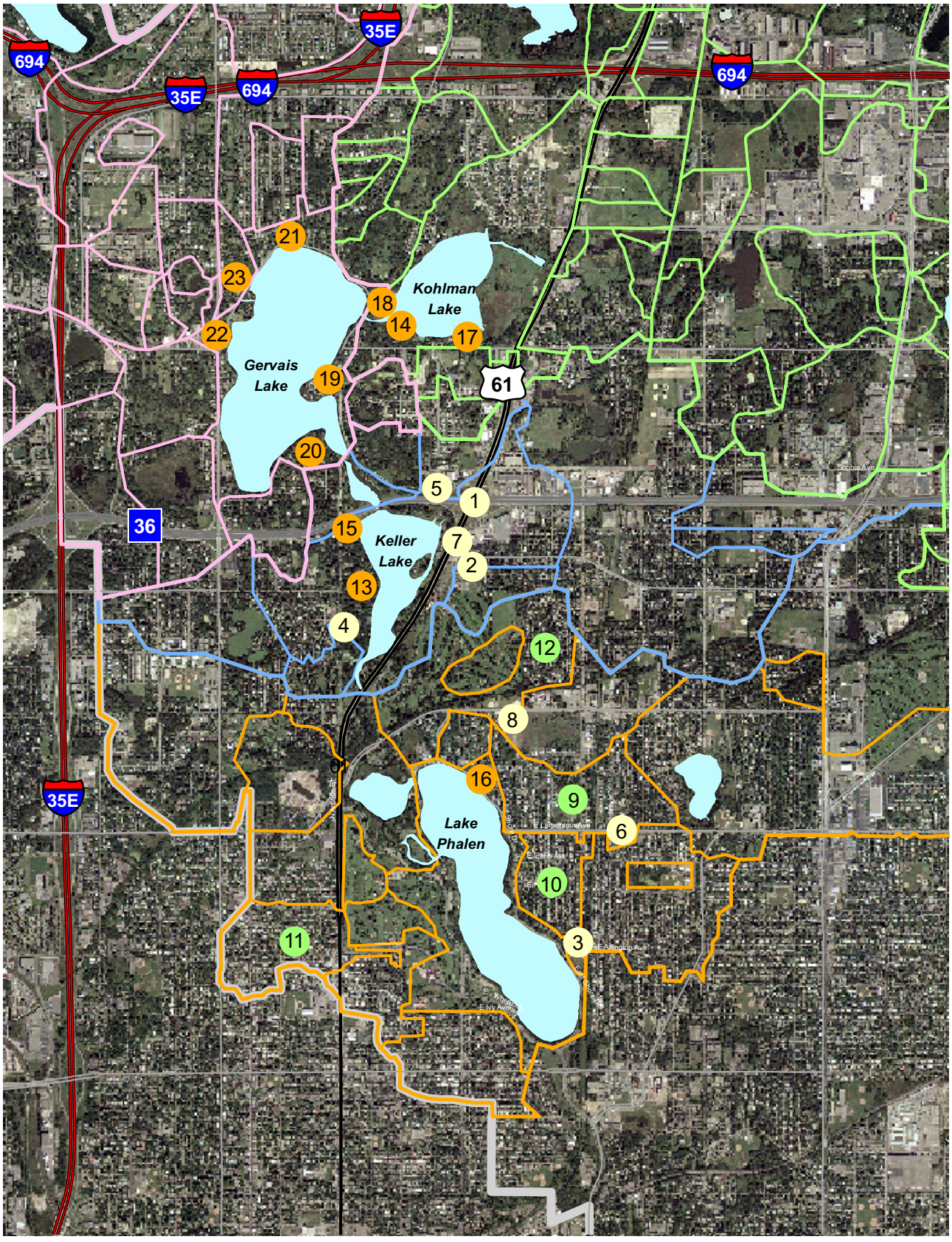
[1] Includes $400,000 for proposed work

[2] Based on modeling and not field monitoring. Without field verification, only 50% of modeling results are being used in this table

[3] Actual field monitoring results

[4] Based on modeling and not field monitoring. Results have not been reduced due to the smaller amounts of TP removed.



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LEGEND

- Gervais Subwatershed
- Kohlman Subwatershed
- Keller Subwatershed
- Phalen Subwatershed
- RWMWD Hydrologic Boundary

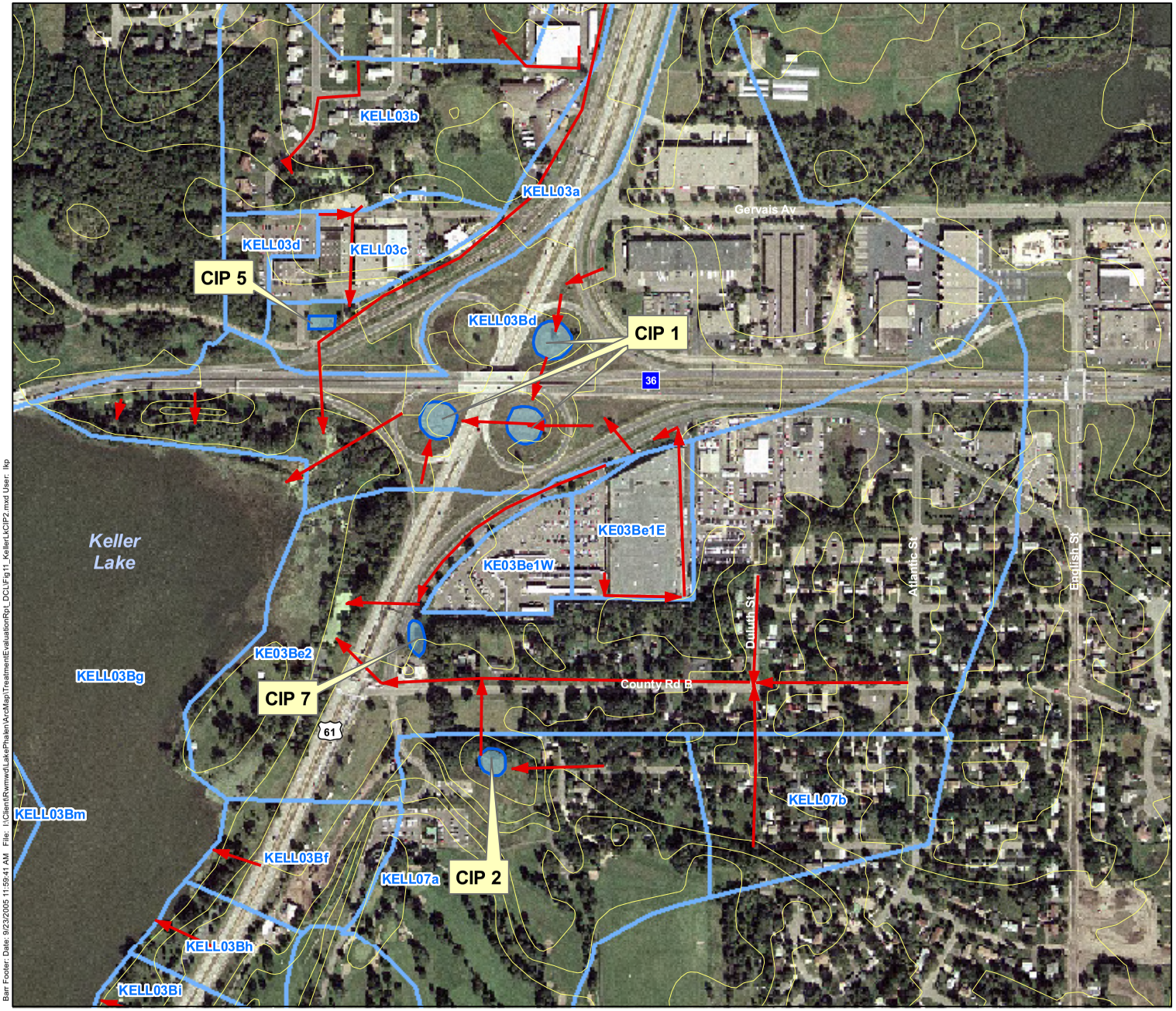
2,000 1,000 0 2,000 4,000

Feet

Figure 10

LOCATION MAP -
TREATMENT MEASURES TO BE
CONSIDERED FOR IMPLEMENTATION

Phalen Chain of Lakes
Ramsey-Washington Metro Watershed District



LEGEND

- Capital Improvement Project Recommendations
- Keller Sub-Drainage Areas
- Key Stormwater Outlets

400 200 0 400

Feet

Ramsey-Washington Metro Watershed District

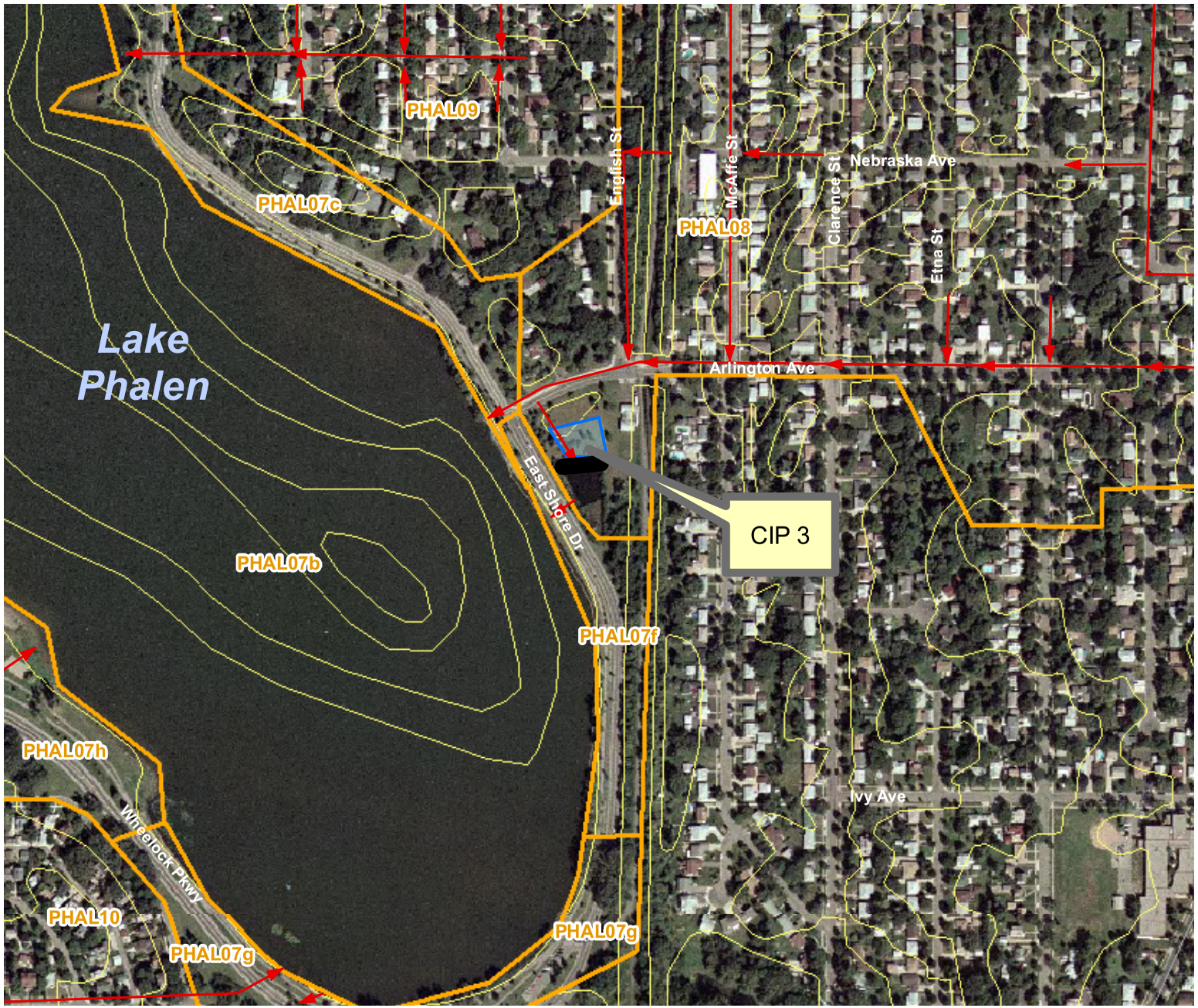
BARR

Figure 11

CAPITAL IMPROVEMENT PROJECT RECOMMENDATIONS

1. KELL-03Bd
2. KELL-03Be2
5. KELL-03a
7. KELL-03Be1W

Phalen Chain of Lakes
Ramsey-Washington Metro Watershed District



LEGEND

- Capital Improvement Project Recommendations
- Phalen Sub-Drainage Areas
- Key Storm Water Outlets

300 150 0 300 600

Feet

Ramsey-Washington Metro Watershed District

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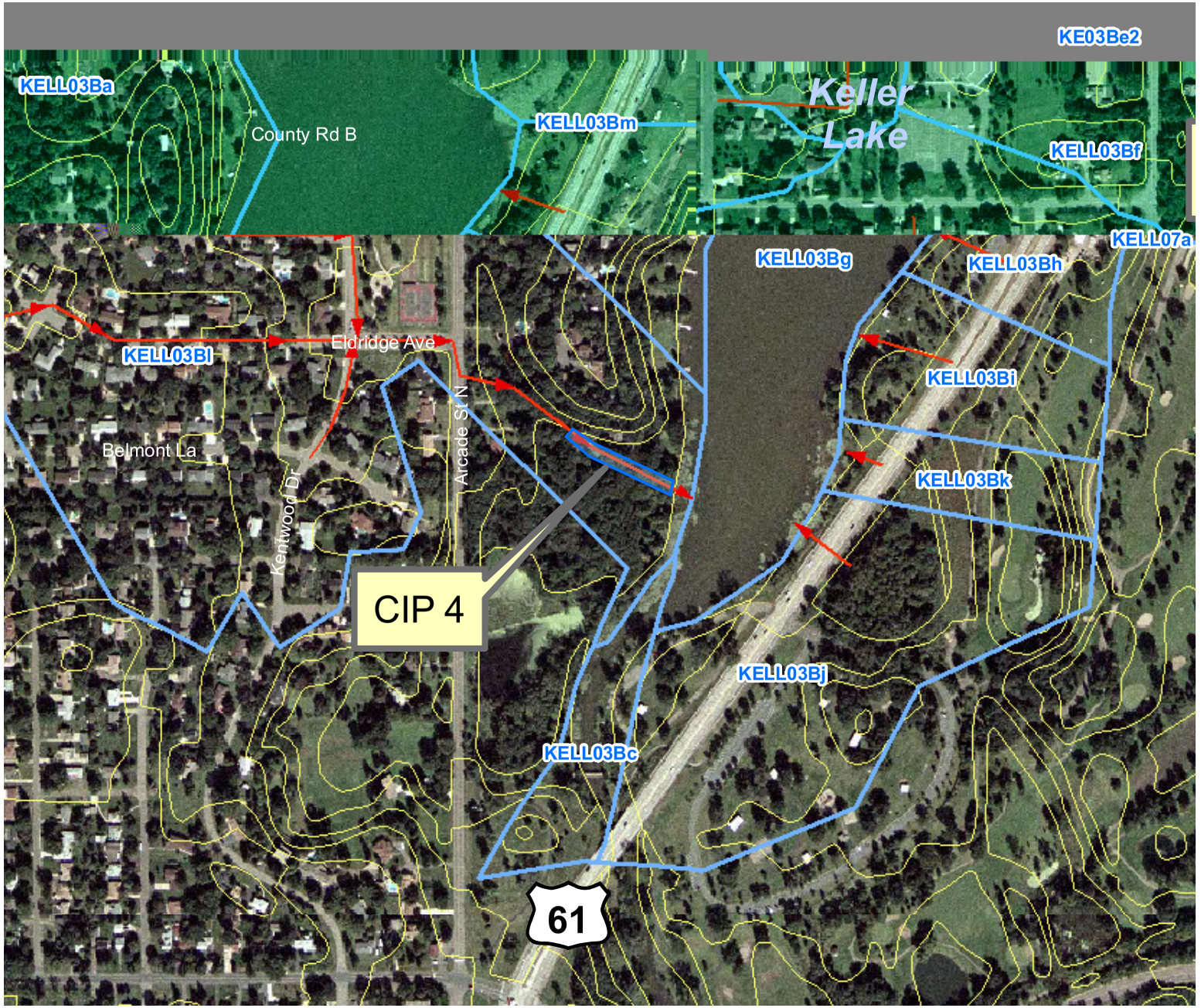
Figure 12

CAPITAL IMPROVEMENT PROJECT RECOMMENDATIONS
3. PHAL-08

Phalen Chain of Lakes
Ramsey-Washington Metro Watershed District



LEGEND

- Capital Improvement Project Recommendations
- Keller Sub-Drainage Areas
- Key Storm Water Outlets

300 150 0 300

Feet

Ramsey-Washington Metro Watershed District

BARR

Figure 13

CAPITAL IMPROVEMENT PROJECT RECOMMENDATIONS
4. KELL-03B1

Phalen Chain of Lakes
Ramsey-Washington Metro Watershed District

LEGEND

- Capital Improvement Project Recommendations
- Phalen Sub-Drainage Areas
- Key Storm Water Outlets

200 100 0 200

Feet

Ramsey-Washington Metro Watershed District

BARR

Figure 14

CAPITAL IMPROVEMENT PROJECT RECOMMENDATIONS
6. PHAL-06a

Phalen Chain of Lakes
Ramsey-Washington Metro Watershed District

LEGEND

- Capital Improvement Project Recommendations Approximate Location
- Phalen Sub-Drainage Areas
- Key Storm Water Outlets

300 150 0 300

Feet

Ramsey-Washington Metro Watershed District

BARR

Figure 15

CAPITAL IMPROVEMENT PROJECT RECOMMENDATIONS
8. PHAL-16b

Phalen Chain of Lakes
Ramsey-Washington Metro Watershed District

4.1 Capital Improvement Project Recommendations for the District

The eight recommended capital improvement projects considered to have the greatest cost effectiveness are:

KELL-03Bd –A series of two detention pond cells followed by an infiltration or filtration cell could be constructed within three (all but the northwest quadrant) of the loops in the Highway 36/61 interchange. The volume of storage required to temporarily hold the first ½ inch of runoff is estimated to be 1.70 acre-feet. There is adequate area within these three loops to contain this volume and initial contact with the Minnesota Department of Transportation (Mn/DOT) indicates that ponds may be acceptable at this location.

KELL-03Be2, KELL-07a, and KELL-07b – These three sub-drainage areas are being combined for treatment consideration since they share a common collection point. A future detention pond south of County Road B, on Keller Golf Course property (but not part of the golf course) is considered a viable option. A pond with an approximate capacity of 1.0 acre-foot is estimated to accommodate the runoff from the first ½ inch of runoff. The flow in an existing 42-inch storm sewer line crossing County Road B would have to be reversed to divert the initial runoff to the south into the recommended detention pond. There appears to be adequate space for this size of pond and preliminary feedback from the Ramsey County Parks and Recreation Department is that making this area more efficient for treatment may be acceptable.

PHAL-08 – The existing Arlington English Storm Pond is estimated to provide 22.8 percent treatment of the stormwater runoff. A 42-inch storm sewer diverts runoff to the pond, with a portion of the flows continuing directly into Lake Phalen. A pond with an approximate capacity of 2.7 acre-feet is estimated to accommodate the runoff from the first ½ inch of runoff in this area. This would be approximately twice as large as the existing pond. The logical expansion area would be to the north and would require excavation depths of approximately 17 feet, but with the large amount of TP to be treated, this is relatively cost effective. Initial contact with the City of St. Paul indicated that such expansion of the existing pond would likely be acceptable, and even possibly a cost-sharing opportunity.

KELL-03BI – Stormwater runoff of this sub-drainage area enters a 30-inch storm sewer on Eldridge Avenue, crosses Arcade Street, and exits into a ditch before entering Keller Lake. There is an easement (most likely 20 feet wide) for the 900 feet of storm sewer and ditch east of Arcade Street. The required storage required is estimated to be 0.92 acre-feet. Although a

rainwater garden was proposed in the initial screening of this study, it is considered too costly and an infiltration swale, together with a detention pond, is considered an acceptable option to treat this runoff prior to entering the lake. Whether the work can be accomplished within the existing easement area is uncertain and no contact has been made with adjacent property owners.

KELL-03a – On Table 2 this sub-drainage area is shown to annually contribute 54.2 pounds of TP to Keller Lake. This amount does not include the 212 pounds flowing through the drainage area from Gerten Pond. Since the runoff from the local drainage area would typically occur well in advance of overflows from Gerten Pond, it is suggested that a detention pond capable of trapping the initial one half inch of runoff be provided adjacent to the existing ditch which passes all of these flows. The pond should be capable of holding 2 acre-feet of storage. The detention pond would be on private property and no contact has been made regarding the acceptance of this measure.

PHAL-06a – This 3-acre sub-drainage area on property owned by the Our Redeemer Lutheran Church is estimated to contribute 12 pounds of phosphorus, which flows to Lake Phalen without any treatment. Although the cost of treatment per pound of phosphorus removed is high, since this area has a high level of visibility in a residential neighborhood setting. As such, one or two rainwater gardens in the sodded areas between the parking lot and street would provide an excellent opportunity for demonstrating and educating the general public on the value of these measures, while treating stormwater runoff. No contact has been made with the church officials regarding acceptance of this measure.

KELL-03Be1W – This 4.4-acre sub-drainage area is on property owned by Menards, is almost entirely paved, and drains to the west end of the parking lot. Although there is some treatment in an existing pond before the stormwater enters Keller Lake, there appears to be an opportunity to further treat this runoff before entering the existing detention pond. As with PHAL-06a above, although the cost of treatment per pound of phosphorus removed is high, this area is highly visible and offers a good opportunity for demonstrating and educating the general public of the value of these measures at this location. Although further evaluation is recommended for determining the best alternative for treatment, either a detention pond or rainwater garden would appear to be implementable.

PHAL-16b – With 274 pounds of TP modeled for this sub-drainage area, further treatment seems justified. It appears that the City of Maplewood is considering development in the area that might be considered for treatment as part of the Gladstone Neighborhood Strategic Planning area. It is suggested that the watershed district develop a cooperative arrangement with developers to achieve greater level of TP reduction.

Other areas, while qualifying as "untreated", did not have individual projects that were deemed feasible, and therefore, did not have accompanying CIPs that were recommended for District action. In these cases, projects were not currently deemed feasible for one of three reasons: (1) runoff from the sub-drainage area did not have a collection point where all (or most) of the stormwater runoff came together at a single point (and could not reasonably be made to do so), or (2) runoff from the sub-drainage area did come together at a single point, but the magnitude of the project needed to treat the runoff, in terms of physical size and project cost seemed excessive under current site conditions, or 3) other reasons relating to site constraints.

4.2 Capital Improvement Projects Recommended for Hot Spot Handout

Sub-drainage areas that fell into the second category (single collection point, but excessive size and cost of project that would treat the runoff) will appear on the Hot Spot handout. After more detailed evaluation of the treatment measures considered for these sub-drainage areas, their estimated cost is too high to consider for implementation by the District at this time:

PHAL-06 – Although a large percent of the 516 pounds of TP from this drainage area are from Wakefield Lake, over 200 pounds come from local runoff in the sub-drainage area. Since there is not a practical location for a detention pond or large scale infiltration measures, treatment in this area can be best accomplished at a smaller scale in localized areas.

PHAL-09 – There is an estimated 1.37 AF of storage needed for ½ inch of runoff from the impervious areas of this drainage area, requiring an infiltration basin of approximately 40,000 ft^2. Using an average cost of \$10/ft^2 for a rainwater garden/infiltration basin project results in an estimated cost of \$400,000. Also, it is doubtful whether such a single infiltration basin could fit in the area available. A detention pond and underground filters were considered, but not viewed as good alternatives for the site.

PHAL-13 – The 72-inch storm sewer line carrying flows from this sub-drainage area across the Phalen Golf Course to Lake Phalen was found to be approximately 25 deep in the location of the proposed detention pond. With this depth of cut required for any treatment system, the cost appears prohibitive at present.

PHAL-16a – Although much of the runoff from this drainage area is treated by passing through ponds, there is yet potential for capturing more of the TP nearer to its source, especially in the residential area on the east end of the sub-drainage area.

4.3 Residential Measure Recommendations

Sub-drainage areas that fell into the first category (no clear collection point for stormwater runoff) could still benefit from a different type of project, described here as "Residential Measures". Residential Measures can be thought of as "prescriptive practices" (as described in the Phalen Chain of Lakes SLMP, Section 2.4.4) that are specific to residential areas. Residential Measures are intended to encourage individual property owners in the area to pursue phosphorus reduction measures on their property. It is felt that through neighborhood education and potential financial incentives, simple measures that can make a difference on nutrient runoff can be most cost effective in these drainage areas. Property owners would be encouraged to implement measures, such as:

- Using organic fertilizers and minimal use of pesticides and herbicides
- Planting buffer strips adjacent to the lake
- Installing downspout infiltration systems, soak away pits, and rain barrels
- Installing a simple rainwater garden

The sub-drainage areas that are appropriate for Residential Measures are listed below in Table 4. Those sub-drainage areas marked with "Yes" for "Potential for Rainwater Gardens" indicate areas that appear to have some potential for rainwater gardens based on an initial field visit that evaluated the topography of the area and its land uses.

Table 4 Sub-Drainage Areas Recommended for Residential Measures

Sub-Drainage Area	Area (acres)	Potential for Rainwater Gardens?	Parcels				
			Residences	Commercial	Public Properties	Other	Total Parcels
GERV-04a	33.4	Yes	61	0	0	1	62
KELL-03Bm	30.2	Yes	21	0	1	0	22
KOHL-02g	22.7		14	0	0	1	15
KOHL-02i	30.1		16	0	3	0	19
PHAL-07d	14.1		39	0	3	0	42
KELL-03Bb	23.3	Yes	16	0	0	1	17
CD16-19	29.1		48	0	0	1	49
GERV-04c	27.5	Yes	59	0	0	2	61
GERV-04d	20.7	Yes	27	0	0	0	27
KOHL-02j	8.6		5	0	1	0	6
GERV-04g	27.0	Yes	43	0	2	1	46
Totals	**266.7**		**349**	**0**	**10**	**7**	**366**

The estimated total cost of the Residential Measures for each sub-drainage area, shown in Table 2, could be adjusted to reflect the level of interest in the area; this would in-turn affect the perceived cost effectiveness. Data in Table 2 assumes that 10 to 15 percent of the estimated TP can be removed with these localized measures. Using this assumption, the amount of annual TP actually removed is relatively small with each drainage area (ranging from 1.4 pounds to 3.5 pounds). However, the estimated TP removed with the Residential Measures for the 11 sub-drainage area totals 25.8 pounds and could be considerably more with active participation by property owners. The total $121,500 estimated first cost for implementing the Residential Measures could be reduced if the greatest area of emphasis was placed on education and less on incentives. The 11 drainage areas are listed in order of cost effectiveness, so neighborhoods can be prioritized in that order.

It is assumed that the District may not wish to pursue residential measures in all of these sub-drainage areas. Rather, the District may choose to implement these measures in a few of the sub-drainage areas (perhaps in those that contribute the highest TP loadings), leaving the rest to be listed on the Hot Spot handout, described in Section 4.5 of this report.

4.4 Projects Not Recommended for Any Action

Sub-drainage areas that fell into the third category (treatment projects not recommended due to other site constraints) will not appear on the Hot Spot handout. In these areas, no recommended projects were identified upon further investigation of site constraints.

KOHL-02a – Although reviewed again in the detailed phase of the study, no treatment system appears practical.

KOHL-02c – Although a detention pond could be placed in a Utilize wetland classification area, the remaining TP for treatment is relatively small and not cost effective.

KOHL-03b – The area of the proposed pond has a Protect (P) wetland classification and any opportunity for treatment upstream of the area is unlikely.

KOHL-05A - The area of the proposed pond has a Protect (P) wetland classification and any opportunity for treatment upstream of the area is unlikely.

GERV-05 – The area of the existing detention pond has a Manage 1 (M1) wetland classification and there does not appear to be adequate space to treat runoff upstream of the pond. Additionally, new detention ponds have been recently provided south of County Road B2 in a new subdivision development, which will provide additional treatment not recognized in the P8 modeling conducted for this study.

PHAL-07c - Although reviewed again in the detailed phase of the study, no treatment system appears practical.

PHAL-07h – Upon further investigation the runoff contributing to the 24-inch storm sewer is less than estimated with the P8 model and the invert elevation of any treatment measure is expected to be restrained by groundwater in the area.

PHAL-10 - Although reviewed again in the detailed phase of the study, no treatment system appears practical.

4.5 Description of Hot Spot Handout

A Hot Spot handout will be distributed to each of the cities in the Phalen Chain of Lakes Subwatershed, with the purpose of showing city officials which sub-drainage areas within their boundaries should be targeted for further treatment in the future as opportunities arise. This handout will be a single page color handout with a map on one side, and possible treatment technologies on the other. Each city will receive a handout specific to their city's boundaries. These handouts will be printed in a format that allows them to be inserted into the Water Management Plan when it is updated later this year.

The intention of the hot spot handouts is to alert city departments when developers present proposed projects that fall within a sub-drainage area that currently provides little or no stormwater treatment. This handout would encourage the construction of stormwater treatment technologies as new sites are being constructed, as roads are re-done, etc. The funding for these projects would come out of cost sharing and cooperative planning between the District and the developer. In this manner, sub-drainage areas whose treatment options currently seem cost and space prohibitive could be more easily implemented in the future.

The following sub-drainage areas will be highlighted in the Hot Spot handout:

- PHAL-06
- PHAL-09
- PHAL-13
- PHAL-16a

Any other sub-drainage areas that have proposed projects (CIP's and residential measures recommended in this report that the District deems important but decides not to pursue on its own at this time.

5.0 References

Barr Engineering Co. October 2004. Draft *Strategic Lake Management Plan for the Phalen Chain of Lakes*.

IEP, Inc. 1990. Program for Predicting Polluting Particle Passage through Pits, Puddles, and Ponds (P8).