Environmental Monitoring of Nicols Fen

Conservation Partnership Grant #CP05-014

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Conservation Partnership Grant #CP05-014
Abstract

Project Title: Environmental Monitoring of Nicols Fen

Lead Implementing Organization: Gun Club Lake Watershed Management Organization

Total Cash/In-kind Contributions Excluding Grant: $ 19,250

Project Description:

- Project size: 525 acres
- Project location: The Nicols Meadow complex is located south of the Minnesota River and east of Cedar Avenue in the City of Eagan.
- Purpose: The purpose of this project was to collect and analyze groundwater and stream flow research within the Nicols Meadow Complex as well as identify sources of disturbance to the hydrologic regime.
- Proposed use of project information: Project information is necessary to identify locations where surface water infiltration may be encouraged or improvements constructed will directly benefit the supply of groundwater resources to the Nicols Meadow area.

Methodology:

- Existing data was collected and analyzed.
- Project meetings were held which representatives from the Minnesota Department of Natural Resources, City of Eagan, Lower Minnesota River Watershed District, Minnesota Department of Transportation, Metropolitan Council Environmental Services, Dakota County Soil and Water Conservation District, and US Fish and Wildlife Service discussed the project.
- Monitoring of the groundwater level in wells through out Nicols Fen, flow and temperature of the streams within Nicols Meadow and precipitation in the area was conducted.
- Site visits were conducted and GPS data was collected on the locations of active wells within the complex.
- A survey of the ground and top of pipe elevations was conducted for the active wells.

Significant Findings and Outcomes:

- Groundwater within Nicols Fen may respond to precipitation.
- Dewatering activities of Seneca Wastewater Treatment Plant may have negatively affected the aquifers of Nicols Fen.
- Determined the recharge area for Nicols Fen.
- Determined Kennealy and Harnack creeks to be unable to sustain trout populations without restoration.

- Stakeholder communication/collaboration with nearly a dozen local, state, and federal agencies.
- Review of historical information.
- Shoreland designation for Kennealy and Harnack creeks.
- Rosgen stream assessments for Kennealy and Harnack creeks.
- Determination of MDNR headwaters for Kennealy and Harnack creeks.
- Preparation of Recommended Implementation Plan for the Nicols Meadow Resources.
- Development of GIS database.
- Identified need to conduct additional ground water resource information.
- Identified need to prepare a Comprehensive Management Plan for Nicols Meadow.

1.0 Preface

The Gun Club Lake Watershed Management Organization (GCLWMO) conducted this project, Environmental Monitoring of Nicols Fen, in the City of Eagan, Minnesota with funding by the Minnesota Department of Natural Resources (DNR) through Conservation Partnership Grant CP05-014.

Matching funds for this project were provided by Lower Minnesota River Watershed District, (LMRWD) and City of Eagan. The project was directed by the GCLWMO. The technical group that guided the project included representatives from the DNR, GCLWMO, LMRWD, City of Eagan, Minnesota Department of Transportation (MnDOT), Metropolitan Council Environmental Services (MCES), Dakota County Soil and Water Conservation District (SWCD), and US Fish and Wildlife Service.

2.0 Introduction

Nicols Fen is located in the City of Eagan just southeast of the Minnesota River, east of Cedar Avenue (TH 77), and northwest of TH 13 as indicated in **Figure 1, Appendix A.** Nicols Fen is one of several calcareous fens that are located along the Minnesota River terrace. Calcareous fens are the most rare wetland type in Minnesota. Characteristics typical of calcareous fens include groundwater discharge that is rich in calcium and magnesium bicarbonates and sulfates, alkaline soil conditions, the presence of rare plant species, and a peat substrate. Trout streams are commonly associated with fens because of groundwater discharge. Nicols Fen is associated with two Trout Waters as defined in Minn. R. 6264.0050 subp. 2 and 4: Kennealy and Harnack creeks.

The purpose of this project is to establish an understanding of groundwater conditions and any factors that influence the groundwater at Nicols Fen. In order to gain this understanding, the following objectives were completed: 1) evaluate historical stream flow, groundwater, and precipitation data; 2) monitor groundwater, stream flow, and precipitation; 3) estimate trends of groundwater levels and estimate causes of historical changes in groundwater levels; 4) provide recommendations for groundwater management to restore and conserve Nicols Fen. To achieve these objectives field monitoring was conducted, a GIS database was developed, collected data were analyzed, and this report was prepared to summarize the findings and provide recommendations.

The environmental monitoring of Nicols Fen resulted in the production of two final products: this report and advancement of the Nicols Fen area GIS database. Copies of the report and GIS database were distributed to the DNR, City of Eagan, and LMRWD.

3.0 History of Nicols Fen

A general history of Nicols Fen includes a variety of disturbances that have affected the soils and vegetation of the area, as well as the hydrologic regime. Historical maps and aerial photographs of Nicols Fen are included in **Appendix B,** and a general timeline of major events affecting Nicols Fen over the last few decades follows.

General History of Nicols Fen									
1867	**1890**	**Great Depression**	**1959**	**1962**	**1971**	**1972**	**1977**	**1992**	**1994**
Railroad, Nicols Flag Station	Original Cedar Avenue Bridge Construction	Trout pond Construction on Kennealy Creek	Eagan Storm Sewer Outfall (#276) Construction	Fort Snelling State Park Established	Bloomington Siphon Construction	Seneca Wastewater Treatment Facility Construction	Improved Cedar Avenue Construction	Seneca Wastewater Treatment Plant Expansion	Bloomington Siphon Improvement Construction

3.1 Minnesota River

The Minnesota River borders Nicols Fen to the northwest, and during high water, the river inundates portions of Nicols Fen. Such inundations have altered and sedimented the lower reaches of both Kennealy and Harnack creeks.

3.2 Fens Along the Minnesota River Terrace

It is presumed that a large area of calcareous fens and other wetland types occupied the Minnesota River terrace in the Twin City area prior to European settlement. Approximately 5,000 acres of fens originally existed along the Minnesota River terrace, but only about 3% remain today according to Welby Smith, fen expert for the DNR (Wallin, 1989). Existing nearby fens include Black Dog Fen located within the Black Dog Unit of the Minnesota Valley National Wildlife Refuge to the southwest of Nicols Fen, Sibley Fen located northeast of Nicols Fen within Ft. Snelling State Park, and Quarry Island fen also located northeast of Nicols Fen within Ft. Snelling State Park.

3.3 Division of Land

Division of the land into parcels came with settlement of the area. Currently, parcels within Nicols Fen area are both publicly and privately owned. Publicly owned parcels are administered by the Minnesota Department of Natural Resources, Minnesota Department of Transportation, US Fish and Wildlife Service, City of Eagan, and MCES. Public parcel ownership and associated uses within Nicols Fen area are outlined in the table below and shown in **Figure 2, Appendix A**.

Nicols Fen Area Public Parcel Ownership and Their Uses	
Agency	**Use**
Minnesota Department of Natural Resources	Portion of Ft. Snelling State Park
Minnesota Department of Transportation	Cedar Avenue/TH 77 and stormwater basin; boat access
US Fish and Wildlife Service	Managed; Portion of Cedar Grove Area
City of Eagan	Former Storm sewer outfall; Portion of Cedar Grove Area
Metropolitan Council	Seneca Wastewater Treatment Facility; sanitary sewer lift stations; open space; Portion of Cedar Grove Area

3.4 Railroad and Nicols

In 1867, Nicols began as a flag station on the Chicago, St. Paul, Minneapolis & Omaha Railroad line (Eagan, 1985), which transects Nicols Fen in a northeast-southwest alignment. Although never officially designated as a town, Nicols was considered a station-town and consisted of a railroad station and a few buildings within Eagan Township (Wallin, 1989). Nicols was often called "Quaketown" because much of it shook when trains passed because of the saturated peaty soils in the area.

Nicols was very successful commercially. Its most famous commercial product, and the reason the Twin Cities became a top metal-pouring center, was high quality molding sand found on land owned by Thomas Kennealy (Wallin, 1989). This sand was in such high demand at one point that it was purchased by the trainload (Wallin, 1989).

Agriculture was also important economically for Nicols. Major crops included onions and potatoes. Corn was also grown in the area, and portions of the grassy lowland were mown for hay. Historical aerial photographs indicate that a large portion of Nicols Fen was disturbed by agricultural activities and mowing. Drain tiles were installed throughout the area to create conditions supportive of agricultural activities. Exact drain tile locations within the complex are not known, but some tiles have been identified in the western lobe of the fen (MWCC, 1993).

Nicols Town Dump is located in the northeast portion of the intersection of Nicols Road and the railroad tracks. Information on the dump is included in **Appendix C**, which includes an annotated aerial photograph of the dump and various buildings of Nicols, as they existed in 1951, as well as a detailed sketch of dump materials identified in March 1999. Dump materials include household items such as stoves and glass, and demolition and construction materials such as cement slabs, flooring tiles, landscaping waste, and creosote treated poles. The dump is located near the previously located storm sewer outfall within Nicols Fen, and dumped materials are partially exposed in the area.

Historically, much of the area was utilized for recreational activities, including hiking and fishing. People frequently fished both Kennealy and Harnack creeks for trout in the spring. The late Joe Kennealy, son of Thomas Kennealy who owned much of the land comprising Nicols Fen, described fishermen parking at the train depot, and then walking along the tracks to fish Kennealy Creek. He also described people from the University of Minnesota often coming to the area in search of rare plants. The complete transcript of an interview with Joe Kennealy is included as **Appendix D**.

Some time after 1993, a culvert was constructed at the crossing of Kennealy Creek beneath the railroad tracks, replacing a bridge that previously existed at this location. The bridge is shown in **Figure 1, Appendix E.** The culvert that replaced the bridge is a 60-inch diameter corrugated metal pipe. Riprap was placed at both ends of the culvert. Current photos of the culvert and vegetation at both ends of it are shown in **Figures 2-4, Appendix E**. There is also a culvert at the crossing of Harnack Creek beneath the tracks.

3.5 Original Cedar Avenue Bridge and Construction of Improved Cedar Avenue (TH 77)

The original Cedar Avenue Bridge was built by Hennepin County in 1890. This bridge connected the City of Eagan to the City of Bloomington and was a hand-opened swing-span bridge built for horse-drawn vehicles and cattle (Eagan, 1985). The original Cedar Avenue in the project area is now known as Nicols Road. Nicols Road transects Nicols Fen in a northwest-southeast alignment. The Swing Bridge over the Minnesota River was destroyed with the construction of the improved Cedar Avenue (TH 77), which began in February 1977 and was completed in the early 1980s.

Construction of the improved Cedar Avenue resulted in the dumping of an estimated 746,000 cubic yards (570,000 cubic meters) of peat and other organic material around the upper reaches of Kennealy Creek in an area of approximately 27 acres (11 hectares) (Johnson, 1978; see also **Appendix D**). The location of the spoil pile is shown in **Figure 3, Appendix A**.

3.6 Trout Pond Alterations to Kennealy Creek

During his interview, Joe Kennealy (see **Appendix D**) described a time during the Great Depression when a man came to his father with an idea to raise trout on the farm. The man suggested damming up Kennealy Creek to create rearing ponds. The man offered $1,500 per year to lease the property, and Joe's father, Thomas, accepted the offer. The man sold stock in the venture. Thomas hired three to five workers that worked for approximately two to three weeks constructing the dams. The venture ended when the $1,500 check bounced and the man could not be contacted again. The alterations to Kennealy Creek are still present and are indicated in **Figure 3, Appendix A**.

3.7 City of Eagan Storm Sewer Outfall

The July 31, 2002 Nicols Fen, Kennealy and Harnack Creeks Project Report stated that the City of Eagan constructed a storm sewer outfall within Nicols Fen in 1959. At the time of that report the stormsewer outfall had created a large "blowout" area and an eroded gully. Following a recommendation of the report, the City of Eagan relocated that storm sewer outfall further to the north and restored the "blowout" area.

3.8 Ft. Snelling State Park

Ft. Snelling State Park was established in 1962. Much of Nicols Fen located north of the railroad tracks is within the park boundaries. In addition to portions of Nicols Fen, the park contains Sibley Fen and Quarry Island Fen.

A gravel surface biking/hiking summer trail within the park bordering the Minnesota River just north of Nicols Fen is also used for skiing or hiking in the winter. Ft. Snelling State Park trail maps are included in **Appendix G**.

During preparation of the 2002 report, the Department of Natural Resources purchased the remaining privately owned parcel near the fen located north of the tracks and east of Nicols Road.

3.9 Bloomington Siphon Construction and Subsequent Improvements

The Bloomington Siphon, a pipe carrying wastewater from the City of Bloomington to the Seneca Wastewater Treatment Facility (Seneca WWTF), was originally constructed in 1971 along the existing alignment of Nicols Road.

In the mid-1990s, the Bloomington Siphon Improvement project resulted in the construction of two additional siphons and rehabilitation of the existing siphon. As a result of legislation regarding calcareous fens in Minnesota, the Minnesota Department of Natural Resources prepared the "Commissioner's Management Plan for Protection of the West Lobe of Nicols Fen." This plan was completed in June 1994 to define the conditions governing the siphon improvement project. Because of the environmental review process, scientific data were collected and presented in the report titled "Nicols Fen Baseline Assessment Report." This report helped define the condition of the west lobe of the fen prior to construction of the siphon improvement project so that determinations could be made regarding any impacts to the fen. The report included only the west lobe of the fen because there was insufficient data for the remainder of the fen to adequately provide a baseline for those areas. The report concluded that the area had undergone a variety of disturbances such that it would not be possible to determine impacts resulting from the siphon project alone.

3.10 Construction and Expansion of the Seneca Wastewater Treatment Facility

The Seneca WWTF was built in 1972, and subsequently expanded in 1992. The Seneca WWTF is shown in **Figure 3, Appendix A**, and is the third largest facility of its kind in the state, providing primary and secondary treatment of wastewater before discharging it to the Minnesota River. The Seneca WWTF has a current capacity of 38 million gallons per day and serves a population of 275,000, including the communities of Apple Valley, Bloomington, Burnsville, Eden Prairie, Edina, Inver Grove Heights, Eagan, Lakeville, and Savage.

Expansion of the facility required dewatering during construction. To mitigate impacts to the fen from dewatering, Metropolitan Council Environmental Services installed an irrigation system and a series of injection wells in 1990 in an attempt to rehydrate the fen. All of the injection wells were sealed on January 17, 1996.

3.11 Developing Land Uses in the City of Eagan and Surrounding Areas

The City of Eagan developed rapidly from the 1970s to the 1990s. The development along the eastern boundary is comprised of industrial, commercial, and residential land uses. Current land use and zoning maps of the Nicols Fen area are shown in **Figures 1-2, Appendix H.** The City has used information collected for the 2002 report to establish shoreland overlay district boundaries around the two creeks. Stormwater management and groundwater recharge is one of many considerations in redevelopment plans of the Cedar Grove Special Area.

4.0 Existing Condition of Nicols Fen

4.1.1 Ground Water

Nicols Fen and both Kennealy and Harnack creeks rely on a constant supply of groundwater. Many groundwater monitoring wells have been installed within Nicols Fen, and maps of these wells and associated data are included in **Figure 1**, **Appendix I**.

The groundwater supply to Nicols Fen can be altered by activities in the immediate area, as well as activities within the groundwater recharge area, which may extend far beyond the immediate area. The presumed recharge area for Nicols Fen is largely composed of residential development with some industrial, commercial, and right-of-way land uses. Activities within the immediate area that likely impact the groundwater hydrology of Nicols Fen are described below.

4.1.2 Surface Water

Increases in impervious surfaces accompany most development and result in an increase in stormwater runoff within an area. Runoff from impervious surfaces is typically warm, and may contain sediment and contaminants. The introduction of sediment and contaminants can reduce the viability of a stream to sustain trout.

Nicols Fen exists where groundwater discharges to the surface, forming both Kennealy and Harnack creeks. Multiple seeps, areas at which groundwater emerges at the surface, have been identified within Nicols Fen. Water that forms the creeks flows above and below the ground surface at different locations throughout the courses of the creeks. Groundwater is typically cold, ranging in temperatures from the 50 to low 60s° F, and has a high dissolved oxygen content. These are characteristics necessary to sustain trout populations.

The subwatershed for Nicols Fen is provided in **Figure 1, Appendix F**. Impervious surfaces in the drainage area include Nicols Road, Cedar Avenue/TH 77 bordering the area on the west, and residential and commercial development to the south and southeast. Data collected during 1996 suggest that water discharging to the upper reaches of Kennealy Creek from a stormwater pond (Eagan AP-52) does not affect the temperature of Kennealy Creek. The City of Eagan rerouted away from the fen area the storm sewer outfall that was constructed in 1959.

4.1.3 Kennealy and Harnack Creeks

Kennealy and Harnack creeks were delineated and mapped as part of the 2002 project, and those data are included in **Appendix J.** This work enabled the City of Eagan to delineate the 300-foot wide shoreland overlay districts, which are subject to city land use regulations.

A variety of activities that may have affected the creeks are described below, followed by a description of their current condition as assessed during the fall of 2001. Summaries of the information collected regarding Kennealy and Harnack creeks are included in **Appendix K** and **Appendix L** respectively.

Activities Affecting the Creeks

Spoil Pile

The spoil pile composed of peat and other organic spoil material potentially (see **Figure 3, Appendix A**), has impacted the water quality of the creek in a variety of ways. Johnson (1978) found increased levels of turbidity and suspended solids in Kennealy Creek following rain events due to inadequate construction of the dike surrounding the spoil pile. He concluded that the material and design of the

dike contributed to the erratic fluctuations in turbidity and suspended solid levels in Kennealy Creek. The spoil pile has since become vegetated.

Railroad Tracks

Single railroad tracks cross both creeks within Nicols Fen. Fill materials under the tracks may act as either a conduit for water movement or an impediment to water movement.

Nicols Road

Nicols Road is a two-lane road that transects Nicols Fen in a northwest-southeast alignment. Multiple utilities exist along this alignment. As is the case with the railroad tracks, fill materials under the road and the utilities within the road may act as either conduit for water movement or an impediment to water movement within Nicols Fen.

Beaver Dams

Records indicate that beaver dams have altered the hydrology of both creeks. In the case of Kennealy Creek, it is noted that no beaver dams existed in a stream survey report dated August 23, 1960. Johnson (1978) documents an "old beaver dam" along Kennealy Creek, and this is the first noted reference to beaver activity at this creek. The earliest record of beaver activity along Harnack Creek is of two active beaver dams south of the railroad tracks documented in a DNR office memorandum dated February 7, 1980. Many earlier records for Harnack Creek were not obtained prior to submittal of this report, and it is possible that beaver activity occurred prior to 1980. A beaver pond currently exists where Harnack Creek discharges northward from beneath the railroad tracks as indicated in **Figure 3, Appendix A**.

MnDOT Pond

Construction of a stormwater retention pond accompanied the construction of the Improved Cedar Avenue/TH 77. This pond treats runoff from Cedar Avenue/TH 77 prior to discharging runoff to the Minnesota River. The pond was constructed in an area that previously had been altered for agriculture. Portions of Black Dog Creek and its associated tributaries also were located within this area, but were replaced by the pond.

The path of Harnack Creek was altered by the construction of Cedar Avenue/TH 77 and the associated MnDOT pond. Harnack Creek appears to have been a tributary to Black Dog Lake, as indicated on historical maps included in **Appendix B**. From the maps, it appears that the construction of Cedar Avenue/TH 77 resulted in removal of the connection of Harnack Creek to Black Dog Lake, as well as the connection of Black Dog Creek to Black Dog Lake. Currently, Harnack Creek joins what remains of Black Dog Creek just east of Nicols Road. Kennealy Creek joins downstream from this location.

Under existing conditions, Harnack Creek flows north from the beaver pond, which is located north of the railroad tracks, towards the MnDOT pond. The creek then flows east within a defined channel that borders the side slope of the road that provides access to the MnDOT pond. It is presumed that this portion of the creek was channelized as a result of the construction of the pond. Harnack Creek then flows beneath Nicols Road where it joins Black Dog Creek as described above.

Stream Channel Assessments, Fall 2001

General Description

Stream segments were delineated and mapped, and classified according to the Rosgen stream method during Fall 2001. Stream type was determined from field estimates of width/depth ratio, substrate, entrenchment ratio, slope, and sinuosity. In addition to the delineation of the streams, features such as spring seeps and well casings also were mapped. The stream delineations and assessment data are included in **Appendix J**.

From the channel assessments, both streams appear to be well connected to the ground water table as multiple seeps were observed throughout their lengths. Stream flow for both streams was composed primarily of cold, clear groundwater capable of sustaining trout. Both streams were classified as predominantly E6 stream types in their upper reaches. This stream type is characteristically narrow and deep, with fair to high sinuosity, and having a broad, well connected floodplain. According to Rosgen reference (1996), "the E6 stream type is very stable unless the streambanks are disturbed and significant changes in sediment supply and/or stream flow occur." Additionally, both streams are subject to inundation from the Minnesota River in their downstream reaches, which likely contributes to the amount of fine sediment present and may limit the suitability of trout habitat at these locations.

Kennealy Creek

Kennealy Creek is located immediately west of the Seneca WWTF, and a review of hydrologic records indicates that some groundwater that historically reached the creek currently may be diverted as a result of pumping activities at the Seneca WWTF. This diversion of groundwater may be limiting the potential for the creek to support trout.

The highest potential trout habitat along Kennealy Creek appears to be the 1,200-foot reach north of the railroad tracks. This reach is classified as an E6 type with considerably more gravel substrate than other reaches and with a number of relatively deep pools and associated riffles. This reach does not appear to be altered except for the channel immediately downstream from the culvert at the railroad crossing.

Harnack Creek

A small natural artesian spring is near the initial formation of Harnack Creek, and highest potential trout habitat may be limited to portions of the upper reaches. In its lower reaches, Harnack Creek has undergone numerous alterations from beaver activity, ditching, and construction activities,

In the portion of Harnack Creek immediately north of the culvert at the railroad crossing, beaver activity has resulted in the impoundment of water, as shown in **Figure 3, Appendix J**. This activity limited the delineation of a segment of Harnack Creek, and this area is indicated in **Figure 1, Appendix J**.

Increased runoff has likely occurred as a result of urbanization near the upper reaches of Harnack Creek, although the extent of this increased runoff is unknown. As mentioned previously, the area immediately south of the upper reaches of Harnack Creek is currently being redeveloped. There is residential and commercial redevelopment proposed in this area. The City of Eagan has completed storm water modeling for development alternatives in order to determine the potential impacts to Harnack Creek and the western lobe of the fen.

Although the upper reaches of Harnack Creek are predominantly classified as an E6 type, notable exceptions do occur. The gradient in the upper reaches increases and headcuts have formed through a peat layer approximately mid-way up this section, resulting in a G6 stream type. The G6 type is described as an entrenched gully system having a narrow and deep channel that is not well connected to a floodplain. More significant is the ditching of the downstream reaches of Harnack Creek that have resulted in a nearly straight section that is also classified as a G6 stream type. According to Rosgen (1996), "the G6 stream types are very sensitive to disturbance and tend to make significant adverse channel adjustments to changes in flow regime and sediment supply."

4.2.1 General Description of Fen Vegetation

Nicols fen was given a quality rank of "C" in the County Biological Survey completed in 1995. The ranking system is based on a continuum of "A" through "D", with a rank of "A" representing a high quality natural community and "D" representing a poor quality natural community. All fens within Ft. Snelling State Park, as well as Nicols Fen, were given a rank of "C" due to the presence of problematic plant species and scattered woods and shrubs. Despite these negative qualities in the fens, high overall diversity of native fen species was observed, with populations of rare plants and fen indicator species at active seepage zones. Minnesota Land Cover Classification System (MLCCS) information for Nicols Fen is shown in **Figure 1, Appendix M**, and Natural Heritage Database natural community features are indicated in **Figure 2, Appendix M**. Plant lists from 1976, 1989, and 1990 are included in **Appendix N**.

4.2.2 Calciphiles and Rare Species

Only a select group of plants are able to withstand the relatively harsh growing conditions that are typical of calcareous fens. Plant species that are capable of tolerating the calcium-rich conditions are referred to as calciphiles. Such species are used as fen indicator species. Calciphiles that have been documented within Nicols Fen include valerian (*Valeriana edulis*), sterile sedge (*Carex sterilis*), needle beak-rush (*Rhynchospora capillacea*), swamp lousewort (*Pedicularis lanceolata*), and beaked spikerush (*Eleocharis rostellata*) (Morley, 1976; Cholewa 1989b; Cholewa, 1990; Dunevitz, 1995). Valerian, sterile sedge, and needle beak-rush are listed in Minnesota as threatened species.

Some plant species are considered to be characteristic of calcareous fens, but may grow in other environments as well. Species of this type that have been documented within Nicols Fen include swamp thistle (*Cirsium muticum*), white lady slipper (*Cypripedium candidum*), grass-of-parnassus (*Parnassia glauca*), and wild timothy (*Muhlenbergia glomerata*) (Morley, 1976; Cholewa, 1989b; Cholewa 1990; Dunevitz, 1995). The white lady slipper is listed as a species of special concern in Minnesota.

Fens typically contain a variety of rare plant species. Nicols Fen contains rare species in addition to those described above. Whorled nut-rush (*Scleria verticillata*) is listed as threatened in Minnesota and has been documented on the site, along with whorled loosestrife (*Lysimachia quadrifolia*), which is listed as a species of special concern in Minnesota (Cholewa, 1989b; Dunevitz, 1995).

Population dynamics of the rare plant species within Nicols Fen have not been thoroughly studied, and at this time it is unknown whether these species are declining or increasing in numbers.

4.2.3 Problematic Plants

Problematic plants are typically invasive species that result in lowered diversity through their ability to create extensive monotypic stands. A variety of characteristics of problematic plants allow these species to displace many beneficial plants, drastically altering natural communities and providing minimal habitat. These invasive species can lead to the decline of rare species. Problematic plants of main concern that were identified in Nicols Fen on September 26, 2001 include reed canary grass (*Phalaris arundinacea*), common buckthorn (*Rhamnus cathartica*), glossy buckthorn (*Rhamnus frangula*), purple loosestrife (*Lythrum salicaria*), and giant reed grass (*Phragmites australis*).

Reed Canary Grass – *Phalaris arundinacea*

Reed canary grass is a problematic species in the wetlands of Minnesota. This species occurs throughout the state and is still being planted due to its ability to quickly and effectively stabilize soil. This species is invading wetlands at an alarming rate, outcompeting most native species, and creating vast monotypes that provide minimal habitat value. Although a native strain of this grass exists, the European strain has essentially assimilated it (Eggers and Reed, 1997).

Reed canary grass was found to be the dominant species in the southwest portion of the fen, which contains the upstream portion of Harnack Creek, in a baseline study of that area undertaken in 1993 (MWCC, 1993). Reed canary grass currently dominates the vegetation along the banks of Kennealy and Harnack creeks, and is found throughout Nicols Fen.

Buckthorn – *Rhamnus spp.*

Both common and glossy buckthorns are becoming increasingly problematic in a variety of habitats in Minnesota. Both species were introduced from Eurasia and have been extensively planted as ornamentals because of their ability to form dense hedges that provide privacy. These are woody species that can grow greater than twenty feet in height, and produce many viable seeds. These species take over the environments into which they are introduced. Many birds eat the berries produced on these species, and the seeds subsequently are spread to a variety of locations.

Invasive woody species such as buckthorn create problems in fens because they can drastically alter characteristics that allow the fens to persist over time. Woody species can alter fen hydrology and vegetative cover by creating drier soil conditions. Additionally, woody species that form dense clumps alter light and temperature regimes causing a decline in vegetative diversity.

Purple Loosestrife – *Lythrum salicaria*

Purple loosestrife is another extremely problematic species that is invading wetlands throughout Minnesota. This species was introduced from Eurasia and is capable of creating vast monotypes. Purple loosestrife has become established throughout Nicols Fen and the surrounding area.

Giant Reed Grass – *Phragmites australis*

Giant reed grass, although native to Minnesota, is considered a problematic plant because of its ability to form extensive monotypic stands. Studies have shown that this species can steadily advance into fen communities, eventually outcompeting most calcareous fen and sedge meadow species and lowering diversity (Eggers, 1995). A few relatively large stands of this species have become established within Nicols Fen, and this species occurs throughout the area. A current photo of a large stand in Nicols Fen is indicated in **Figure 3, Appendix M**.

Other Problematic Plants

Other problematic plant species within Nicols Fen that may require management include Canada thistle (*Cirsium arvense*), birdsfoot trefoil (*Lotus corniculatus*), and honey locust (*Gleditsia triacanthos*).

4.3 Soils

The soils identified on the Soil Survey of Dakota County Minnesota (USDA, 1983) within Nicols Fen include a variety of mucks and loams within the lower topographic areas along the Minnesota River and including the majority of the fen, and mainly sands and loams in the higher topographic areas to the southeast. The mapped soils are shown in **Figure 1, Appendix O** and outlined in the table below:

Mapped Soils Within Nicols Fen,

NAME	SYMBOL
Sparta loamy fine sand	8A, 8B
Dickinson sandy loam	27B
Terril loam	94C
Oshawa silty clay loam	317
Tallula silt loam	320B
Minneiska loam	463
Boots muck	522
Palms muck	539
Seelyville muck	540; sloping: 1825C
Rondeau muck	545
Hawick loamy sand	611F
Urban land-Hubbard Complex	865B
Wet Udorthents	1027
Gravel pits	1029
Ponded Aquolls and Histosols	1055

Source: USDA Soil Survey of Dakota County

The Dakota County Geologic Atlas indicates that the depth to bedrock within Nicols Fen ranges from 101-201 feet, as shown in **Figure 2, Appendix O**.

Nicols Fen is located in the valley of the ancient Glacial River Warren. St. Peter Sandstone underlays deposits of unconsolidated glacial drift. The unconsolidated drift material that covers most of the Minnesota River Basin is calcareous, and is the likely source of the dissolved calcium carbonate load transported by ground water to fens in this area (Leete). Leete found that the depth to carbonate bedrock for the Nicols Fen is approximately 50 meters.

5.0 Procedures and Methods

5.1 Groundwater Monitoring

Several agencies collectively have established historical information about the fen. Along with information on the history of the area, monitoring results dating back to1989 were compiled in an Excel Spreadsheet. A review of this information identified gaps in monitoring efforts. Recent monitoring efforts of the MCES, SWCD, as funded by LMRWD and City of Eagan provided additional data to estimate current groundwater conditions and historical trends.

To date, nine wells are monitored along with the continued monitoring of the thirteen original wells. The monitored wells are dispersed through out the area as some are on the interior of the fen, some on the edge, and others are located outside of the Fen. The well data collected allows for the creation of limited contour images of the water table within the fen, and allowed for the limited interpretation of groundwater trends.

There are twenty-two piezometers of interest located within the Nicols Fen area. The SWCD recently has been monitoring thirteen of the piezometers each month via financial support by the LMRWD. SWCD monitors the nine wells identified as pertinent after analysis of the historic data, these include W3, W2, W5, 1LS, 1LN, W5-USGS, W1, W1-USGS and W4. Measurements are taken at wells F1, F2, F3 and F4 by both SWCD and MCES. Measurements are made using a hand-cranked steel tape graduated in feet, tenths of feet, and hundredths of feet or an electronic water level meter. Results are recorded manually and transferred to the well monitoring database following all in-field measurements (Bistodeau). Locations of the wells and piezometers being monitored are shown on Figure 1, in Appendix P.

Measurements are taken at the thirteen historically monitored wells by MCES. MCES provides data on a quarterly basis. Each quarterly report contains monthly monitoring data of the following wells; OBS-4, OBS-4A, OBS-6, OBS-10, MW-3, MW-7A, MW-8A and MW-9A, and bi-monthly data for OBS-5, F1, F2, F3 and F4. The wells monitored by MCES are dispersed throughout the area and lay mostly to the east of the Fen near Seneca Wastewater Treatment Facility. The method of measurement used by MCES is an electronic water level meter.

The position of the piezometers within the fen were located and recorded using a GPS unit. The condition of each of the wells was also noted. The well locations were stored in a GIS database and used to create a map of the active wells within the region. This information was then combined with the monitoring information and is the basis for the GIS database. It was realized that a recent survey of the well elevations was necessary to accurately analyze the monitoring data. A survey was conducted measuring the top of well elevations along with the ground surface elevation at each well. This information along with the results of the monitoring was mapped and a contour map of the area was created, **Figure 1, Appendix R**.

5.2 Stream Flow Monitoring

Stream flows were monitored to estimate trout habitat potential. Both temperature and flow of Kennealy Creek and Harnack Creek have been monitored since October of 1998 and continue to be monitored. The MCES monitors both creeks twice monthly and provides the data in their quarterly reports with the well monitoring data.

5.3 Precipitation Monitoring

Precipitation was monitored via existing stations in proximity to the Nicols Fen area, and precipitation data were compared to groundwater elevation data to estimate if there were any hydrological trends. **Figure 1, Appendix Q** shows the monthly and annual precipitation over the last 20 years.

6.0 Data Analysis

6.1 Groundwater Data

Compilation of all known monitoring data associated with Nicols Fen was entered into an Excel Spreadsheet and analyzed using several graphical comparisons. This resulted in several figures which indicate correlations between precipitation and groundwater levels as well as potential impacts of Seneca WWTP and other development. The data also resulted in the development of a GIS database used to develop typical cross sections and a contour map (**Figure 1, Appendix R)** to portray the current condition of groundwater elevations within the Fen.

Figure 2, Appendix Q displays the annual precipitation and the average yearly groundwater elevations at wells MW3, MW7A, MW8A, and MW9A from 1998 through 2007. **Figure 3, Appendix Q** shows the annual precipitation and the average yearly groundwater elevations at wells OBS4, OBS4A, OBS5, OBS6, and OBS10 during the same time period.

Monitoring data for wells F1, F2, F3 and F4 have been collected for the longest period of time and at the most consistent intervals. Groundwater elevations of these wells from 1989 through 2007 along with the annual precipitation are displayed on **Figure 4, Appendix Q**. Precipitation data presented in Figure 4 begins in 1987 provide 3-years of previous rainfall data to assist in determining the impact of precipitation on groundwater levels. On the same graph, the dates of two major construction projects are shown, the Seneca WWTP Expansion and the Bloomington Siphon Improvement Project.

Figure 5, Appendix Q is similar to **Figure 4** with all of the storm events greater than one inch reduced to one-inch events. For example a rainfall event of 2.5” was reduced to 1”.

This method was developed in an attempt to screen out rainfall events that may have generated more surficial runoff and less groundwater infiltration. The modified precipitation data may more reasonably show the amount and frequency of water that may influence groundwater levels.

Groundwater contour maps have been developed using GIS software and monitoring data for the Nicols Fen area. **Figure 1, Appendix R** shows the approximate groundwater levels as monitored in 2007.

Ground elevations have been graphed to see if there has been any variation over the last 18 years. **Figure 6, Appendix Q** displays ground elevations for the wells where data were available. **Figures 2 and 3 in Appendix R** are cross sections of groundwater and ground elevations in Nicols Fen.

The City of Eagan's Wellhead Protection Plan was reviewed to determine areas of the city that may generate groundwater recharge to Nicols Fen and the amount of time required for this movement of water within the aquifer. **Figure 4, Appendix R** shows the expected recharge area at Nicols Fen assuming similar conditions to the Wellhead Protection Plan.

6.2 Stream Data

This project monitored temperature and flow in Kennealy and Harnack creeks. Measurements were recorded to establish trends and determine the viability of the streams. Over the last ten years the highest temperature recorded for Kennealy Creek has been 65 degrees and Harnack Creek was 63 degrees (**Figure 7, Appendix Q**).

Flow monitoring was performed at both creeks to determine the viability of the streams to maintain adequate flow to support trout populations. The data reveals that in many instances during the past ten years the flow in each of the creeks has dropped well below 0.5 cfs. Measurements recorded in August of 2004 indicate no flow present in Kennealy Creek (**Figure 8, Appendix Q**).

7.0 Groundwater Observations

Upon review of the analyzed data, a number of observations in regard to groundwater information within the Nicols Meadow area can reasonably be made. These observations and the source of these observations are discussed below:

1. **Figures 2, 3, and 4 in Appendix Q** compare the annual precipitation to the average annual groundwater elevation measured within the Nicols Fen complex. Upon review of the tables, a reasonable observation can be made that as precipitation decreases, the groundwater within the fen complex responds within a

1-2 year period with reduced groundwater elevations. This observation has been highlighted in the figures located in **Appendix Q**.

2. **Figure 4 in Appendix Q** contains the wells with the longest period of recorded groundwater elevations. Groundwater monitoring goes back to 1989 and shows the affect of the dewatering operations for the construction of the Seneca Treatment Plant expansion on groundwater elevations within the fen. The left side of the draft clearly shows the impact of the groundwater dewatering and the recovery of the groundwater during the early 1990's as construction dewatering ceased.

3. **Figure 1 in Appendix** R is a groundwater contour map highlighting the depth of the groundwater below the existing ground elevations in the vicinity of the monitored wells. This figure indicates that large portions of the fen complex have groundwater at or above the surface elevation of the ground. This represents an artesian condition which is consistent with trout stream and fen conditions for groundwater hydrology. As we proceed to the northeast, toward the Seneca Wastewater Treatment Facility, groundwater elevations begin to be depressed to elevations at 12 to 15 feet below the surface of the ground. This indicates that groundwater elevation in and around the Seneca Wastewater Treatment Plant is significantly lower in relation to the ground elevation as areas directly to the southwest. There is a possibility that this depressed area of groundwater is the result of ongoing dewatering operations within the Seneca Wastewater Treatment Plant. **Figure 2 in Appendix R** is a cross-section of the fen as you travel from southwest to northeast, and again confirms that as you travel closer to the Seneca Wastewater Treatment Facility, the elevation of groundwater is depressed in the vicinity of the Seneca Wastewater Plant.

4. **Figure 4 of Appendix R** shows the water temperature recorded in Kennealy and Harnack Creeks for the time period from 1998 to 2008. As can be seen in the charts, the water temperature within Kennealy and Harnack Creeks is maintained between 10 and 18 degrees Celsius (50 and 65 degrees Fahrenheit). The stream temperatures within Kennealy and Harnack Creeks are ideal for trout habitat and clearly indicate the groundwater influence within the streams. However, **Figure 8** in the same appendix shows the flows present within the streams from 1998 to 2007. As can be seen in the Figure, stream flows within both Kennealy and Harnack Creeks routinely drop well below 0.5 cfs, and many times to zero. This indicates that the streams are currently operating in an intermittent condition and would be insufficient to support sustainable trout populations.

5. **Figure 4 in Appendix R** is the hypothetical groundwater recharge area for Nicols Fen. The figure indicates that the 1-year travel time for groundwater adjacent to the fen is approximately located along the boundaries of Trunk Highway 13 and that the 10-year time of travel for groundwater within the area tributary to Nicols Fen is approximately a half mile south of Trunk Highway 13. This hypothetical groundwater recharge area was derived using the City's Wellhead Protection Plan

and translating those distances from the wellhead plan to the Nicols Fen area. In addition, utilizing the precipitation and groundwater elevation data observations, it appears that there is a 1-2 year relationship between precipitation and groundwater elevations within the fen.

In addition to the findings associated with analyzing the data, there are a number of observations which cannot be made with the data currently available. These observations include the following:

1. The exact impact of the Seneca Wastewater Treatment Plant and its current dewatering operations are on groundwater elevations within the Nicols Fen and Kennealy Trout Stream areas. It also cannot be concluded at this time that altering the dewatering operations at Seneca Plant or reducing its footprint of groundwater influence will restore flows to Kennealy or Nicols Fen.

2. **Figure 4 in Appendix R**, the hypothetical groundwater recharge area for Nicols Fen can be used as a tool for local governments to analyze land use practices or redevelopment scenarios to further enhance or look for opportunities to increase infiltration. The data does not clearly indicate that increasing infiltration within the area will necessarily restore flows within Kennealy and Harnack Creeks and Nicols Fen. One should be cautious when drawing these types of conclusions based on the limited database currently available.

3. The data analyzed in this study clearly shows that the dewatering operations during the construction of the Seneca Treatment Plant had a major impact on groundwater elevations within the Nicols Fen and Kennealy and Harnack Trout Stream areas. Though we see a recovery in the early 1990's, there is no data present prior to the dewatering operation to allow for any analysis to determine if groundwater elevations post Seneca Treatment Plant expansion have fully recovered to conditions which existed prior to the dewatering operation. With the reduced amount of information available on pre-construction activity impacts, this does not adequately provide the necessary window to determine whether local and recent impacts have permanent and long-lasting effects.

Though we have drawn many reasonable observations from the data analyzed and reviewed, it is further recommended that prior to any corrective actions being undertaken, individual studies associated with that individual task be completed to gain further understanding as to how those activities may benefit or impact the Nicols Fen area.

8.0 Discussion

8.1 Nicols Fen

There is a long history of disturbance within Nicols Fen. During the data analysis period, 1989 to 1997, there have been two major construction projects that could have negatively impacted the fen area, the Seneca WWTP Expansion and the Bloomington Siphon Improvement Project. The data indicates that the dewatering that sustains the Seneca WWTP may lower groundwater elevations near Nicols Fen. Analysis of the data suggests a relationship between distance from Seneca and groundwater elevations. Groundwater level measurements appear to increase significantly in wells farthest away from Seneca, leading to the conclusion that the dewatering activities for the Seneca WWTP, may negatively impacted the groundwater levels in the Nicols Fen area.

Precipitation data for Nicols Fen has been compared to the groundwater elevation levels across the fen. The data shows that the groundwater responds to large amounts of precipitation or long droughts. The data indicate that precipitation and groundwater levels follow similar trends but the groundwater does not always respond exactly to the precipitation. This is most likely due to factors such as runoff and evaporation. Precipitation within an undisturbed calcareous fen will not influence groundwater elevations, as a fen is dependent on the underlying aquifers. It takes many years of erratic precipitation to alter these aquifers (Leete). The reaction time for Nicols Fen to respond to precipitation is 18 to 24 months indicating that outside factors are influencing the groundwater in Nicols Fen.

As the groundwater of a calcareous fen decreases, peat may oxidize and be reduced in elevation to a point where the groundwater will again support the peat and plant communities. This recession time where the ground is sinking to find the support of the groundwater is a vulnerable time for the fen. The native plants of the fen will not receive the essential nutrients that they need and problematic invasive plants can begin taking over. Fen ecosystems rely on a fine balance of hydrology. The water demand of plants in the summer may be equivalent to groundwater discharge; however when transpiration slows in the winter months discharge should not be so great to cause erosion (Leete). Disruptions to the Nicols Fen ecosystem have lead to a change in groundwater elevations, a decrease in natural fen vegetation and an increase in problematic invasive plants. Reversing this trend may be a very difficult process.

The survey information collected as part of this study suggests that there has not been significant reduction in the peat layer and that ground elevations remain unchanged, although water elevations have been reduced. As water levels decrease the peat foundation of the fen becomes less saturated, allowing the peat to contract. The dewatering allows for oxidation of the peat resulting in degradation, erosion and ultimately loss of the vital nutrients that had been tied up in the system. Regeneration of the fen will require the ground elevation and water levels to again correspond even if the original elevation is not restored.

Restoring the peat and aquifer to the same level will positively impact the system, however water loss is occurring at all edges of the fen. A fen boundary is defined as any area that surrounds and affects the system and the buffer area is typically large. Fens are composed of a mosaic of various wetland communities consisting as a seepage face upper edge and a repeated flood zone as the lower edge (Leete). Due to the disturbances surrounding Nicols Fen the buffer area is fairly small. The boundaries of Nicols Fen can be defined as the road, intersecting railroad track, neighboring development and Seneca WWTP. Alterations in the surrounding environment have also lead to changes in the flooding regime impacting nutrients in the fen.

The ideal outcome of this research is to lessen the degradation to Nicols Fen. Future research will determine whether the fen is stabilizing from past disturbance or currently degrading. Conservation efforts will determine whether the fen has been detrimentally impacted or whether restoring the hydrologic regime will restore native plant communities. Goals for restoration will focus on restoring the balance of the fen ecosystem. Previous experience indicates that restoration is possible. Restoration of Nicols Fen and its hydrology has the possibility to set the standard of future fen management and conservation.

8.2 Kennealy and Harnack Creeks

Examination of flow monitoring data indicates that Kennealy Creek and Harnack Creek are unable to support trout populations at the present time. The temperatures are within the range of ideal trout habitat; however the flows are not consistent enough to support a viable trout population. The data indicates that without restoration and an increase of stream flow, an investment of public dollars to improve trout habitat is not practical.

9.0 Conclusions and Recommendations

Current and historical groundwater and stream flow data for the Nicols Fen area were analyzed during this study. Based on this analysis and the 2002 study the following recommendations are made:

9.1 Recommendationss

9.1.1 Groundwater Hydrology

Groundwater is the lifeblood of the Nicols Fen and Kennealy and Harnack Creeks resources. Activities associated with the restoration or further understanding of groundwater hydrology should be of the highest priority in looking at opportunities to positively impact this region. Based on observations made through this study, the following recommendations are made:

1. Encourage the continued monitoring of the wells and streams located within Nicols Fen and Kennealy Creek areas to track trends in groundwater behavior in future years.

2. Stakeholders and landowners located within the hypothetical recharge area include the Mn/DNR, City of Eagan, Gun Club Lake Watershed Management Organization, MCES, Dakota SWCD, Lower Minnesota River Watershed District, and others should consider possible actions to encourage and protect the existing infiltration areas located within the probable recharge zone.

3. No groundwater sampling for chemistry was completed as part of this test, but we encourage future groundwater evaluations to include chemical composition monitoring to provide a historical record on the groundwater discharges and compare them to other calcareous fens within the state to assist in determining the effects of the various impacts on the Nicols Fen area.

9.1.2 Adjacent Development

Observations indicate that there are clearly some impacts located immediately adjacent to Nicols Fen which may have the possibility to be mitigated or should require additional study to determine their influence on the Nicols Fen and trout stream areas. These recommendations include the following:

1. Conduct an analysis to determine the effects and boundaries of dewatering activity at the Seneca Wastewater Treatment Plant on the Kennealy Creek and Nicols Fen area.

2. If studies of the Seneca Wastewater Treatment Plant dewatering operations identify impacts that reach Kennealy and the Nicols Fen area, options should be explored for reducing the footprint of impact of the Seneca Wastewater Treatment Plant dewatering operations on these resources.

9.1.3 Vegetation

Several threatened and species of concern vegetation are present within the Nicols Fen area. A number vegetation surveys have been completed over the years and should continue to be undertaken and reproduced in an effort to track the health of the fen and the native species community. Therefore, we recommend the following:

1. Conduct population surveys of vegetation within Nicols Fen area to determine the ratio of native to invasive species and to screen for indicator species such as white lady slipper and valerian. These vegetation surveys

should be conducted at regular intervals to track the health of the Nicols Fen complex.

2. Vegetation surveys and sampling will continue to assist to determine if native plants can re-establish themselves in locations of the fen or if invasive problematic plants are becoming the dominant species.

3. The Mn/DNR has proposed a woody biomass project for the Nicols Fen area. It is recommended that this woody biomass project make efforts to remove as many invasive plant species from the area in conjunction with that project.

9.1.4 Agency Cooperation

Due to the large number of stakeholders, both landowners, regulatory agencies, and others located in and around the fen, we support the following recommendations for continued cooperation:

1. Continue multi-agency collaboration between the Mn/DNR, City of Eagan, GCLWMO, MCES, Dakota SWCD, Mn/DOT, LMRWD, US Fish & Wildlife Service, and others for the purposes of maintaining consistent data gathering techniques, exploring restoration avenues, and to maintain consistency of message for areas in and around the Nicols Fen, Kennealy and Harnack Creek areas.

2. Multi-agency collaboration should continue for the purposes of discussing potential ideas on preservation of the fen and to determine the Best Management Practices for future restoration and management activities. We recommend that the free flow of ideas continue between the stakeholders for the purposes of gathering future data, discussing potential ideas on preservation of the fen, and for determining the Best Management Practices for the future restoration of management activities to occur in and around Nicols Fen, Kennealy and Harnack Creeks.

9.1.5 Public Contact/Education

Due to the location of the Nicols Fen, Kennealy and Harnack Creeks adjacent to Ft. Snelling State Park and the National Wildlife Refuge, along with the populations of the City of Bloomington and the City of Eagan, this resource is located in a prime location for public exposure for educational opportunities to share the importance and the rarity of calcareous fens and trout streams.

9.1.6 Kennealy and Harnack Creeks

Based on the analysis of Kennealy and Harnack Creek temperature and flow monitoring data, the following recommendations are made:

1. Unfortunately, at this time, it is not feasible invest in the restoration of habitat for the purposes of stocking trout in Kennealy or Harnack Creek. There is currently not adequate stream flow to support trout populations at this time.

2. Flow monitoring and temperature monitoring of Kennealy and Harnack Creeks should be continued at some consistent level in the event that future restoration efforts or improvement, or changes within the watershed, contribute to more steady flows in the stream channels to the point where restoration options may be considered.

3. Based on discussions with the Mn/DNR and to establish historical understanding of these streams, additional research on the history of the Kennealy and Harnack Creeks could be undertaken to determine whether these streams ever had sustainable viable trout populations or whether the streams merely existed as take and put populations in the past.

9.2 Recommendations from 2002 Report

In the 2002 report, a number of recommendations were made in regard to the Nicols Fen and Kennealy Creek, Harnack Creek areas. We have restated several of these recommendations in this location in an effort to maintain consistency and a one-stop shop for information in regard to work that has been completed recently in the Nicols Fen and Kennealy and Harnack Creek areas. The recommendations from the 2002 report were as follows:

9.2.1 Fen

- Locate drain tiles within the area, then remove or disable them. A determination should be made regarding whether rare species could be impacted from this activity though, and the least disruptive method should be utilized in areas of high quality or at which rare species occur.

- Delineation of fen not easily distinguished, buffered with native communities (sedge meadow, wet prairie). If an attempt to restore the fen is not possible, the restoration of the next best wetland community may be possible.

- Controlled burns needed to manage problematic plants (RCG, Phragmites – increase thatch; buckthorn & woody problematics)

9.2.2 Harnack Creek

- Steep slope on the north segment just west of Nicols Road is creating a steep down cut channel. To increase the available habitat for trout and improve the streams viability, stream channel improvements may be necessary.

- Removal and maintenance of beaver dams and population may be necessary. A determination should be made prior to implementing whether this activity will cause more harm than good to the creek.

9.2.3 Kennealy Creek

- Determine the existing condition of the spoil pile and whether removal of it would result in the best long-term solution for Nicols Fen.

- Remove trout pond dams

9.2.4 Groundwater Hydrology

- Should monitoring show reasonable levels of stable ground water, complete stream habitat improvements.
    - Lengthening and adding meander to Harnack
    - Remove problematic species
    - Remove alterations at west branch of Kennealy
    - Relocate/recycle spoil pile material within the fen

- Identify and develop policies to protect the sources of infiltration that contribute to the Nicols fen Complex.

- Perform a study of Seneca dewatering alternatives with the goal of reducing the zone of influence from dewatering activities on the fen, trout streams, and sources of water. Construct improvements at Seneca from study findings if alternatives are feasible.

9.2.5 Vegetation

- Determine current extent of problematic species and identify the most dense areas and species on a map.

- Complete a management plan for problematic plants. Determine the best single method or a combination of methods to control specific species in particular areas of Nicols Fen. Methods considered should include herbicide application, prescribed burning, and mechanical removal. This effort should consider impacts

to rare species and should not be done in a manner that might result in negative impacts to these species.

9.2.6 Public Contact/Education

- Develop overall management plan for the fen complex that includes public use and education within the resource, and perhaps a designation of the fen as an active laboratory.

- Determine the potential for restoration of native plant communities such that Nicols Fen may serve as a model restoration site.

- Develop a trail system that connects the fen to Ft. Snelling State Park trails, Minnesota Valley National Wildlife Refuge trails, City of Eagan and Dakota County trails. Ensure an appropriate level of accessibility that is not likely to increase degradation of the most sensitive portions of the fen, yet allows for public access for educational and recreational activities.

- Develop educational kiosks to raise public awareness about the unique and important functions that the fen complex can provide
    - Plants
    - Source of water for fen
    - Water chemistry
    - Amphibians
    - Birds
    - Macroinvertebrates
    - Butterflies

9.2.7 Future Adjacent Development

- The City of Eagan to establish development guidelines for the Cedar Grove Area.

- Seneca waste water treatment plant expansions.

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