Interim Results Summary
CD Besadny Fish and Wildlife Area
Kewaunee Marsh, Wisconsin
August 2001

I. Background Investigation and Interim Measures

In 1993, WDNR became aware of a wetland area within the state owned CD Besadny Wildlife Area in Kewaunee County that was devoid of vegetation and showed signs of high stress. Subsequent sampling confirmed the presence of arsenic to levels as high as 68,000 mg/kg. The site is a remote area adjacent to an abandoned railroad bed crossing through the wetland. The spill, presumably the result of a train car derailment in the mid-1940's, is located approximately 1,200 feet from the Kewaunee River and is approximately one mile upstream of the mouth of the River at Lake Michigan. The spilled material is alleged to have been a powder or granular arsenic compound (sodium arsenite).

In 1994, Fox Valley and Western Railroad (FVWR), the potential responsible party, agreed to investigate the impacted area. STS Consultants, LTD. were hired to conduct water and soil investigative sampling and perform groundwater and stormwater modeling to predict long term impacts of the arsenic. Through water sampling, well monitoring, and sediment borings, the consultants identified an approximately 15-acre area of the marsh as the area of greatest concern. In 1996, a consent agreement was made between WDNR and FVWR to take interim measures to limit both the human and wildlife health threat of direct contact with arsenic in the area of greatest risk. As a result, a 6-foot cyclone security fence was placed around the area of greatest concern. In addition, a cap consisting of geo-textile fabric covered with a wood chip/yard waste mixture was placed on the most highly impacted soils, an area of about 200 by 400 feet.

In 1996, using data collected by WDNR and STS, STS Consultants produced a one-dimensional groundwater flow model that predicted a peak arsenic concentration in the Kewaunee River of 300 mg/L in 2700 years. Their conclusion stated "Results of hydraulic modeling indicate that arsenic transported to the Kewaunee River should not exceed surface water standards." At the time of the study, the surface water standard was the Wisconsin Administrative Code NR 105 Human Cancer Criteria of 50 ug/L (micrograms per liter) of arsenic.

In August 1997, Wisconsin Administrative Code NR 105 Criteria for arsenic contamination was revised. The following table shows the revised criteria.

Protection of Aquatic Life		Human Cancer Criteria
Acute Toxicity Criteria	Chronic Toxicity Criteria	
339.8 ug/L	148 ug/L	0.185 ug/L

The new standard for Human Cancer Criteria of 0.185 ug/L is considerably lower than the prior standard of 50 ug/L used in the models.

II. Recent Sampling Results

In lieu of the results of the 1996 modeling, WDNR Bureau of Watershed Management Staff felt that more investigation of the site was necessary to assess current background levels of arsenic, and to provide updated site information to the WDNR Remediation and Redevelopment program. On May 30-31, 2001, surface water samples were collected from ten locations

throughout the marsh, and ten additional groundwater monitoring wells were installed. The wells extend approximately three feet (36 inches) into the ground, and are screened at the bottom 14 inches. These new wells were then sampled in early June 2001.

Figure 1 shows the arsenic concentrations of the ten surface water samples collected in May 2001. The small-dotted line represents the boundary of the capped region, and the solid line shows the outline of the security fence. The larger dotted line represents the centerline of the abandoned railroad bed. All arsenic concentrations are in micrograms per liter (ug/L) and are unfiltered samples.

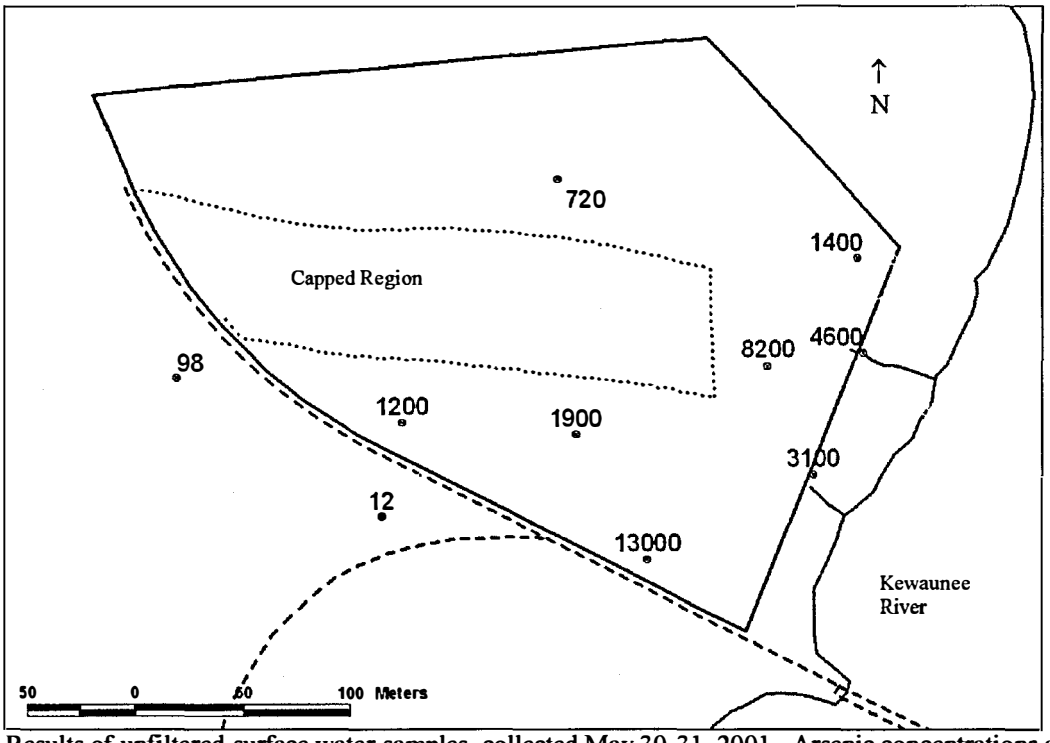


Figure 1. Results of unfiltered surface water samples, collected May 30-31, 2001. Arsenic concentrations are in micrograms per liter (ug/L).

The results of the 2001 surface water sampling raise significant questions when compared with the 1996 model results and the conclusions drawn from them; The 2001 results indicate that arsenic levels far exceeding Human Cancer Criteria standards are already present at the fenced edge of the area of concern. Surface water samples from the two main sloughs that drain from the marsh to the river have extremely high arsenic levels: 4,600 ug/L in the northern slough and 3,100 ug/L in the southern slough. These May 2001 values were a significant increase over the June 1997 slough concentrations of 24 ug/L and 9 ug/L, respectively. In addition, the highest surface water concentration ever recorded outside of the capped region, an arsenic concentration of 13,000 ug/L, was collected in the southeast corner of the fenced area.

Figure 2 shows previous surface water samples taken on the marsh between the years of 1994 and 1997, collected by both STS and WDNR. All sampling of the capped area was performed by STS before the cap was implemented in 1996. Numbers in italic correspond to samples that were filtered in the field. All other samples were unfiltered.

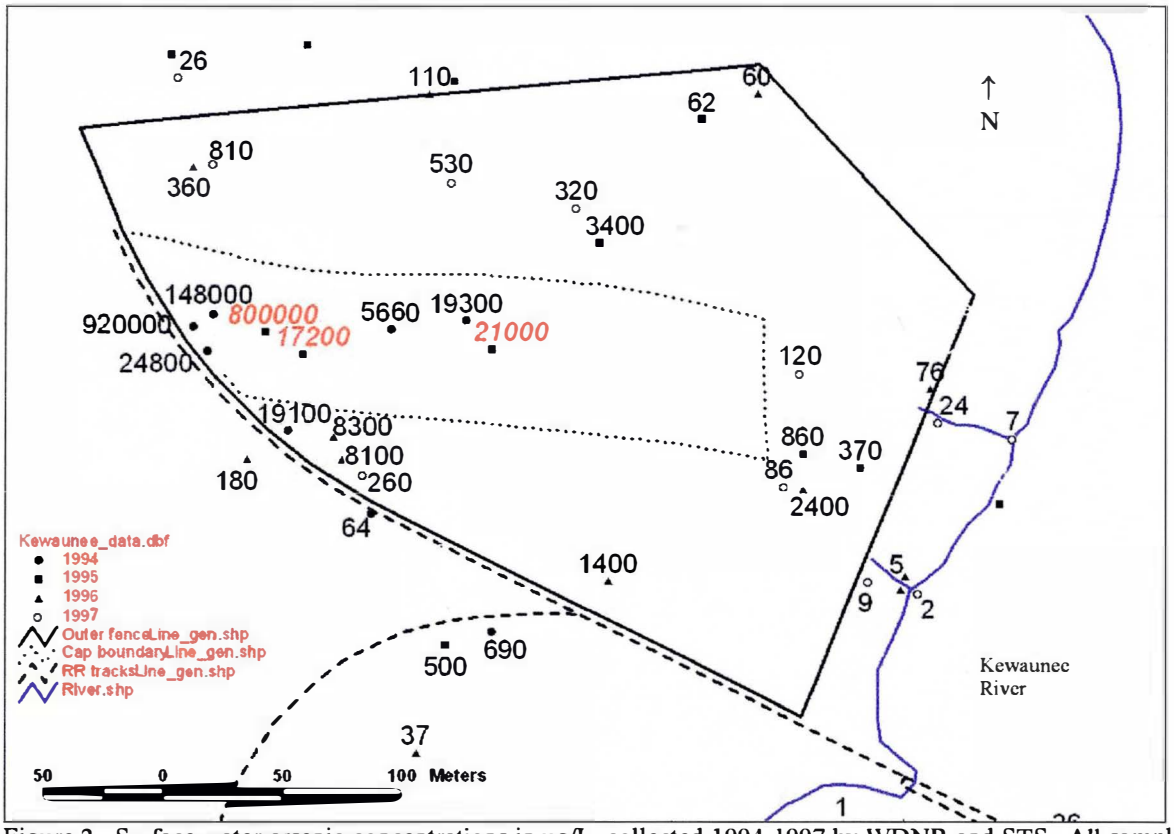


Figure 2. Surface water arsenic concentrations in ug/L, collected 1994-1997 by WDNR and STS. All samples are unfiltered except values in italic, which indicate filtered samples.

The ten shallow groundwater wells installed in May 2001 were sampled on June 5th, 2001. The results of the 2001 groundwater samples are shown in Figure 3.

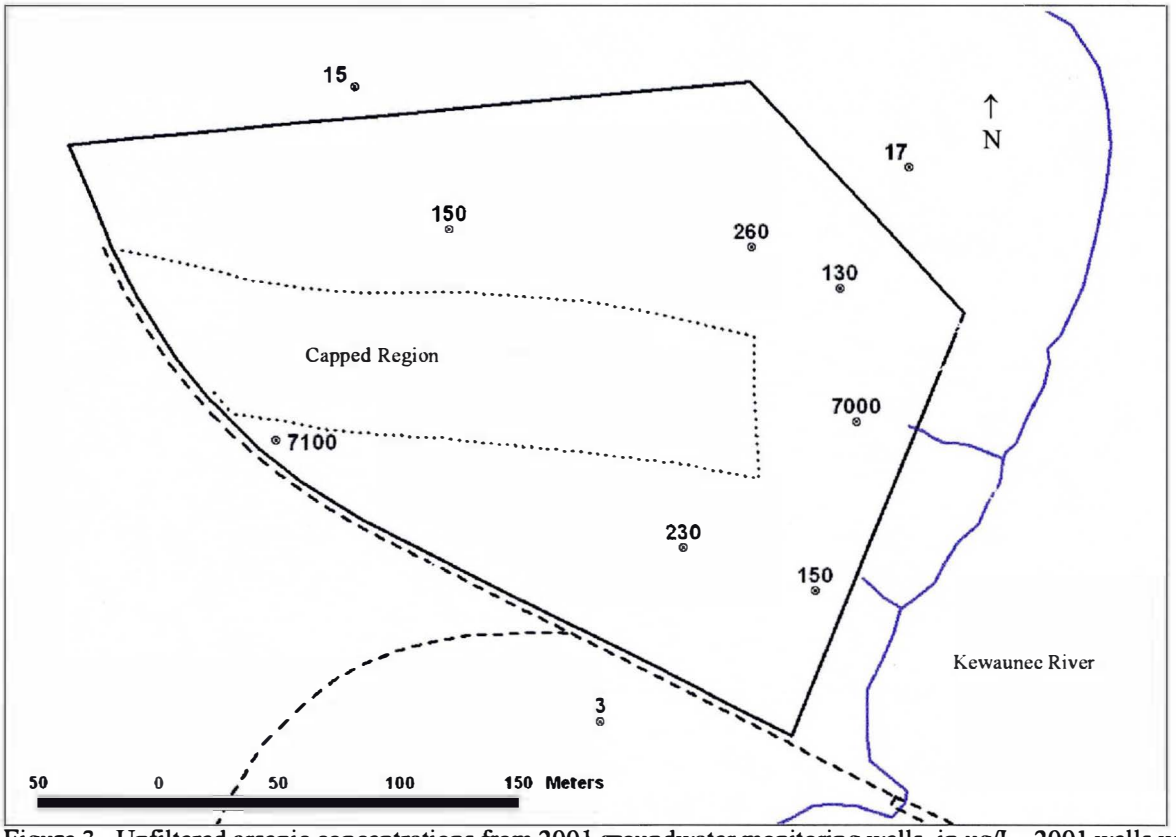


Figure 3. Unfiltered arsenic concentrations from 2001 groundwater monitoring wells, in ug/L. 2001 wells were installed in May and sampled in June, and all samples were unfiltered.

Shallow groundwater arsenic levels ever sampled on the marsh of 7,100 ug/L and 7,000 ug/L came from wells installed in May 2001. One is located just south of the cap, and the other is between the cap and the river, in the path of the north slough. The well (GW01-9) with the arsenic concentration of 7,100 ug/L may be a misleading value. There was very little water in the well at the time of the sampling, and the level was not reflective of surface water levels in the immediate area as was common with the other wells. The sampled water was taken from the bottom of the well, and had a high amount of organic material. If water levels in this well are not responsive at future site visits, the well will be abandoned. The well (GW01-6) with the arsenic concentration of 7,000 ug/L may be influenced by the strong surface water gradient associated with the drainage of the north slough. With the exception of these two extremely high arsenic concentrations, the groundwater wells had lower concentrations than the surface water samples collected in May 2001. The surface water samples had much higher amounts of suspended solids that may have trapped high levels of arsenic.

For the purpose of comparison, Figure 4 shows the previous groundwater concentrations collected from wells installed by STS and WDNR in 1996. Values to the right of the wells are the unfiltered arsenic concentrations, and the italic values to the left of the wells are filtered. Wells with three concentrations listed were sampled by STS over three seasons in 1996: spring, summer, and fall.

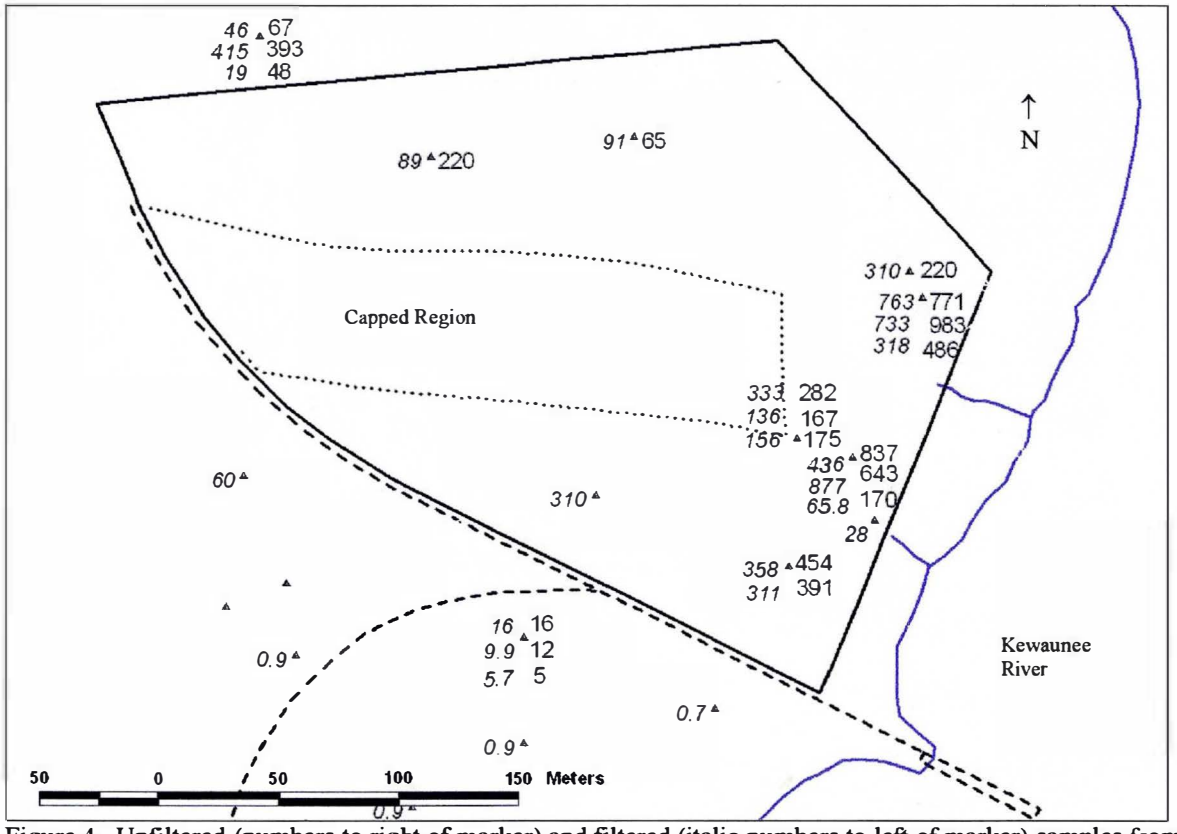


Figure 4. Unfiltered (numbers to right of marker) and filtered (italic numbers to left of marker) samples from monitoring wells performed by STS and WDNR in 1996. Top number indicates sample taken in spring 1996, middle number indicates summer 1996, and bottom number indicates fall 1996.

(Figure 7)

Although filtered samples are typically, but not always, lower than the unfiltered results, they usually within 90% of the unfiltered values.

In addition to the 2001 surface and groundwater sampling, WDNR also collected ten sediment samples from the marsh on June 11th, 2001. Figure 5 shows the previous sediment boring locations and the arsenic concentrations associated with various boring depths. As of the date of this summary, results for the 2001 sediment samples have not yet returned from the lab, but the locations of the 2001 samples are shown on Figure 5 with stars.

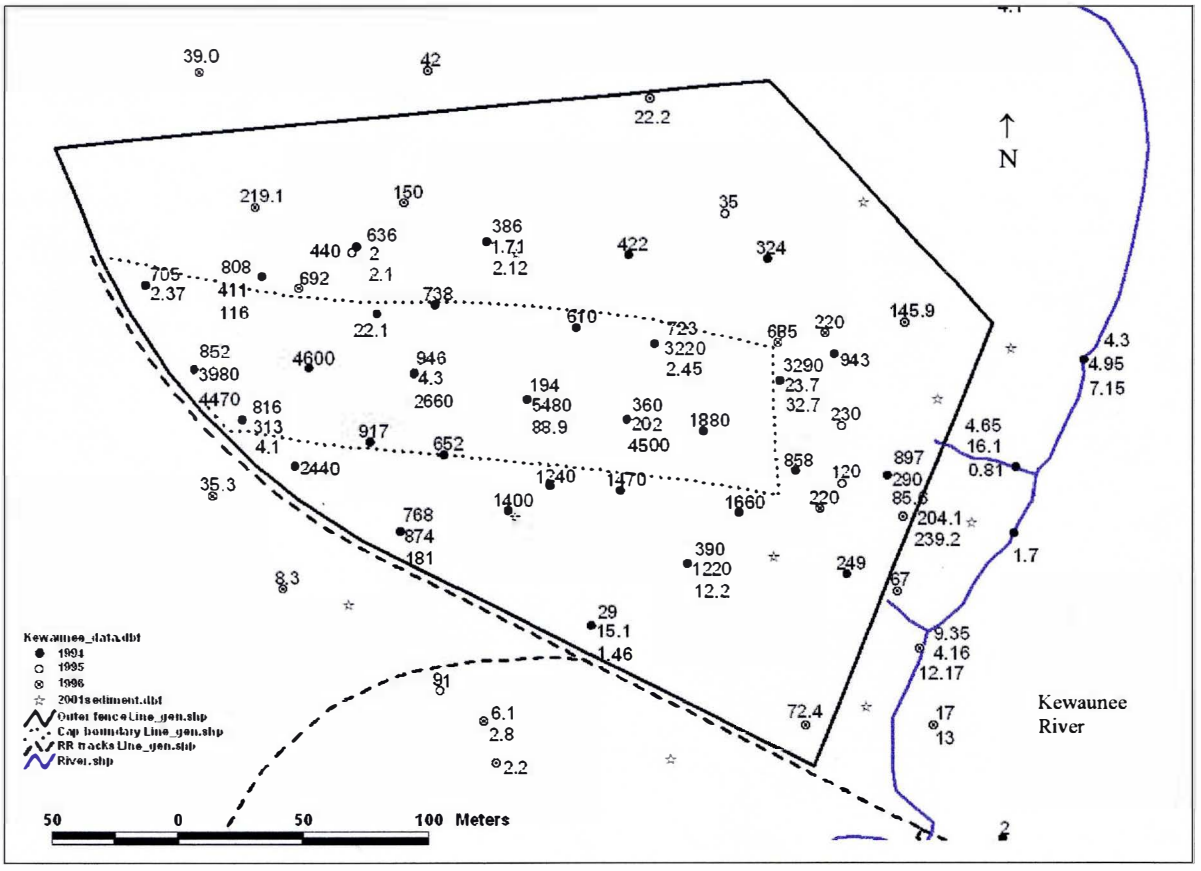
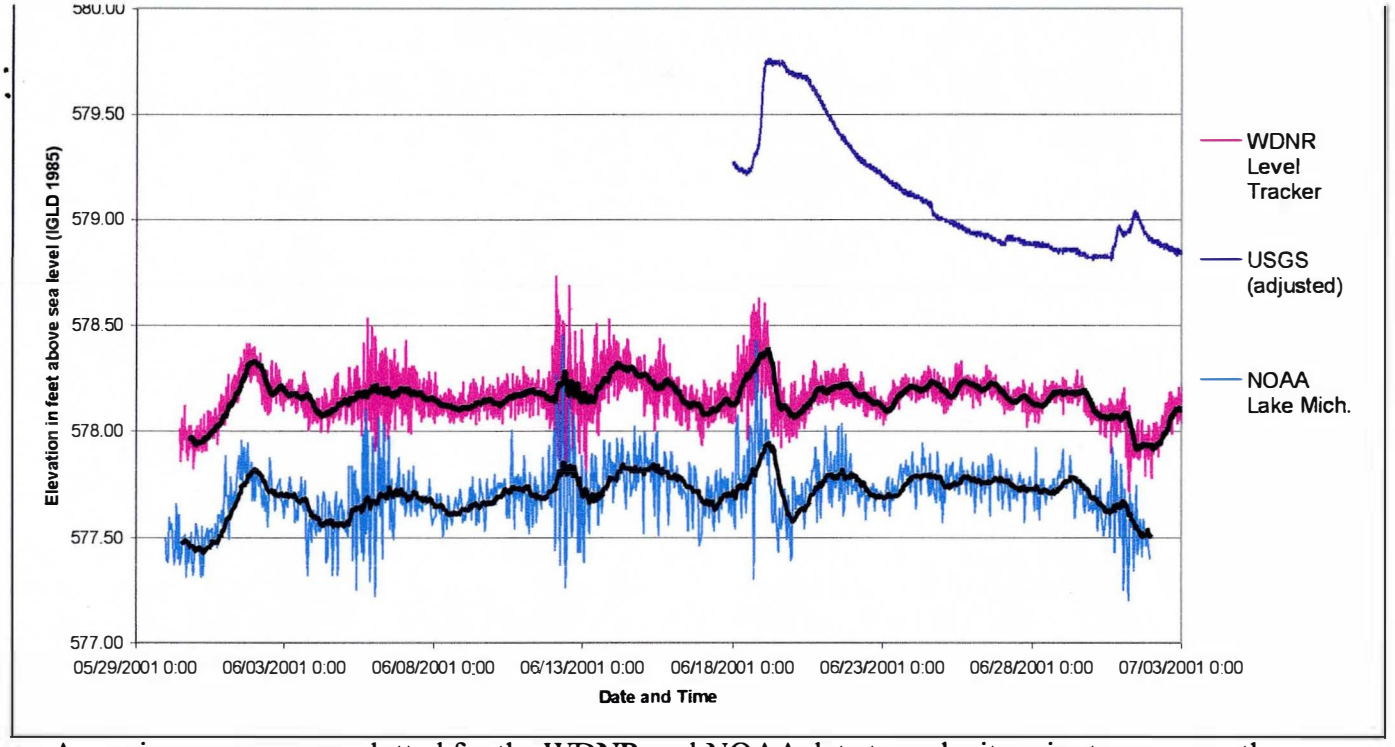


Figure 5. Previous sediment borings taken by STS and WDNR in years 1994-1996. Arsenic concentrations are in mg/kg. Locations of the ten 2001 sediment samples are indicated by stars.

III. Water Level Conditions

Water level conditions in the marsh were monitored during the summer of 2001 to characterize the surface runoff and groundwater flow conditions present in the marsh. Groundwater levels in wells were/are recorded monthly, and water levels in the Kewaunee River are recorded continuously using an automated water level tracker installed by WDNR on May 30, 2001, on the railroad bridge at the Kewaunee River. Additional nearby water level information is obtained from USGS Gage 04085200, located on the Kewaunee River six miles upstream of the site, and NOAA Gage 9087068, located one mile downstream of the site in the Kewaunee Harbor on Lake Michigan.

Information provided by the three gages shows evidence that the water level in the Kewaunee River immediately adjacent to the site is highly influenced by the fluctuating water level of Lake Michigan, and is not significantly influenced by upstream flow conditions. Figure 6 shows a plot of Lake Michigan water levels compared with Kewaunee River levels for the time period of May 30th to July 1st, 2001. The WDNR level tracker data and the USGS Kewaunee River data are plotted at 15-minute intervals while the NOAA Lake Michigan data is plotted at 1-hour intervals.



A moving average was plotted for the WDNR and NOAA data to make it easier to compare the two sets of data. Note that the USGS Gage data has been adjusted by -10 feet in order to emphasize similarities and differences in the water level patterns.

Figure 6. Water level data for WDNR level tracker at railroad bridge on Kewaunee River (middle line) and NOAA Lake Michigan water level data (bottom line) and USGS Gage data (at top). Dark lines represent moving averages, and are plotted to more easily compare data.

It is clear that the Kewaunee River elevation varies directly with fluctuations in Lake Michigan water elevation. In general, elevations at the railroad bridge are about a half-foot higher than elevations at the Kewaunee Harbor. There is no visible relationship, however, between the upstream USGS data and the level tracker data at the bridge. Recent attempts at measuring flow in the river adjacent to the site have likewise shown that the hydrology of the area is better defined by estuary dynamics rather than typical channel flow.
It is also important to note that the elevation of Lake Michigan is historically low this summer (2001). Water elevations in Lake Michigan are an average of three feet lower than the levels of July 1997; the last time any sampling was done on the marsh. The Kewaunee River is, therefore, also three feet lower now than in 1997, and it is reasonable to assume that the water levels in the marsh have changed in response to these lower base levels.

Figures 7 and 8 are water level elevations at the site in summer of 1996 and 2001, respectively. As compared to the 1996 water levels, the 2001 elevation gradient increases dramatically in the eastern one-third of the site (from the east edge of the cap to the river). It is possible that the increased gradient, due in large to the low lake/river levels, has acted to increase the rate of arsenic transport towards the river.

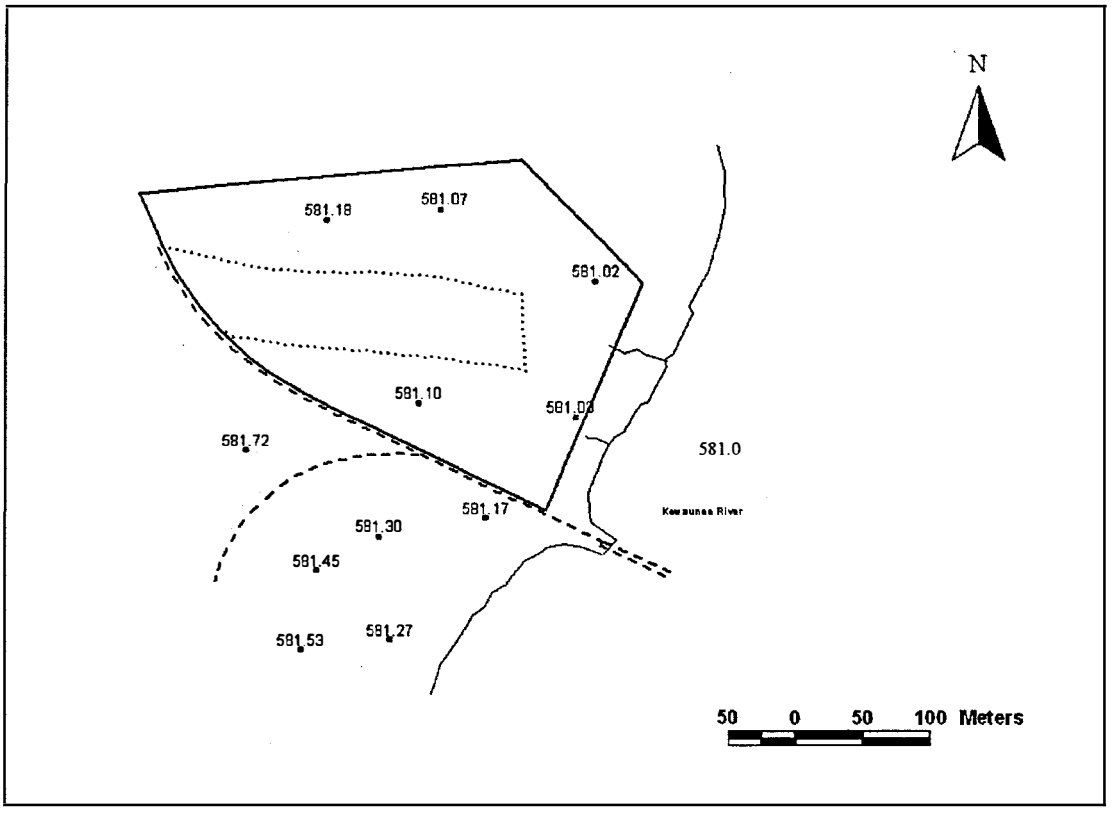


Figure 7. Water Elevations in sampling wells; August 1996.

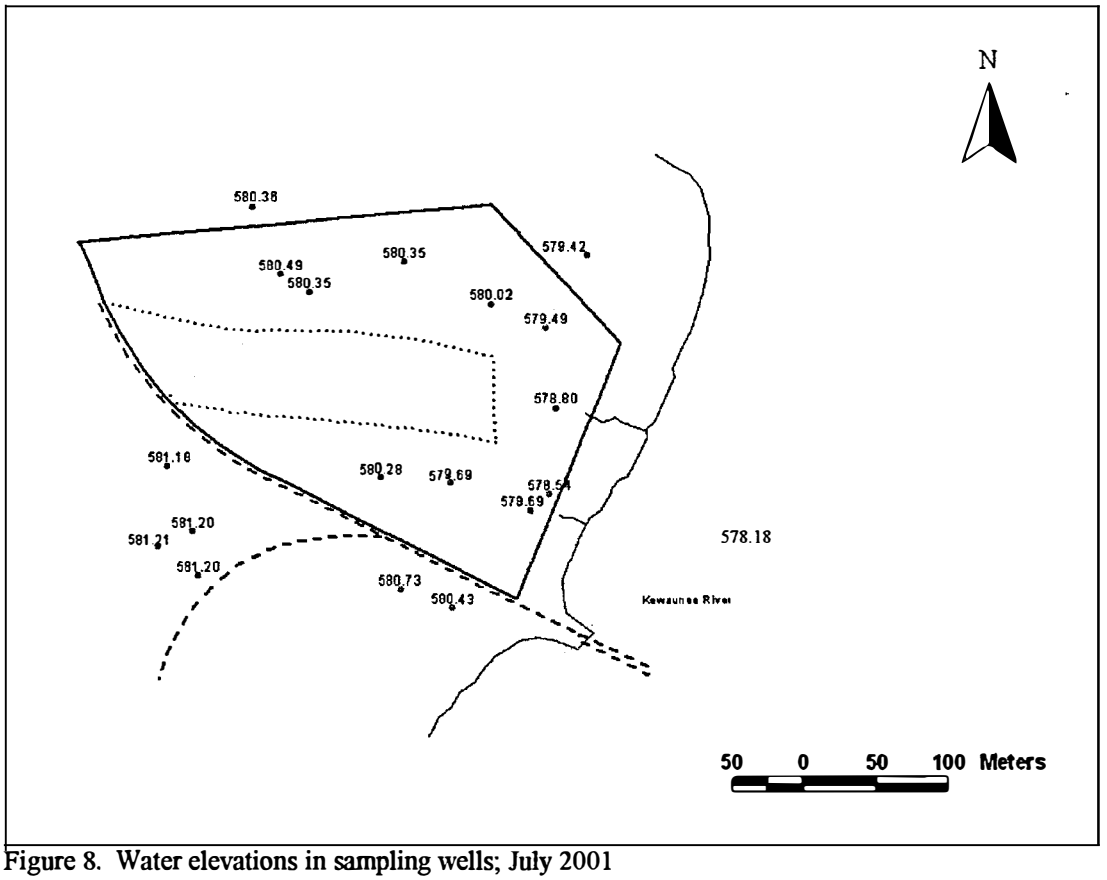


Figure 8. Water elevations in sampling wells; July 2001

IV. Further Study and Objectives of 2001 Monitoring

Further sampling and water level monitoring in the Kewaunee River and marsh adjacent to, upstream, and downstream of the site will help quantify the actual rate of arsenic infiltration to the river.
Questions to answer:

How is the arsenic concentration and movement within the marsh being affected by water level fluctuations in the river?

How can the varying rates of As movement within the marsh and transport from the marsh to the river be best modeled?

How should river flow conditions be modeled to accurately predict arsenic loading to Lake Michigan?