ACKNOWLEDGEMENTS

This Groundwater Dependent Natural Resource Management Plan has been developed by the Brown's Creek Watershed District (BCWD) with the assistance of a Technical Advisory Group (TAG) established for the purpose of assisting with development of this plan. The BCWD would like to thank the following individuals for participating on the Technical Advisory Group:

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In addition, the BCWD would like to thank Mike Regan for his participation in this project, access to the property, and for providing valuable local knowledge of the resource being studied.

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1.0 Introduction

As the Twin Cities Metropolitan Area continues to expand, residential and commercial development are changing the landscape and impacting natural resources. Since it's inception in 1997, the Brown's Creek Watershed District (BCWD) has been subject to increasing development pressures. This development pressure prompted the Board to develop its first set of Rules and Regulations in 1998. These rules were the first in the State of Minnesota to incorporate a volume control standard; designed to protect Brown's Creek, a cold-water fishery, from the increasing levels of imperviousness in the landscape.

Since these first rules were adopted by the BCWD, growing appreciation for the quality and quantity of groundwater dependent natural resources remaining in Washington County prompted the Board to go even further in the protection of these important and unique natural resources. In 2007, the BCWD adopted a revised set of Rules and Regulations. These rules contain a number of standards designed to protect the groundwater dependent natural resources of the watershed.

For example, per BCWD Rule 2.8 Groundwater Dependent Natural Resource Management Plans which states:

> "If the District has prepared a management plan for groundwater-dependent natural resource and incorporated management standards in that plan into its Rules through a formal rulemaking process, any land-altering activity within the surface water contributing area or overlying the groundwater recharge area of that resource must conform to applicable standards in the plan."

This groundwater dependent natural resource management plan (GDNRMP) was developed by the BCWD to outline a comprehensive approach to protecting the long-term sustainability of the groundwater dependent natural resources understanding the balance between development and natural resource management. The main objectives of this effort were (1) to determine the level of effort required to develop this type of plan and (2) to serve as a template for the development of future GDNRMPs.

Since this was the first GDNRMP developed by the BCWD, it was decided that the resource being evaluated should be as easy to define as possible. As a result, the BCWD decided to develop a GDNRMP for a small perched fen system that had previously been identified as part of a concept plan for a golf course expansion that never came to fruition. This GDNRMP applies to this resource only. Given the unique nature of each groundwater dependent natural resource, a separate management plan will need to be developed for each GDNR to ensure its management and protection.

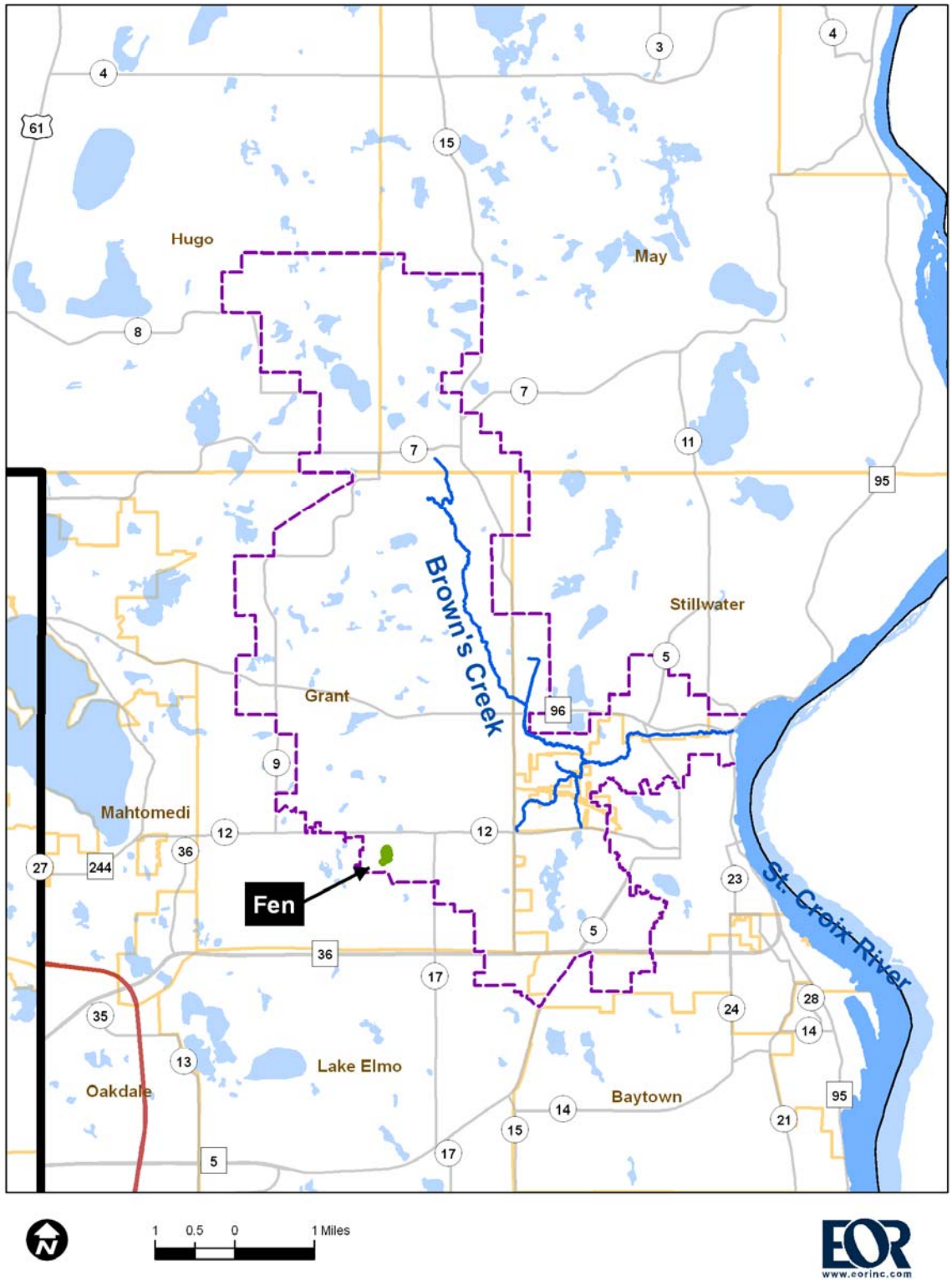
Once this GDNRMP is adopted by the BCWD, the standards set forth in this plan will take precedence over rule language contained in the District's 2007 Rules and Regulations for development taking place within the management area defined for the specific resource. Any Rule Revisions taking place subsequent to May 2007 may supersede the standards contained in this management plan.

One final note regarding the development of this GDNRMP: this analysis did not look at potential impacts associated with climate change. As the BCWD begins to evaluate the hydrologic and natural resource impacts association with climate change, the standards in this management plan may need to be re-evaluated.

1.1 Description of the Resource

The fen evaluated for this GDNRMP is located on a sloping, east facing hillside in the southwestern portion of Section 26 of Township 30, Range 21 (Figure 1). This shallow wetland community is dominated by sedges and grasses on a deep (>2 feet) peat substrate.

Figure 1. Location Map



The ground layer is dominated by tussock sedge, lake sedge, wooly sedge, and other sedges and grasses along with swamp saxifrage, water hemlock, and sensitive fern. Although a generally open community, this fen also contains pockets of woody shrubs including willows and dogwoods. As a whole, this fen has retained its status as being high quality and high functioning. However several areas of this fen have been partially degraded where scattered pockets of reed canary grass, an invasive exotic plant species, occur. At the base of the slope where the fen is located, iron-rich groundwater is discharging, which is indication of groundwater discharging into the fen. Photographs taken during a site visit in June, 2008, are included throughout this Plan.

Sloping Fen with Sensitive Fern

1.2 Resource Goal

The goal for BCWD's groundwater dependent natural resources is to ensure that they function at or near maximum potential and that they are not significantly compromised due to anthropogenic factors. For those resources currently existing in a natural or semi-natural state, the goal is to maintain the pre-development groundwater and surface water hydrology and quality for the resource.

Groundwater dependent natural resources are physical and biological systems where groundwater discharges to the surface or within 12-inches of the surface in the form of springs or seeps. These systems may include plant communities and/or aquatic ecosystems that are reliant upon the chemical, hydrologic and thermal conditions that are sustained by groundwater and that serve to maintain the structure, function and diversity of groundwater dependent natural resources. These resources represent relatively undisturbed natural areas which have unusual groundwater flow patters and water chemistry. As a result, these resources can typically contain rare and endangered plant species. Given their dependency upon groundwater contributions, groundwater dependent natural resources are very sensitive to any changes in the quantity and quality (chemistry and thermal) of groundwater contributions to the resource.

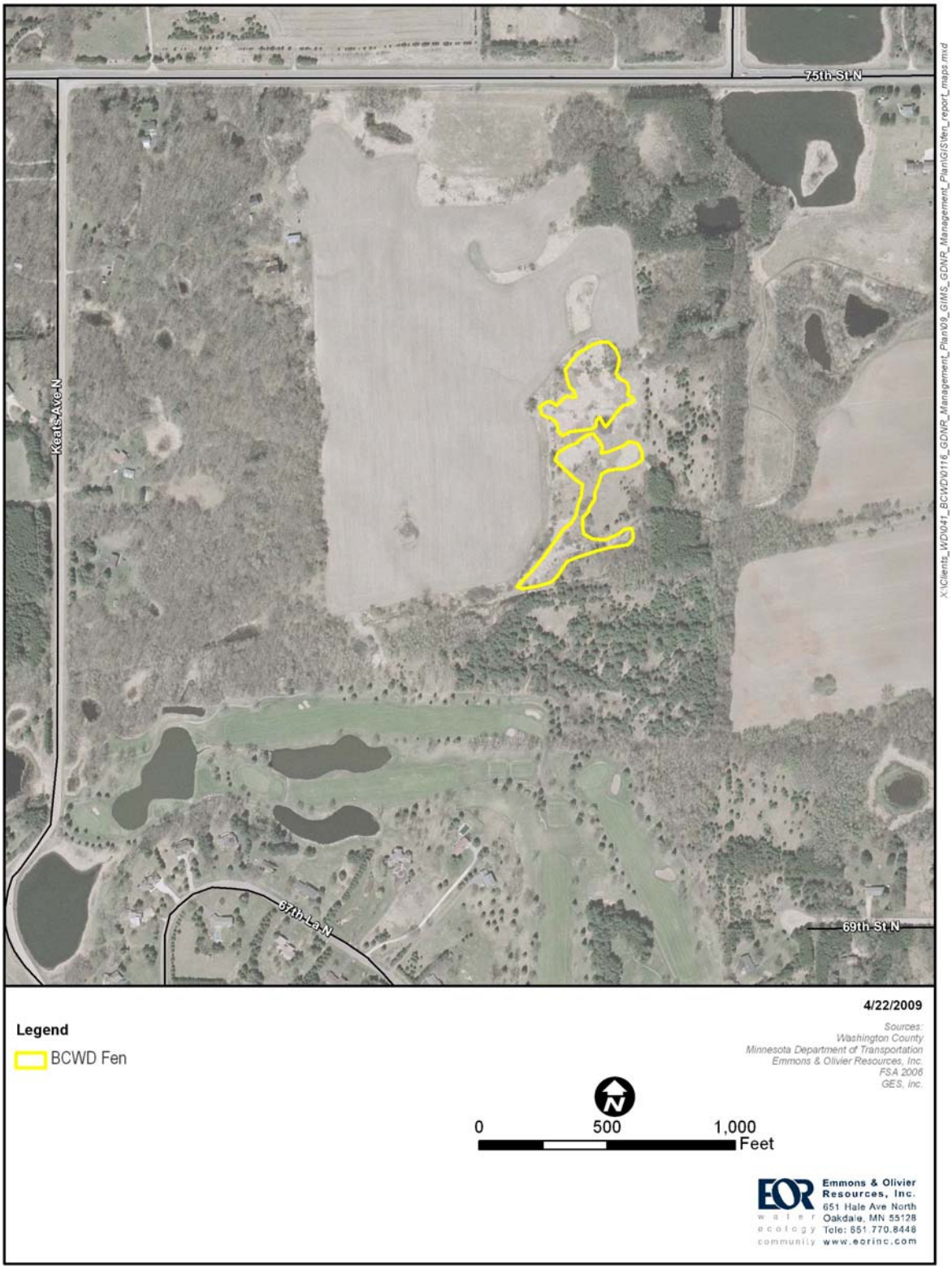
2.0 Background Information

2.1 Site History

In 2002, Mike Regan, owner of the Indian Hills Golf Course, applied for a BCWD Permit for the construction of a golf course expansion. This expansion included the construction of 29 single family lots and an 18-hole golf course to the north of the existing Indian Hills Golf Course. This proposed development would have had a direct impact on the fen being evaluated for this management plan. Mike Regan withdrew the request for a BCWD Permit and the plans for the golf course expansion were put on hold. The wetland is currently on land under ownership by Mike Regan.

The site wetlands (Figure 2) were identified through the 2000 BCWD Natural Resources Inventory and Wetland Function and Value Assessment as being groundwater supported rich fens. The wetland function and value assessment conducted was based on the Minnesota Routine Assessment Method (MnRAM) for Evaluating Wetland Functions - Version 2.0 developed by the Minnesota Interagency Wetlands Group. The BCWD Wetland Function and Value Assessment documented the presence of strong groundwater discharge hydrology in sloping wetlands which form the fen, and characterized the wetland as very high quality with high groundwater function.

Figure 2. Wetlands



The Washington Conservation District (WCD) staff charged with administering the Wetland Conservation Act for the area, Jyneen Thatcher, was notified of the unique resource and joined Watershed District representatives in the field for an assessment of the site early in the spring of 2001. This field visit and others by WCD Staff over the years have continuously documented this groundwater discharge presence, as well as a suite of plant species that are dependent on groundwater hydrology.

In addition, GES, Inc. delineated these wetlands in 2001 and identified them as seepage/fen wetlands. GES, Inc. also found these wetlands to be of relatively high function and value compared to the other wetlands on the site. Upon discovering the rare fens on the site, GES, Inc. contacted several interested parties (including Jyneen Thatcher, EOR, MN DNR staff, and other botanists) for a detailed plant inventory of the site. As a result, an independent plant ecologist from Critical Connections, Inc. was hired to collect data on the wetlands. A floristic inventory of the wetlands was conducted which concluded that the wetland plant communities identified as "fens" in Figure 2 are supported by groundwater seepage hydrology. No state or federally-listed threatened, endangered or special concern plant species were identified by this inventory, but over 50 native plant species were encountered on the site during the field visit, representing one of the most diverse wetlands in the BCWD. The majority of the plant species found within the wetland are not encountered in any other wetland in the District

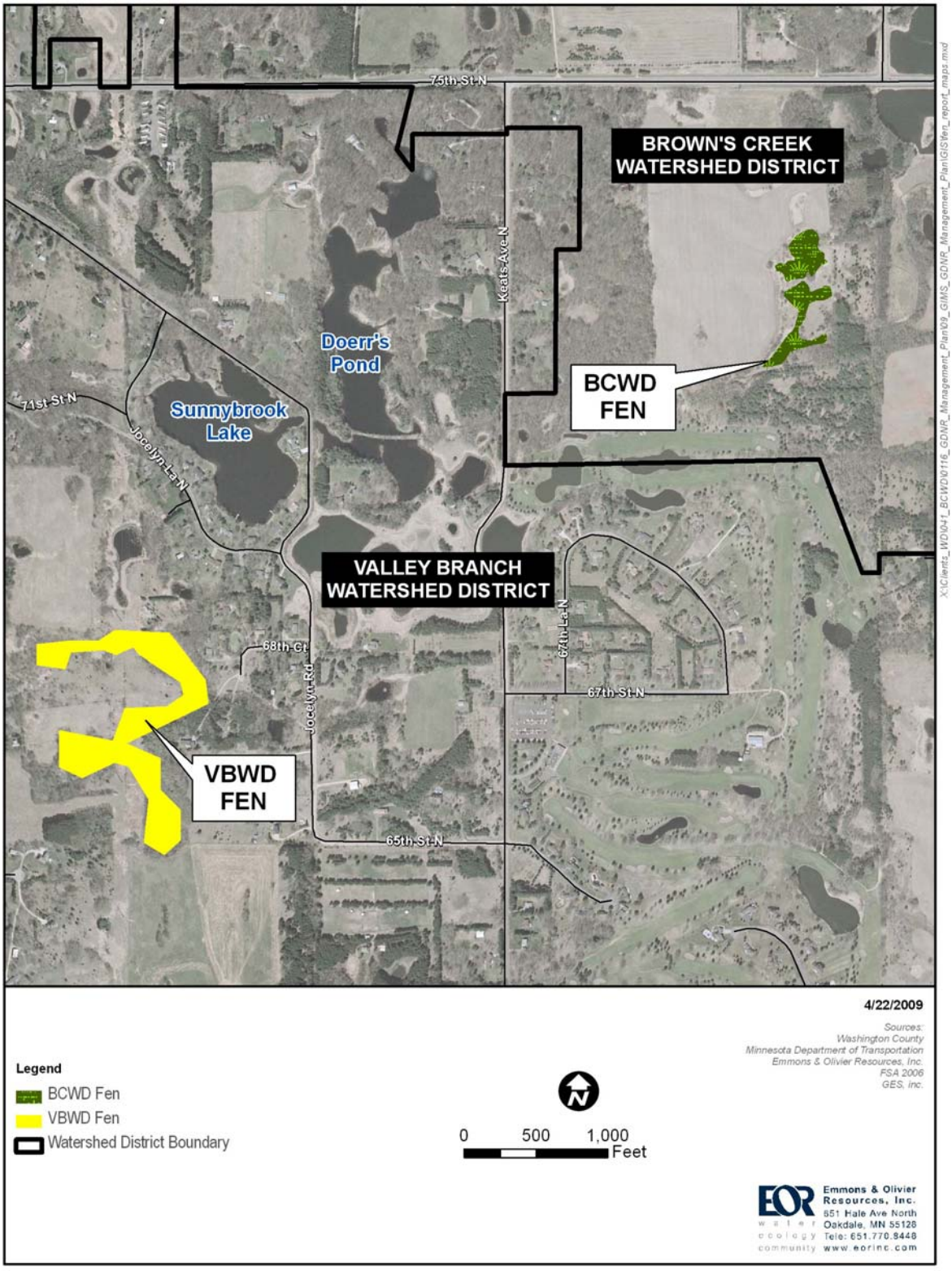
Photo of Sloping Fen

2.2 Topography and Geomorphology

The topography in the study area is a result of the St. Croix Moraine, and characterized by hummocky topography, consisting of many hills and depressions. There are several small wetland basins in the upland area to the west of the fen. Doerr's Pond and its downstream ponds are regionally landlocked and are located to the west and southwest of the fen. The fen itself is located along a hillside slope, a feature unique to fens.

In the summer of 2008, staff from the WCD discovered a very similar groundwater dependent wetland system in Valley Branch Watershed District (VBWD) approximately one mile from the fen. This fen in VBWD is located south of Sunnybrook Lake in the City of Grant in the middle of Section 34 of Township 30, Range 21. It has a similar topographic setting and is located upslope from a landlocked basin (Figure 3). This other fen is also dominated by similar wetland plant species that prefer groundwater dependent conditions.

Figure 3. VBWD Fen Location

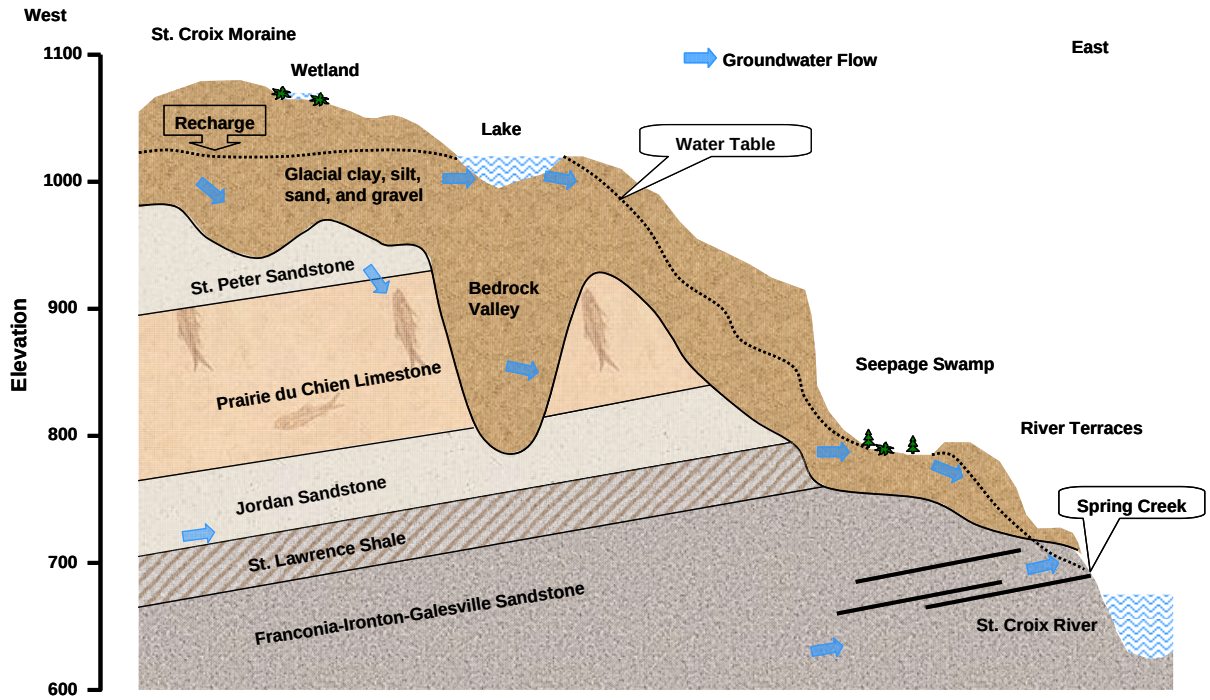


2.3 Soils and Geology

The geology of the area consists of Quaternary unconsolidated sediments overlying bedrock formations. The Quaternary sediments consist of glacial till deposited by the St. Croix phase of the Superior lobe glacial advancement. Till deposited at the terminus of this glacial advancement formed the St. Croix Moraine in which the fen is situated. Till deposits in the vicinity of the fen are typically sand-loam and silt loam textured with unsorted gravel, pebble, and sand. They are typically reddish brown, and range in density. Lenses of fine grained materials are typical and can cause perched water table conditions within the till deposits. These fine grained lenses are likely responsible for the fen's presence. A deeper confining layer is also present near the study area, as identified in the County Well Index to the southeast of the fen. A buried artesian aquifer is present below this confining layer, within the Quaternary deposits. Quaternary deposits in the region near the fen are typically greater than 100 feet thick.

Beneath the Quaternary deposits are marine sedimentary rocks. Figure 4 shows a generalized cross section of geology between the St. Croix Moraine and the St. Croix River (EOR, 2003). Two bedrock groups subcrop (are exposed in the subsurface directly below the Quaternary sediment) within the study area including the St. Peter Sandstone and the Prairie du Chien Group. Bedrock is typically at least 100 feet below the surface. Beneath these bedrock formations lie the Jordan sandstone. The St. Peter is discontinuous throughout the study area and is generally not used as a drinking water source. This unit consists of fine to medium-grained quartz sandstone. In some areas, the lower part of the unit is referred to as the Basal St. Peter and acts as a confining unit. The basal St. Peter impedes the downward movement of water due to the high proportions of fine grained rock such as mudstone, siltstone, and shale. This unit is found throughout the study area except for within a buried bedrock valley that runs in a north south trajectory to the west of the fen in the vicinity of Doerr's Pond. The Prairie du Chien Group underlies the St. Peter. The upper two thirds are sandy with thin-bedded dolostone and solution cavities. The lower third consists of massive dolostone. The Prairie du Chien Group is underlain by the Jordan Sandstone. This unit is a medium to coarse-grained sandstone. Together, the Jordan and Prairie du Chien form a regionally significant aquifer.

Figure 4. Generalized Geologic Cross Section (EOR, 2003)



3.0 Description of Resource

3.1 Site Visit

On June 18, 2008 Jennifer Olson, P.G and Melissa Arikian, Ecologist, of Emmons & Olivier Resources, Inc. and BCWD Manager Rick Vanzwol met with the landowner Mike Regan on his property to visit the fen and discuss current conditions of the existing wetland complex. In addition to verifying the setting and condition of the fen on this property, the location of the pre-existing wetland delineation lines were also checked to ensure the mapped boundaries are correct (see Figure 2).

3.2 Plant Communities

The fen is located on an east-facing side slope with groundwater discharging at the toe of the slope. Groundwater seepage provides highly specialized hydrologic conditions that support this unique wetland plant community. This shallow wetland community is dominated by sedges and grasses on a peat substrate. The ground layer is dominated by tussock sedge, lake sedge, wooly sedge, and other sedges and grasses along with swamp saxifrage, water hemlock, and sensitive fern. Several pockets of cattail and reed canary grass also exist scattered throughout this fen. Although a generally open community, this fen also contains pockets of woody shrubs including willows and dogwoods. In total over 50 native plant species have been documented on the site during numerous field visits, making it one of the most diverse wetlands in the BCWD. The majority of the plant species found within the wetland are not encountered in any other wetland in the District and many uniquely inhabit rich fens.

Swamp Saxifrage

3.3 Surface Water Hydrology

The surface water contribution to the fen is dependent on the soils, land slope, and land use or land cover present in the area with the potential to contribute surface runoff to the fen based on local topography.

The surface watershed was mapped based on 2-foot topographic data and field verified (Figure 5). During field verification, a breach was noted beneath the old street car line to the south of the fen complex, providing a connection for surface water runoff from the South to enter the wetland/fen complex. This breach is identified on Figure 5. The breach is allowing stormwater runoff to reach the fen which could be contributing to the slightly degraded state of the fen.

The surface watershed to the fen is small at 39.9 acres. The surface watershed is dominated by agricultural, forest, and wetland land cover/land use (Table 1, from MLCCS data). There are no direct connections such as storm sewer contributing drainage to the fen. The breach in the old street car line does provide for a surface water inlet from the south.

Figure 5. Fen Surface Watershed

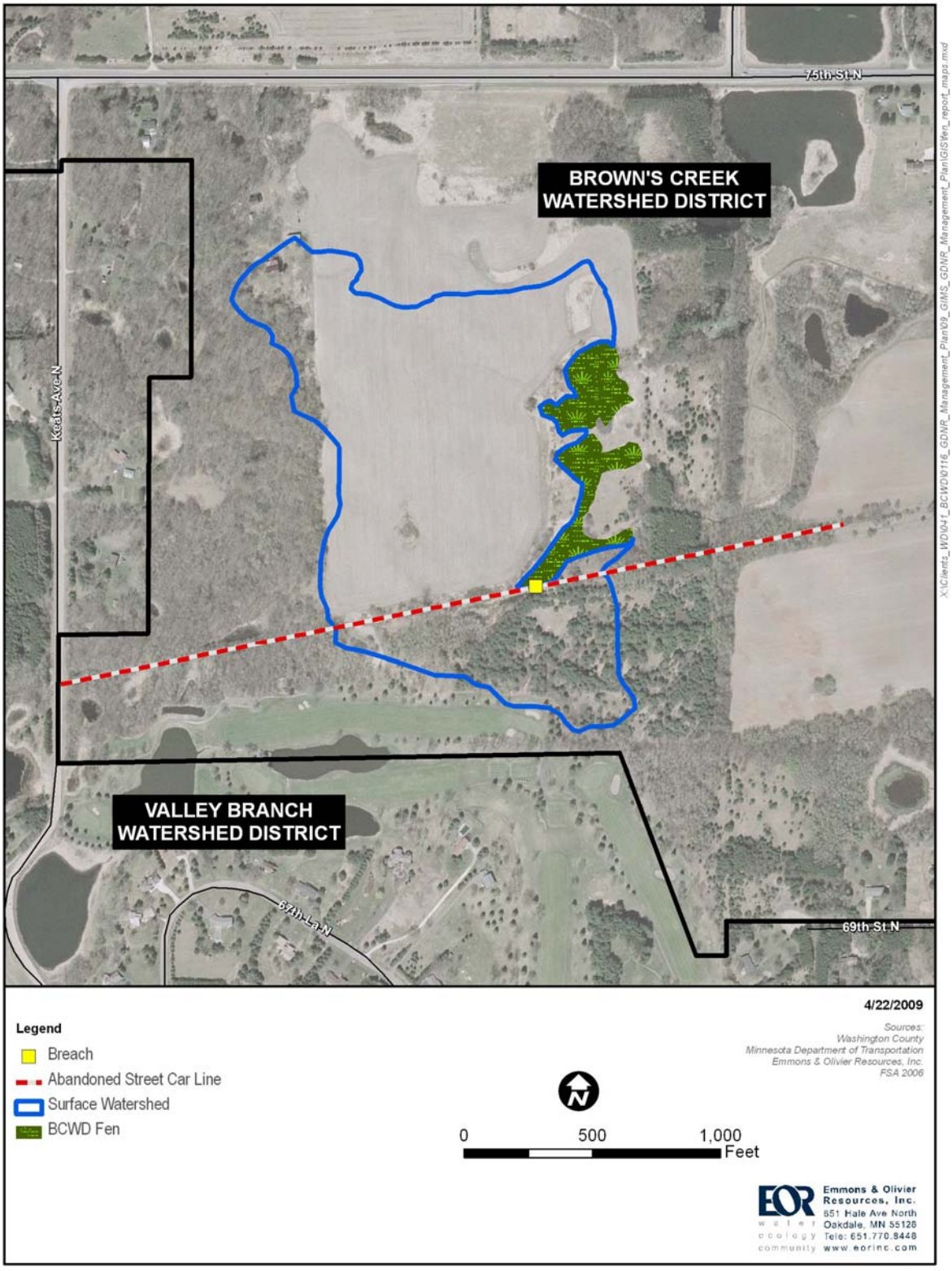


Table 1. Existing Land Use and Land Cover in Surface Watershed

Land Use	% of Watershed
Forest-Deciduous	7%
Forest-Evergreen	14%
Hay or Row Crop Agriculture	53%
Oak	3%
Pasture	4%
Residential-Low Density	1%
Wetlands-Non-Forested	19%

3.4 Groundwater Hydrology

Regional groundwater flow in the vicinity of the fen occurs from west to east within the Quaternary and upper bedrock formations. Groundwater flow is towards the St. Croix River which acts as a regional groundwater discharge area. Figures 6-10 present available data on the groundwater flow direction and groundwater elevations in the study area for each unit (EOR, 2003; TCT, 2001). These figures indicate that generalized groundwater flows laterally in an easterly direction towards the St. Croix River and vertically with upper aquifer units flowing downward into lower aquifers units. The mapped water elevations for each aquifer were based on a regional dataset.

Groundwater Discharging in the Fen

Geotechnical boring logs characterized by Twin City Testing (TCT) as part of their investigation at the proposed Indian Hills Country Club expansion describe shallow geology to the west of the fen as predominately silty sand with gravels. Interspersed throughout the borings are descriptions of sand layers of greater than 1 foot. These silty sand and sand layers are transmissive layers that allow for the movement of groundwater. Many of the boring logs additionally describe thin layers, of approximately 1 foot, of clayey sand or lean clay. In addition to describing the site geology, these borings verify that a sloping water table exists at the approximate elevation of the fen (Figure 6). Soil boring data collected by TCT indicate that groundwater elevations mimic topography to the west of the fen. Groundwater elevations were measured in December 2001.

The study area is located in a regional groundwater recharge area, as presented in the North Washington County Groundwater Study. The regional shallow groundwater divide (St. Croix and Mississippi Rivers) is located to the west of the fen site, approximately 1.5 miles. Figure 6 illustrates that the regional Quaternary Water Table is nearly 70 feet below the water surface of the fen, Doerr's Pond, and Sunnybrook Lake based on a well owned and monitored by the VBWD. This indicates that the groundwatershed supplying groundwater to the fen is perched and localized.

Based on available data, the fen is being fed by shallow groundwater discharge associated with a perched shallow water table aquifer (till and sand). Buried Quaternary aquifers as well as bedrock aquifers (St. Peter and Prairie du Chien) are also present in the vicinity; however, the groundwater elevations in these aquifers are well below the fen elevation.

Figure 6. Quaternary Groundwater Conceptual Model

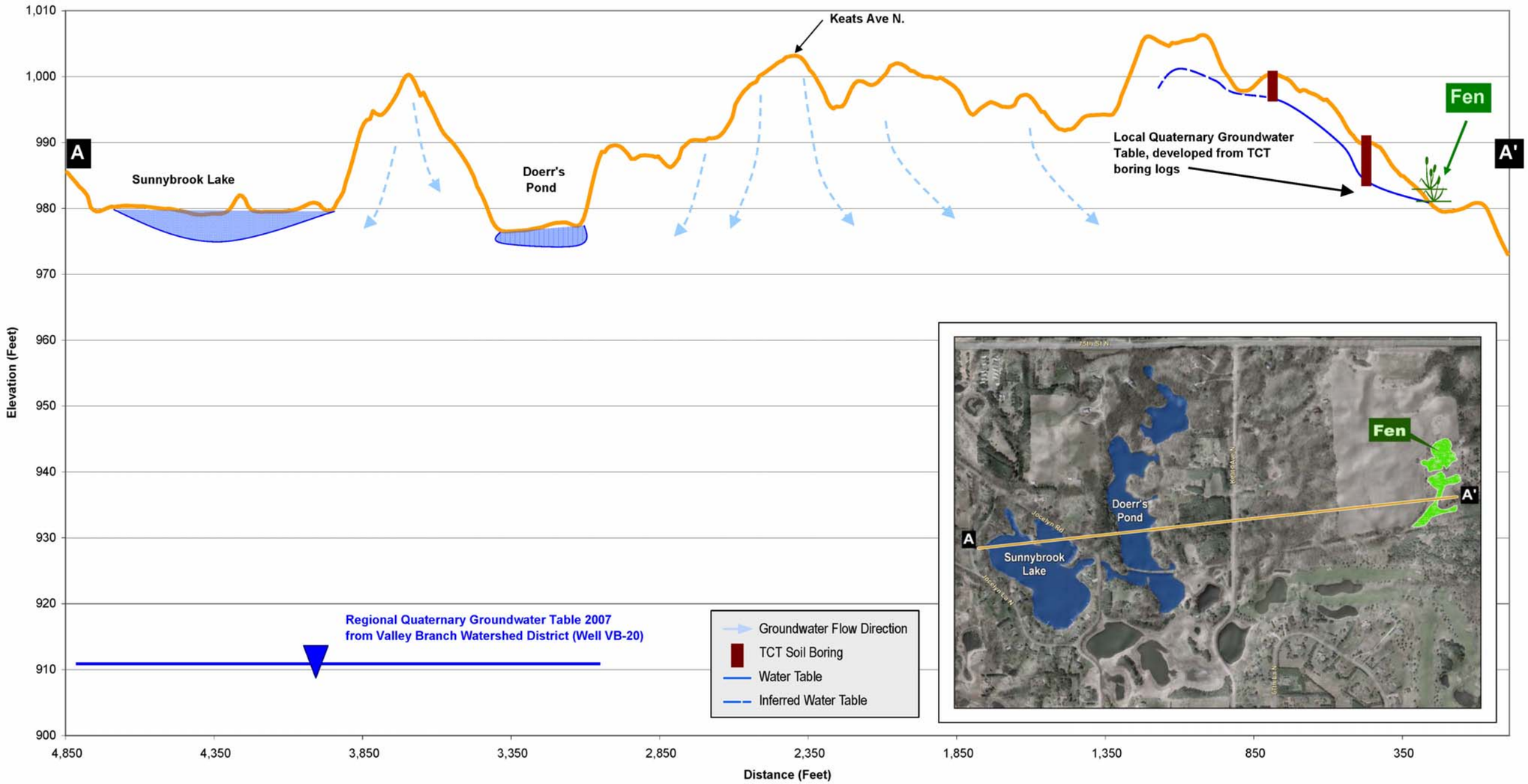


Figure 7. Quaternary Contours

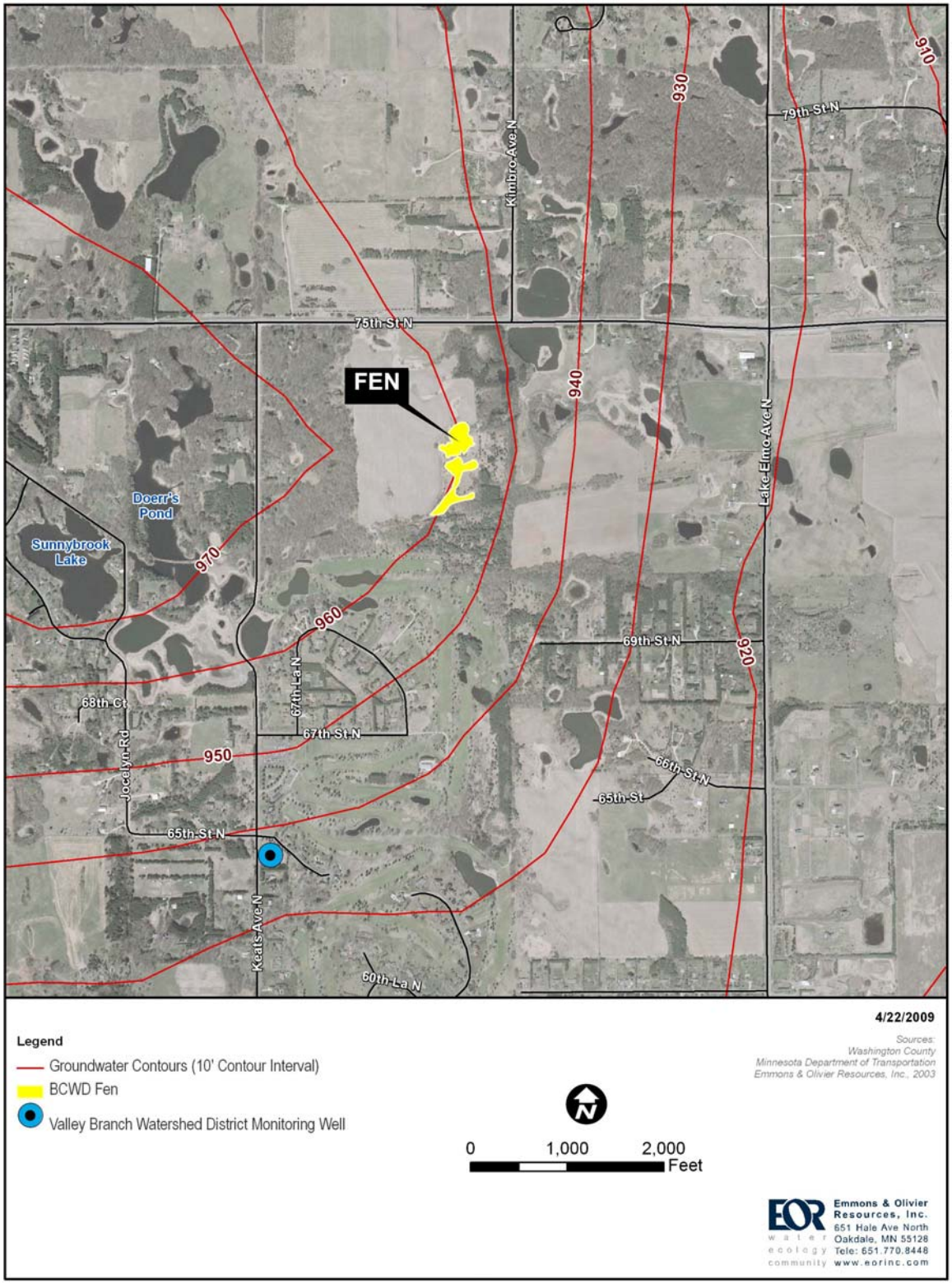


Figure 8. St. Peter Aquifer Contours

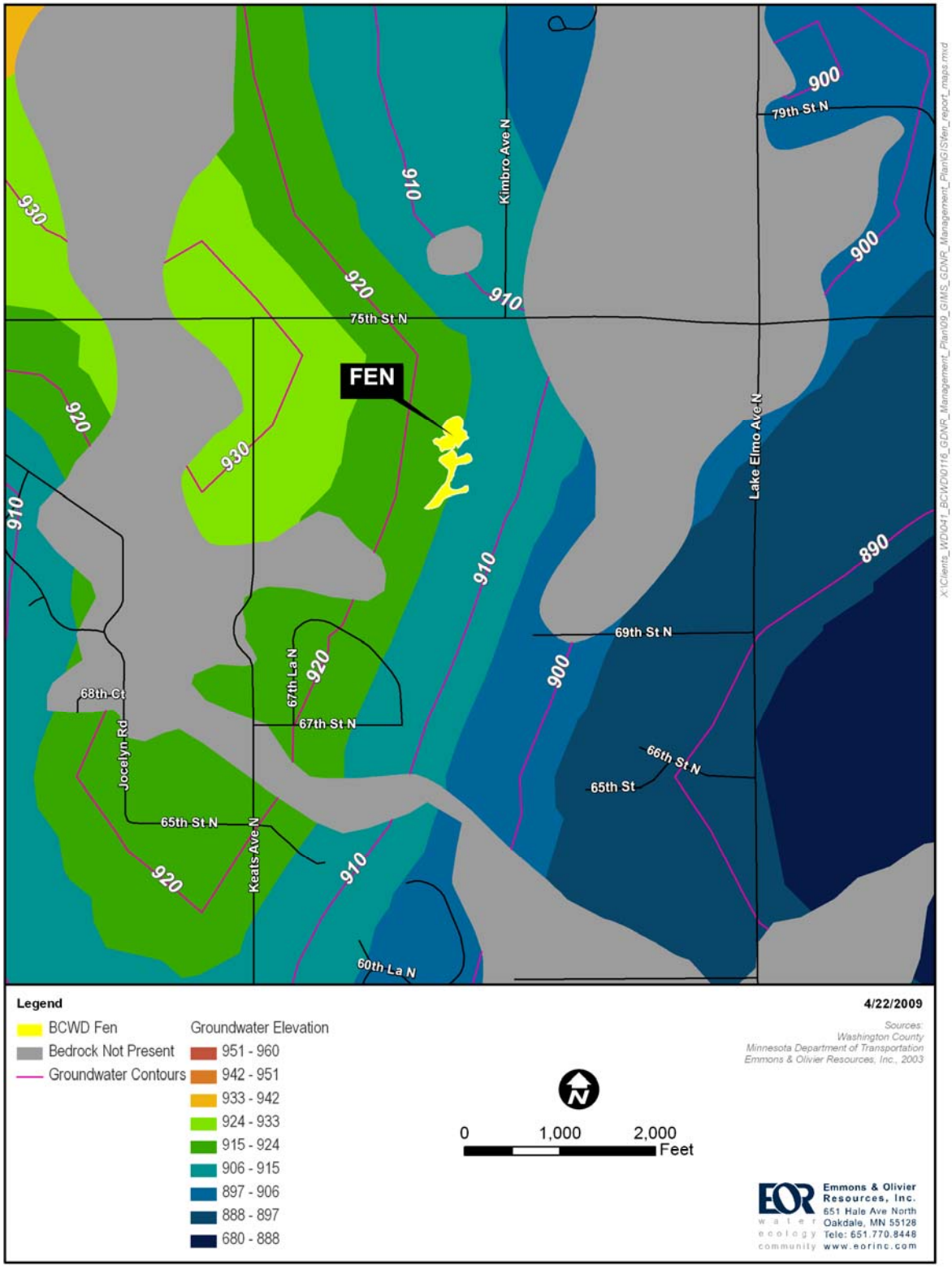


Figure 9. Prairie du Chien Group Aquifer Contours

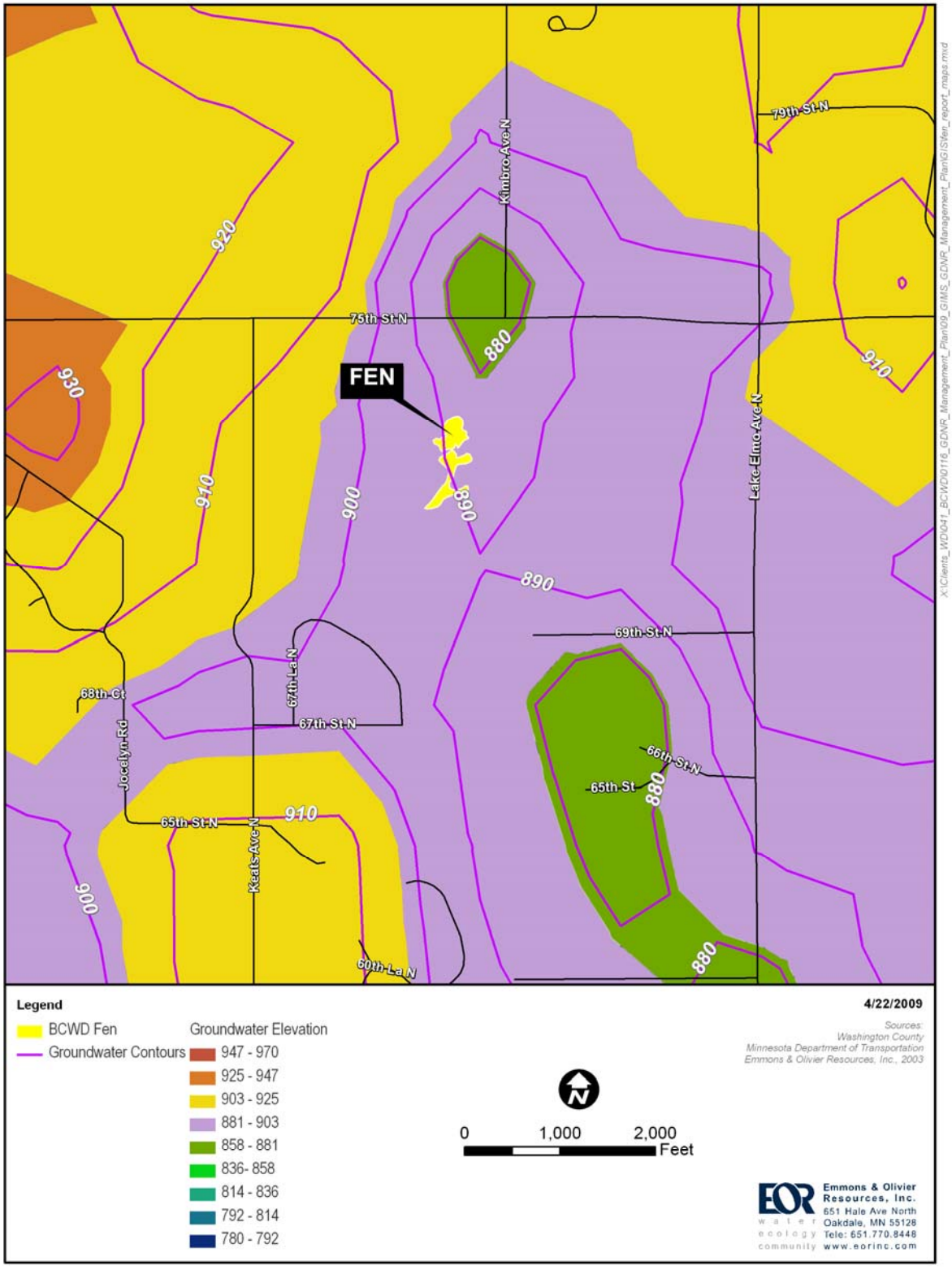
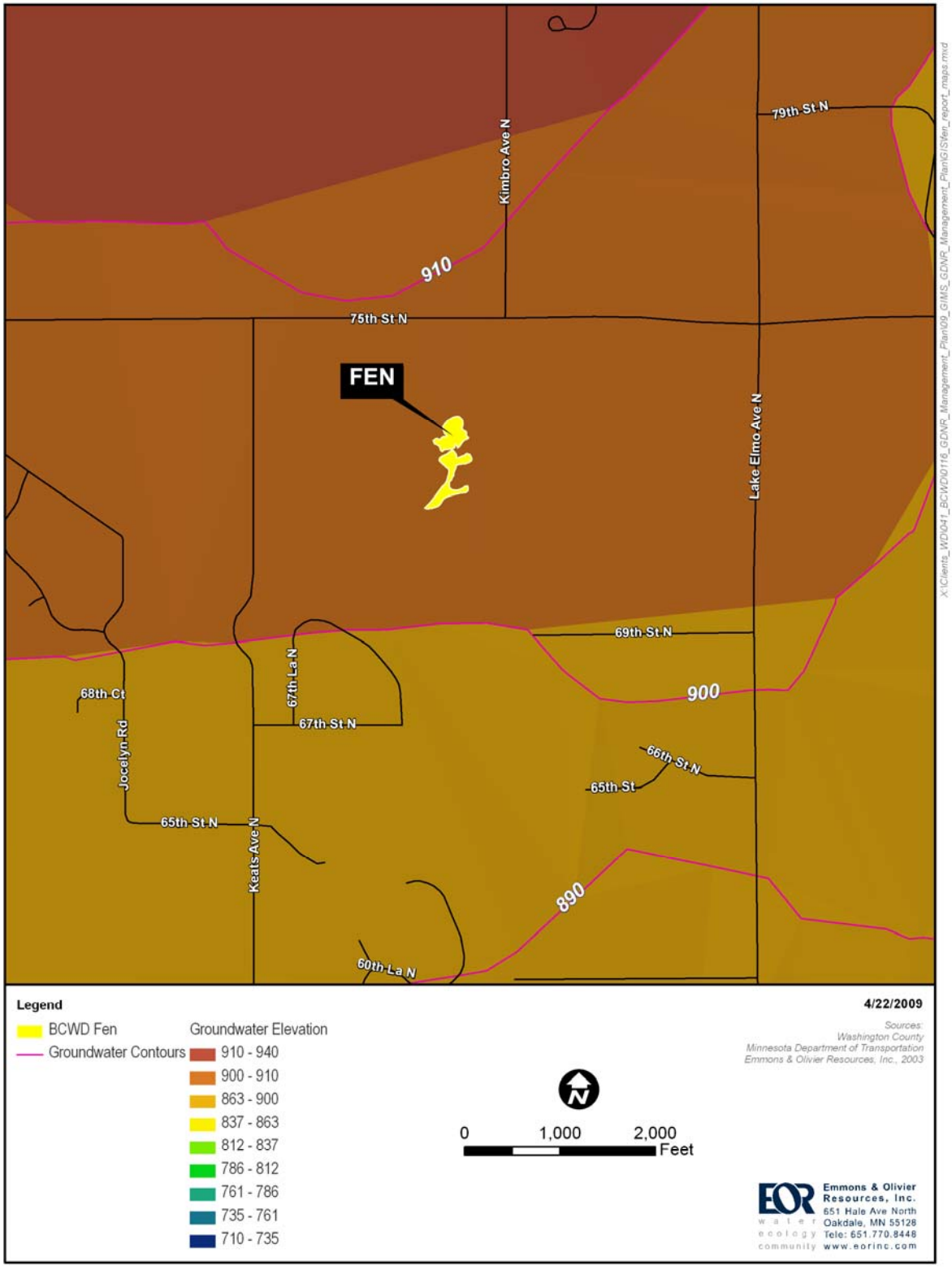


Figure 10. Jordan Aquifer Contours



Sunnybrook Lake is located southwest of the fen and has been previously identified by the VBWD as a precipitation driven lake with very little interaction with groundwater, serving as a groundwater recharge lake. Doerr's Pond is located to the west of the fen and is downstream of Sunnybrook Lake. A review of the water bodies within the general vicinity of the fen revealed that the fen, Sunnybrook Lake, and Doerr's Pond are at very similar elevations, while surrounding water bodies to the north and further west of the fen are at elevations more than 25 feet higher and consist of scattered small wetlands and lakes. The evidence, although limited, suggests that shallow groundwater is recharged along the topographic high running parallel to Keats Avenue where it moves laterally and vertically to either discharge at the fen site, and perhaps interact with Doerr's Pond, or recharge lower aquifers.

Groundwatershed

The groundwatershed area delineated for this investigation is the land area where rainfall and snowmelt has the potential to move vertically and horizontally through the soil column and geologic materials and reach the fen through subsurface flow. The groundwatershed was mapped based on available Quaternary contour data contained within the North Washington County Groundwater Study (EOR, 2003), groundwater elevation data obtained from TCT (2001) as part of the proposed golf course expansion, and data related to the elevations of surface water features in the area.

During evaluation of the local water table as described in Figure 6, it was determined that there was a localized groundwater divide between Doerr's Pond and the BCWD Fen that runs approximately along Keats Avenue. The area that would be groundwater tributary to Doerr's Pond was therefore removed from the fen's groundwatershed. Surface water drainage areas that were tributary to the groundwatershed were also added based on the premise that the shallow water table follows topography in the area.

Figure 11 illustrates the area of the final groundwatershed. It is 68.78 acres in size and contains many small depressions and wetlands that act as recharge areas for the shallow water table.

4.0 Management Area Mapping and Modeling

The management area for the fen has been mapped based on the combined groundwater recharge area (groundwatershed) and surface watershed contributing area. Figure 12 includes the designated management area for the fen which is 79.8 acres in size. The management area will serve as an overlay where standards included within this Plan will be enforced. The management area includes a portion of the VBWD. Extensive coordination will be needed with the VBWD during plan implementation.

Figure 11. Fen Groundwatershed

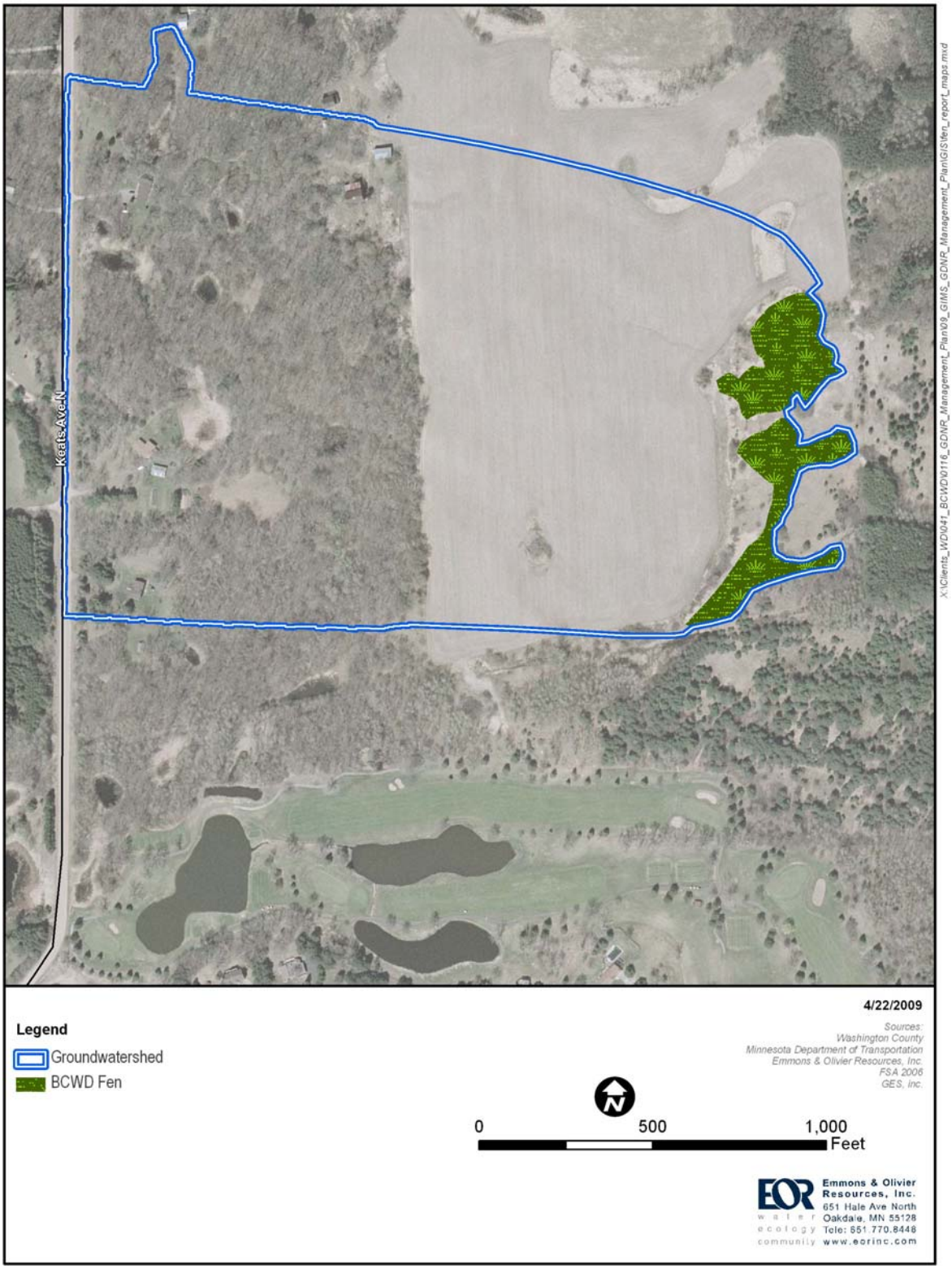
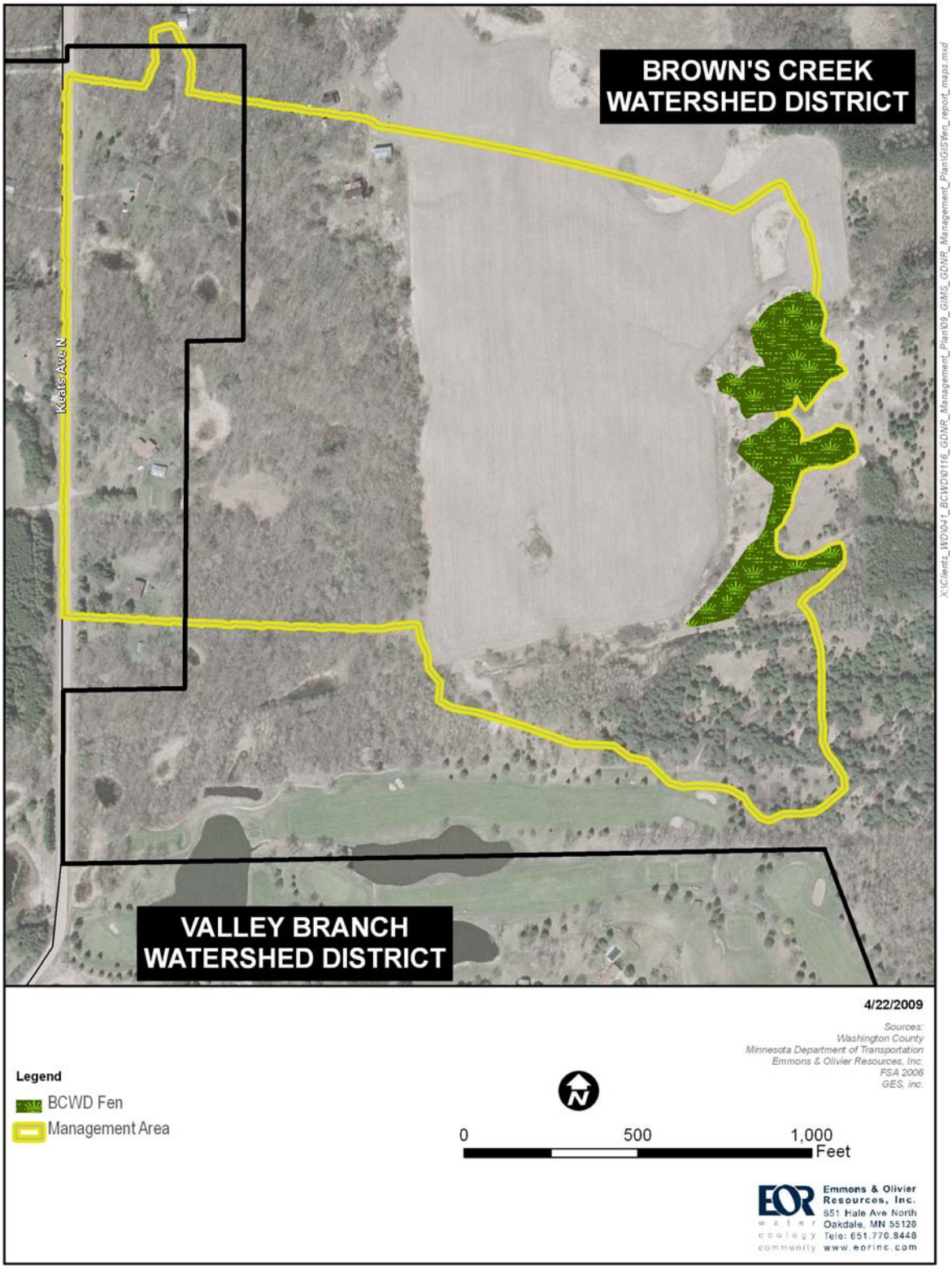


Figure 12. Management Area



4.1 Surface and Groundwater Modeling

An evaluation of the potential changes in surface water and groundwater conditions was conducted with the purpose being to determine if additional, or more stringent, standards were needed to protect the fen with regard to volume control.

A Soil & Water Assessment Tool (SWAT) model was developed for the surface watershed of the fen to simulate existing conditions and quantify the changes in runoff and infiltration characteristics under two theoretical future land uses. Model assistance was obtained from Solomon Folle, PhD candidate and Research Associate at the University of Minnesota, Department of Soil, Water and Climate. SWAT uses soils, topography, land use, land cover, and weather data to evaluate the transport of water as surface runoff, into shallow and deep aquifers, and to the atmosphere through evaporation and transpiration. The modeled domain is 45.1 acres in size and includes the majority of the contributing surface water drainage area and is representative of the existing land uses. The groundwatershed area was not modeled as there was no change in land use projected within this area. A buffer of native vegetation around the fen was also not modeled under future conditions as the SWAT model is not designed to model such a buffer.

The model's default runoff and plant growth parameters were revised to more accurately reflect the specific conditions of the land use in the fen's drainage area. The SWAT model has a total of 159 input parameters ranging from management practices including mowing and harvesting biomass to compaction created by land development scenarios. Each of these parameters were evaluated and adjusted when necessary for the different land use scenarios. The existing hay/row crop agriculture area (Table 1) was further investigated through the use of the Crop Land Database to determine the land use as a corn-soybean crop rotation. The SWAT model was run for an 8 year period (2000-2008) using the first three years to "warm up" the model without cataloging the data as part of the output. No monitoring data were available for the fen or for the local surficial groundwater table. Therefore, calibration of the model was conducted by establishing a known loss to evapotranspiration for this area and then calibrating the model parameters to meet this condition.

The future condition scenarios analyzed the impact of alterations in land use and land cover for two potential scenarios. Under both of these future land use scenarios, the only land use that changed was the current corn soybean crop. The two future condition scenarios evaluated were:

1. Golf course (TURF): The portion of the surface watershed currently in corn soybean crop rotation north of Indian Hills Golf Course is developed as a golf course.
2. Residential development (URLD): The portion of the surface watershed currently in corn soybean crop rotation is developed at the maximum allowable density of one residence per ten acres, with 5% impervious.

Water Budget

Figure 13 illustrates the comparison of each modeled scenario's baseflow contribution to the fen. Baseflow to the fen increases under a golf course scenario (TURF) and decreases under a low density residential development scenario (URLD), when compared with existing conditions. The full water balance for each of the scenarios is presented in Table 2 as annual averages. All units are presented in millimeters.

Figure 13. Modeled Baseflow Conditions, Cumulative Monthly

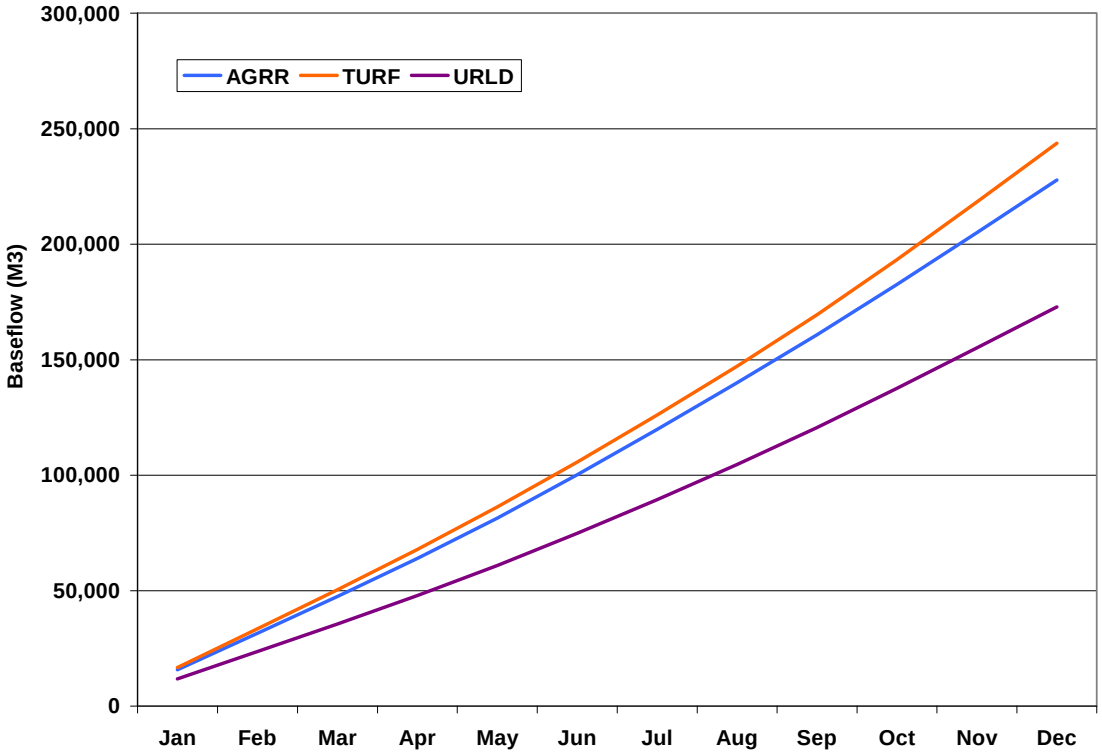


Table 2. Modeled Water Balance, Annual Average

COMPONENT	AGRR	TURF	URLD
PRECIPITATION (mm)	772.20	772.2	772.20
SUBLIMATION (mm)	12.14	12.14	12.14
SURFACE RUNOFF FLOW (mm)	81.32	65.63	98.21
LATERAL SOIL FLOW (mm)	10.31	11.62	7.53
SHALLOW AQUIFER FLOW (mm)	88.93	128.52	66.29
REVAP FROM SHALLOW AQUIFER TO SOILS (mm)	26.85	26.85	26.64
DEEP AQUIFER RECHARGE (mm)	7.83	11.40	6.46
EVAPOTRANSPIRATION (mm)	537.30	506.00	544.60
TRANSMISSION LOSSES IN THE CHANNEL (mm)	4.42	3.42	7.41
CHANGE IN SOIL STORAGE (mm)	3.10	6.62	2.92
TOTAL	**772.20**	**772.20**	**772.20**

A summary of the relevant parameters is presented here. A detailed description of each of the parameters can be found in the SWAT documentation available www.brc.tamus.edu/swat.

Precipitation data were obtained from the National Weather Serve station in Stillwater. Precipitation falls onto the land surface and either becomes runoff (SURFACE RUNOFF FLOW) or infiltrates into the soil. The model reports a decrease in runoff for the golf course scenario and an increase in runoff for the residential development. The increase in runoff under the residential scenario is a result of compaction in

the watershed soils and an increase in impervious area. The decrease in runoff from existing conditions to golf course is a result of the change in vegetation and its associated properties. The model determined that a perennial crop (turf grass) will have less runoff than the current corn-soybean rotation.

The precipitation that is infiltrated into the ground will either be taken up by the plants or evaporated from the soil (EVAPOTRANSPIRATION), move laterally though the soil column (LATERAL SOIL FLOW), or move vertically to the shallow aquifer (SHALLOW AQUIFER FLOW). Water can also move upward from the shallow aquifer to the soils through capillary action (REVAP). Evapotranspiration makes up the largest loss of water within the overall budget, and is mainly based on the type of vegetation and its water use requirements. The shallow aquifer flow represents that majority of water becoming baseflow within the model. The large increase in shallow aquifer flow (45%) from existing conditions to golf course is due to a decrease in evapotranspiration and surface water runoff as a result of the change in vegetation. The decrease in baseflow under the residential development scenario (- 25%) is due to increased surface water runoff and other minor gains in the system.

Evaluation of Existing BCWD Volume Control Rule

The BCWD currently has a standard prohibiting increases in stormwater flow volume from a site, as compared with the pre-settlement conditions for a 24-hour precipitation event with a return frequency of two years or five years within a landlocked basin or subwatershed draining to a landlocked basin. For the developable area contributing to the fen, the current BCWD standard requires approximately 0.012 ac-ft of volume control per acre of 5% impervious residential development. For the modeled years, the volume control requirement will result in the storage of approximately 97% of the number of rainfall events and the capture of 88% of the total runoff-producing rainfall volume. If implemented as infiltration practices over the portion of the surface watershed expected to be developed, the standard results in a shallow aquifer contribution to the fen that is greater than was modeled under the URLD and AGRR scenarios, thus providing adequate baseflow to support the fen.

Future land use change showed the potential to impact the fen through decreased groundwater inputs if residential development does not include adequate infiltration or exceeds the expected approximate average of 5% impervious. Irrigation of the golf course could also impact the fen depending on the source of the water used. Any tile drainage used on the golf course could impact the fen if it intercepts water that would have contributed to recharge or lateral flow to the fen. Additionally, other factors associated with land use change have the potential to impact the fen, but aren't modeled by SWAT. These factors are discussed within section 5.0 and include, among others:

- grading and construction impacts and potential sediment and nutrient input to fen;
- thermal impacts caused by higher temperature water entering the fen;
- the location of infrastructure such as building foundations, road beds, and utilities that may alter the groundwater input to the fen; and
- snow management on new roads close to the fen that could result in salt and sediment input to the fen.

The fen will likely be impacted by any change in existing hydrology and chemistry, from both surface water and groundwater. The modeling results and an evaluation of the impact of the rule indicate that additional or more stringent volume control rules are not necessary to protect the fen, although some modifications will be made to the rules to ensure volume control requirements are met through infiltration. This modeling work also demonstrates that there will not be a significant burden on a developer in the area to ensure that future land use maintains existing hydrology, mainly due to the type of potential land uses that could be developed.

4.2 Management Area

The management area for the fen includes both the surface water contributing area and the groundwater recharge area as illustrated in Figure 12. While this area covers portions of both the Brown's Creek Watershed District (BCWD) and the Valley Branch Watershed District (VBWD), standards set forth in this document will apply to that portion of the management area within the BCWD. Coordination with the Valley Branch Watershed District will, however, be critical in the future management of the fen.

The standards in 6.0, developed for the fen in the southwest corner of T29N R21W Section 26, shall be met under post-development conditions.

5.0 Potential Impacts to Resource

The section describes the direct and indirect impact of potential development activities on the fen. These impacts will be evaluated for any proposed development scenario to determine whether or not additional standards need to be adopted by the BCWD to protect the fen as it exists today. A number of the direct and indirect impacts indentified below have previously been reported by the Minnesota Department of Natural Resources in the DRAFT Savage Fen Resource Plan (DNR, 1998).

5.1 Direct Impacts

Filling and Construction Activities – Filling can change local groundwater flow patterns within the groundwater dependent natural resource, or in the case of the fen have an impact on the direction and amount of flow from the sub-peat springs through the peat blanket. This disruption to groundwater flow will alter and degrade the plant community composition. In addition, filling degrades the resource by covering hydric soils that exist in the upper part of the soil profile and provide the opportunity for invasive species to degrade the fen's high quality plant community.

Borrowing materials (another form of filling where an area of the site is over-excavated to extract high quality materials and replaced with lower quality, typically less permeable, materials) is also discouraged in the contributing drainage area to a groundwater dependent natural resource for the reasons stated above.

Erosion and Sedimentation – The impacts associated with the introduction of sediment plumes are articulated above under *Filling and Construction Activities.*

Plant Community Impacts – Any impacts associated with disruption to the groundwater hydrology and amount of sediment reaching the fen will favor the introduction and succession of invasive plant species, allowing them to out-compete the existing native plant communities.

Fire Suppression – The suppression of naturally occurring fires can cause changes in plant communities and create an environment that favors the introduction and/or succession of invasive plant species.

Fluctuations in Groundwater Levels – Variations in groundwater levels provide opportunities for invasive species to out-compete sensitive plant communities that are unique to groundwater dependent natural

resources. Increased groundwater levels favor aquatic plants (e.g. cattails) and depressed water levels favor trees and shrubs. The quantity of groundwater discharge, the rate of groundwater movement through the peat, and the tolerance of vascular plants to varying water levels are all major factors affecting plant distribution in groundwater dependent natural resources.

Infrastructure (e.g. sanitary sewer, storm sewer, and water mains) – Infrastructure has the potential to adversely affect groundwater dependent natural resources by altering groundwater hydrology through the use of dewatering during construction or the creating of a preferential flow path (gravel backfill) diverting water away from the resource.

Water System Improvements (e.g. water supply wells) – The introduction of water supply or irrigation wells can change the groundwater contribution feeding the resource (depending upon the depth of the well and the source of the groundwater contribution) by lowering the water table.

Road Modifications – The installation of roads and other utilities can have a direct impact on groundwater dependent natural resources by changing the flow path of groundwater to the resource. For example, the construction of road beds and utilities can intersect impermeable layers, draining shallow groundwater tables.

Public Use – Inappropriate use by the public can result in the degradation of groundwater dependent natural resources. This can be avoided by planning for the appropriate use of the resource. Demarcate the resource and establish trails in a manner that will avoid impacts to the function and value of the resource, while providing opportunities for education and viewing.

5.2 Indirect Impacts

Groundwater Use – While the discharge rate of domestic wells may be low, the impact of these groundwater appropriations could impact the quantity and quality of groundwater discharge, as well as the rate of groundwater discharge, depending on where and how deep the well is placed. Irrigation wells, if placed within the water table aquifer or in an aquifer that is not protected by a confining layer, can have a significant impact on the water table (due to high pumping rates) and therefore the fen. The goal for evaluating groundwater appropriations is to maintain pre-development groundwater flow conditions to the fen.

Groundwater Recharge – Any changes in the contribution of groundwater (quality and quantity) has a direct impact on the groundwater-dependent natural resource. To maintain groundwater contribution from both the shallow and regional groundwater system, it is important to ensure that pre-development infiltration and recharge rates are being maintained within the surface watershed as well as the groundwatershed.

Stormwater Runoff – Groundwater dependent natural resources are very sensitive to changes in water quality (chemistry and temperature) and quantity. To avoid indirect impacts associated with stormwater runoff, eliminate stormwater discharge to a groundwater dependent natural resource (consistent with undeveloped watershed conditions).

Road Spray – Groundwater dependent natural resources are very susceptible to airborne sources of contamination (e.g. deicing agents). Road spray from deicing agents damages foliage and changes soil chemistry. Distance of salt travel varies greatly. Factors that affect distance of travel are the quantity of road salt applied, the direction and strength of prevailing winds, obstructions to travel (e.g. jersey barriers, trees, etc.), speed limits, snow removal methods, the proportion of trucks to automobiles, and roadway elevation (DNR, 1998). Numerous studies cited in the Savage Fen Management Plan (DNR, 1998)

indicate that the distance of travel for chloride ions can range from 100 feet to 400 feet from the application location.

Land Use – Increases in imperious area in the contributing drainage area to a groundwater dependent natural resource typically decreases the amount of water infiltrating to the groundwater system and increases the amount of surface water runoff.

6.0 Management Standards

The main objective of a GDNRMP is to identify strategies that will minimize the degradation of the District's groundwater dependent natural resources under developed conditions. The BCWD Rule 2.8 Groundwater Dependent Natural Resource Management Plans states:

> "If the District has prepared a management plan for groundwater-dependent natural resource and incorporated management standards in that plan into its Rules through a formal rulemaking process, any land-altering activity within the surface water contributing area or overlying the groundwater recharge area of that resource must conform to applicable standards in the plan."

The standards presented in this section of the GDNRMP have either been modified from what is presented in the Brown's Creek Watershed District Rules (Adopted April 9, 2007, Effective May 1, 2007) or are unique (new) to the protection of this resource. The Permit Applicant will need to use both documents, the Brown's Creek Watershed District Rules (Adopted April 9, 2007, Effective May 1, 2007) and the Groundwater Dependent Natural Resource Management Plan developed for the fen, to determine what compliance measures will be required for proposed development activity within the management area to the fen.

6.1 Definitions

Confining Layer – A geologic formation located adjacent to an aquifer that impedes the movement of water.

Contributing Drainage Area – The area defined by Figure 5 and subsequent revisions based on alterations and grading approved as part of a BCWD permit. A portion of this area is outside of the BCWD legal boundary, and therefore BCWD standards would not apply without implementation by the Valley Branch Watershed District.

Fen – For the purposes of the following standards, the term "fen" includes the delineated area of the fen. GES, Inc. completed a wetland delineation of these wetlands in 2001 which is no longer valid since it exceeds the 5 year validation date. Figure 2 shows the approximate boundary of the fen based on the GES, Inc. delineation; however, a valid delineation will be necessary in the future to define the fen boundary and apply the watershed standards.

Management Area – The area defined by Figure 12, and any subsequent revision based on alterations and grading approved as part of a BCWD permit, that includes both the contributing surface and ground watershed to the fen.

6.2 Standards

2.0 Stormwater Management

2.4.1 Management Standards. An applicant for a stormwater management permit must demonstrate to the District that the proposed land-altering activity will not:

(a) Increase peak stormwater flow from the site, as compared with the pre-settlement condition, for a 24-hour precipitation event with a return frequency of two, 10, or 100 years for all points where discharge leaves a site. There shall be no surface water discharge to the fen or its buffer (excepting rear yard drainage from homes adjacent to the fen).
(b) Increase stormwater flow volume from the management area, as compared with the pre-settlement condition, for a 24-hour precipitation event with a return frequency of two years. There shall be no surface water discharge to the fen or its buffer (excepting rear yard drainage from homes adjacent to the fen).
(c) At the upstream boundary of the fen's buffer, increase annual phosphorous loading as compared with the pre-development condition. There is to be no direct discharge of stormwater runoff (including 100-year + overflow) to the fen or its buffer post-construction or for any phase of the construction process; all stormwater runoff shall either be infiltrated into the ground outside of the boundaries of the fen and its buffer or be routed around the fen and its buffer (excepting rear yard drainage from homes adjacent to the fen). In addition:
    - Roads and parking lots shall be located a minimum of 400 feet from the edge of the fen.
    - There shall be no application of fertilizers or herbicides within the post-development contributing drainage area of the fen by any property owner or their representatives without a BCWD approved turf management plan that mitigates for any potential impact to the fen.
    - There shall be no stockpiling of snow associated with plowing of streets or parking lots in the post-development contributing drainage area of the fen. Plowed snow can be placed in locations that do not contribute surface drainage to the fen and its buffer. This standard does not apply to private homeowners.

2.5.1 Sequence of Management Methods. To meet the standards of section 2.4, site-based stormwater management methods shall be used in the following sequence.

(a) Better Site Design practices
(b) On-site infiltration

2.5.5 Infiltration Pretreatment. Surface flows to infiltration facilities must be pretreated for long-term removal of at least 80 percent of sediment loads. In the event an infiltration facility is constructed in the vicinity downstream of a potential hot spot, a skimmer shall be installed to facilitate clean-up and a spill response plan will be required.

2.5.6 Basin in Contributing Area to Groundwater-Dependent Natural Resource. A stormwater basin within the management area to the fen must contain and infiltrate the volume generated by a two-year, 24-hour storm event. The basin bottom must be at least three feet above the seasonally high water table, bedrock or other impeding layer. If other stormwater management facilities are required to meet the stormwater management

requirements, outflow from these practices shall be routed away from or around the fen and its buffer as there shall be no surface water discharge to the fen or its buffer (excepting rear yard drainage from homes adjacent to the fen).

2.6 Required Exhibits. The following items, submitted in duplicate and certified by a professional engineer registered in the State of Minnesota, registered land surveyor, or other appropriate professional shall accompany all permit applications submitted to the District pursuant to Rule 2.0:

2.6.16 Snow management plan that identifies areas for snow storage.

3.0 Erosion Control

3.2.2 The erosion control plan shall be consistent with the specifications of the MPCA manual "Protecting Water Quality in Urban Areas" and its current revisions, and specifically shall conform to manual recommendations on the following subjects, as applicable:

(a) Implementation schedule and construction sequencing
(b) Critical erosion areas
(c) Limits of disturbed areas
(d) Stabilizing exposed and soil stockpile areas
(e) Stabilizing waterways and outlets (including managing five-year 24-hour event)
(f) Protecting adjacent properties from erosion
(g) Storm sewer inlet protection
(h) Riprap at culvert outfalls
(i) Rock construction entrances
(j) BMP construction details
(k) Horizontal slope grading
(l) Permanent erosion control
(m) Prior to any activity on the site, the buffer perimeter must be clearly delineated with orange construction fencing. Appropriate (as determined by BCWD engineer) perimeter erosion control is also required along the buffer perimeter such as heavy-duty or machine sliced silt fence, biorolls, and/or compost berms. For any portion of the site that drains to the buffer, a vegetated soil berm sized to prevent runoff from the 2-year from entering the fen and appropriately sown with a BCWD approved native seed mix that is certified weed free is also required adjacent to other required perimeter erosion control practices. All practices are to be maintained until the contributing drainage area is stabilized (as determined by BCWD engineer) and removed at that time, except the soil berm which is to remain in place.
(n) Mass grading within the contributing drainage area to the fen shall be staged to minimize the amount of open land at a given point in time. The erosion and sediment control plan shall address the issue of mass grading within the contributing drainage area to the fen by including a construction sequencing plan.
(o) Temporary erosion and sedimentation practices shall not result in the discharge of surface water to the fen or its buffer. All construction stormwater shall be diverted away from the fen and its buffer.
(p) During grading activities on the site, there shall be no stockpiling of material within areas that may temporarily drain to the fen. Stockpiling refers to the temporary storage of soil, aggregate, or debris that will be used or disposed of at a later date.

3.3.3 All grading activity within the pre- and post-development contributing drainage area to the fen must be stabilized as soon as possible to limit soil erosion, but in no case later than 5 days after construction activity in this portion of the site has temporarily or permanently ceased. Temporary cover shall be consistent with the MN Stormwater Manual recommendations and must include appropriately sown certified weed free BWSR Upland Temporary Seed Mix UT1 or approved equal. Permanent cover must be in place within 5 days of establishing final grade and within 45 calendar days of initiating grading activities. Road and utility installations are exempt from this requirement.

For road and utility installations, perimeter control is required at the right-of-way boundary. Perimeter control can consist of heavy-duty or machine sliced silt fence, biorolls, and/or compost berms with construction fencing. Permanent cover must be in place within 5 days of establishing final grade.

4.0 Lake, Stream, and Wetland Buffer Requirements

4.2 Applicability.

4.2.1 Rule 4.0 applies to land:

(a) adjacent to Brown's Creek; a tributary of Brown's Creek designated as a public water pursuant to Minn. Stat. §103G.005, subd. 15, as amended; a recreational development or natural environment lake designated as a public water under Minn. Stat. §103G.005, subd. 15, as amended; a wetland one acre or larger; or a groundwater-dependent natural resource; and
(b) the proposed activity requires a BCWD permit.

4.3.6 Buffer width may vary where the applicant can clearly demonstrate the need to vary from the District's rule or when there is a potential to provide benefits to the resources of the District, provided the minimum 100 foot width is maintained on the upstream side of the fen, that the average width at least equals the applicable width of subsection 4.3.1, the buffer is at least half of that width at all points, and the buffer provides water resource and habitat protection at least equivalent to that of a uniform buffer of the required width. Buffer area calculation will exclude any part of the buffer exceeding twice the width specified in subsection 4.3.1.

4.4 Limitations in Buffer Zones.

4.4.2 Lake and Wetland Buffers; Streamside Zone of Stream Buffer. The following activities are prohibited within the buffer to the fen:

(a) Creating impervious cover.
(b) Excavating fill (temporarily or permanently) or placing fill (temporarily or permanently) or debris.
(c) Altering vegetation, except for (i) vegetative enhancements, as approved in writing by staff; and (ii) the removal of invasive exotic species or of trees for disease control or revegetation. A tree larger than six inches in diameter at a point two feet above the ground may be removed only on written authorization from District staff on a determination that the tree removal will not impact the groundwater dependent natural resource and the function of the buffer will not be diminished.

(d) Applying phosphorous-containing fertilizers.
(e) Locating roads, trails or utilities.

4.6 Temporary Alterations. There are to be no temporary alterations within the buffer to the fen excepting alterations required to implement a District-approved buffer restoration plan.

4.7 Roads and Utilities. There shall be no crossing of the fen.

4.8 Exceptions.

4.8.2 Access to the fen for a lawful private or public use of the resource may be created and maintained 50 feet from the fen boundary on the east side (downstream side) of the fen. All access surfaces (trails) within the buffer zone must be pervious and permanent vegetative disturbance shall be limited to that necessary for access in light of the nature and extent of the permitted use. This exception will be granted upon approval of the trail construction documents.

6.0 Watercourse and Basin Crossings

6.2 Regulation. No person shall use the bed of the fen for the placement or roads, highways and utilities.

7.0 Floodplain and Drainage Alterations

7.3.1 There shall be no floodplain filling within the boundary of the fen.

12.0 Additional Standards

12.1 Groundwater Appropriations.

12.1.1 Wells must be placed within aquifers that are below a confining layer or applicant must demonstrate that all appropriations from the well will not impact the pre-development groundwater contributions to the fen.

12.1.2 Required Exhibits. The following items, submitted in duplicate and certified by a professional geologist registered in the State of Minnesota, or other appropriate professional shall accompany all permit applications submitted to the District pursuant to Rule 12.0:

(a) Irrigation well or community supply well must submit an irrigation plan that demonstrates no impact to the fen.

(b) Copy of well logs for proposed appropriation well and associated monitoring wells indicating geologic stratigraphy, groundwater elevations, proposed appropriation, and location.

(c) Results of aquifer test plan for community supply well and preliminary wellhead protection plan.

(d) Information relative to determining if a continuous confining layer is present including laboratory tests when needed to determine confining characteristics of the

confining layer, groundwater flow modeling, and geologic characterization of the area.

12.2 Construction Activity within Management Area.

12.2.1 There shall be no borrowing of materials within the contributing drainage area of the fen. All grading activities shall leave in-situ materials in place.

12.2.2 The construction of road beds and utilities (water, sanitary, gas, electric, cable) shall demonstrate that impermeable layers in the soil profile are not being intersected, that the excavation area will not create a preferential flow path for the shallow groundwater system and that there will be no adverse impact to the fen.

12.2.3 It shall be demonstrated that proper joint sealings are used on manholes and stormsewer pipes to prevent the inflow of groundwater.

7.0 References

Brown's Creek Watershed District (BCWD), 2007. Third Generation Watershed Management Plan. Prepared by Emmons & Olivier Resources, Inc.

Brown's Creek Watershed District (BCWD), 2007. Watershed District Rules.

Emmons & Olivier Resources, Inc., 2003. Integrating Groundwater & Surface Water Management Northern Washington County. Prepared for Washington County, MN.

Folle, S., 2009. Memorandum on SWAT Modeling of BCWD Fen Watershed Hydrology. Prepared for Emmons & Olivier Resources, Inc.

Graham Environmental Services, Inc. (GES, Inc.), 2001. Indian Hills Golf Club, Wetland Delineation Report.

Minnesota Department of Natural Resources, 1998. DRAFT Savage Fen Resource Plan – A Comprehensive Framework for Sustaining the Savage Fen Wetland Complex. Public Review Draft.

Minnesota Department of Natural Resources - MIS Bureau (DNR), 2008. Land Cover - Minnesota Land Cover Classification System

Minnesota Geological Survey, 1992. Geologic Atlas of Washington County, Minnesota

Twin City Testing Corporation (TCT), 2001. Geotechnical Exploration Program, Proposed Indian Hills Country Club Expansion Project. Prepared for Mogrow, Inc.