BCWD Best Management Practice (BMP)

Monitoring Report

A. Project Background

In 2005, the Brown's Creek Watershed District (BCWD) levied tax funds for the monitoring of Best Management Practices (BMP). This activity is identified in the BCWD Second Generation Watershed Management Plan and is intended to provide data that can be applied to future BMP design and operation and maintenance activities in the District.

To initiate this program, the BCWD selected the following two projects to monitor:

1. Kern Center Pond located in Oak Park Heights, Minnesota
2. Bradshaw Development Park located in Stillwater, Minnesota

Figure 1 shows the location of the subwatershed of both the Kern Center Pond and the Bradshaw Infiltration Basin.

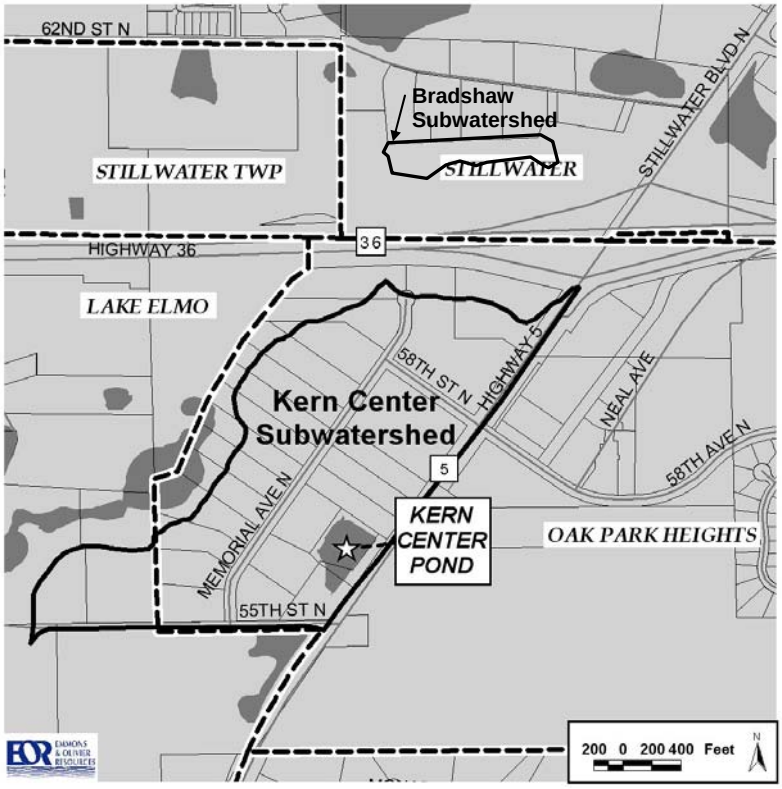

Figure 1. Location Map

This report provides a description of each of these sites as well as a summary of the monitoring efforts, the results from the 2005 monitoring season and recommendations for future/on-going monitoring efforts.

B. Site Description

B-1. Kern Center Pond

The Kern Center Pond is a regional stormwater management facility that serves the Kern Center Commercial Area (see Figure 1). The commercial area, which is approximately 92 acres in size, is bounded by Hwy 5 on the east and Hwy 36 to the north. Drainage from the Kern Center Pond enters a series of wetlands that drains north through an existing 30" diameter RCP culvert under Hwy 36 and discharges into Long Lake. In 2005, the contributing drainage area was 75% developed.

In 2002, the BCWD identified the Kern Center Pond as a potential demonstration site for the District's rules. In order to ensure that future development within the Kern Center Commercial Area would meet the District's standards, and that peak flow rates and volumes under Hwy 36 were reduced, the BCWD offered to design the modifications that would achieve these goals. These modifications to the Kern Center Pond were intended to result in the following improvements:

- Increased storage capacity;
- Pretreatment of stormwater runoff;
- Increased infiltration; and
- Improved wildlife habitat.

During the course of this project, the BCWD and the City of Oak Park Heights collaborated on the following: development of a Cooperative Agreement (see Appendix); design of the pond modifications; development of an Operation and Maintenance Plan; development of a Monitoring Plan; the construction process. Construction of the Kern Center Pond modifications began in December of 2004 and final excavation and restoration of the site was completed in the spring of 2005 (Figure 2).

During construction of the modifications of the Kern Center Pond, pumping was performed in order to dewater the facility as well as to ensure the viability of the wetland plantings during the plant establishment period (1 year from date of planting). The regular pond outlet, described as follows, was not in operation in 2005. The outlet consists of a 48" x 18" skimmer opening at the bottom of a 72" diameter manhole. The outlet pipe on the back of the manhole is a 42" Reinforced Concrete Pipe (RCP) that has been restricted with a 12" PVC section in order to reduce peak discharge rates. A high water level outlet grate is located at the top of the manhole structure. A detail of the outlet structure is provided in Figure 3.

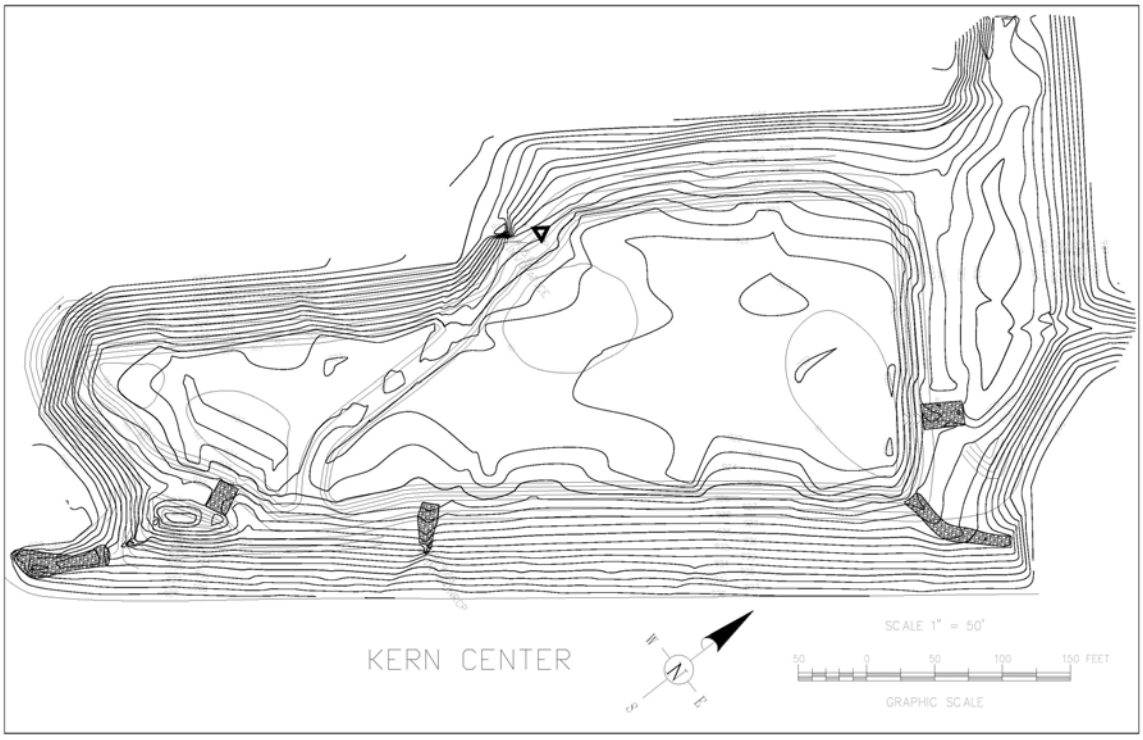

Figure 2: Kern Center Pond As-Built Survey (September 1, 2005)

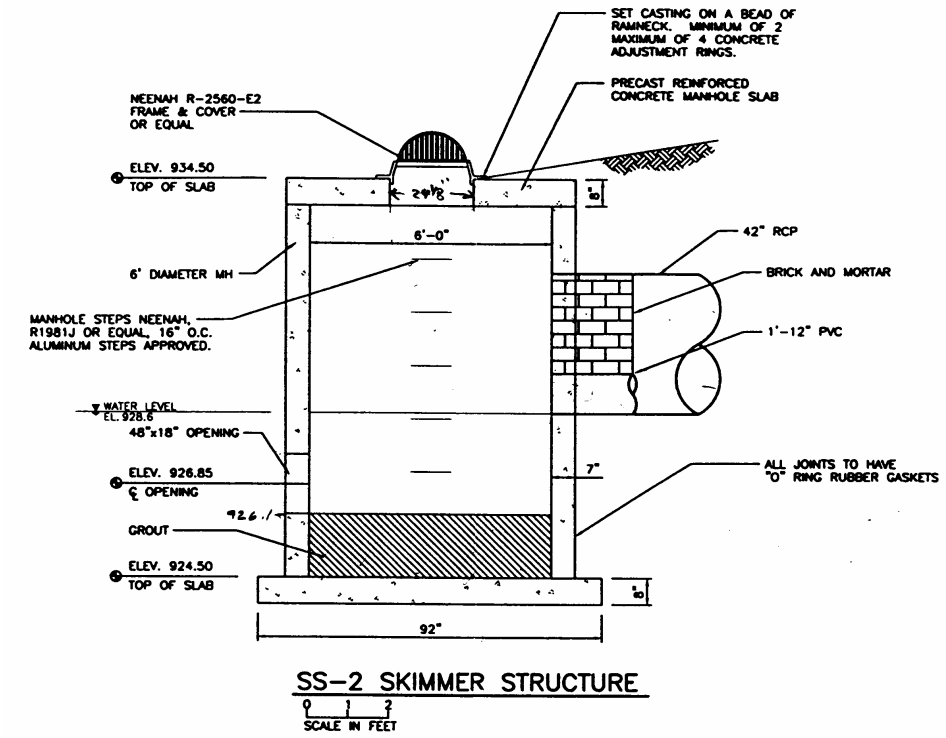

Figure 3: Kern Center Pond outlet structure detail (Bonestroo Rosene Anderlik & Associates, Oak Park Heights, Minnesota Kern Center Improvements Sheet 16, 8/10/1998)

Soil borings were completed in 2002 to characterize site sub-surface geology as needed for the preliminary design and in 2005 to verify that trenches were unnecessary. A total of thirteen separate sites were investigated in and around the vicinity of the Kern Center Pond. Both the 2002 and 2005 borings indicate the site is dominated by fine to medium grained silty sands separated by silts and less frequently by clay. Site observations during the 2005 construction noted water moving laterally along bedding planes from west to east. High angle cross beds with fractures perpendicular to bedding planes were noted onsite (Figure 4). Such fractures provide conduits for vertical movement of water. Site geology, fine to medium grained silty sand, coupled with orthogonal bedding plane fractures makes the Kern Center site conducive for infiltration.

Figure 4. Cross Bedding and Vertical Fractures at Kern Center Pond

B -2. *Bradshaw Infiltration Basin*

The stormwater management plan for the Bradshaw site showcases the applicability of the District's volume control standard. This four-lot commercial site was designed to meet the BCWD rules through the use of infiltration practices. Stormwater practices were strategically located throughout the site to take advantage of soils suitable for infiltration. Approximately 21 percent of the 26-acre site drains into the monitored infiltration basin (Figure 1). The contributing drainage area consists of direct runoff from

three of the four commercial lots. In 2005, construction was completed or in progress on two of the three lots that drain to the infiltration basin. Under extreme rainfall events, or series of events, an additional 2.1 acres of the commercial area may drain to this infiltration basin (from the fourth lot). This will only occur if the underground volume control system for this area is overwhelmed. In the event that the stormwater management system reaches full capacity (greater than the 100-year 24-hour event or cumulative equivalent), the infiltration basin will overflow to the west via a riprap swale (elevation 943.5) and ultimately flow into the south end of Long Lake.

When the infiltration basin monitored for this project was excavated in 2002 (Figure 5) filter fabric was installed in the bottom of the basin to protect the soils from clogging during construction of the commercial lots. This filter fabric is located beneath about 6 inches of topsoil and covers much of the basin but is not a continuous barrier throughout. Soil borings conducted in 2000 showed fine to medium grained sand and fine to medium grained silty sands in the basin. These soils, present below the topsoil and fabric layer, are conducive to infiltration.

The basin's outlet is an overland emergency overflow at an elevation of 943.5. The basin did not outlet during the 2005 monitoring season.

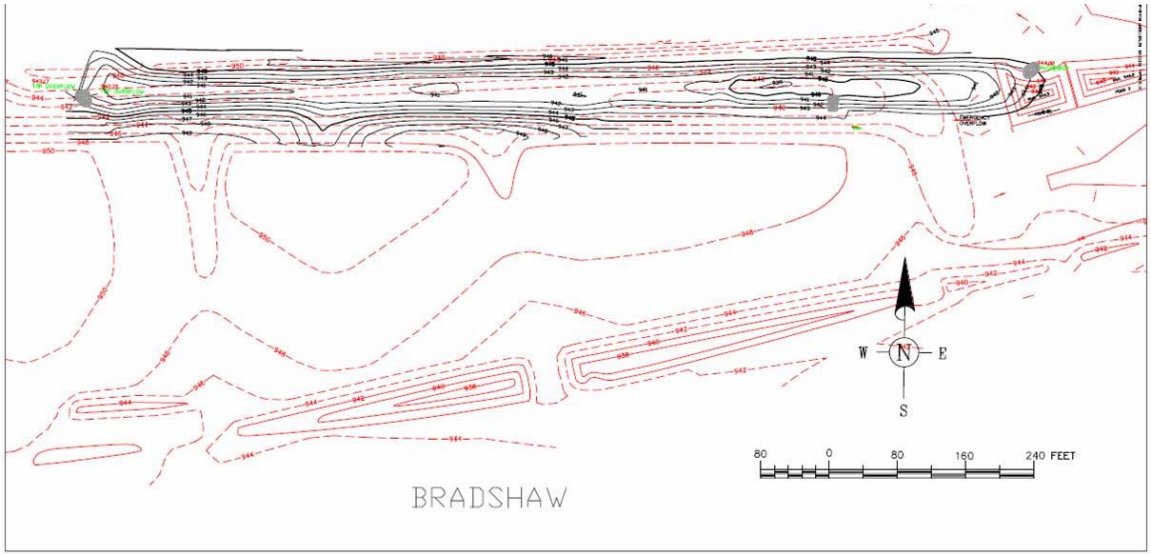

Figure 5: Bradshaw Infiltration Basin As-Built Survey (August 31, 2005)

C. Methodology

In order to monitor infiltration rates, water level monitoring equipment was installed at each site. This equipment was obtained, installed, and monitored by the Washington Conservation District. At both sites, staff gages, Global Water WL15 pressure transducers, and data loggers were installed. The pressure transducers measured the water level every 15 minutes and stored the data on the onsite data logger. The pressure transducers were installed in the lowest portion of each basin. Field inspection and

maintenance of each of the data loggers was performed routinely (every 8 days on average). Staff gage readings were used to calibrate and confirm the readings of the pressure transducer and adjustments were made to the pressure transducer as necessary.

Emmons and Olivier Resources, Inc. performed an as-built survey of each basin, surveyed the location of the monitoring equipment and performed the infiltration rate analysis. Infiltration rates for the basins were determined by calculating the slope (ΔDepth/ΔTime) of the water elevation vs. time curve every eight hours for each infiltration event in the Kern Center Pond and every four hours for each infiltration event in the Bradshaw Infiltration Basin. An eight-hour infiltration rate analysis time period was used for the Kern Center Pond because the infiltration rate was slow enough that, quite often over the course of four hours, no change in water surface elevation could be measured within the accuracy of the equipment used. The Bradshaw Infiltration Basin is a smaller system with a more rapid infiltration rate. Thus, a four-hour infiltration rate analysis time period was needed to measure the changes in infiltration rate as the water level in the pond decreased. The average infiltration rate is the slope of the best-fit line through the water elevation vs. time curve for the full event. Infiltration events were determined from a visual inspection of the water elevation vs. time curve and from observed dates of precipitation.

The analysis of the Kern Center Pond monitoring data required an additional step that was not required for the Bradshaw infiltration basin. Since the Kern Center Pond modifications were constructed in 2005, the contractor was required to pump the basin in order to protect the native plantings along the sides of the basin. As a result, the pumping periods were not included in the infiltration rate analysis. The pumping rate was calculated as volume of pumped water (from drawdown elevation and as-built survey) over the pumping time as is evident on the monitoring curves. An assumed infiltration/evaporation rate of 0.04 inch/hour was subtracted to yield a pumping rate of 1.97 cfs. This rate was checked by creating a simple HydroCAD model of the volume of water that was pumped out of the facility.

D. Results

D-1. *Kern Center Pond*

The Kern Center Pond survey, completed on September 1, 2005 was performed to develop as-built contour information for the infiltration rate analysis. The pond was found to have a smaller volume than specified in the design (about 20% less capacity). This survey information is provided on Figure 2. Table 1 translates this survey information into water surface elevation (column 1) versus pond surface area (column 3). This information was used to generate the volume of stormwater being infiltrated over the monitoring period. Figure 8 is a graphical representation of the raw data as it is collected in the field: it illustrates the water surface elevation in the Kern Center Pond over the monitoring period (August 25 to October 26). As mentioned previously, the

water surface elevation recorded for the Kern Center Pond in 2005 includes a number of pumping events.

As Figure 6 illustrates, two infiltration events were identified over the course of the monitoring season for the Kern Center Pond (August 28 – 30, October 7 – 12). The average infiltration rate determined for each of these events is shown on Figure 6 and summarized in Table 2. The size of the rainfall event, the average and range of infiltration rates and the average and range of volumetric infiltration rates are also indicated in Table 2. The recorded infiltration rate ranged from 0.02 in/hr to 0.12 in/hr. The recorded volumetric infiltration rate ranged from 0.06 cfs to 0.66 cfs. The 8-hour interval infiltration rates from each event are compared in Figure 7 with respect to water surface elevation. Figure 7 displays how the infiltration rate changes as water surface elevation changes. Typically the infiltration rate decreases as the water surface elevation decreases. In this case, the infiltration rate did not change as the water surface elevation decreased.

Table 1. Kern Center Pond Elevation versus Area

Elevation [ft]	Depth [ft]	Area [acres]
921	0	0.00
922	1	0.71
923	2	1.25
924	3	1.77
925	4	2.11
926	5	2.37
927	6	2.71
928	9	3.34
929	10	3.61
930	11	3.85
931	12	4.41
932	14	5.09

Table 2: Average Infiltration Rates for Kern Center Pond

Infiltration Event	Rainfall	Infiltration Rate Range	Average Infiltration Rate	Volumetric Infiltration Rate Range	Average Volumetric Infiltration Rate
Event 1: Aug. 28-30, 2005	2.9 in.	0.02 in/hr - 0.12 in/hr	0.04 in/hr	0.06 cfs – 0.44 cfs	0.15 cfs
Event 2: Oct. 7-12, 2005	5.0 in.	0.02 in/hr - 0.07 in/hr	0.04 in/hr	0.08 cfs - 0.66 cfs	0.28 cfs

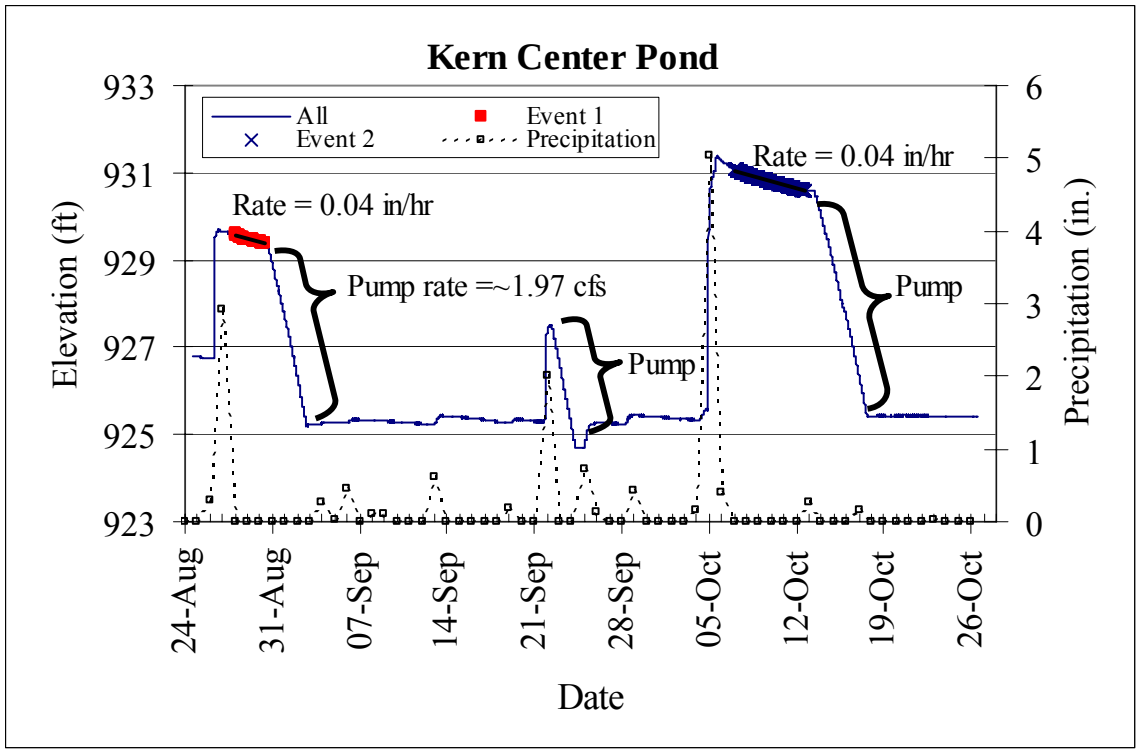

Figure 6: Water Surface Elevations in the Kern Center Pond

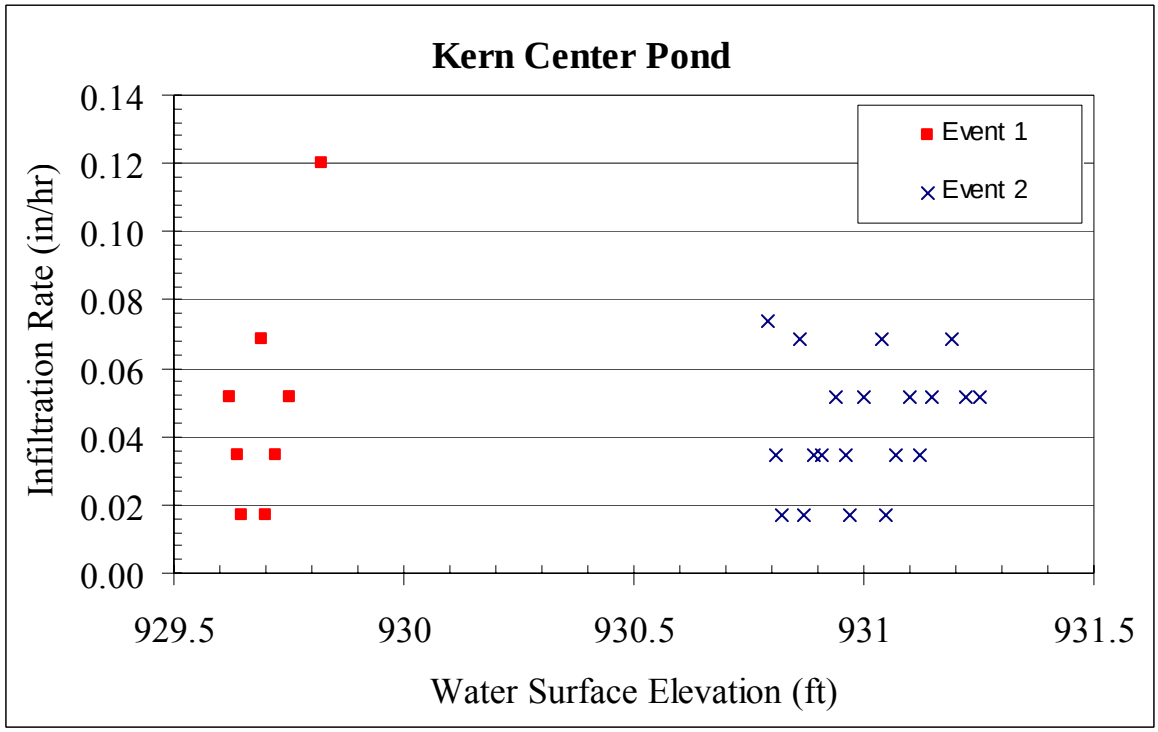

Figure 7: Eight-hour Interval Infiltration Rates for the Kern Center Pond

D-2. *Bradshaw Infiltration Basin*

On November 7, 2005, an inspection found that people were driving through the infiltration basin. It was apparent from vehicle tracking that driving across the basin to the north was done repeatedly, possibly for access to adjacent land. Other vehicle ruts had been ripped down the length of the basin (see Figures 8 and 9). When the landowner was alerted to this activity, concerns were raised regarding snowmobile use in this area of the property during the winter.

Figure 8. November 7, 2005 observed vehicle tracking in Bradshaw Pond

Figure 9. November 7, 2005 observed vehicle ruts in Bradshaw Pond

Because this type of stormwater management practice is highly susceptible to soil clogging and compaction, potentially reducing or eliminating the capacity of the soils to infiltrate water, a letter from the District was issued to surrounding landowners requesting that there be no vehicular traffic occurring in the basin as this will potentially result in non-compliance with the District's Rules and Regulations.

The Bradshaw Infiltration Basin was surveyed on August 31, 2005 to develop as-built contour information for the infiltration rate analysis. This survey information is provided on Figure 5. The basin was determined to have a volume only slightly smaller than designed. Table 3 translates this survey information into water surface elevation (column 1) versus pond surface area (column 3). This information was used to evaluate the volume of stormwater being infiltrated over the monitoring period. Figure 10 is a graphical representation of the water surface elevation data as it is collected in the field: it illustrates the water surface elevation in the Bradshaw Infiltration Basin over the monitoring period (September 1 to October 26).

Two major infiltration events were identified over the course of the monitoring season. To determine average infiltration rates, these events were split into two portions for the first event and three portions for the second event. The event splits are based on observed changes in slope at certain water surface elevations (1a-1b and 2b-2c) and a small precipitation event on October 6th (2a-2b). The average infiltration rate determined for each of these events is shown on Figure 10 and summarized in Table 4. The size of the rainfall event, the average and range of infiltration rates and the average and range of volumetric infiltration rates are also indicated in Table 4. The recorded infiltration rate ranged from 0.15 in/hr to 0.54 in/hr. The recorded volumetric infiltration rate ranged from 0.01 cfs to 0.28 cfs. The average infiltration rate showed a change at a water surface elevation of about 940.25. Both events showed similar overall infiltration rates. The 4-hour interval infiltration rates from each event are compared in Figure 11 with respect to water surface elevation. Figure 11 displays how the infiltration rate changes as water surface elevation changes. As would be expected, the rate of infiltration decreased as the water level in the basin decreased.

Table 3. Bradshaw Infiltration Basin Elevation Versus Area

Elevation [ft]	Depth [ft]	Area [acres]
939	0	0.00
940	1	0.09
941	2	0.29
942	3	0.73
943	4	1.02
944	5	1.31

Table 4: Average Infiltration Rates for Bradshaw Infiltration Basin

Infiltration Event	Rainfall	Infiltration Rate Range	Average Infiltration Rate	Volumetric Infiltration Rate Range	Average Volumetric Infiltration Rate
Event 1: Sep. 22 - 24, 2005	2.0 in.	0.15 in/hr – 0.36 in/hr	a) 0.28 in/hr b) 0.23 in/hr	0.01 cfs – 0.07 cfs	0.04 cfs
Event 2: Oct. 5 - 8, 2005	5.0 in.	0.15 in/hr – 0.54 in/hr	a) 0.44 in/hr b) 0.32 in/hr c) 0.24 in/hr	0.01 cfs – 0.28 cfs	0.08 cfs

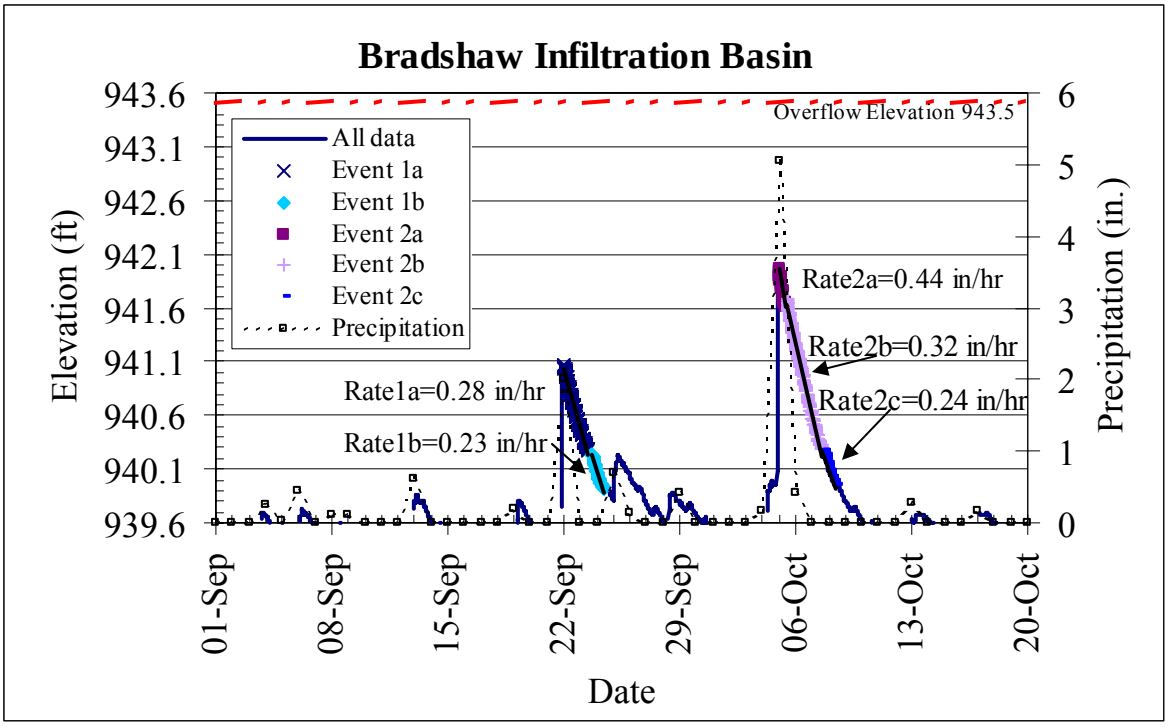

Figure 10: Water Surface Elevations in the Bradshaw Infiltration Basin

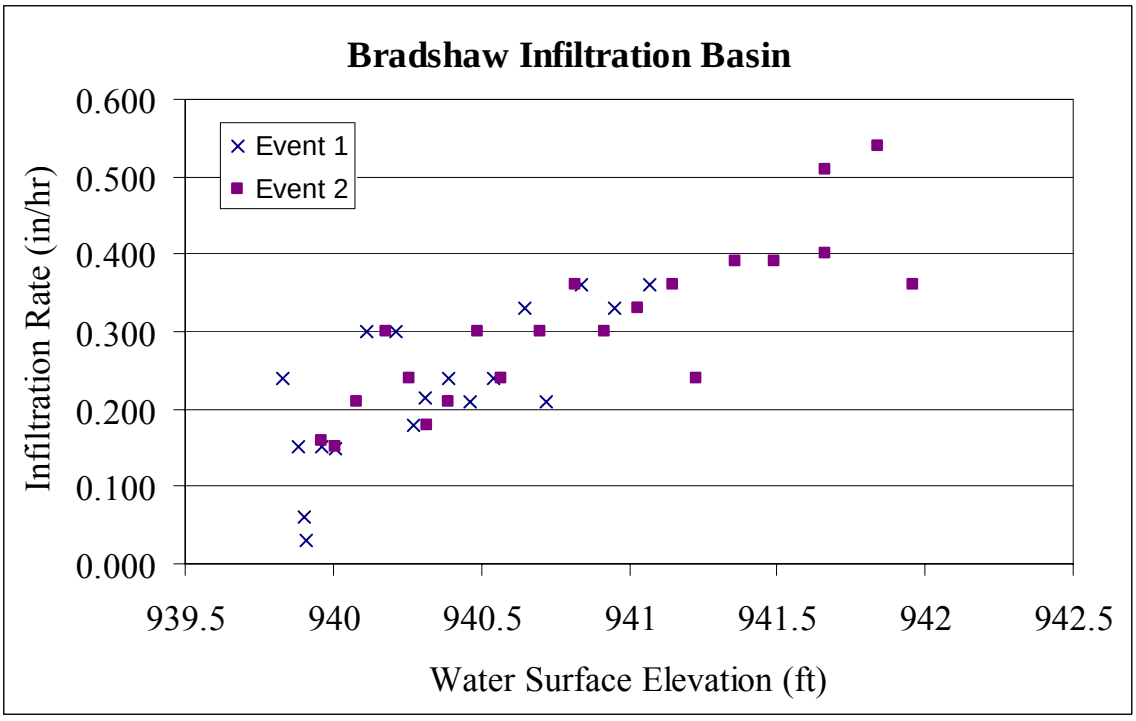

Figure 11: Four-hour Interval Infiltration Rates for Bradshaw Infiltration Basin

E. Conclusion

E-1. Kern Center Pond

An overall infiltration rate of 0.25 inch per hour was assumed for the design of the Kern Center Pond. The infiltration rates used for the pond size analysis were determined using the following information:

- A total of five soil borings performed along the perimeter of the pond in 2002;
- The County Well Index developed by the Minnesota Geologic Survey;
- The Soil Survey of Washington County; and
- Field measured infiltration rates for Washington County (specifically for the SWWD and an infiltration basin constructed by the Minnesota Department of Transportation along State Highway 5 approximately two miles south of the Kern Center pond).

During 2005, the first year in operation, the observed infiltration rates of 0.02 in/hr to 0.12 in/hr are lower than the overall expected rate of 0.25 in/hr. This discrepancy may be due to the following factors:

- Soil variability resulting in less permeable soils than anticipated by borings and surveys.
- Deep-rooted vegetation in the pond not fully established.
- Locally high groundwater table.

It is encouraging to note that as the vegetation becomes established, infiltration rates may increase. The larger root structures of developed vegetation increase pore space in the soils and allow more rapid transport of water into the soil. A high groundwater table could also be decreasing the infiltration rate of the pond. Monitoring of groundwater levels at the Kern Center Pond site would allow an analysis of the effect of the groundwater table on the infiltration capacity of the pond.

Because 2005 was the first year in operation, specific maintenance activities will not be recommended at this time. Monitoring in 2006 and later years will allow an analysis of the longer-term function of the pond after vegetation is more established and the outlet structure is operating as designed. Additional monitoring in 2006 and subsequent years will allow and analysis of how often the pond discharges, any changes in infiltration rate, and how well the BCWD volume control rule is met. Specific maintenance activities can be recommended at that time.

E-2. Bradshaw Infiltration Basin

The assumed infiltration rate for the Bradshaw Pond was 2 inches per hour. This infiltration rate was taken from the best information available at the time of design, the infiltration rates given in the Washington County Soil Survey, and is not representative of the conditions expected in a constructed infiltration basin based on more recent data. The observed infiltration rate of 0.15 in/hr to 0.54 in/hr is only slightly lower than the range expected for the pond based on more recent infiltration data.

The pond, however, is currently covered by filter fabric and topsoil. The observed infiltration rates of 0.15 in/hr to 0.54 in/hr may be more representative of the infiltration through this topsoil layer. The topsoil has a higher percentage of fine soil particles which fill the pore spaces that allow infiltration. Additionally, vehicle traffic within the basin could have compacted the soils and reduced the infiltration rate. Infiltration rates are expected to increase somewhat when the basin can be brought to final design following completion of construction on all lots. The completion of the pond to final design will expose the underlying soils and establish permanent vegetation, both of which are likely to increase infiltration.

The basin was designed to accommodate a 100-year event (5.9-inch rainfall). As observed in 2005, the basin was able to infiltrate the runoff from a 5-inch rainfall event (between a 25-year and 50-year event) indicating that the basin is operating as expected.

E-3. Recommendations

- Continue monitoring of the Kern Center Pond and Bradshaw Infiltration Basin.
- Install a groundwater monitoring well at the Kern Center Pond and monitor groundwater levels.
- Install monitoring equipment prior to the spring snowmelt event to monitor performance early in the season.

- Take pictures of the site in the same location at each site visit to create a photo log of the monitoring season (fulfills the requirements of the monitoring portion of the Cooperative Agreement with the City of Oak Park Heights).
- Finalize the Bradshaw Infiltration Basin as soon as the final lot is developed.

Appendix

Kern Center Monitoring Plan
as written in the Cooperative Agreement between the City of Oak Park Heights and the Brown's Creek Watershed District

KERN CENTER MONITORING PLAN

This monitoring plan has been developed to determine the infiltration capacity of the Kern Center Pond. It will also enable the Brown's Creek Watershed District (BCWD) to evaluate how this stormwater management facility meets the District's volume control standard by measuring how often the water level exceeds the outlet elevation (928.6 feet).

Identification of the infiltration rates (depth/time) and the volumetric infiltration rates (cfs/time) will also enable the BCWD and the City of Oak Park Heights to evaluate the performance of this basin. This information will be valuable in determining the potential long-term maintenance requirements for this facility.

The following tasks outline the major components of this monitoring plan:

Task 1. Data Collection

1.1 Purchase Equipment. Purchase an automatic water level recorder and a staff gage for the Kern Center Pond.

1.2 Installation. Monitoring equipment will be installed prior to the spring melt. Equipment will be calibrated and checked for defects or other hardware problems prior to installation in the field. Permission will be obtained from land owners. Equipment and staff gauges will be surveyed for exact locations and elevations during installation and removal of equipment.

1.3 Maintenance. Equipment will be maintained in the field during the field season. If necessary, equipment will be sent to the manufacturer for repair.

1.4 Field Visits. Site will be visited once every two weeks during the field season for the purposes of installing equipment, visual recording (photos), staff gauge readings, verification of measured data and electronic transfer of data.

Task 2. Data Analysis and Monitoring Report

2.1 Infiltration Data Analysis. Data collected over the field season (time and water level recordings) will be imported into a database which will be tabulated and analyzed for infiltration rates. These infiltration rates will

enable the District and the City to evaluate the performance of the Kern Center Basin over time.

2.2 Report. A Monitoring Report will be produced at the end of the field season that will identify trends in infiltration performance and state appropriate recommendations to effectively manage the system for long-term operation and viability.