Appendix C

Evaluation of Groundwater Remediation on Local Pond and Lake Levels
Conestoga-Rovers & Associates
August 1992

EVALUATION OF GROUNDWATER REMEDIATION ON LOCAL POND AND LAKE LEVELS

Highway 96 Site
White Bear Township, Minnesota

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CONESTOGA-ROVERS & ASSOCIATES

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1.0 INTRODUCTION

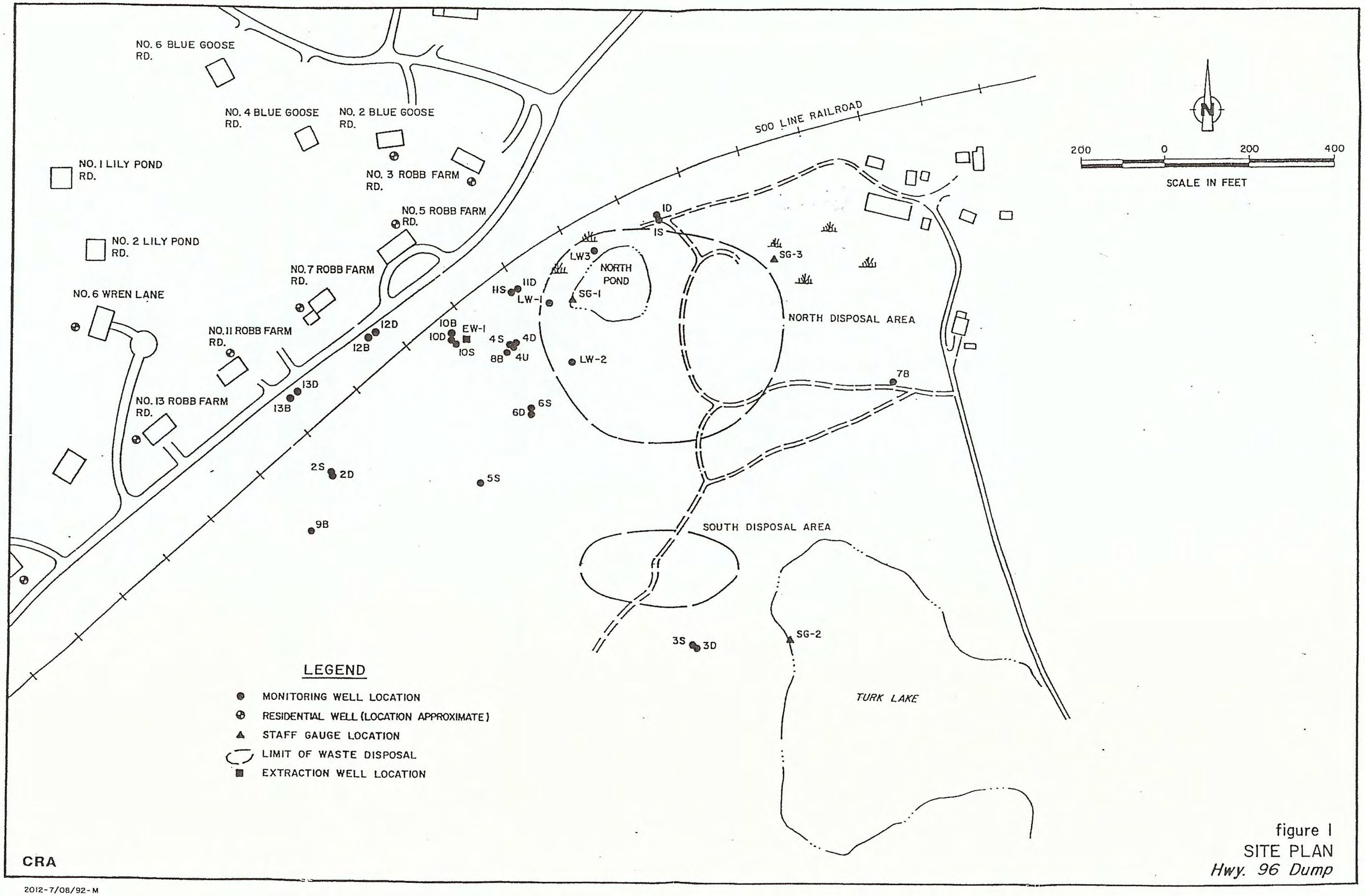
In 1991 a group of North Oaks residents became concerned about declining water levels at lakes and ponds in the southeastern region of the North Oaks community. The lake and ponds evaluated include John Pond, Gilfillan Lake, Sora, North and South Mallard Ponds and Teal Pond. Ms. Joan Brainerd, a representative of the group, stated that lake and pond levels coincidentally began dropping at about the time that Whirlpool and Reynolds began its groundwater extraction system at the Highway 96 Dump (Site). CRA and Ms. Brainerd jointly inspected the lake and ponds in May 1992. Ms. Brainerd stated that water levels have dropped as much as 18 inches since 1989 and that area residents are concerned about the decreasing pond and lake levels and their affect on the local aesthetics. The North Oaks residents group approached Whirlpool and Reynolds and requested that they evaluate whether the groundwater extraction system is affecting pond and lake levels. In response, Whirlpool and Reynolds requested that their consultant, Conestoga-Rovers and Associates (CRA), conduct the evaluation.

Based on this evaluation, CRA concluded that pumping at the Highway 96 Dump is not lowering lake or pond levels in North Oaks. This conclusion is supported by an extensive hydrogeologic study at the Highway 96 Site which has demonstrated that pumping from the Lower Aquifer does not influence shallow groundwater levels or pond levels. Further, a review of the historical lake augmentation program in North Oaks shows that the maintenance of water levels is dependent upon lake augmentation which ceased in 1989. Hence, the declining water levels are attributed to a lack of lake augmentation over the past three years.

2.0 BACKGROUND

Groundwater investigations at the Highway 96 Site began in 1985. A total of 26 monitoring wells have been installed to monitor groundwater levels and groundwater quality. In 1989, an extraction well was installed to contain and remove contaminated groundwater at the Highway 96 Dump. The investigation and continued monitoring have resulted in a detailed understanding of the Site hydrogeology.

An extraction well was constructed and began operation in June 1989 with an average annual pumping rate of 45 gallons per minute (approximately 23.7 million gallons per year). The extraction well is located on the north central portion of the Site as shown on Figure 1, and is located approximately 1,000 feet from Sora Pond, the closest pond evaluated in this report.



CRA

figure 1
SITE PLAN
Hwy. 96 Dump

2012-7/08/92-M

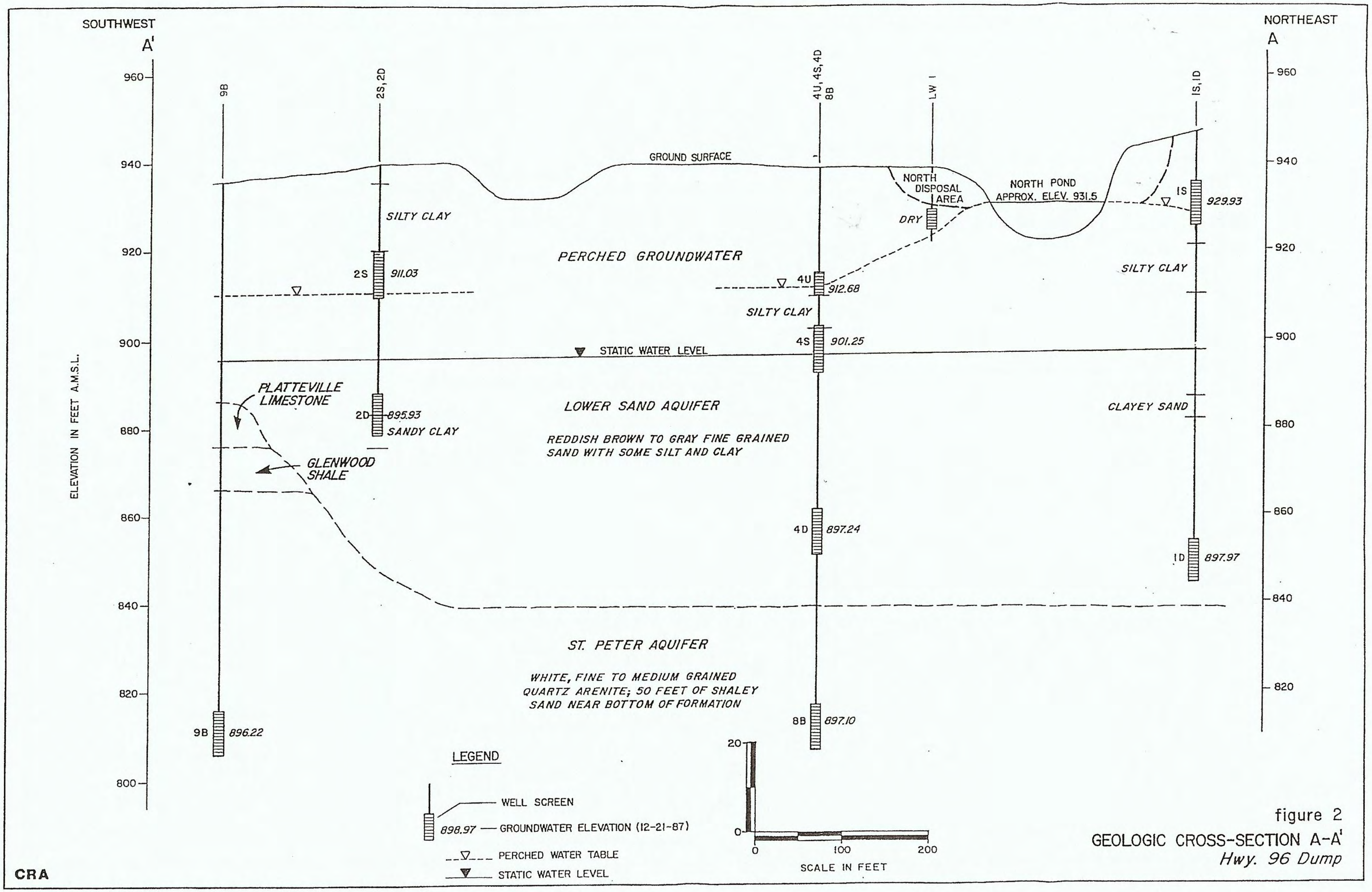
3.0 INVESTIGATION

3.1 SITE HYDROGEOLOGY

Three groundwater systems exist at the Highway 96 Site: perched, Lower Sand Aquifer and the St. Peter Aquifer. Perched groundwater is found at relatively shallow depths around the North Pond and Turk Lake and is a result of less permeable silts and clays retarding downward movement of the water. The Lower Sand Aquifer is hydraulically connected to the St. Peter Aquifer.

Perched groundwater has a lower elevation than the North Pond and Turk Lake which demonstrates that these bodies of water seep into the perched groundwater. Pond and lake levels are not affected by the hydraulics of the Lower Sand Aquifer since the Lower Sand Aquifer does not recharge the perched groundwater, pond and lake system local to the Highway 96 Site. Figure 2 presents a hydrogeologic cross-section of the stratigraphy and the corresponding aquifer.

During the pumping of the extraction well, water levels monitored in perched groundwater and the North Pond did not drop due to pumping even though water levels from the Lower Sand/St. Peter aquifer dropped, as shown on Figure 3. This illustrates that the water level at the closest pond to the extraction well was not affected by pumping from the extraction. Figure 3 also presents the area impacted by pumping referred to as a, "capture zone" which affects only the Lower Aquifer in the immediate area of the Highway 96 Dump.



CRA

figure 2
GEOLOGIC CROSS-SECTION A-A'
Hwy. 96 Dump

2012-11/01/88-9-D-0

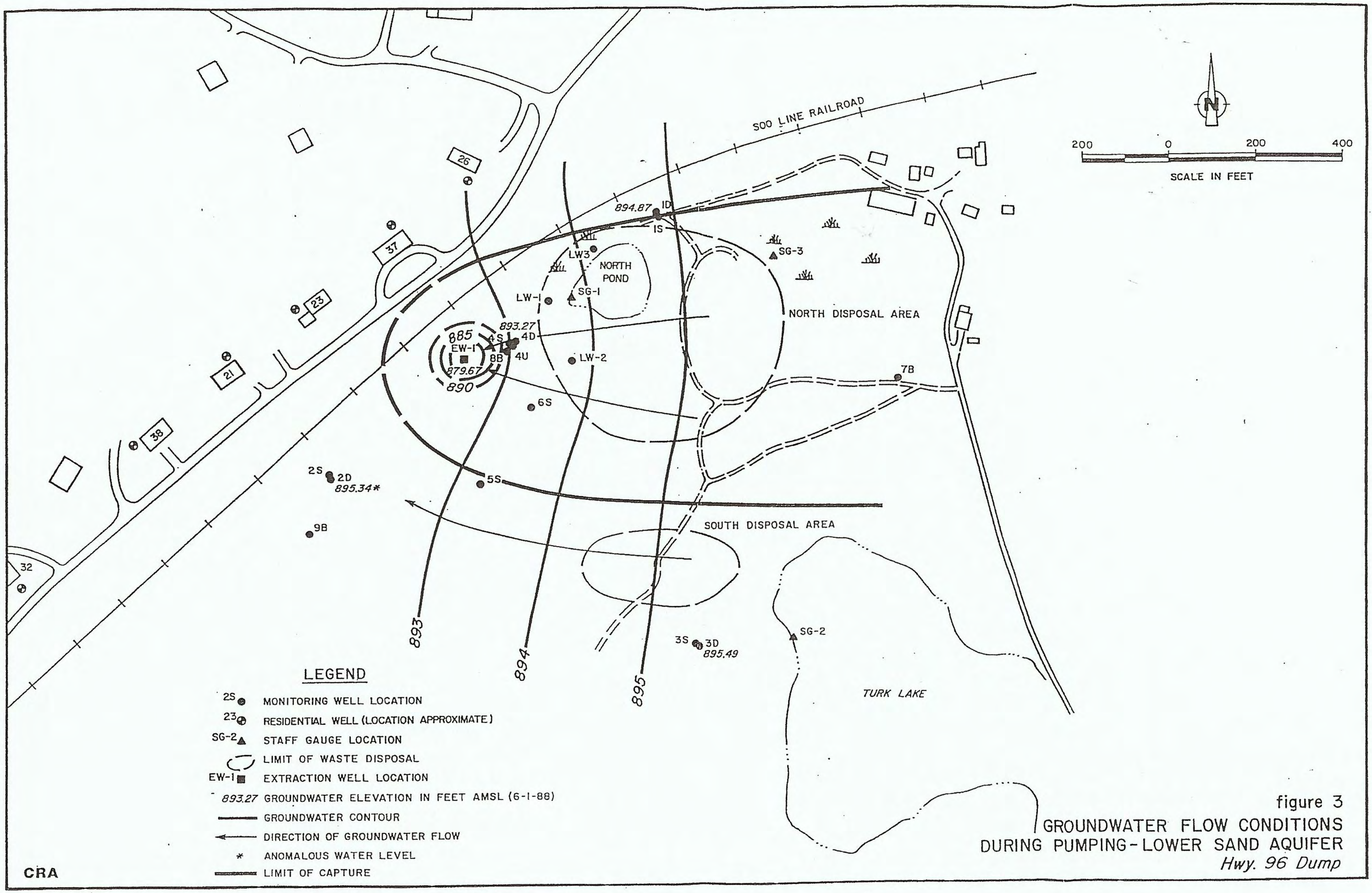


figure 3
GROUNDWATER FLOW CONDITIONS
DURING PUMPING - LOWER SAND AQUIFER
Hwy. 96 Dump

2012-17/07/87-M

3.2 AUGMENT PUMPING

According to Ms. Brainerd, an augmentation well was constructed in 1950 (near Sora Pond) to pump and discharge groundwater in to Sora Pond. A system of culverts connecting the ponds provide flow from Sora Pond to Teal Pond and then to Gilfillan Lake and John Pond. North and South Mallard ponds are also connected to this system, however, flow from Teal Pond is controlled manually.

Approximate pumping rates from the augmentation well have been estimated using the kilowatt hours consumed for the years of 1977 through 1980 and 1989 and the specifications of the pump. The remaining years have been interpolated based on dollar amounts, as provided by Ms. Brainerd. Table 1 illustrates the gallons pumped annually compared to the precipitation rates.

Obviously, pumping rates increase as precipitation averages decline and vice versa. Pumping for lake augmentation, since 1974, has averaged approximately 60 million gallons a year.

In comparison since 1989, pumping at the Highway 96 Site has averaged 23.7 million gallons per year from the Lower Sand and St. Peter Aquifer. Although the total amount of groundwater removed from the Highway 96 Site appears substantial, the effects of pumping influences only a localized area in the Lower Sand Aquifer, as shown on Figure 3 and does not

TABLE 1

ANNUAL PRECIPITATION AND AUGMENTATION SUMMARY

Year	Precipitation (inches)	Estimated Augmentation (million gal/yr)
1969	17.1	0
1970	32.4	0
1971	31.6	0
1972	26.1	0
1973	30.5	0
1974	23.0	119
1975	44.4	0
1976	16.1	102
1977	39.4	102
1978	37.9	67
1979	32.1	11
1980	32.4	103
1981	29.7	61
1982	31.2	42
1983	32.5	13
1984	35.9	18
1985	32.7	18
1986	35.0	8
1987	20.7	92
1988	25.7	114
1989	21.8	108
Average	29.9	61.1 (Since 1974)

NOTE:
Precipitation - annual measurements from Forest Lake, Minnesota
Augmentation - annual measurements calculated from KWHr on billing invoice

76-89
only 2 years did they exceed 61 million
all pumping over 40 million
went to Gilbert

affect perched groundwater or pond levels at the Site, as these are not hydraulically connected to the Lower Sand Aquifer.

3.3 DNR PERMIT REVOCATION

In 1988 the DNR (Groundwater Division) withdrew all permits for wells used to augment lakes and ponds for cosmetic reasons. At the time, Minnesota was in a period of drought and there was concern about depleting the water supply aquifers. This concern likely influenced the DNR decision to ban the use of groundwater for lake and pond augmentation. The pumping well near Sora Pond was designed for the augmentation of the lake and pond system was shut down in the summer of 1989, about the same time groundwater pumping of the Lower Sand Aquifer began at the Site.

3.4 WATER LEVEL INTERPRETATION

Groundwater elevations at the Highway 96 Site range from 890 to 900 feet AMSL in the Lower Sand Aquifer and the St. Peter Aquifer. Wells monitored have shown a gradual increase in the groundwater levels since 1989 as presented in Table 2 which corresponds to the increase in precipitation as shown on Table 1. Despite the increase in the groundwater levels, lake and pond levels at North Oaks appear to continue to decline. The North Pond water level has also increased since 1989. The groundwater pumping at the Site has only a local affect on the groundwater levels within the Lower Sand Aquifer and St. Peter Aquifer and does not

TABLE 2

HIGHWAY 96
GROUNDWATER ELEVATIONS (ft.)

WELL	DATE					
	JUL 1987	AUG 1988	AUG 1989	AUG 1990	AUG 1991	APR 1992
MW1S*	930.74	929.13	929.38	929.11	934.05	937.79
MW1D	897.52	893.93	891.87	891.93	894.27	896.02
MW2S*	914.26	Dry	Dry	Dry	911.23	921.40
MW2D	895.18	893.66	893.27	894.66	896.26	897.86
MW3S*	933.69	931.21	937.61	938.46	940.62	943.13
MW3D	897.92	893.88	892.39	892.25	894.53	896.44
MW4U*	915.42	Dry	NT	Dry	912.30	913.26
MW4S	902.51	896.96	894.08	Dry	895.79	898.13
MW4D	896.70	893.11	890.26	890.40	893.27	894.38
MW5S*	Dry	Dry	Dry	Dry	Dry	Dry
MW6S*	925.94	926.55	927.79	930.89	931.93	932.99
MW6D	NI	894.05	891.68	891.05	893.85	895.57
MW7B	NI	NT	893.31	893.03	895.19	897.14
MW8B	NI	893.05	890.05	890.18	893.15	894.19
MW9B	NI	892.14	889.96	890.36	892.79	894.49
MW10S*	NI	Dry	NT	927.34	928.89	929.94
MW10D	NI	900.81	895.48	892.94	897.34	899.75
MW10B	NI	NT	NT	890.23	893.03	894.19
MW11S*	NI	923.90	922.24	931.45	932.00	932.56
MW11D	NI	898.08	894.76	894.59	898.30	900.22
MW12D	NI	NI	NI	NI	895.83	898.62
MW12B	NI	NI	NI	NI	892.94	894.37
MW13D	NI	NI	NI	NI	895.44	898.12
MW13B	NI	NI	NI	NI	892.78	894.42
EW1	NI	892.89	877.59	873.13	883.91	856.84
LW1*	Dry	Dry	NT	Dry	930.20	933.6
LW2*	930.43	NT	930.01	929.98	931.43	934.05
LW3*	NI	NT	930.42	932.10	932.63	933.98
North Pond	931.50	NT	930.79	932.35	933.05	Missing

NOTES:
* Denotes wells located in the perched aquifer
NI - Not installed
NT - Not Taken

impact the levels of the North Pond because the North Pond is not spring fed from either the Lower Sand or St. Peter Aquifers.

Lake and pond elevations in North Oaks were taken in August 1990 and are presented on Table 3. These levels are 10 to 15 feet higher in elevation than the Lower Sand Aquifer found on-site. These data indicate that the lake and ponds are not recharged by the Lower Sand Aquifer, rather the lake and ponds in the North Oaks area may hydraulically resemble the North Pond and actually recharge the Lower Sand Aquifer.

3.5 PREVIOUS INVESTIGATION

An investigation was conducted by Professional Engineering Consultants Inc. in 1990 for the North Oaks residents. The purpose of the investigation was to determine the cause of the declining lake and pond levels.

The results of the investigation concluded the following reasons for the low levels:

1. the lake and ponds are the product of a relatively small watershed;

2. the drought of 1987, 1988 and 1989 reduced run-off;

3. permit revocation by the Minnesota DNR in 1988;

TABLE 3

LAKE AND POND ELEVATIONS
AUGUST 1990

Location	Elevation (ft.)
Gilfillan Lake	909.4
John Pond	912.5
Teal Pond	909.0
Average Lower Sand and Bedrock Aquifer	892.0
Perched Aquifer (avg.)	931.3
North Pond	932.4

4. inadequate placement of the inlets and outlets that connect Gilfillan Lake to Teal Pond;

5. slight leakage of the lake and ponds; and

6. some siltation of the lake and ponds.

3.6 PHOTO INTERPRETATION

Aerial photos were collected from the area and are shown in Figures 4 and 5. The photos illustrate the Highway 96 Dump, Sora Pond, a portion of Gilfillan Lake and John Pond for the years of 1945 and 1962. The 1945 photo shows Gilfillan Lake at a considerably lower level (as indicated by the smaller lake area and the presence of aquatic vegetation) than the photo in 1962. John Pond is virtually non-existent in 1945 compared to 1962.

The photos compare pond and lake levels before augmentation (in 1945) to after augmentation (in 1962). As shown, the lake and ponds are significantly larger following the start of augmentation, indicating an increase in surface water in North Oaks. As the photos indicate, the lake and pond levels have historically been low and require augmentation to maintain their present levels.

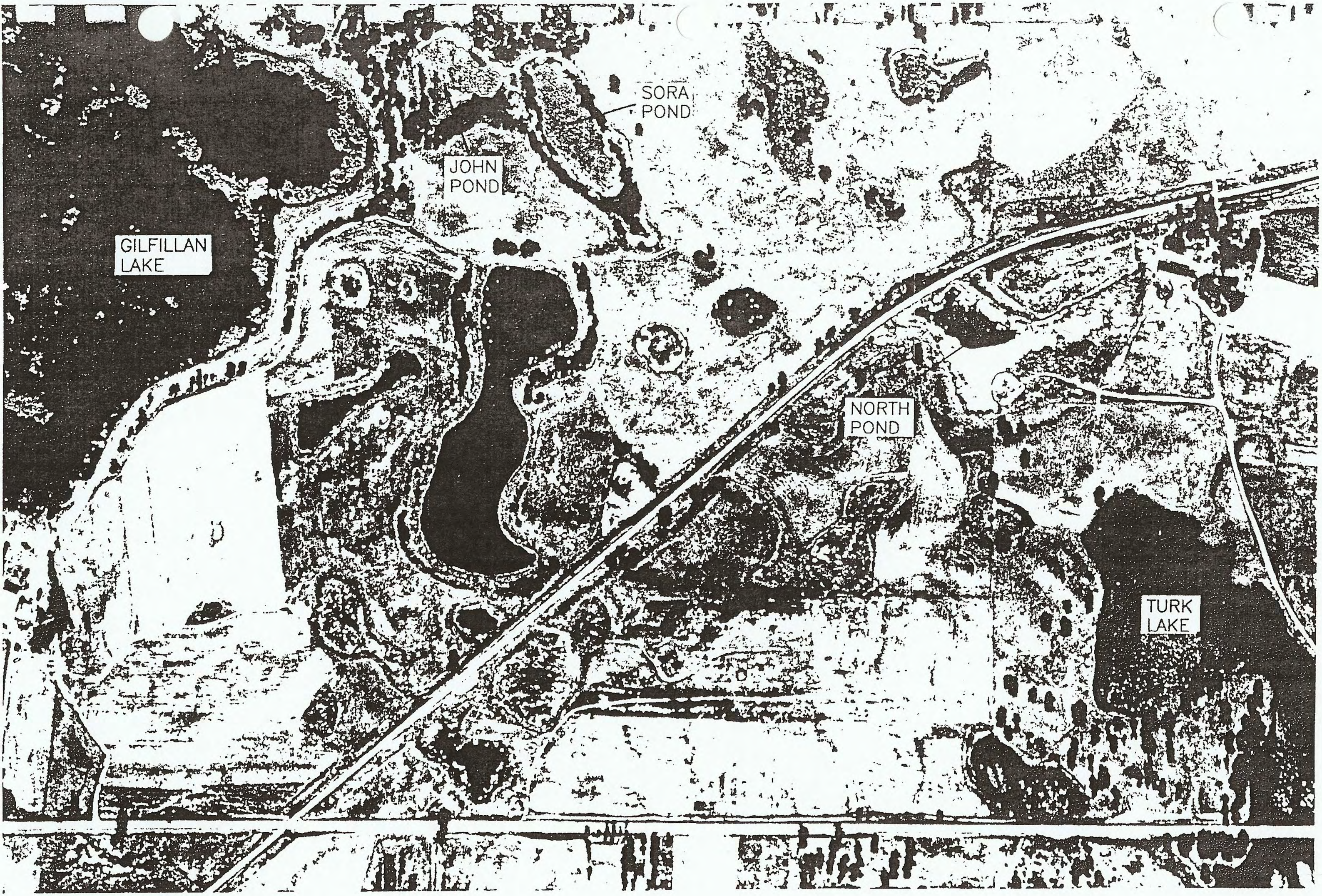


figure 4
AERIAL PHOTOGRAPH—1945
Hwy. 96 Dump

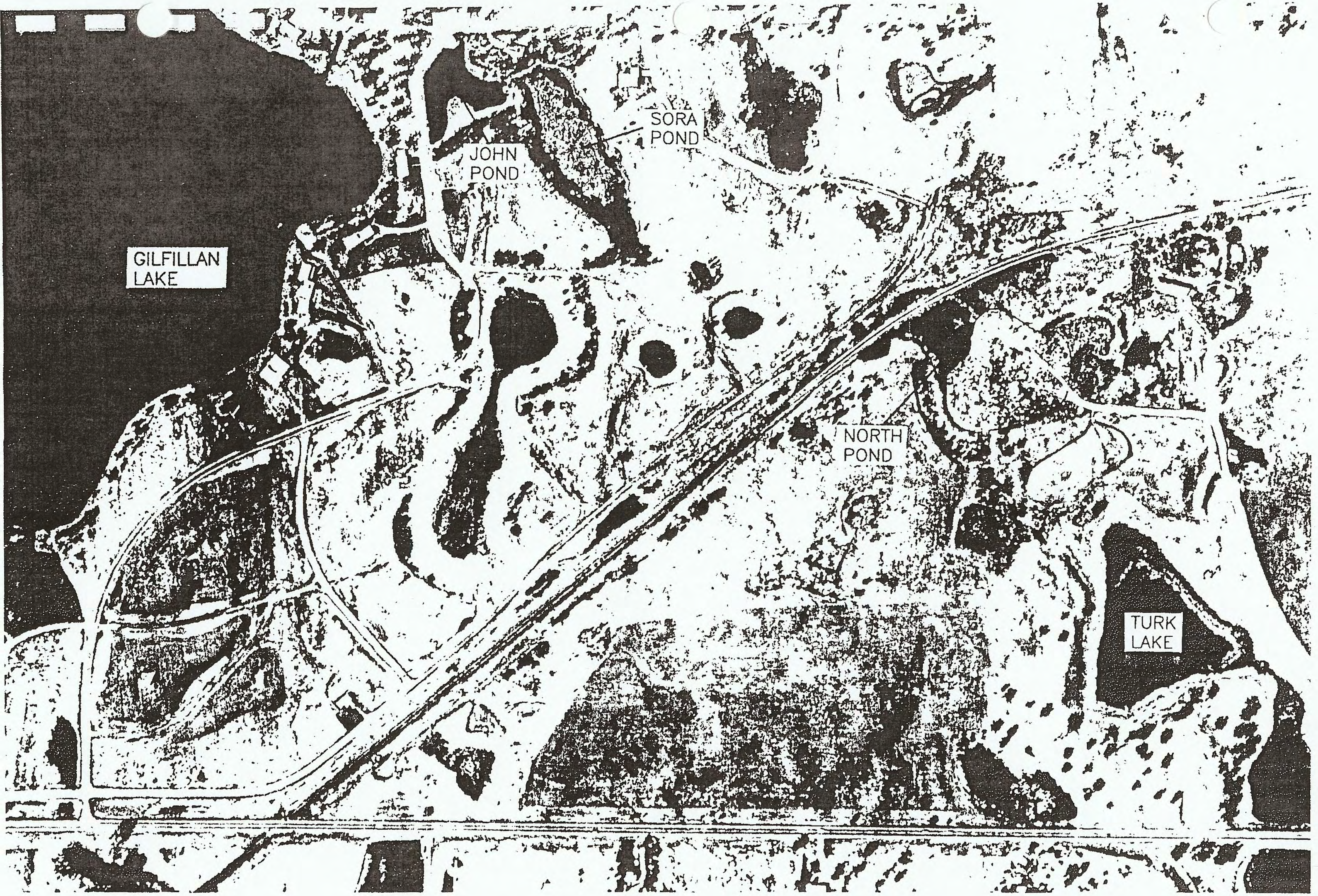


figure 5
AERIAL PHOTOGRAPH–1962
Hwy. 96 Dump

4.0 CONCLUSIONS

The data collected from the Highway 96 Dump wells compared to the elevations of the lake and ponds show no evidence that pumping at the Highway 96 Dump is causing the lake and pond levels in North Oaks to decrease. The North Oaks lake and ponds are likely not spring-fed and therefore could not be lowered by groundwater pumping at the Highway 96 Site. By comparison, the North Pond, located adjacent to the extraction well, has not exhibited significant water level decline over the same period. If the North Pond was spring-fed from the Lower Sand Aquifer, the North Pond would have shown the greatest water level decline because it is much closer to the extraction well.

It appears that the lake and ponds are topographically a result of micro drainage basins with very little water shed area to support the desired levels. Since 1974, an average of 61.1 million gallons per year of water was pumped into the local ponds and lakes to sustain the water levels. When this augmentation ceased in 1989, the pond water levels correspondingly declined. The pumping used to augment the lake and ponds was coincidentally terminated in 1989, the same year that the Highway 96 Dump began pumping the Lower Sand Aquifer.

Based on the assessment of data available, it is concluded that the declining water levels in North Oaks ponds and lakes are the result of discontinued lake augmentation. Without augmentation, the lake and ponds will return to approximately their natural levels as shown in the 1945

photograph, as discussed in Section 3.4. Variations in precipitation will also directly affect water levels in these ponds.