# 6.0 Discussion

## 6.1 General Discussion of Improvement Options

This section discusses improvement options and general Best Management Practices (BMPs) to remove phosphorus and/or reduce sediment and litter entering a lake. Three types of BMPs were considered during the preparation of this report: structural, in-lake, and nonstructural.

1. Structural BMPs remove a fraction of the pollutants and sediment loads contained in stormwater runoff prior to discharge into receiving waters.
2. In-Lake BMPs reduce phosphorus already present in a lake, and/or prevent the release of phosphorus from anoxic lake sediments.
3. Nonstructural BMPs (source control) eliminate pollutants at the source and prevent pollutants from entering stormwater flows.

### 6.1.1 Structural BMPs

Structural BMPs temporarily store and treat urban stormwater runoff to reduce flooding, remove pollutants, and provide other amenities (Schueler, 1987). Water quality BMPs are specifically designed for pollutant removal. Their effectiveness is summarized in Table 6-1. Structural BMPs control total suspended solids and total phosphorus loadings by slowing stormwater and allowing particles to settle in areas before they reach the receiving waters. Settling areas can be ponds, storm sewer sediment traps, or vegetative buffer strips. Settling can be enhanced by treatment with flocculating chemicals prior to entering the settling basin (see alum treatment plants below).

When choosing a structural BMP, the ultimate objective must be well understood. The BMP should accomplish the following (Schueler 1987):

1. Reproduce, as nearly as possible, the stream flow before development
2. Remove at least a moderate amount of most urban pollutants
3. Require reasonable maintenance
4. Have a neutral impact on the natural and human environments
5. Be reasonably cost effective compared with other BMPs

**Table 6-1 General Effectiveness of Stormwater BMPs at Removing Common Pollutants from Runoff**

| Best Management Practice (BMP) | Suspended Sediment | Total Phosphorus | Total Nitrogen | Oxygen Demand | Trace Metals | Bacteria | Overall Removal |
|---|---|---|---|---|---|---|---|
| Wet Pond | 5 | 3 | 2 | 3 | 4 | ? | 4 |
| Infiltration Trench or Basin | 5 | 3 | 3 | 4 | 5 | 4 | 4 |
| Porous Pavement | 4 | 4 | 4 | 4 | 4 | 5 | 4 |
| Water Quality Inlet (Grit Chamber) | 1 | ? | ? | ? | ? | ? | ? |
| Filter Strip | 2 | 1 | 1 | 1 | 1 | ? | 1 |

| Percent Removal | Score |
|---|---|
| 80 to 100 | 5 |
| 60 to 80 | 4 |
| 40 to 60 | 3 |
| 20 to 40 | 2 |
| 0 to 20 | 1 |
| Insufficient Knowledge | ? |

Source: Schueler 1987

Examples of structural BMPs commonly installed to improve water quality include:

- Wet detention ponds
- Vegetative buffer strips
- Oil and grit separators
- Alum treatment plants

Each of the BMPs is described below and their general effectiveness is summarized in Table 6-1.

#### 6.1.1.1 Wet Detention Ponds

Wet detention ponds (sometimes called "NURP" ponds after the Nationwide Urban Runoff Program) are impoundments that have a permanent pool of water and also have the capacity to hold runoff and release it at slower rates than incoming flows. Wet detention ponds are one of the most effective methods available for treatment of stormwater runoff. Wet detention ponds are used to interrupt the transport phase of sediment and pollutants associated with it, such as trace metals, hydrocarbons, nutrients, and pesticides. When designed properly, wet detention ponds can also provide some removal of dissolved nutrients. Detention ponds have also been credited with reducing the amount of bacteria and oxygen-demanding substances as runoff flows through the pond.

During a storm, polluted runoff enters the detention basin and displaces "clean" water until the plume of polluted runoff reaches the basin's outlet structure. When the polluted runoff does reach the outlet, it has been diluted by the water previously held in the basin. This dilution further reduces the pollutant concentration of the outflow. In addition, much of the total suspended solids and total phosphorus being transported by the polluted runoff and the pollutants associated with these sediments are trapped in the detention basin. A well-designed wet detention pond could remove approximately 80 to 95 percent of total suspended solids and 40 to 60 percent of total phosphorus entering the pond (MPCA, 1989).

As storm flows subside, finer sediments suspended in the pond's pool will have a relatively longer period of time to settle out of suspension during the intervals between storm events. These finer sediments eventually trapped in the pond's permanent pool will continue to settle until the next storm flow occurs. In addition to efficient settling, this long detention time allows some removal of dissolved nutrients through biological activity (Walker, 1987). These dissolved nutrients are mainly removed by algae and aquatic plants. After the algae die, the dead algae can settle to the bottom of the pond, carrying with them the dissolved nutrients that were consumed, to become part of the bottom sediments.

The wet detention process results in good pollutant removal from small storm events. Runoff from larger storms will experience pollutant removal, but not with the same high efficiency levels as the runoff from smaller storms. Studies have shown that because of the frequency distribution of storm events, good control for more frequent small storms (wet detention's strength) is very important to long-term pollutant removal.

#### 6.1.1.2 Infiltration

Infiltration is the movement of water into the soil surface. For a given storm event, the infiltration rate will tend to vary with time. At the beginning of the storm, the initial infiltration rate represents the maximum infiltration that can occur because the soil surface is typically dry and full of air spaces. The infiltration rate will tend to gradually decrease as the storm event continues because the soil air spaces fill with water. For long duration storms the infiltration rate will eventually reach a constant value, the minimum infiltration rate (the design infiltration rate). The infiltrated runoff helps recharge the groundwater and mitigate the impacts of development. Stormwater flows into an infiltration basin, pools on the ground surface, and gradually infiltrates into the soil bed. Pollutants are removed by adsorption, filtration, volatilization, ion exchange, and decomposition. Therefore, infiltration is one of a few BMPs that can reduce the amount of dissolved pollutant in stormwater. Infiltration BMP devices, such as porous pavements, infiltration trenches and basins, and rainwater gardens, can be utilized to promote a variety of water management objectives, including:

- Reduced downstream flooding
- Increased groundwater recharge
- Reduced peak stormwater discharges and volumes
- Improved stormwater quality

An infiltration basin collects and stores stormwater until it infiltrates to the surrounding soil and evaporates to the atmosphere. Infiltration basins remove fine sediment, nutrients (including dissolved nutrients), trace metals, and organics through filtration by surface vegetation, and through infiltration through the subsurface soil. Deep-rooted vegetation can increase infiltration capacity by creating small conduits for water flow. Infiltration basins are designed as a grass-covered depression underlain with geotextile fabric and coarse gravel. A layer of topsoil is usually placed between the gravel layer and the grassed surface. Pretreatment is often required to remove any coarse particulates (leaves and debris), oil and grease, and soluble organics to reduce the potential of groundwater contamination and the likelihood of the soil pores being plugged. Infiltration can also be promoted in existing detention ponds by excavating excess sediments (typically the fines that have seal the bottom of the pond) and exposing a granular sub-base (assuming one was present prior to the original construction of the detention pond).

Rainwater gardens (a form of bio-retention) are shallow, landscaped depressions that channel and collect runoff. To increase infiltration, the soil bed is sometimes amended with mulch or soils with greater infiltration capacity. Vegetation in the rainwater gardens take up nutrients and stored runoff is reduced through evapotranspiration. Bio-retention is commonly located in parking lot islands, or within small pockets in residential areas. Bio-retention is primarily designed to remove sediment, nutrients, metals, and oil and grease. Secondary benefits include flow attenuation, volume reduction, and removal of floatables, fecal coliform, and BOD.

#### 6.1.1.3 Vegetated Buffer Strips

Vegetative buffer strips are low sloping areas that are designed to accommodate stormwater runoff traveling by overland sheet flow. Vegetated buffer strips perform several pollutant attenuation functions, mitigating the impact of development. Urban watershed development often involves disturbing natural vegetated buffers for the construction of homes, parking lots, and lawns. When natural vegetation is removed, pollutants are given a direct path to the lake—sediments cannot settle out; nutrients and other pollutants cannot be removed. Additional problems resulting from removal of natural vegetation include streambank erosion and loss of valuable wildlife habitat (Rhode Island Department of Environmental Management, 1990).

The effectiveness of buffer strips is dependent on the width of the buffer, the slope of the site, and the type of vegetation present. Buffer strips should be 20-feet wide at a minimum, however 50 to 75 feet is recommended. Many attractive native plant species can be planted in buffer strips to create aesthetically pleasing landscapes, as well as havens for wildlife and birds. When properly designed, buffer strips can remove 30 to 50 percent of total suspended solids from lawn runoff. In addition, well-designed buffer strips will discourage waterfowl from nesting and feeding on shoreland lawns. Such waterfowl can be a significant source of phosphorus to ponds, by grazing turfed areas adjacent to the water and defecating in or near the water's edge where washoff into the pond is probable.

#### 6.1.1.4 Oil and Grit Separators

Oil-grit separators (e.g., StormCeptors) are concrete chambers designed to remove oil, sediments, and floatable debris from runoff, and are typically used in areas with heavy traffic or high potential for petroleum spills such as parking lots, gas stations, roads, and holding areas. A three-chamber design is common; the first chamber traps sediment, the second chamber separates oil, and a third chamber holds the overflow pipe. The three-chambered unit is enclosed in reinforced concrete. They are good at removing coarse particulates, but soluble pollutants tend to pass through. In order to operate properly, the devices must be cleaned out regularly (at least twice a year). Oil-grit separators can be especially beneficial when used as pre-treatment for an infiltration basin or pond. They can also be incorporated into existing stormwater system or included in an underground vault detention system when no available land exists for a surface detention basin. Only moderate removals of total suspended solids can be expected; however, oil and floatable debris are effectively removed from properly designed oil and grit separators.

#### 6.1.1.5 Alum Treatment Plants

In addition to the commonly installed structural BMPs discussed above, alum treatment plants are becoming an option for efficiently removing phosphorus from tributaries, rather than directly treating the lake with alum to remove phosphorus. Alum (aluminum sulfate) is commonly used as a flocculent in water treatment plants and as an in-lake treatment for phosphorus removal. To treat inflows in streams or storm sewers, part of the flow is diverted (e.g., 5 cfs) from the main flow and treated with alum. After the alum is injected in the diverted flow it passes to a detention pond to allow the flocculent to settle out before the water enters the lake. Alum treatment has been shown to remove up to 90 percent of the soluble and particulate phosphorus from the inflows.

### 6.1.2 In-Lake BMPs

In-lake BMPs reduce phosphorus already present in a lake or prevent the release of phosphorus from the lake sediments. Several in-lake BMPs are discussed below.

#### 6.1.2.1 Removal of Benthivorous (Bottom-Feeding) Fish

Benthivorous fish, such as carp and bullhead, can have a direct influence on the phosphorus concentration in a lake (LaMarra, 1975). These fish typically feed on decaying plant and animal matter and other organic particulates found at the sediment surface. The fish digest the organic matter, and excrete soluble nutrients, thereby transforming sediment phosphorus into soluble phosphorus available for uptake by algae at the lake surface. Depending on the number of benthivorous fish present, this process can occur at rates similar to watershed phosphorus loads.

Benthivorous fish can also cause resuspension of sediments in shallow ponds and lakes, causing reduced water clarity and poor aquatic plant growth, as well as high phosphorus concentrations (Cooke et al., 1993). In some cases, the water quality impairment caused by benthivorous fish can negate the positive effects of BMPs and lake restoration. Depending on the numbers of fish present, the removal of benthivorous fish may cause an immediate improvement in lake water quality. The predicted water quality improvement following removal of the bottom-feeding fish is difficult to estimate, and will require permitting and guidance from the MDNR. In addition, using fish barriers to prevent benthivorous fish from spawning may adversely affect the spawning of game fish, such as northern pike.

#### 6.1.2.2 Application of Alum (Aluminum Sulfate)

Internal loading due to release from the sediment can be a significant source of phosphorus loading to a lake. Sediment release of phosphorus to the lake occurs during the summer months, when the water overlying the sediments is depleted of oxygen. This internal load of phosphorus is transported to the entire lake during late summer or early fall, when the surface waters cool sufficiently for wind-mixing to mix the entire lake (often referred to as “fall turnover”). Phosphorus released from the sediments is typically in a dissolved form, which can be quickly utilized by algae, leading to intense algae blooms. Areal application of alum has proven to be a highly effective and long-lasting control of phosphorus release from the sediments, especially where an adequate dose has been delivered to the sediments and where watershed sediment and phosphorus loads have been minimized (Moore and Thorton, 1988). Alum will remove phosphorus from the water column as it settles and then forms a layer on the lake bottom that covers the sediments and prevents phosphorus from entering the lake as internal load. An application of alum to the lake sediments can decrease the internal phosphorus load by 80 percent (*Effectiveness and Longevity of Phosphorus Inactivation with Alum*, Welch and Cook, 1999) and will likely be effective for approximately 7 to 10 years, depending on the control of watershed nutrient loads.

#### 6.1.2.3 Application of Herbicides

Controlling Curlyleaf pondweed can be done by herbicide treatments applied from a barge or boat or by mechanical harvesting, or by a combination of these methods. Herbicide treatments are more effective at eradicating the plant but MDNR regulations limit the extent of the lake that can be treated in any year. Aquatic herbicides are among the most closely scrutinized compounds known, and must be registered for use by both the U.S. EPA and the State of Minnesota. Registration of an aquatic herbicide requires extensive testing. Consequently, all of the aquatic herbicides currently registered for use are characterized by excellent toxicology packages, are only bio-active for short periods of time, have relatively short-lived residuals, and are not bioconcentrated (*The Lake Association Leader's Aquatic Vegetation Management Guidance Manual*, Pullmann, 1992). Examples of two aquatic herbicides appropriate for use in controlling the Curlyleaf pondweed growth in lakes are Reward (active ingredient = Diquat) and Aquathol-K (active ingredient = Endothall).

The use of low-level Sonar application has recently been found to selectively control exotic weed species such as Eurasian watermilfoil and Curlyleaf pondweed (*Whole-Lake Applications of Sonar for Selective Control of Eurasian Watermilfoil*, Getsinger *et al*, 2001). Due to past history of Sonar applications and the limited research on the new low level applications the use of Sonar is not feasibly at this time.

Both chemical and mechanical harvesting of macrophytes has been occurring in Lake Owasso for several decades. Until 2009, the MDNR permit for macrophyte management in Lake Owasso allowed for treatment of approximately 62 acres annually (up to 28 percent of the littoral area), which is greater than what the MDNR typically permits for herbicide treatment of macrophytes. Unless otherwise approved, the MDNR will currently only permit 15 percent of the littoral zone of a given lake be treated with herbicides.

#### 6.1.2.4 Application of Copper Sulfate

Copper sulfate applications can be a highly effective algaecides in some cases, but these efforts are always temporary (days) and can have high annual costs. In addition, care must be taken to limit the impacts on none target organisms, such as invertebrates, and possible sediment contamination with copper. The primary effects on algae include inhibition of photosynthesis and cell division as a result of the additional cupric ion, the form of copper toxic to algae, present in the water column (Cooke *et al*, 1993). Blue-green algae are particularly sensitive to copper sulfate treatments. As a result, after a copper sulfate treatment is made the blue-green algae concentration is knocked back. However, after a few days the green algae (fast growers) take control and within a few weeks the chlorophyll *a* concentration can be back to pretreatment levels (Ed Swain, MPCA). As the algae die and settle out of the water column they take with them the nutrients they used for growth. Therefore, copper sulfate application may temporarily reduce the total phosphorus concentration in a water body by removing the phosphorus that is associated with algal biomass. Once the algae have settled out of the water column and start to decompose, soluble phosphorus is released back into the water column that can be used for future algal growth. As a result, copper sulfate treatments are typically not considered a long-term solution to nutrient loading problems.

#### 6.1.2.5 Mechanical Harvesting

Harvesting of lake macrophytes is typically used to remove plants that are interfering with uses such as boating, fishing, swimming, or aesthetic viewing. Mechanical control involves macrophyte removal via harvesting, hand pulling, hand digging, rotovation/cultivation, or diver-operated suction dredging. Small-scale harvesting may involve the use of the hand or hand-operated equipment such as rakes, cutting blades, or motorized trimmers. Individual residents frequently clear swimming areas via small-scale harvesting or hand pulling or hand digging.

Large-scale mechanical control often uses floating, motorized harvesting machines that cut the plants and remove them from the water onto land, where they can be disposed. Mechanical harvesters consist of a barge, a reciprocating mower in front of the barge that can cut up to a depth of roughly 8 feet, and an inclined porous conveyer system to collect the cuttings and bring them to the surface. Typically a lake association or homeowner would contract a large scale harvesting operation at an estimated cost of $500/acre (McComas, 2007).

Removal of aquatic vegetation through mechanical harvesting has been shown to not be an effective nutrient control method (Cooke et al, 1993). However, none of this research was focused on the internal phosphorus load reduction due to mechanical harvesting of Curlyleaf pondweed. Blue Water

Science's 2000 *Orchard Lake Management Plan* suggests that there is up to 5.5 pounds of phosphorus per acre of Curlyleaf pondweed. Additional research mentions that harvesting can reduce the extent of nuisance Curlyleaf pondweed growth if harvesting occurs for several years and reduce stem densities by up to 80 percent (McComas and Stuckert, 2000). Therefore, harvesting of Curlyleaf pondweed may significantly reduce the phosphorus in the water column of a lake assuming enough biomass can be removed from the lake. This assumes that enough time and equipment would be available to harvest the Curlyleaf pondweed prior to die-back in early July.

While mechanical harvesting is more acceptable to the MDNR than chemical methods, it would still require an MDNR permit and provide only temporary benefits and must be repeated annually. The MDNR regulations state that the maximum area that can be harvested is 50 percent of the littoral zone.

#### 6.1.2.6 Hypolimnetic Withdrawal

Hypolimnetic withdrawal involves discharging the nutrient-rich waters from hypolimnion instead of surface waters. This typically results in a reduced hypolimnetic detention time, decreased chance for anaerobic conditions to develop, and reduced phosphorus availability for epilimnetic entrainment. The withdrawal is accomplished by extending a pipe from the lakes outlet along the lake bottom to the deepest part of the lake. This pipe can act as either a siphon or water can be pumped at a predetermined rate. By discharging nutrient-rich water from the hypolimnion the internal phosphorus load available when stratification breaks down can be reduced.

#### 6.1.2.7 Hypolimnetic Aeration

Hypolimnetic aeration involves the oxygenation in the hypolimnion of a thermally-stratified lake to raise the dissolved oxygen content within this layer of the lake without disrupting the stratification or temperature. By aerating the hypoliminion, the anoxic conditions that often develop along the sediment-water interface during the summer months in many thermally-stratified lakes can be minimized, reducing the internal phosphorus loading from the lake sediments into the water column. Hypolimnetic aeration can achieved through a variety of designs and set-ups, which can include mechanical agitation, injection of pure oxygen, and injection of air.

#### 6.1.2.8 Iron Salt Applications

The application of iron salts (such as ferric chloride or ferric sulfate) can be used to reduce TP concentrations within a lake. In aerobic conditions, the iron salts can be used to precipitate and/or inactivate the TP associated with lake sediments. Application of iron salts alone has not been shown to be effective in the long term. However, when used in combination with hypolimentic aeration, the results of the treatment have been more effective.

### 6.1.3 Nonstructural BMPs

Nonstructural ("Good Housekeeping") BMPs discussed below include:

1. Public Education
2. City Ordinances
3. Street Sweeping
4. Deterrence of waterfowl

Good housekeeping practices reduce the pollutant at its source.

#### 6.1.3.1 Public Education

Public education regarding proper lawn care practices, such as fertilizer use and disposal of lawn debris, can result in reduced organic matter and phosphorus loadings to the lake. A public information and education program may be implemented to teach residents within the Lake Owasso watersheds how to protect and improve the quality of the lake. The program would include distribution of fliers to all residents in the watershed and placement of advertisements and articles in the city's newsletters and the local newspapers. Information could also be distributed through organizations such as lake associations, local schools, Girl Scouts and Boy Scouts, and other local service clubs.

Initiation of a stenciling program to educate the public about stormwater could help reduce loadings to the storm sewer system. Volunteers could place stenciled messages (i.e., "Dump No Waste, Drains to Lake Owasso") on all storm sewer catch basins within the Lake Owasso watershed.

#### 6.1.3.2 City Ordinances

Fortunately, Minnesota already has a statewide phosphorus fertilizer ban already in place that restricts the residential use of phosphorus fertilizer.

#### 6.1.3.3 Street Sweeping

Most often, street sweeping is performed only in the spring, after the snow has melted and in the fall, after the leaves have fallen, to reduce this potential source of phosphorus from entering the storm sewer. For most urban areas, street sweeping has relatively low effectiveness from late spring (after the streets are cleaned of accumulated loads) until early fall (prior to the onset of leaf fall) (Bannerman, 1983). The use of vacuum sweepers is preferred over the use of mechanical, brush sweepers. The vacuum sweepers are more efficient at removing small phosphorus-bearing particles from impervious surfaces within the watershed. Fall street sweeping is particularly important in the watersheds directly tributary to the lakes, where treatment of stormwater is not available.

#### 6.1.3.4 Deterrence of Waterfowl

The role of waterfowl in the transport of phosphorus to lakes is often not considered. However, when the waterfowl population of a lake is large relative to the lake size, a substantial portion of the total phosphorus load to the lake may be caused by the waterfowl. Waterfowl tend to feed primarily on plant material in or near a lake; the digestive processes alters the form of phosphorus in the food from particulate to dissolved. Waterfowl feces deposited in or near a lake may result in an elevated load of dissolved phosphorus to the lake. One recent study estimated that one Canada goose might produce 82 grams of feces per day (dry weight) while a mallard may produce 27 grams of feces per day (dry weight) (Scherer et al., 2002). Waterfowl prefer to feed and rest on areas of short grass adjacent to a lake or pond. Therefore, shoreline lawns that extend to the water's edge will attract waterfowl. The practice of feeding bread and scraps to waterfowl at the lakeshore not only adds nutrients to the lake, but attracts more waterfowl to the lake and encourages migratory waterfowl to remain at the lake longer in the fall.

Two practices often recommended to deter waterfowl are construction of vegetated buffer strips, and prohibiting the feeding of waterfowl on public shoreline property. As stated above, vegetated strips along a shoreline will discourage geese and ducks from feeding and nesting on lawns adjacent to the lake, and may decrease the waterfowl population.

## 6.2 Previous Water Quality Improvement Recommendations

Several studies have been completed for Lake Owasso. This section summarizes the key recommendations, as discussed in the previous studies. Additionally, a brief discussion of any work aligning with the study recommendations that has been performed since the completion of these studies is also discussed.

### 6.2.1 *Water Quality Management Alternatives* Report (1991)

The *Water Quality Management Alternatives: A Report on the Diagnostic-Feasibility Study of Lake Owasso, Lake Wabasso, and Snail Lake* (Barr, 1991) made a variety of BMP recommendations for the Lake Owasso watershed to improved water quality in the lake. BMP recommendations were limited to projects within the watershed, and do not focus on addressing internal loading in Lake Owasso.

Some of the key BMP recommendations included:

- Development of extended detention in the Central Park – West wetland (LO_S_1),, in Charlie Pond (LO_W_1c), and in Ladyslipper Park ((LO_E_1j and LO_E_1k) near the bay on the southeast side of Lake Owasso) – either through the increase in storage or modification of outlet structure

- Increase wetland treatment in the Central Park – West wetland and in Ladyslipper Park
- Implementation of proprietary devices (oil/grit separators) throughout the watershed, including the area directly tributary to the lake
- Implementation of "Good Housekeeping Practices" throughout the watershed (fertilizer management, litter control, catch basin cleaning, and street sweeping).

Since the completion of the *Water Quality Management Alternatives* study, several BMPs based on the projects recommended in the 1991 report have been implemented throughout the watershed. These BMPs include:

- Additional storage and water quality treatment developed in the Central Park –West wetland in 1995.
- Rain gardens and a series of sedimentation ponds were constructed in Ladyslipper Park during the reconstruction of South Owasso Boulevard in 2006.
- Several proprietary structures have been implemented throughout the watershed including oil/grit separators in subwatersheds Dschg36 (2001), Dschg18 (2006), and LO_W_2a (2007). Additionally, and underground storage and treatment system was constructed along Owasso Heights Road in 2007, collecting runoff from subwatershed Dschg50, redirecting normal flows to the Charlie Pond system for treatment rather than discharging directly to the lake.

### 6.2.2 *Lake Owasso Management Plan* (2000)

The Lake Owasso Management Plan was developed as a response to concerns raised by residents to changes to the management of Lake Owasso. This study discussed the following management options:

- Maintain high water clarity as the result of continued protection of the lake's native macrophytes while controlling Eurasian watermilfoil and other nonnative species through continued monitoring of water quality, aquatic plant surveys, and regular milfoil inspections.
- Prevention of Eurasian watermilfoil from becoming problematic – this item was not longer valid as Eurasian watermilfoil was discovered in the lake in 2000.
- Provide safe and pleasant recreational uses by continuing their aquatic nuisance control plan and conducting a scientifically-based lake use study of Lake Owasso.
- Finding a solution to low lake levels by exploring feasible options for lake level augmentation

- Coordinate lake management by:
    - Continued work with the MDNR for aquatic plant management activities
    - Increased control and enforcement of recreational uses of the lake
    - Management of the fisheries by the MDNR
    - Management of lake levels
    - Dredging of Lake Owasso to remove materials that have been artificially or excessively deposited in the lake
    - Control of geese by encouraging lake shore restoration
    - Continued monitoring and evaluation of lake water quality
    - Continued implementation of watershed and stormwater management

The *Lake Owasso Management Plan* as included a discussion about the "Shallow Lake Bonus," related to the balanced management of aquatic plants. The idea of the shallow lake bonus suggests that when a lake supports healthy and diverse aquatic plants, water clarity increases. There are typically two types of stable lake systems that have very different characteristics and management methods: plant-dominated systems as well as algae dominated systems.

## 6.3 Feasibility Analysis

A trend analysis of the past 10 years of water quality data indicates that there has been a significant decrease in the water clarity in Lake Owasso, with an average summer transparency of 1.7 meters, just meeting the existing GLWMO goal. This value, however, does not meet the "action level" established by the GLWMO for Lake Owasso, and as a result, this UAA was required to evaluate Lake Owasso's current water quality conditions as well as evaluate management options that will help improve water quality in the lake.

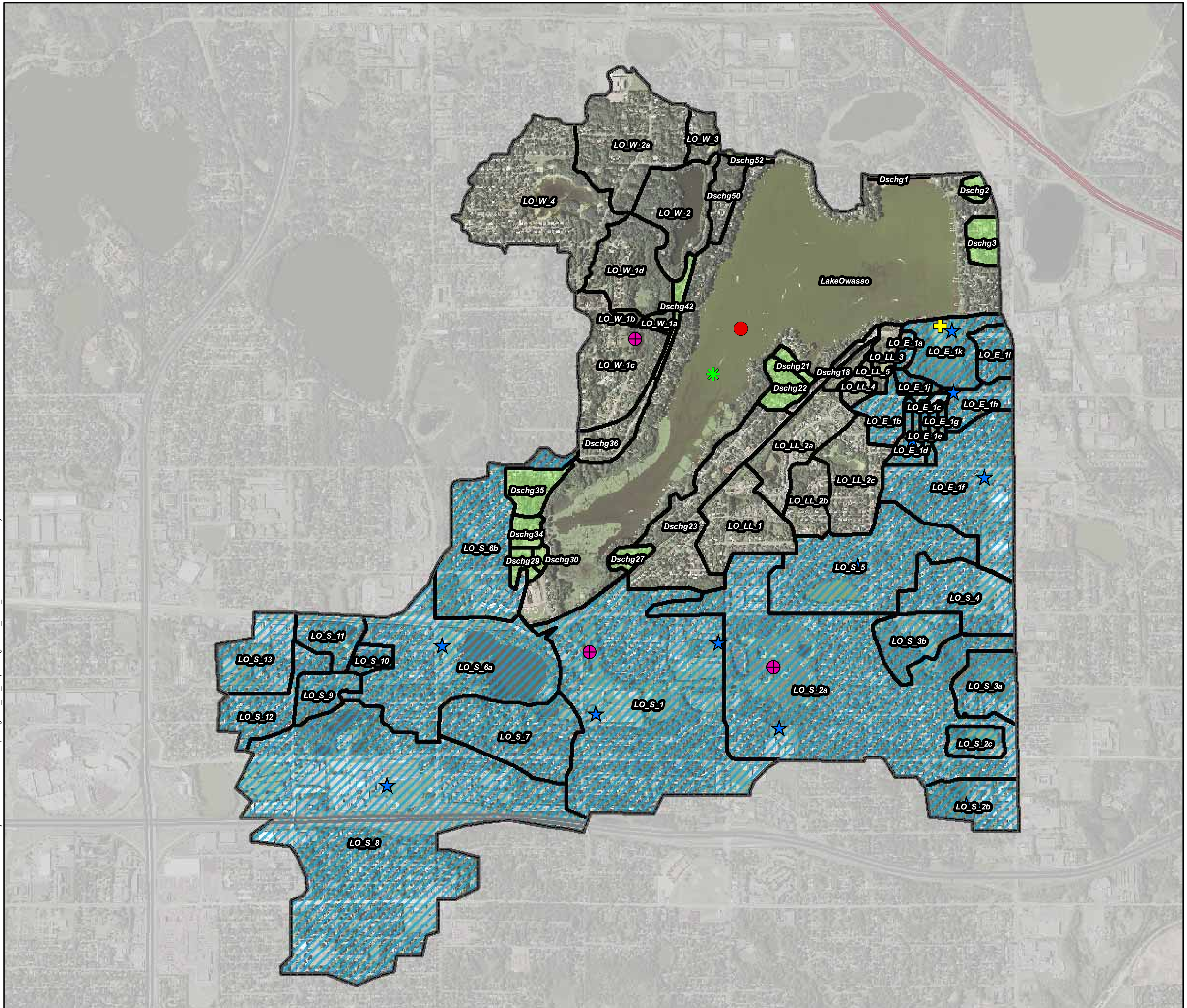
To maintain or improve the water quality in Lake Owasso, it will be necessary to implement BMPs in the lake as well as in the watershed. .A handful of treatment BMPs have been implemented in the Lake Owasso watershed in recent years as opportunities arose from road reconstruction or redevelopment. Some of these projects are summarized in Section 6.2.

Three types of BMPs were considered for recommendation in this plan:

1. Structural
2. In-lake
3. Nonstructural

Each of these types of BMPs are defined and discussed in Section 6.1. For watershed and in-lake water quality modeling, only structural and in-lake BMPs were evaluated for their potential impact on Lake Owasso's water quality. Section 6.3.14 includes a discussion of nonstructural BMPs as they apply to the Lake Owasso watershed.

Specific BMP alternatives that were considered for Lake Owasso and its watershed are discussed below and shown in Figure 6-1. Selection of the BMP scenarios was primarily based upon the Lake Owasso phosphorus budgets developed for the various climatic conditions to target the major sources of phosphorus to the lake. Table 6-2 summarizes the results of the various BMP scenarios evaluated as part of this UAA. Included in this summary is the predicted in-lake water quality (TP and SD) for each climatic conditions as well as a planning level cost estimate for the BMPs evaluated. A more detailed breakdown of estimated costs is available in Appendix N. Figure 6-2 shows the estimated summer average total phosphorus concentration and Secchi depth in comparison with the MPCA and GLWMO goals for Lake Owasso. It is important to note that not all of the BMP alternatives discussed below are recommended for implementation.




Scenario2:
Curlyleaf Pondweed Management

Scenarios 3 & 4:
Reduction in Internal Loading (10% & 50% Reduction)

Scenario 6:
Extended Detention in Bay (Ladyslipper Park)

Scenario 8:
Infiltration of 0.5" of Runoff from Contributing Impervious Area

Scenario 9:
Alum Treatment

Secnario 5:
Treatment to NURP Standards

Scenario 7:
Infiltration of 0.5" of Runoff from ALL Impervious Surfaces

Subwatershed

Feet
1,750 0 1,750

N

Figure 6-1

LAKE OWASSO
SUMMARY OF BMP SCENARIOS

Lake Owasso UAA
Grass Lake Watershed Management Organization

## Table 6-2 Lake Owasso Summary of BMP Scenarios

| Scenario | | Summer Average Water Quality | | | | | | | Reduction in TP (%) | Estimated BMP Cost ($) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Wet | | Dry | | | Average | | | |
| | | 2001-2002 | | 2007-2008 | | | 2004-2005 | | | |
| | | TP (µg/L) | SD (m)[10] | Site[1] | TP (µg/L) | SD (m)[10] | TP (µg/L) | SD (m)[10] | | |
| 1 | Existing Conditions[2] | 32 | 2.4 | 5403 | 41 | 2.0 | 45 | 1.5 | -- | -- |
| | | | | 5401 | 32 | 2.1 | | | | |
| 2 | 80% Reduction in Curlyleaf Pondweed[6] | 21 | 3.7 | 5403 | 29 | 2.6 | 33 | 2.3 | 27 - 39% | $649,000 |
| | | | | 5401 | 19 | 4.2 | | | | |
| 3 | 10% Reduction in the Internal Loading from Watershed Waterbodies | 31 | 2.4 | 5403 | 38 | 2.0 | 44 | 1.8 | 2 - 4% | N/A[12] |
| | | | | 5401 | 31 | 2.4 | | | | |
| 4 | 50% Reduction in the Internal Loading from Watershed Waterbodies | 28 | 2.6 | 5403 | 29 | 2.5 | 42 | 1.9 | 7 - 13% | N/A[12] |
| | | | | 5401 | 30 | 2.5 | | | | |
| 5 | Treatment of All "Untreated" Discharges to NURP Standards[5] | 32 | 2.3 | 5403 | 40 | 2.0 | 45 | 1.8 | 0 - 3% | $350,000 |
| | | | | 5401 | 31 | 2.4 | | | | |
| 6 | Extended Detention in Ladyslipper Park Pond (Replace outlet under the Railroad)[7] | 32 | 2.3 | 5403 | 41 | 1.9 | 45 | 1.8 | 0 - 3% | $55,000 |
| | | | | 5401 | 31 | 2.4 | | | | |
| 7 | Infiltration of 0.5 inches of Runoff from ALL Impervious Surfaces in the South and East Drainage Districts[3,8,11] | 26 | 2.9 | 5403 | 32 | 2.3 | 37 | 2.1 | 4 - 20% | $4,770,000 |
| | | | | 5401 | 30 | 2.4 | | | | |
| 8 | Infiltration of 0.5 inches of Runoff from Select Impervious Surfaces in the South and East Drainage Districts[3,9,11] | 31 | 2.4 | 5403 | 37 | 2.1 | 44 | 1.8 | 2 - 3% | $389,000 |
| | | | | 5401 | 31 | 2.4 | | | | |
| 9 | Alum Treatment (80% Reduction in Internal Load from Sediments) | 28 | 2.6 | 5403 | 40 | 2.0 | 43 | 1.9 | 6 - 11% | $198,000 |
| | | | | 5401 | 30 | 2.5 | | | | |
| 10 (2 + 3) | 80% Reduction in Curlyleaf Pondweed & 10% Reduction in the Internal Loading from Watershed Waterbodies[6] | 20 | 3.9 | 5403 | 26 | 2.8 | 32 | 2.3 | 29 - 39% | N/A[12] |
| | | | | 5401 | 19 | 4.2 | | | | |
| 11 (2 + 4) | 80% Reduction in Curlyleaf Pondweed & 50% Reduction in the Internal Loading from Watershed Waterbodies[6] | 17 | 5.4 | 5403 | 17 | 5.1 | 29 | 2.5 | 35 - 47% | N/A[12] |
| | | | | 5401 | 18 | 4.6 | | | | |
| 12 (2 + 8) | 80% Reduction in Curlyleaf Pondweed & Infiltration of 0.5 inches of Runoff from Select Impervious Surfaces in the South and East Drainage Districts[6,3,9] | 20 | 3.9 | 5403 | 25 | 3.0 | 31 | 2.4 | 31 - 38% | $1,038,000 |
| | | | | 5401 | 20 | 4.1 | | | | |
| 13 (2 + 9) | 80% Reduction in Curlyleaf Pondweed & Alum Treatment (80% Reduction in Internal Load from Sediments)[6] | 17 | 5.1 | 5403 | 28 | 2.6 | 30 | 2.4 | 33 - 46% | $847,000 |
| | | | | 5401 | 18 | 4.6 | | | | |

TP: Total Phosphorus Chl*a*: Chlorophyll *a* SD: Secchi Depth

1 - For 2008 (Dry Climatic Conditions), Lake Owasso was modeled as 2 separate basins (5403 - Southern Basin, and 5401 - Northern Basin) as there was water quality data available for both areas of the lake. For 2002 (Wet Climatic Conditions) and 2005 (Average Climatic Conditions), the water quality data was only collected at basin 5401 and the lake was modeled as a single basin.

2 - Existing land use and 2008 watershed/BMP conditions. Very few changes are expected in land use as the Lake Owasso watershed is fully-developed. Therefore, it was assumed that existing land use is also reflective of future land use conditions.

3 - Internal loading from the watershed was modified for the infiltration scenario based on the reduction in water load to the wetlands.

4 - It is not feasible to treat all currently untreated direct discharges to Lake Owasso using a single NURP pond. This analysis was performed to demonstrate the impact that treating each discharge to NURP standards would have on overall lake water quality

5 - This scenario is not physically feasible as the currently "untreated" direct discharges are distributed around the entire shoreline of Lake Owasso. Additionally, there is not sufficient space to incorporate NURP ponds in each of the direct discharge watersheds. This scenario was evaluated to demonstrate the impact of treating all direct discharges on the overall water quality in Lake Owasso. This cost estimate is based on the construction of a single, hypothetical NURP pond sized to treat all "untreated" discharges to Lake Owasso.

6 - The estimated cost of the Curlyleaf Pondweed Treatment includes the MDNR variance to treat the entire littoral area of Lake Owasso, 4-years of herbicide application to the Lake, as well as 4-years of detailed macrophyte monitoring to track the herbicide treatment on the Curlyleaf pondweed coverage

7 - Development of an extended detention basin in Lady Slipper Park (in subwatershed LO_E_1k) along with the replacement of the outlet under the railroad embankment with a weir structure were evaluated as part of the 1991 *Report on the Diagnostic-Feasibility Study of Lake Owasso, Lake Wabasso, and Snail Lake.* Since 1991, the City of Roseville developed infiltration and sedimentation ponds in this area as part of the South Owasso Boulevard road reconstruction project in 2006. This study evaluates replacing the outlet under the railroad embankment only.

8 - Infiltration of 0.5" from all impervious surfaces in the South and East Drainage Districts is not feasible. This scenario was evaluated to estimate the maximum impact infiltration could potentially have on Lake Owasso's water quality.

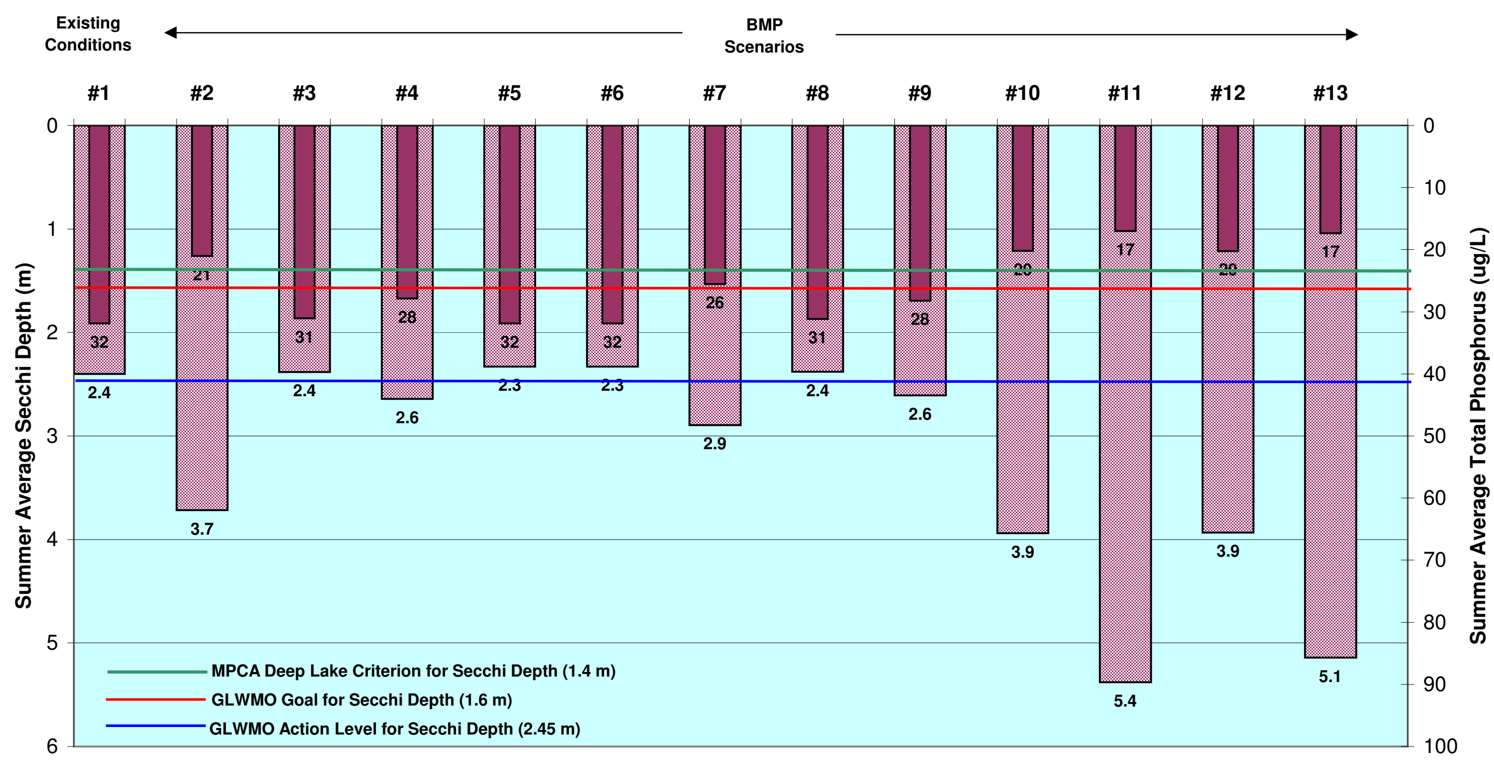
9 - Selected potential infiltration sites include 11 preliminary locations within the South and East Drainage Districts. Sites were selected based on the presence of open space, proximity to existing storm sewer (potential to reroute or divert flows), and topography. Available soils data were condsidered although much of the Lake Owasso is classified as undefined hydrologic soils group. These are planning level cost estimates and each site would require a more complete feasibility study before final design.

10 - Existing Condition summer average Secchi depth based on 2008 monitoring data; For all BMP scenarios, estimated based on the Secchi Depth versus Total Phosphorus Regression Relationship for Lake Owasso (See Figure

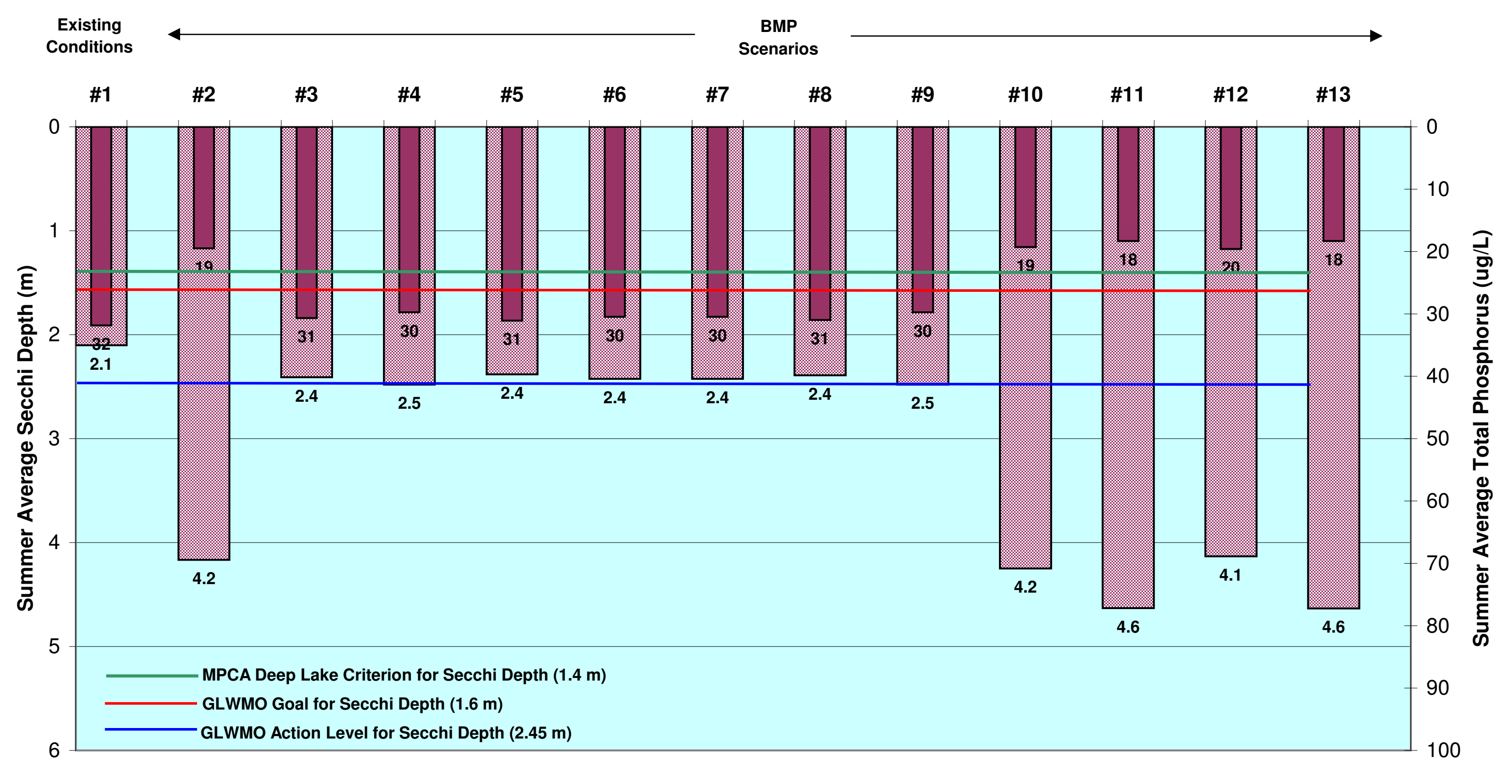
11 - The estimated cost of infiltration BMPs is based on typical unit costs ($13/sq.ft.) estimated for the construction of rain gardens plus 30 percent for engineering and design. Depression storage was assumed to be 18 inches. This cost does not include any potentially significant changes to the storm sewer system/additional piping that may be needed.

12 - Because specific BMPs to address the internal loading in the waterbodies within the watershed are not recommended until further studies of the internal loading can be completed, no costs have been estimated for these scenarios.

Lake Owasso Water Quality
Wet Year (2002) Climatic Conditions




Lake Owasso Water Quality
Dry Year (2008) Climatic Conditions*




*Site 5401

Lake Owasso Water Quality
Average Year (2005) Climatic Conditions

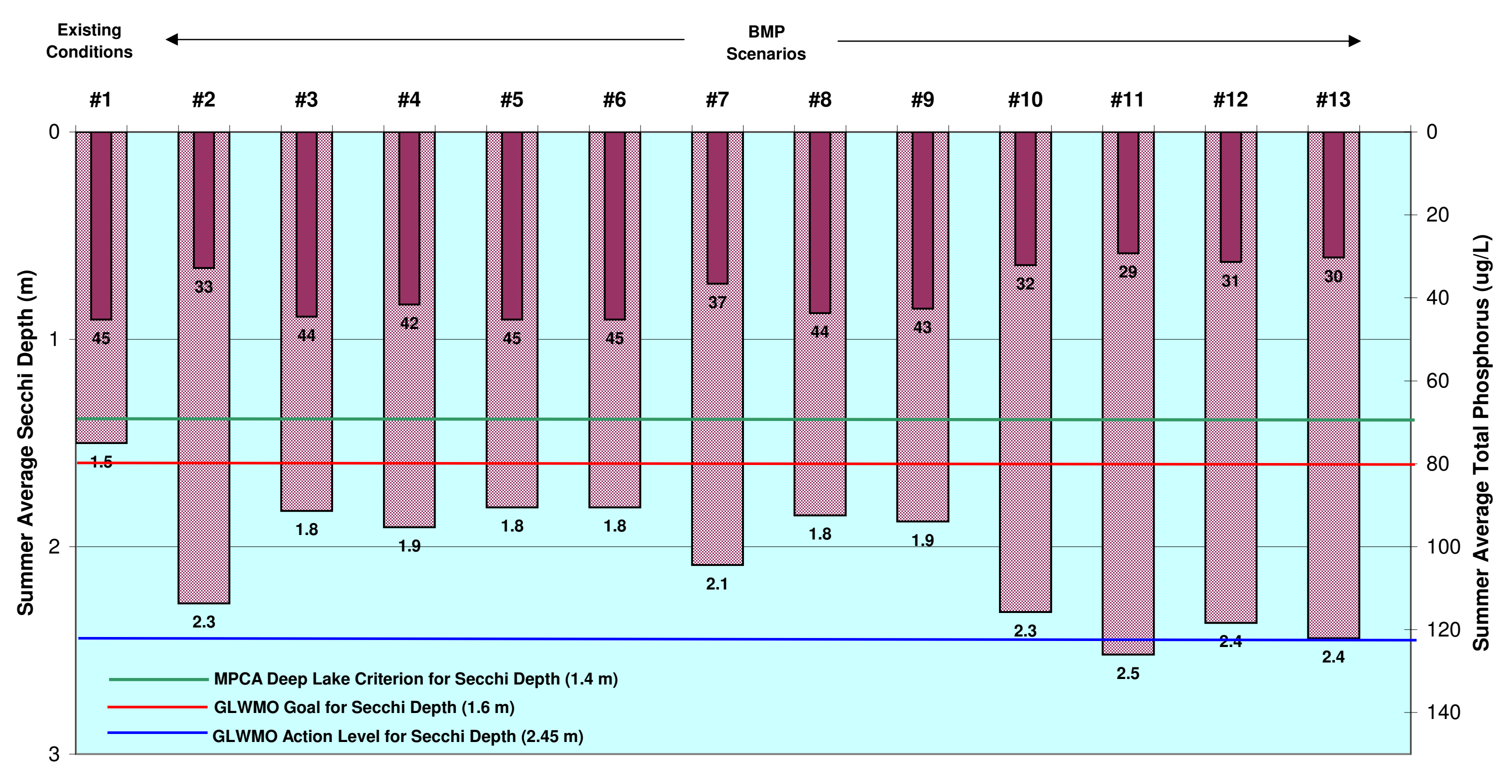



**Figure 6-2**
**Lake Owasso Summary of BMP Scenario Results and Comparison with MPCA and GLWMO Goals**

### 6.3.1 Scenario 1: Existing Conditions

The existing conditions scenario is reflective of existing land use and the 2008 watershed and BMP conditions for the wet, dry, and average climatic scenarios. These values (based on the monitoring data for each year reflective of the climatic conditions) are used as a baseline for comparison when evaluating the impact of potential BMPs on the overall water quality of Lake Owasso.

### 6.3.2 Scenario 2: Curlyleaf Pondweed Treatment

Both historic and current macrophyte surveys of Lake Owasso indicate the widespread presence of problematic non-native species in Lake Owasso: Curlyleaf pondweed. Survey results from May 2007 indicate that Curlyleaf pondweed was found at moderate densities in several areas of the lake. Curlyleaf pondweed was especially focused in the southern "arm" of the lake as well as along the shoreline north of the railroad tracks. Historic surveys, as far back as 1981, indicate that Curlyleaf pondweed has been present in Lake Owasso.

Management of Curlyleaf pondweed is recommended to protect the lake's native plant community and prevent dense plant growths that create recreational nuisance conditions. Management of Curlyleaf pondweed may also minimize the impact of die-off that typically occurs in early to mid-summer, which can cause increased phosphorus levels in the lake resulting in algal growth and decreased water quality and clarity.

Water quality modeling indicates that phosphorus released from the die-back of Curlyleaf pondweed can significantly affect Lake Owasso's water quality during the summer months, accounting for about 17 to 33 percent of the phosphorus load to the lake on an annual basis. Following treatment of Curlyleaf pondweed in Lake Owasso, modeling simulations indicate the summer-average total phosphorus concentration would be reduced by 27 to 39 percent based on the various climatic conditions (See Table 6-2). This translates to a reduction in the summer average total phosphorus concentrations by 11 to 13 μg/L. The estimated total phosphorus concentrations would result in a summer-average Secchi disc transparency of 2.3 to 4.2 meters (increased from 1.5 to 2.4 meters for existing conditions), depending on the climatic condition .

The model assumes that the treatment of Curlyleaf pondweed will decrease the internal phosphorus load from the die-back of the macrophyte by 80 percent.

The estimated capital cost of the Curlyleaf pondweed treatment is $649,000 (or approximately $162,000 annually). This estimate includes a variety of components including:

- Obtaining the MDNR treatment permit and letter of variance
- Obtaining letters of permission to treat within 150 feet of shoreline property boundaries
- 4-years of Endothall treatments of Lake Owasso (this assumes treatment of the entire littoral area, approximately 293 acres)
- 4-years of Monitoring, Analysis, and Reporting

Currently, the Lake Owasso homeowners association spends $50,000 – 60,000 per year on macrophyte management. See Section 8.3.1 for a more detailed discussion of the proposed Curlyleaf pondweed management plan for Lake Owasso and Appendix N for a more detailed breakdown of the estimated costs.

Because the management of Curlyleaf pondweed can have a significant impact on the Lake Owasso summer water quality, is one of the recommended in-lake BMPs.

### 6.3.3 Scenario 3: 10% Reduction in the Internal Loading from Watershed Waterbodies

Evaluation of the runoff monitoring data along with modeling results indicated that internal loading occurs in several water bodies within the watershed and contributes a significant portion of the annual phosphorus load to Lake Owasso (5 to 9 percent). Because additional monitoring and studies are recommended to better understand these sources of phosphorus to Lake Owasso, the impact of specific BMPs could not be evaluated. However, modeling scenario assuming a 10 percent reduction in this internal load was evaluated to estimate the impact on the overall water quality in Lake Owasso.

Modeling simulations indicate that by reducing the internal load from waterbodies in the watershed, the summer-average total phosphorus concentration would be reduced by 2 to 4 percent based on the various climatic conditions (See Table 6-2). This translates to a reduction in the summer average total phosphorus concentration by 1 to 3 μg/L. The estimated total phosphorus concentrations would result in a summer-average Secchi disc transparency of 1.8 to 2.4 meters (increased from 1.5 to 2.4 meters for existing conditions), depending on the climatic condition.

Specific BMPs to address the internal loading from waterbodies in the watershed are not recommended at this time. Current information suggests that the loading is the result of carp activity in the wetlands or potentially the release of phosphorus from the sediments in the wetland. Further investigations and monitoring are recommended to develop appropriate management plans for the waterbodies (see Section 8.1 for a more complete discussion of the recommended monitoring and studies). Therefore, costs have not been estimated at this time.

### 6.3.4 Scenario 4: 50% Reduction in the Internal Loading from Watershed Waterbodies

Similar to BMP Scenario 3, this modeling scenario assumes a 50 percent reduction in the internal load. Modeling simulations indicate that by reducing the internal load from waterbodies in the watershed, the summer-average total phosphorus concentration would be reduced by 7 to 13 percent based on the various climatic conditions (See Table 6-2). This translates to a reduction in the summer average total phosphorus concentrations by 2 to 4 μg/L. The estimated total phosphorus concentrations would result in a summer-average Secchi disc transparency of 1.9 to 2.6 meters (increased from 1.5 to 2.4 meters for existing conditions), depending on the climatic condition.

Like Scenario 3, specific BMPs to address the internal loading from waterbodies in the watershed are not recommended at this time. However, further investigations and monitoring are recommended to develop appropriate management plans for the waterbodies (see Section 8.1 for a more complete discussion of the recommended monitoring and studies). Therefore, costs have not been estimated at this time.

### 6.3.5 Scenario 5: Treatment of All Currently "Untreated" Direct Discharges to NURP Standards

Appoximately 55 direct discharges to Lake Owasso, under both public (23) and private (32) jurisdiction, have been identified and inventoried, as a response to address concerns of lake residents. About half of the public discharges have water quality treatment upstream of Lake Owasso. There are, however, about 45 (13 public and 32 private) of these discharges that currently receive no water quality treatment before discharging to the lake.

To better understand the impact of these currently untreated watershed discharges on the overall water quality of Lake Owasso, a hypothetical scenario was developed, evaluating the treatment of all direct discharges to Lake Owasso to NURP water quality removal standards. Only those discharges that are under public jurisdiction were evaluated (see Figure 6-1 for the 10 subwatersheds) and were routed to a water quality treatment pond designed to NURP standards. It is important to note that this BMP scenario is not feasible due to space limitations within the currently untreated watersheds and was only performed to demonstrate the impact of water quality treatment in these watersheds on Lake Owasso's water quality.

Water quality modeling indicates that treating the currently untreated direct discharges will have little impact on Lake Owasso's water quality during the summer months. Treatment to NURP water quality standards would only result in a 0 to 3 percent reduction in the total phosphorus concentration in the lake for the three climatic conditions (See Table 6-2). This translates to a reduction in the summer average total phosphorus concentrations by 0 to 1 μg/L. The estimated total phosphorus concentrations would result in a summer-average Secchi disc transparencies similar to what is observed during existing conditions.

As a result of this analysis, the construction of NURP water quality treatment ponds in the currently untreated watersheds is not recommended as a structural BMP for implementation It should also be noted that NURP ponds area typically designed for the removal of particulates (and phosphorus bound to the particulates), and have very little impact on dissolved phosphorus. However, as opportunities arise to retrofit stormwater BMPs in these specific subwatersheds, as well as throughout the Lake Owasso watershed, .the Cities of Roseville and Shoreview, along with the GLWMO, should continue to consider the implementation of infiltrations practices, such as the 2009 pervious pavement project planned in the Woodridge area of Shoreview, which address both particulate and dissolved phosphorus fractions, where feasible.

#### 6.3.6 Scenario 6: Extended Detention in Ladyslipper Park Pond

As part of *Water Quality Management Alternatives* study (Barr, 1991), extended detention in Ladyslipper Park (subwatershed LO_E_1k) was one of the recommended BMPs within the Lake Owasso watershed, either through the creation of a extended detention basin within the park or through the installation of a weir structure at the outlet from the bay under the Northern Pacific Railroad.

In 2006, as part of the South Owasso Boulevard road reconstruction project, several sedimentation ponds were constructed on the south end of the park, although these are not extended detention basins, as recommended in the *Water Quality Management Alternatives* study (Barr, 1991).

Extended detention through the installation of a weir-structure was reevaluated as part of this study. Flows could be detained within the bay for a longer period through the use of a restricted outlet structure, such as a notched-weir. The current outlet is an open channel flowing from the bay to Lake Owasso. Installation of this structure would need approval from the from the Northern Pacific Railroad for work to be completed within the railroad right-of-way as well as from the MDNR for work to be completed within a public wetland and proposed modifications to a wetland elevation.

Water quality modeling indicates that extended detention within the bay in Ladyslipper Park will have little impact on Lake Owasso's water quality during the summer months. The extended detention would only result in a 0 to 3 percent reduction in the total phosphorus concentration in the lake for the three climatic conditions (See Table 6-2). This translates to a reduction in the summer average total phosphorus concentrations by 0 to 1 μg/L. The estimated total phosphorus concentrations would result in a summer-average Secchi disc transparencies similar to what is observed during existing conditions.

The estimated capital cost of the installation of weir structure at the outlet of the bay for extended detention is approximately $55,000. However, because of the limited impact of extended detention on the overall water quality of Lake Owasso for all climatic conditions, it is not a recommended BMP for implementation.

### 6.3.7 Scenario 7: Infiltration of 0.5 Inches of Runoff from all Impervious Surfaces in the South and East Drainage Districts

Implementation of infiltration BMPs in the Lake Owasso watershed was evaluated to determine the potential reduction in watershed runoff and nutrient loading to Lake Owasso and the associated impacts on in-lake water quality.

The first step was to identify the feasibility of infiltration in the watershed based on soil conditions, topography, and land use. Based on information from the Ramsey County soil survey, the soils in much of the Lake Owasso watershed are primarily undefined or urban soil types. This is because much of the Lake Owasso watershed was already developed at the time the soils surveys were originally completed. Soils that are classified are typically Hydrologic Soil Group B (moderate infiltration potential) with some areas of Hydrologic Soils Group A (high infiltration potential) in the far eastern parts of the watershed. Most wetland areas have soils classified as Type D soils, or soils not good for the infiltration of stormwater. Conversations with the City of Shoreview also indicated that soils in the western part of the Lake Owasso watershed are not conducive to infiltration. Additionally, the western part of the watershed has a much steeper terrain than in the south and east, which is not ideal for infiltration BMPs. Therefore, as the result of the general soils conditions and the topography in the western watersheds, implementation of infiltration BMPs was only considered in the South and East drainage districts.

The first scenario evaluated served as an extreme case for the implementation of infiltration throughout the Lake Owasso watershed. This scenario assumed that the first 0.5 inches of runoff from ALL impervious surfaces in both the South and East drainage districts would be able to be infiltrated, regardless of the actual opportunities (available open space, topography, soil type, proximity to existing storm sewer, etc.) to retrofit infiltration BMPs throughout the watershed. Under this scenario, approximately 300 acres of impervious surface would be treated by infiltration.

Water quality modeling indicates that implementation of infiltration practices throughout the Lake Owasso watershed can significantly affect Lake Owasso's water quality during the summer months. Currently, watershed runoff accounts for about 22 to 31 percent of the phosphorus load to the lake on an annual basis. Modeling simulations indicate that with the implementation of infiltration throughout the watershed, the summer-average total phosphorus concentrations in the lake would be reduced by 4 to 20 percent based on the various climatic conditions (See Table 6-2). This translates to a reduction in the summer average total phosphorus concentrations by 2 to 8 μg/L. The estimated total phosphorus concentrations would result in a summer-average Secchi disc transparency of 2.1 to 2.9 meters (increased from 1.5 to 2.4 meters for existing conditions), depending on the climatic condition.

It is important to note that infiltration not only reduces the volume of watershed runoff but can also result in the reduction of the estimated internal load from upstream waterbodies in the watershed to Lake Owasso. This is related to a reduction in the overall phosphorus and water loads to the waterbodies that potentially act a source of phosphorus to Lake Owasso. Reducing the water load to these water bodies also reduces the discharge volume, and thus the phosphorus load, to Lake Owasso.

Again, this scenario represents an extreme condition that is not likely feasible in the Lake Owasso watershed. However, a planning level cost estimate was developed for implementation of infiltration at this scale. This cost estimate for this scenario assumes that the infiltration practices will be designed with 18 inches of depression storage. Assuming a typical unit cost for the design and construction of rain garden infiltration systems, the estimated cost for infiltration of runoff from all impervious surfaces in the South and East drainage districts is $4,770,000.

The next scenario looks at select sites for the implementation of potential infiltration BMPs within the South and East drainage districts.

### 6.3.8 Scenario 8: Infiltration of 0.5 Inches of Runoff from Select Impervious Surfaces in the South and East Drainage Districts

This scenario further refines the previous scenario (Scenario 7) that considered infiltration of 0.5 inches of runoff from all impervious surfaces in the South and East drainage districts. This scenario considered available open space. In some cases, the open space includes developed park areas (such as ballfields and other playing fields) and the selection of sites did not distinguish between public and private land. Topography and the proximity to existing storm sewer where also used to identify sites that could provide more regional infiltration opportunities by diverting and treating a portion of the runoff from the existing storm sewer system.

Eleven potential infiltration sites were selected throughout the South and East drainage districts, to infiltrate runoff from approximately 25 acres of impervious surface within this area (See Figure 6-3 and Table 6-3 for locations and location descriptions). Because of the limited area available in some locations for the development of infiltration areas, as well as the generally large size of the expected contributing areas, it was assumed that only a fraction of the flows from the contributing area would be diverted to the proposed regional infiltration basins. On average, it was assumed that about 50 percent of the flows from the first 0.5 inches of runoff from the impervious surfaces within the entire contributing area would be treated by infiltration.

Water quality modeling indicates that implementation of select regional infiltration practices throughout the Lake Owasso watershed can impact Lake Owasso's water quality during the summer months. Modeling simulations indicate that with the implementation of select regional infiltration throughout the watershed, the summer-average total phosphorus concentrations in the lake would be reduced by 2 to 3 percent based on the various climatic conditions (See Table 6-2). This translates to a reduction in the summer average total phosphorus concentrations by 1 to 4 µg/L. The estimated total phosphorus concentrations would result in a summer-average Secchi disc transparency of 1.8 to 2.4 meters (increased from 1.5 to 2.4 meters for existing conditions), depending on the climatic condition.

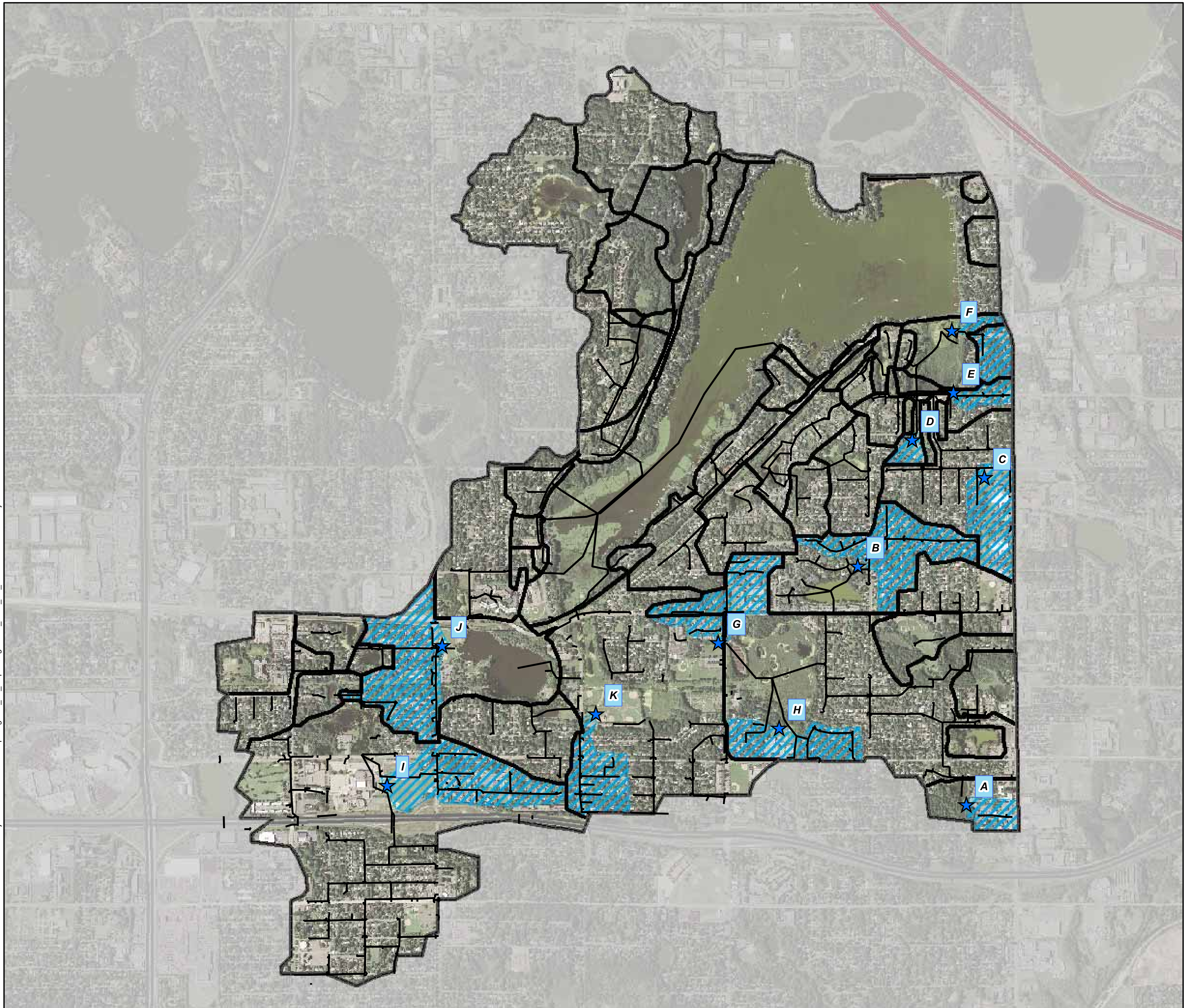
**Table 6-3 Location Description of Select Infiltration BMPs**

| Infiltration Area ID | Location Description |
|---|---|
| A | Materion Park - On Southside of Pond |
| B | Open space in the Southwest Corner of Woodhill Drive and Western Ave N |
| C | Northwest Corner of Rosedale Estates |
| D | Mapleview Park |
| E | Private Parcel Along Southeast Corner of Ladyslipper Park |
| F | Private Parcel Along Northeast Corner of Ladyslipper Park |
| G | Central Park - North of Soccer Field |
| H | Central Park Elementary School Ballfields |
| I | Roseville High School - Playing Fields |
| J | Central Park - Ballfields West of Bennett Lake |
| K | Central Park - Ballfields South of Central Park - West Wetland |

Implementation of infiltration practices throughout the Lake Owasso watershed is recommended. As previously mentioned, unlike NURP treatment (wet detention), infiltration can reduce both dissolved and particulate fractions of phosphorus in stormwater runoff as well as runoff volumes. As opportunities arise to retrofit stormwater BMPs the Lake Owasso watershed, the Cities of Roseville and Shoreview, along with the GLWMO, should continue to consider the implementation of infiltrations practices where feasible.

The planning level cost estimates for the select infiltration projects is $389,000. This estimate is based on the same assumptions for infiltration as outlined for Scenario 7. Potential additional costs for each specific project shown in Figure 6-3 may include the following:

- Complete feasibility studies that would verify local site conditions are conducive for infiltration and to identify specific needs for each project
- Costs associated with the purchase of private land or obtaining easements
- Complexity of the project to preserve existing uses of the area (e.g. infiltration in areas that are currently ball/playing fields)
- Costs associated with the rerouting of existing storm sewer and the construction of flow diversion structures.




Infiltration of 0.5" of Runoff from Contributing Impervious Area

Infiltration BMPs Subwatersheds

Storm Sewer

Subwatershed

Note: For watersheds and in-lake modeling, it was assumed that only a fraction of watershed runoff would be diverted to the proposed infiltration BMPs.

Feet

1,750 0 1,750

Figure 6-3

SCENARIO 7: LOCATION & APPROXIMATE WATERSHEDS OF SELECT INFILTRATION BMPs

Lake Owasso UAA
Grass Lake Watershed Management Organization

### 6.3.9 Scenario 9: Alum Treatment

In-lake application of alum (aluminum sulfate) to prevent sediment phosphorus release in Lake Owasso during the summer months was also evaluated. Water quality modeling indicates that sediment-released phosphorus can affect the lake's water quality during the summer months, accounting for about 16 to 37 percent of the phosphorus load to the lake on an annual basis.

Following an alum treatment of Lake Owasso, which based on literature was assumed to decrease the internal phosphorus load by 80 percent, modeling simulations indicate the summer-average total phosphorus concentration would be reduced by 6 to 11 percent based on the various climatic conditions (See Table 6-2). This translates to a reduction in the summer average total phosphorus concentrations by 2 to 4 μg/L. This would result in summer-average Secchi disc transparencies ranging from 1.9 to 2.6 meters (increased from 1.5 to 2.4 meters for existing conditions), depending on the climatic condition.

The estimated capital cost of an in-lake alum application in Lake Owasso is $198,000, based on dosing information that pertains to the internal loading rate calculated for the lake's sediments using the results from the 2007 sediment core analysis (see Section 5.3.2 for more discussion about the sediment core analysis).

The longevity of an alum treatment is difficult to estimate, as it depends on many factors including the degree to which watershed sediment and phosphorus loads are controlled, flow regimes (especially in shallow lakes) and the accuracy with which the alum treatment was dosed. Because sediment core analyses allow for a more accurate dosing calculation, it is reasonable to expect that an alum treatment of Lake Owasso would be correctly dosed. For this reason, it is estimated that an alum treatment of Lake Owasso could last as long as 10 years, especially in the deeper areas of the lake. This assumption is consistent with observations of other alum-treated lakes (Welch and Cooke, 1999).

An alum treatment of Lake Owasso is currently not recommended at this time. This may be an option for future consideration, after the Curlyleaf pondweed management plan has been implemented and the impacts of that management effort have been evaluated.

### 6.3.10 Scenario 10: Curlyleaf Pondweed Treatment + 10% Reduction in the Internal Loading from Watershed Waterbodies

Scenario 10 evaluated the implementation of the treatment of Curlyleaf pondweed to address internal phosphorus loads as well as reducing the internal phosphorus loads from the upstream waterbodies within the watershed by 10 percent. Modeling simulations indicate this combination of BMPs would reduce the summer-average total phosphorus concentrations by 29 to 30 percent depending on the various climatic conditions (See Table 6-2). This translates to a reduction in the summer average total phosphorus concentration of 12 to 13 μg/L. The estimated total phosphorus concentrations would result in a summer-average Secchi disc transparency of 2.3 to 4.2 meters (increased from 1.5 to 2.4 meters for existing conditions), depending on the climatic condition.

Because specific BMPs to reduce the internal loading from the watershed waterbodies have not been recommended until further studies can be completed in these waterbodies. As a result, the costs for the internal load reductions have not been estimated. The expected costs for Curlyleaf pondweed are discussed in Section 6.3.2. More details about Curlyleaf pondweed management area discussed in Section 8.3.1.

### 6.3.11 Scenario 11: Curlyleaf pondweed treatment + 50% Reduction in the Internal Loading from Watershed Waterbodies

Scenario 11 evaluated the implementation of the treatment of Curlyleaf pondweed to address internal phosphorus loads as well as reducing the internal phosphorus loads from the waterbodies within the watershed by 50 percent. Modeling simulations indicate this combination of BMPs would reduce, the summer-average total phosphorus concentrations by 35 to 47 percent based on the various climatic conditions (See Table 6-2). This translates to a reduction in the summer average total phosphorus concentration of 14 to 16 μg/L. The estimated total phosphorus concentrations would result in a summer-average Secchi disc transparency of 2.5 to 5.4 meters (increased from 1.5 to 2.4 meters for existing conditions), depending on the climatic condition.

Because specific BMPs to reduce the internal loading from the watershed waterbodies have not been recommended until further studies can be completed in these waterbodies. As a result, the costs for the internal load reductions have not been estimated. The expected costs for Curlyleaf pondweed are discussed in Section 6.3.2. More details about Curlyleaf pondweed management area discussed in Section 8.3.1.

### 6.3.12 Scenario 12: Curlyleaf pondweed treatment + Infiltration of 0. 5 Inches of Runoff from Select Impervious Surfaces in the South and East Drainage Districts

Scenario 12 evaluated the implementation of the treatment of Curlyleaf pondweed to address internal phosphorus loads as well as distributed infiltration BMPs throughout the Lake Owasso watershed. Water quality modeling indicates that implementation this combination of BMPs can significantly improve Lake Owasso's water quality during the summer months, indicating that the summer-average total phosphorus concentrations in the lake would be reduced by 31 to 38 percent depending on the various climatic conditions (See Table 6-2). This translates to a reduction in the summer average total phosphorus concentrations of 12 to 14 µg/L. The estimated total phosphorus concentrations would result in a summer-average Secchi disc transparency of 2.4 to 4.1 meters (increased from 1.5 to 2.4 meters for existing conditions), depending on the climatic condition.

The estimated cost of the combined treatments, including the Curlyleaf pondweed management and the implementation of infiltrations BMPs throughout the watershed was $1,038,000.

### 6.3.13 Scenario 13: Curlyleaf Pondweed Treatment + Alum Treatment

Scenario 13 evaluated the implementation of two different in-lake treatments to address the major sources of internal phosphorus loading: management of Curlyleaf pondweed and an alum treatment to reduce loading from the sediments. Water quality modeling indicates that implementation this combination of BMPs can significantly improve Lake Owasso's water quality during the summer months, indicating that the summer-average total phosphorus concentrations in the lake would be reduced by 33 to 46 percent depending on the various climatic conditions (See Table 6-2). This translates to a reduction in the summer average total phosphorus concentrations of 14 to 15 µg/L. The estimated total phosphorus concentrations would result in a summer-average Secchi disc transparency of 2.4 to 5.1 meters (increased from 1.5 to 2.4 meters for existing conditions), depending on the climatic condition.

The estimated cost of the combined treatments, including the Curlyleaf pondweed management and the alum treatment was $847,000.

### 6.3.14 Nonstructural BMP Alternatives for Lake Owasso

Water quality treatment ponds and other traditional BMPs are effective at removing most coarse particulates and phosphorus associated with coarse particles. However, these BMPs may not be highly effective at removing soluble phosphorus, or phosphorus associated with extremely small particles. Therefore, source control becomes extremely important in reducing the amount of phosphorus contained in stormwater runoff. Nonstructural BMPs are effective at reducing the amount of phosphorus on-site, prior to transport by stormwater runoff. Examples of effective nonstructural BMPs that would be appropriate for the Lake Owasso watershed include:

1. Provide public education programs to inform the residents of the Lake Owasso watershed of ways to reduce phosphorus loading through proper handling of yard wastes, fertilizers, pet wastes, soaps, and detergents.
2. Encourage industrial/commercial area owners to institute good housekeeping practices, including appropriate disposal of yard wastes, appropriate disposal of trash and debris, appropriate storage and handling of soil and gravel stockpiles.
3. Discourage the feeding of waterfowl at shoreline areas around Lake Owasso.
4. Encourage vegetated buffers between yards and wetlands and ponds.
5. Require vegetated buffers between yards and the shore of Lake Owasso.
6. Perform regular street sweeping, especially in high-density residential areas, industrial/commercial areas, and any other areas containing large areas of impervious (paved surfaces), such as school and church parking lots. Spring and fall street sweeping will provide the most benefits for phosphorus source reduction.

It is not possible to model the effects of all nonstructural BMPs accurately, but studies have shown that they are moderately effective at reducing phosphorus loads.