Prairie Island Nuclear Generating Plant
2006 Hydrogeology Summarization

Prepared by Xcel Energy
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H-53

Introduction

As part of a 2006 self-assessment, NMC and Xcel Energy staff re-evaluated its tritium ground water monitoring program. The self-assessment concluded, the monitoring program is functional and provides the necessary information. The team recommended the preparation of an updated report summarizing external studies, local hydrogeology and monitoring results. This report identifies pertinent ground water studies, re-interprets the hydrogeology, and provides a 10-year summary of tritium monitoring results.

Back Ground Chronology

1989 A special tritium sampling program was established following the detection of tritium in a domestic well (Sutter residence) located south of the PINGP.

1991 The outfall, for PINGP liquid discharges of tritium, was extended to the distal end of the discharge canal. The reduced retention time reduced the probability of tritium infiltrating into the local ground water.

1992 The plant modified it's liquid discharge piping from the Aux building to the discharge canal. Tritium releases due to pipe leaks were suspected.

2006 Discharge of tritiated water to the "Land lock" was terminated, to the extent practical.

Literature review

NSP's 1992 "Tritium Groundwater Investigation Report" was a compilation of earlier reports. Since 1992, three studies have been conducted which are pertinent to the PINGP monitoring program. The studies are identified below along with a brief description of the report

- Water Resources of the Prairie Island Indian Reservation, Minnesota 1994 –1997. USGS. 1999.
  - This report summarizes the regions geologic history, and ground water quality. Organic, inorganic and radiological samples were collected and analyzed as part of this project.
- Hydraulic Properties of the Mt Simon Aquifer, Prairie Island Indian Community, South Eastern Minnesota, 2001. USGS. 2002.
  - This report discusses and summarizes a recent pump test used to determine aquifer properties. The aquifer studied is isolated from the PINGP by the confining properties of the Franconia formation.
- Simulation of Ground Water Flow and Delineation of areas Contributing Recharge within the Mt Simon – Hinckley Aquifer to Well Fields in the Prairie Island Indian community, Minnesota. USGS 2002.
  - ModFlow, a ground water computer model was used to evaluate the pumping influences of the communities two public well fields. A ten and 50 year recharge area was delineated for each well field. The aquifer studied is also isolated from the PINGP by the confining properties of the Franconia formation.

Hydrogeology

The PINGP is located on the Mississippi flood plain; topography is flat and soils are sandy in nature. The valley contains the Mississippi River, situated north of the plant, and the Vermillion River, south of the plant. The Mississippi River Valley is approximately 3 miles wide at the plant site. Steep bluffs composed of limestone & sandstones bound the valley. Bluff tops are approximately 350ft higher than the valley floor.

The bedrock valley existed prior to the last glaciation. During the Wisconsin glaciation, a thick deposit of well-sorted outwash was deposited in the Mississippi River Valley. The formation of Glacial Lake Agassiz, resulted in a relatively sediment free water flowing through the Mississippi River Valley. This water eroded the valley deposits leaving a channel and higher terraces. The intial flooding of Lake Pepin flooded of all but the higher terraces at the PINGP. Lacustrine sedimentation and subsequent retreat of lake Pepin yielded the substrate for the lakes and wetlands, which currently surround the plant.

Figure 1 illustrates the stratigraphic profile for the region. Figure 2 illustrates a geologic cross section for the river valley. The upper three bedrock strata have been eroded away; the first bedrock formation beneath the PINGP is the Franconia formation. The Franconia is buried beneath 168 ft of outwash sands and gravel. Ground water originating in the adjacent upland bed rock formations discharge into the unconsolidated material along their eroded margins. Ground water flow direction in the Franconia is upward beneath Prairie Island.

Major aquifers beneath the site (Ironton-Galesville and Mt Simon) are protected from local recharge by the Franconia formation. The Franconia is considered a confining layer at the site due to it's shaly beds. Ground water modeling, preformed by the USGS also indicates the PINGP would not impact the high capacity Community wells (Figure 3).

Surface water bodies are generally interconnected. Lock and Dam #3 regulates the Mississippi River elevation at the plant. The Vermillion River typically records a lower river elevation since it connects to the Mississippi River below lock and Dam #3. The disparity in surface water elevations predominantly control ground water flow in the water table aquifer.

Typically the Mississippi River elevation is >6.5ft higher than the Vermillion River. This results in a typical ground water flow direction of NE to SW. (Figure 4) However during periods of high rain fall the USGS[1] has documented radial flow near the PINGP. The radial flow directions are caused by a disproportionate rise in the Vermillion River elevation which flattens the gradient

[1] USGS Water Resources of the Prairie Island Indian Reservation, Mn 1994-1997. 2002.

and rapid ground infiltration which has a mounding effect. (Figures 5 and 6). Once typical river elevations and precipitation rates return, the dominant flow direction of NE to SW returns. (Figure 7)

Typical ground water travel velocities at PINGP were estimated to range from 70 to 800 ft/yr using Darcy's equations: $V_t = (k\ i\ /p)\ uc$. [2] These velocities do not reflect periods when radial flow is evident.

Where:
V_t = the average travel velocity
k = hydraulic conductivity ($4x10^{-2}$cm/sec to $2x10^{-1}$cm/sec)
i = ground water gradient (reported gradients range from 0.001ft/ft to 0.0004ft/ft)
p = porosity (0.25 was assumed for a sandy outwash aquifer)
uc = unit conversion coef (1034646 x V_t in cm/sec = V_t in ft/yr)

Environmental Monitoring

Many types of wells (domestic, environmental and high capacity production wells) have been used to evaluate tritium levels in the PINGP vicinity. Although sampling the domestic and high capacity wells serves a purpose; the environmental monitoring wells (shallow, 2" diameter wells) are best suited for characterizing tritium releases at the plant site. These wells are located close to potential sources and they predominantly screen the water table surface.

Environmental Monitoring System (EMS)

Figure 8 illustrates the locations of the environmental monitoring wells. Table 1 describes well construction and Figure 9 illustrates where the water table is relative to the well screen.

An attempt to plot 2006 ground water elevations failed to produce reasonable results. In-accurate riser pipe elevations are believed to be the root cause for this failure. It is recommended that the EMS wells be resurveyed.

Sampling Methods

Ground water sampling at the PINGP follows Xcel Energy's General Ground Water Sampling Protocol. The one exception to this protocol: ground water samples are not filtered. The protocol is summarized below:

- A static water level measurement is collected at the onset of sample collection.
- The well is purged, at a rate less than 0.5 gpm, to ensure fresh ground water will be sampled. Temperature, pH, specific conductivity, and DO measurements are taken after each well volume is evacuated. Ground water samples are collected after the stabilization test documents three

[2] NSP PINGP Tritium GW investigation Report & Work Plan. 1992.

consecutive well volumes, with similar temperatures, pH, and conductivity measurements.

- Each sampling event will include Static Water Levels for all wells, measured within a 24hr period.
- All non-dedicated sample equipment is de-contaminated in the lab between facilities.
- Field de-con, consisting of a quick equipment rinse/flush, is preformed between each well.
- Field sheets document well stabilization test results and field conditions.
- A Chain of Custody will be completed for each day of sampling.

Environmental Monitoring Results

It was not the purpose of this report to provide an in-depth analysis of tritium results. Figure 10 illustrates tritium concentrations for the past ten years from the onsite monitoring wells. These results indicate the wells are capable of monitoring tritium releases at the PINGP.

Currently P-10 is exhibiting significant spikes in tritium concentrations which indicate a near by source. The "land lock", has been identified as a possible source, however additional work needs to be preformed to confirm this relationship. A refined estimate of ground water travel velocities may improve the correlation between land lock releases and observed spikes in ground water concentrations.

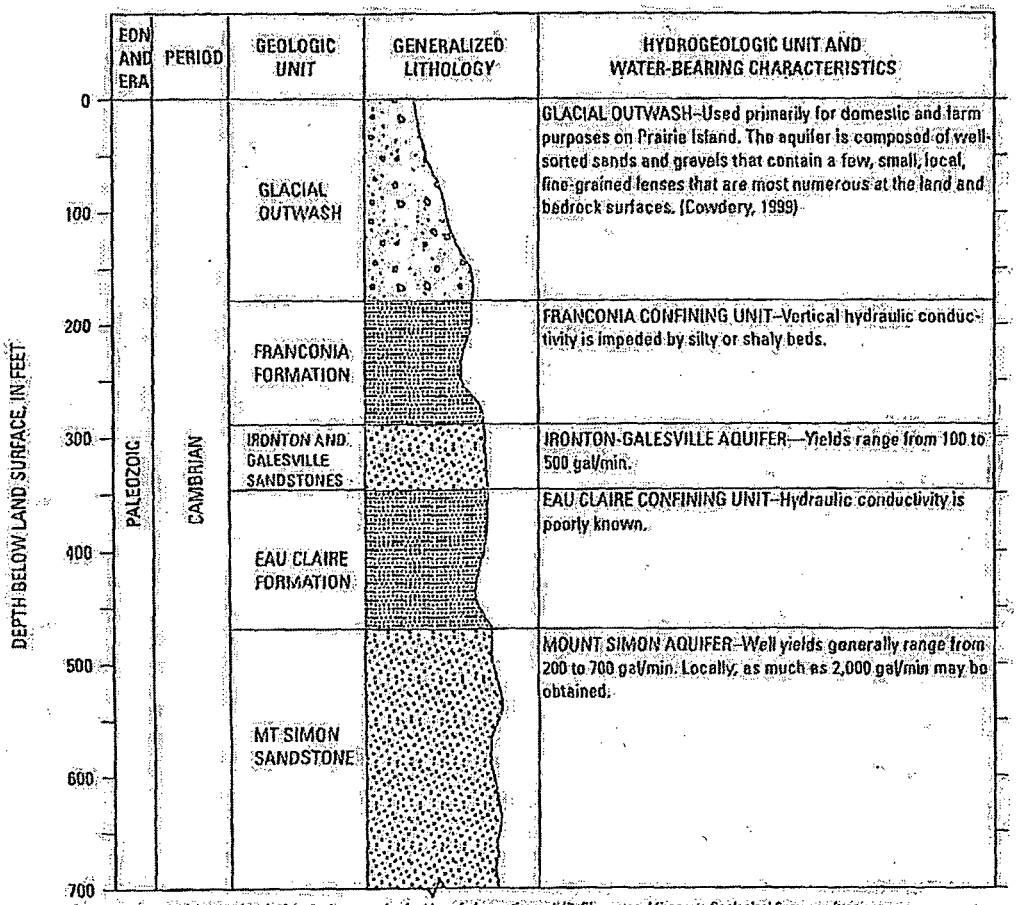
Conclusions

- The existing environmental ground water monitoring system, is functional and capable of detecting tritium releases. The close proximity of these wells to the plant buildings and their construction make them well suited for early detection of a release.
- A tritium release from the PINGP would be expected to flow SW in the water table aquifer. Short term deviations to the from this flow direction are possible during periods of high rains.
- Impacts to the nearby Prairie Island Indian Community public wells are not predicted for two reasons.
    - The community wells are screened in a deeper aquifer. The Franconia formation would prevent the deeper migration of a release due to its confining properties.
    - Ground Water Modeling, preformed by the USGS indicates the PINGP is beyond the 50-year recharge zone for the community wells.
- Currently there is insufficient data to confirm a link between P-10 and tritium releases to the "land lock".

Table 1 PINGP Environmental Monitoring System – Well Construction Summarization.

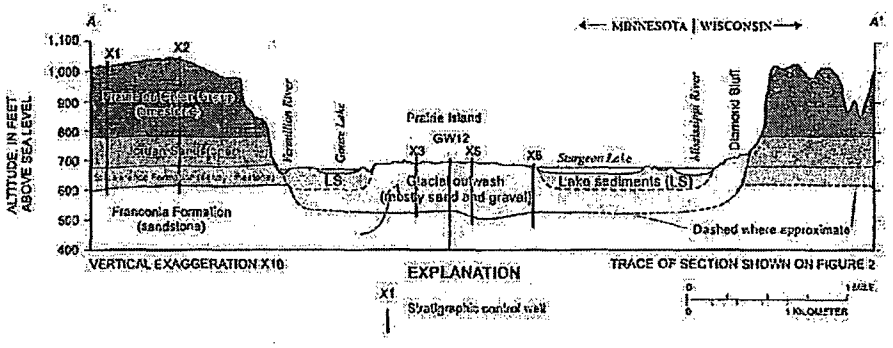
Well	North	East	Top of Riser Pipe Elev	Top of Screen Elev	GW ElevJul-2006	Bottom of Screen Elev
P-2	594449	2354002	697.86	665	673.1	675
P-3	592998	2353999	698.14	666	672.34	676
P-4	594449	2354503	694.88	662	673.63	673
P-5	594003	2354501	695.46	668	673.01	678
P-6	595250	2354802	699.28	666	673.3	676
P-7	594449	2355235	697.32	665	672.68	675
P-10	593538	2355498	693.12	669	674.32	679
P-11	594949	2355297	698.17	663	673.43	673
PZ-1	596790	2354935	680.67	648	671.47	651
PZ-2	596616	2352641	689.01	658	673.05	661
PZ-4	594262	2352599	696.51	660	672.45	663
PZ-5	591503	2356300	695.87	643	671.89	646
PZ-7	594470	2356159	697.84	645	673.95	648
PZ-8	595471	2353662	696.48	653	672.97	656
MW-4	592236	2355091	693.00	-	672.33	-
MW-5	592200	2356566	686.81	-	672.82	-
MW-6	591642	2357597	682.31	-	672.96	-

Figure 1 General Stratigraphy



Source: U S Dept of Interior & U S Geologic Survey. Hydraulic Properties of Mt Simon Aquifer, Prairie Island Indian Community, Southeastern Minnesota, 2001. Water-Resources Investigation Report 02-4263.

Figure 2 Geologic Cross Section of River Valley



Source: U S Dept of Interior & U S Geologic Survey. Water Resources of the Prairie Island Reservation, Minnesota, 1994-1997. Water-Resources Investigation Report 99-4069.

Figure 3 Fifty Year Recharge Zone for Community Wells.

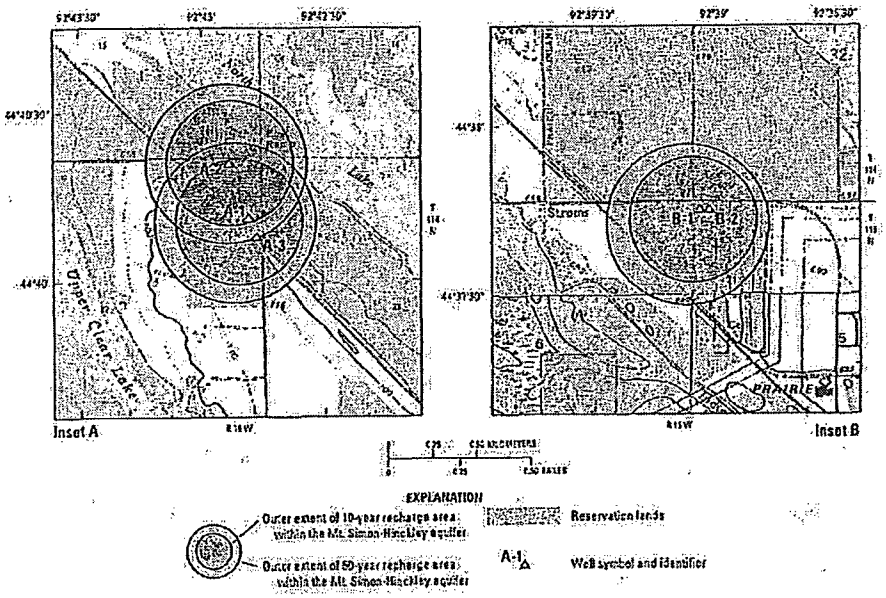
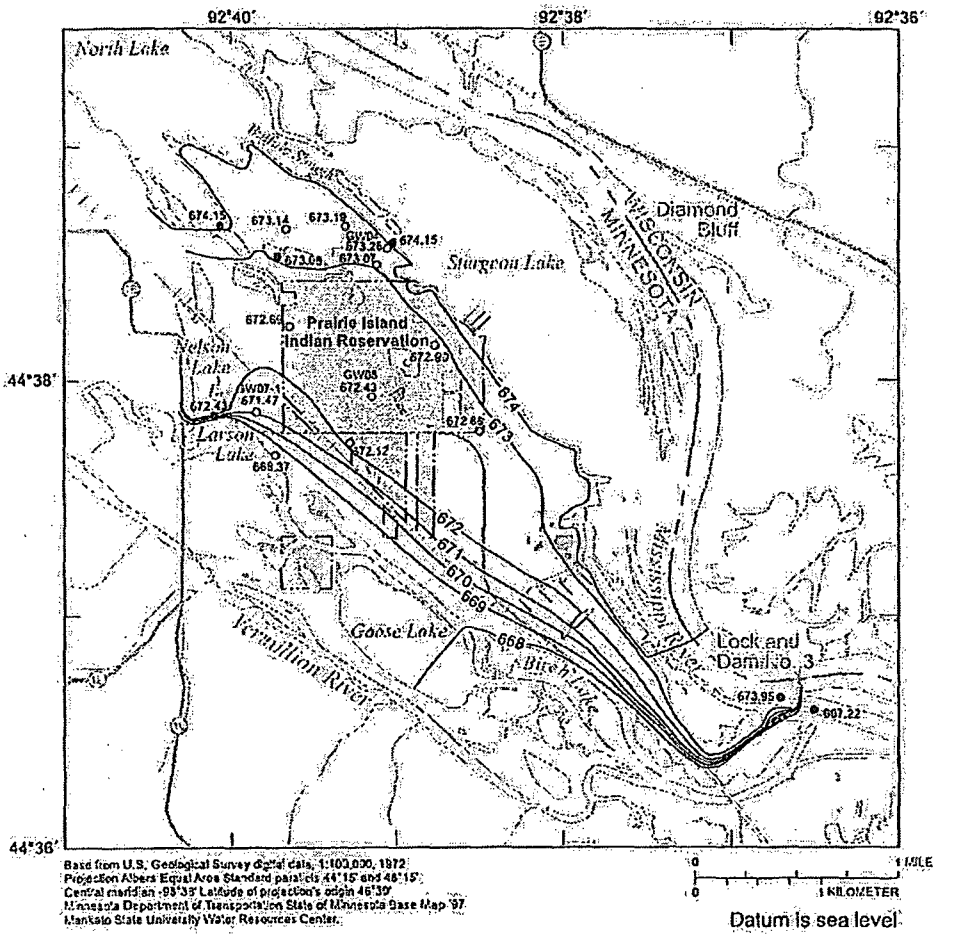


Figure 3. Recharge areas within the Mt. Simon-Hinckley aquifer to well fields A and B based on a rate of withdrawal of 625 cubic meters per day for each well field, Prairie Island Indian Community, east-central Minnesota.

Source: U S Dept of Interior & U S Geologic Survey. Simulation of Ground-Water Flow and Delineation of Areas Contributing Recharge within the Mt simon-Hinkley Aquifer to Well Fields in the Prairie Island Indian community, Minnesota. Water-Resources Investigation Report 02-4155.

Figure 4 Typical Ground Water Flows



EXPLANATION

- Reservation
- 672 — Water table contour— Contour interval 1 foot
- 672.69 Well and water-level elevation
- 674.15 Surface-water site and water-level elevation
- Building

Figure 4. Normal water-table surface, February 9, 1995.

Source: U S Dept of Interior & U S Geologic Survey. Water Resources of the Prairie Island Reservation, Minnesota, 1994-1997. Water-Resources Investigation Report 99-4069.

Figure 5 Radial Flow During Rainy periods

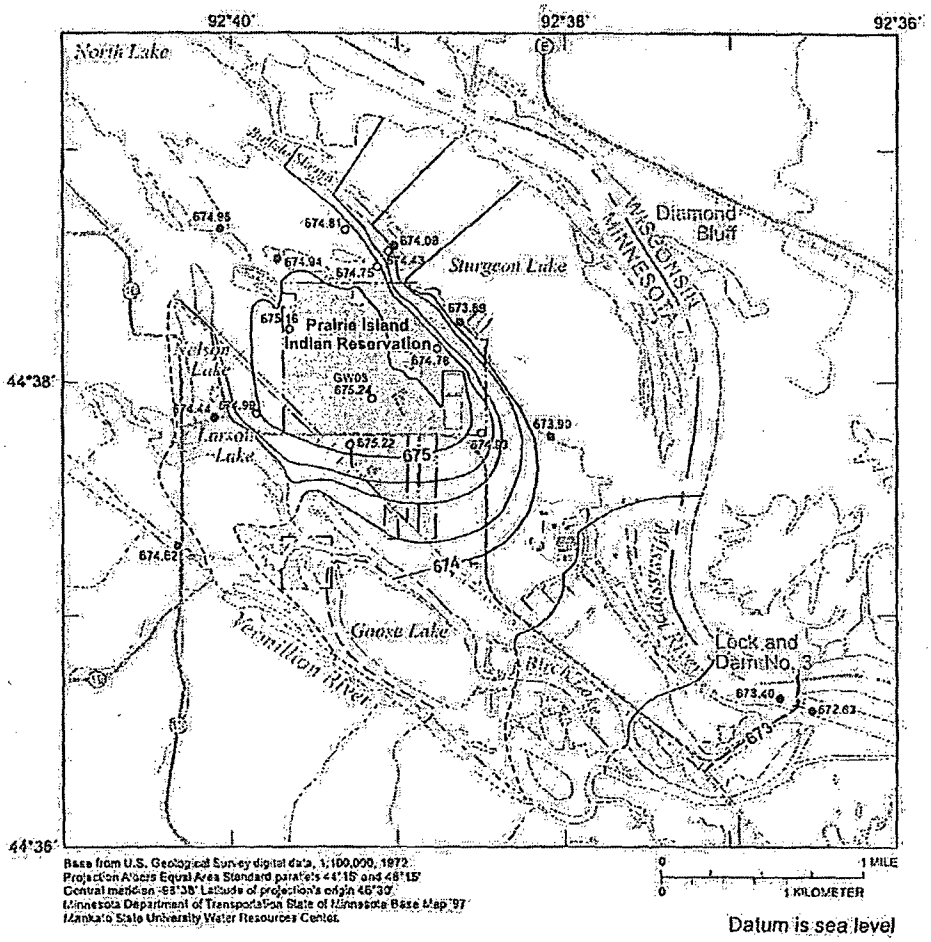


Figure 6. Water-table surface, August 7, 1997, following high rainfall.

Source: U S Dept of Interior & U S Geologic Survey. Water Resources of the Prairie Island Reservation, Minnesota, 1994-1997. Water-Resources Investigation Report 99-4069

Figure 6 Ground Water and River elevation Comparison

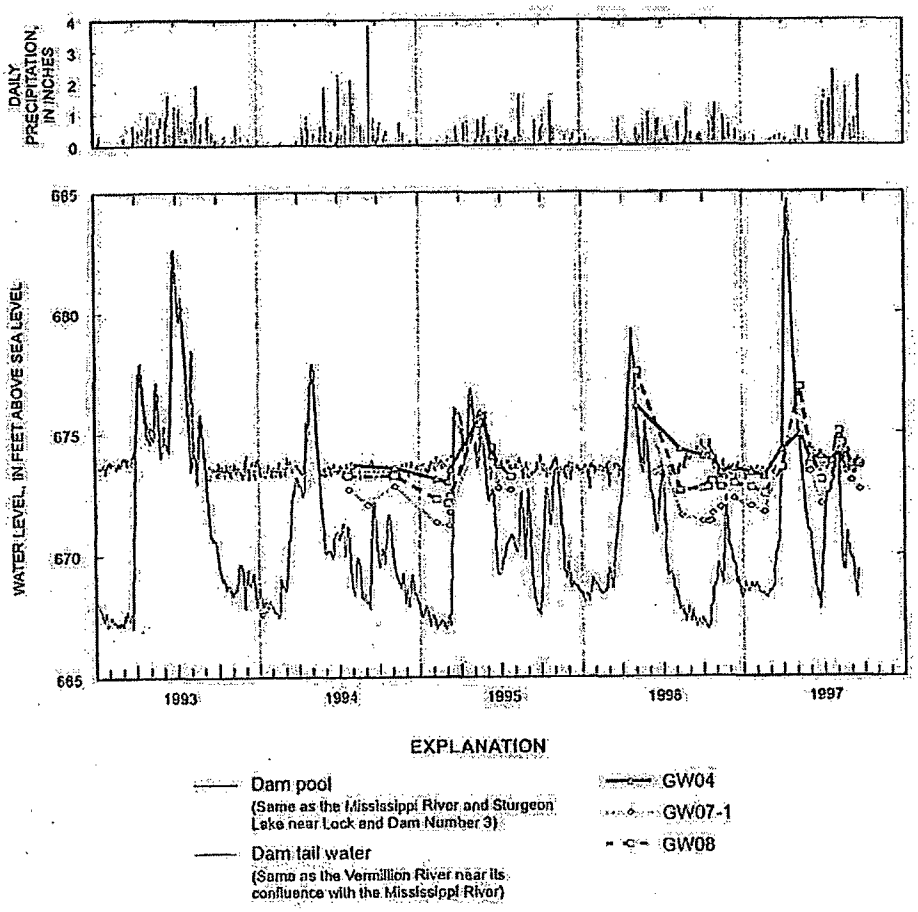
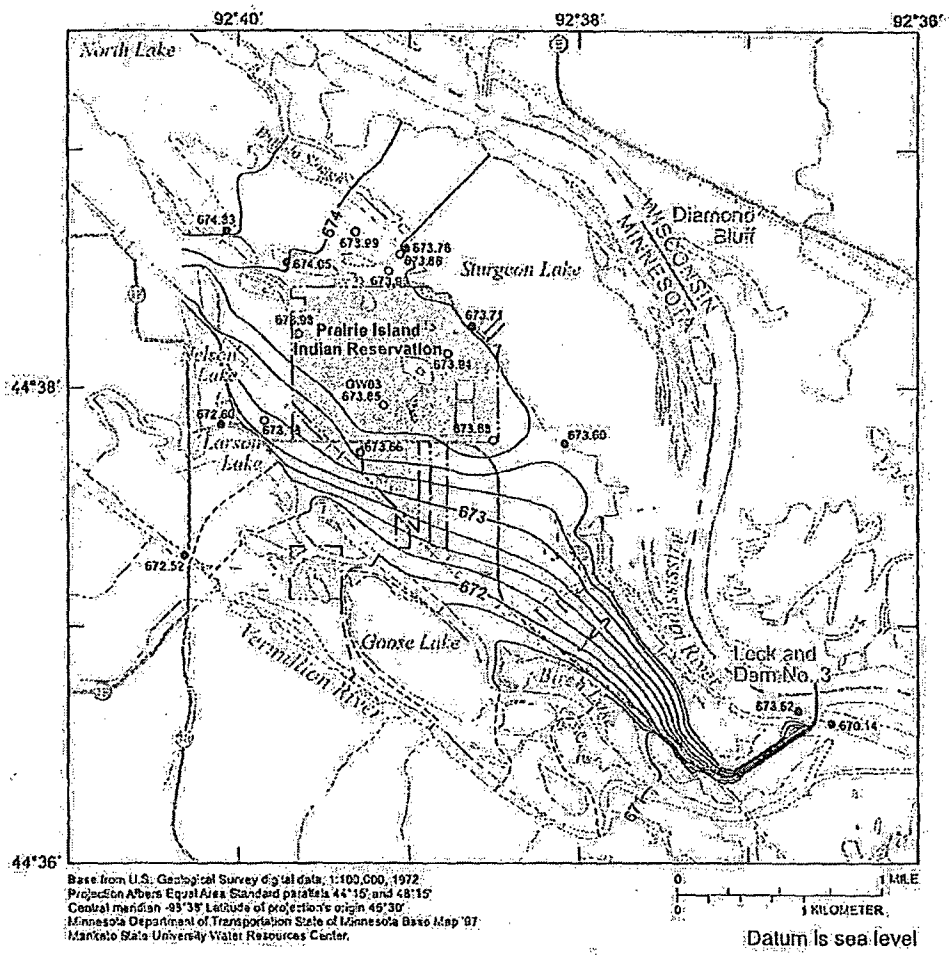


Figure 4. Surface- and ground-water hydrographs and precipitation, 1993–97.

Source: U S Dept of Interior & U S Geologic Survey: Water Resources of the Prairie Island Reservation, Minnesota, 1994-1997. Water-Resources Investigation Report 99-4069

Figure 7 Return To Normal Flow Directions after 30 Days



EXPLANATION

- Reservation
- —673— Water table contour. Dashed where approximate—Contour interval 0.25 foot
- 673.94 Well and water-level elevation
- 672.60 Surface-water site and water-level elevation
- Building

Figure 7. Water-table surface, September 3, 1997, about one month after high rainfall ended.

Source: U S Dept of Interior & U S Geologic Survey. Water Resources of the Prairie Island Reservation, Minnesota, 1994-1997. Water-Resources Investigation Report 99-4069

Figure 8 Environmental Monitoring Well Locations

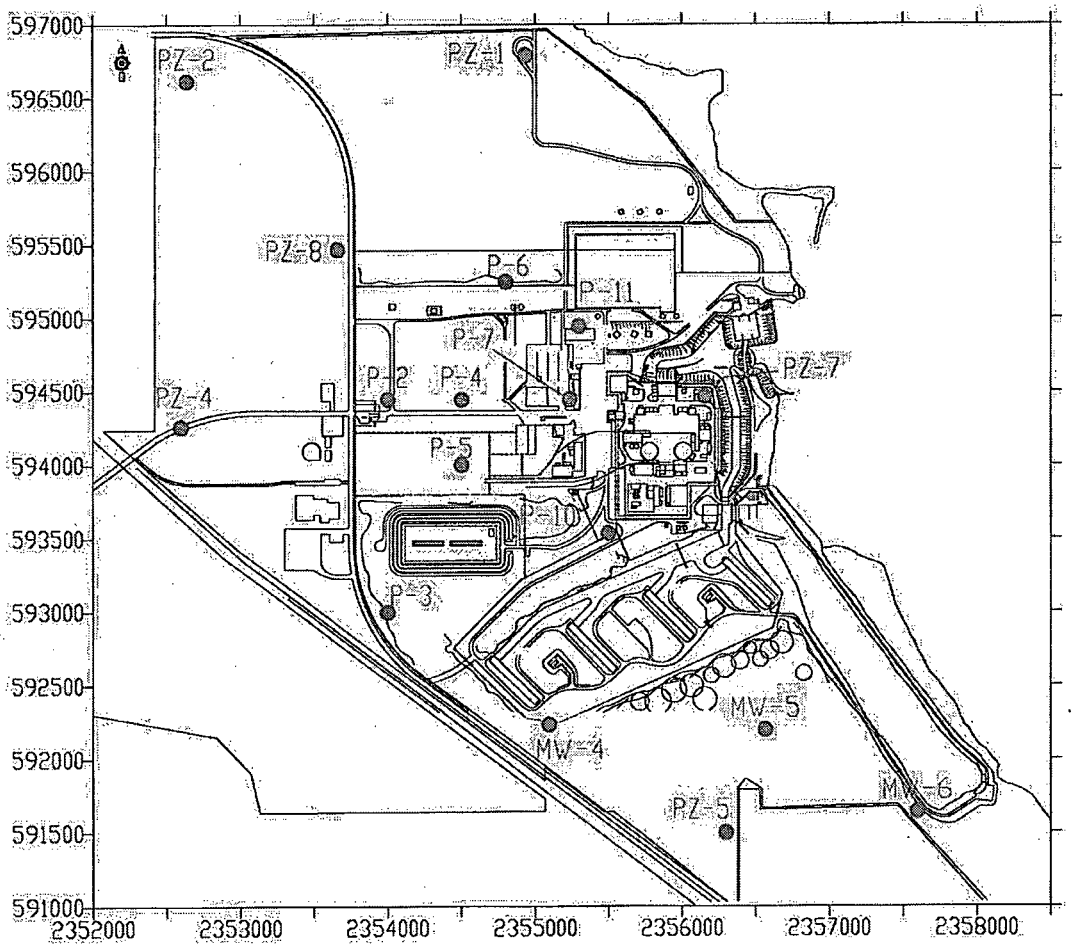
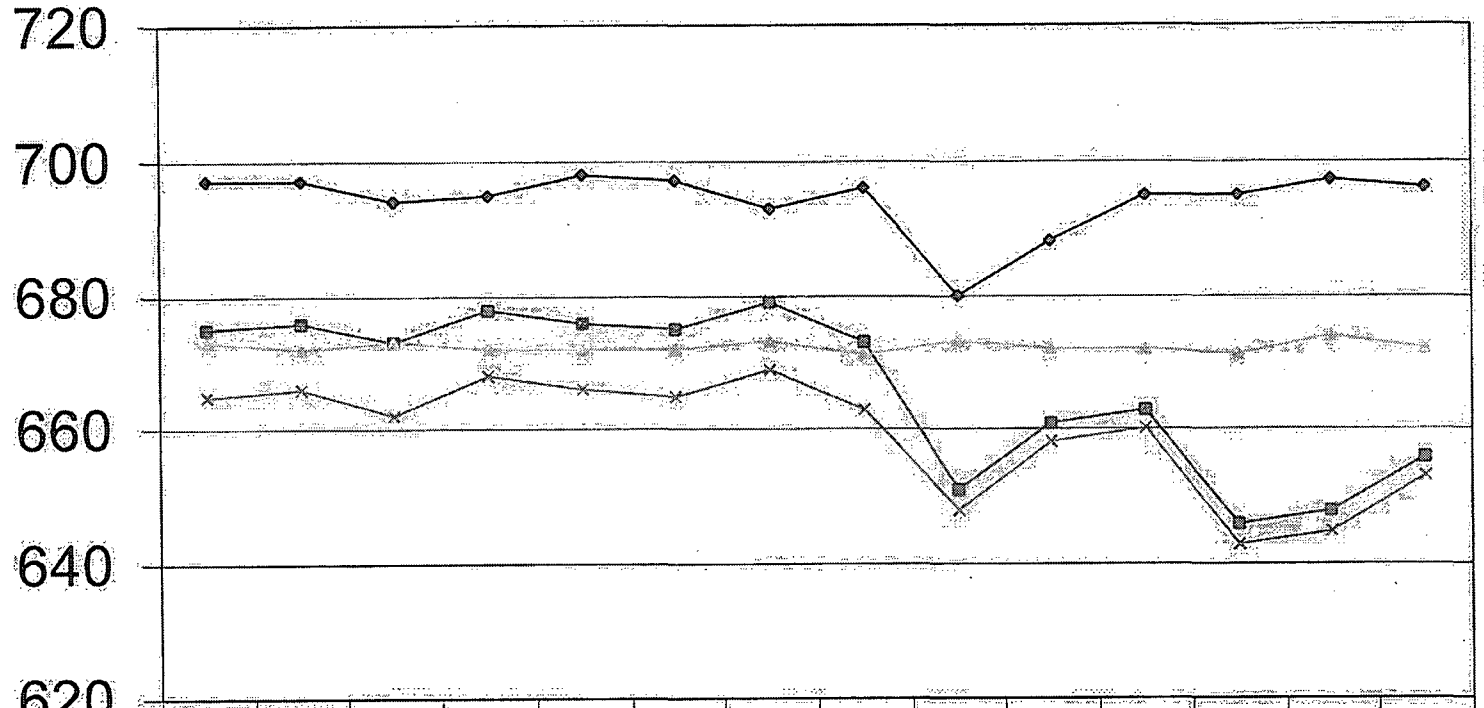


Figure 9 EMS Well Screen Location



	P-2	P-3	P-4	P-5	P-6	P-7	P-10	P-11	PZ-1	PZ-2	PZ-4	PZ-5	PZ-7	PZ-8
gnd	697	697	694	695	698	697	693	696	680	688	695	695	697	696
top of screen	675	676	673	678	676	675	679	673	651	661	663	646	648	656
gw elev	673	672	673	672	672	672	673	671	673	672	672	671	674	672
btt of screen	665	666	662	668	666	665	669	663	648	658	660	643	645	653