Assessing and Communicating Risk: A Partnership to Evaluate a Superfund Site on Leech Lake Tribal Lands

Groundwater Panel Report

Groundwater Panel

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Groundwater Panel Report

Background:

Groundwater was contaminated by the operation of a wood preserving business located on the Leech Lake Chippewa Tribal Lands in the city of Cass Lake in the Chippewa National Forest. It is bounded on the north by Burlington Northern and Soo Line Railroads, and on the west by Minnesota Highway 371 (Fig. 1). The surface waters drain to Pike Bay and the channel that flows from Pike Bay to Cass Lake. These waters then empty into the headwater area of the Mississippi River. Groundwater flow in the area is generally from west to east.

Beginning in 1957, the St. Regis Company operated a wood preserving business at the site on land leased from the Great Northern Railroad (subsequently becoming part of BN Railroad). The site was later expanded to the south. Creosote use began in 1957, and pentachlorophenol (PCP) in 1960. Both chemicals were in use until the facility closed in 1985. PCP was generally combined with #2 fuel oil, and this mixture tends to float on groundwater. In later years of operation a water-dispersible PCP concentrate (PCP and ketone mixture) was used; this mixture is more dense than water and sinks in groundwater. From 1969 until 1973 a water-soluble copper-chromium-arsenate salt solution was also used for wood treating.

Champion International Corporation assumed responsibility for the site when it acquired and merged with St. Regis Company in January 1985. The wood preserving operation ceased in September of 1985, and in 1986 Champion dismantled facilities on the site.

Champion installed a groundwater containment/extraction system for the contaminants on the site using a series of extraction wells, and subsequent treatment with granular activated charcoal, prior to discharge to Pike Bay/channel. Unfortunately, a plume of contaminated groundwater has migrated generally to the east, off-site. In this area, there appears to be two aquifers separated by till. There are two types of contaminant plumes that have been detected, a sinking dense non-aqueous phase liquid, DNAPL, and a light, floating non-aqueous phase liquid, LNAPL, which move at the bottom and top of the aquifers, respectively.

(The above background is taken from Minnesota Pollution Control Agency 1995, five year review report, St. Regis Company site, Cass Lake, Minnesota.)

The glacial geology of this area is complex. There are areas where there appear to be two aquifers separated by till. In other areas, there is evidence that the confining till layers are absent between the upper and lower aquifers. There are numerous monitoring wells east of the treatment facility site. In recent years, contaminated groundwater has been detected in some of these wells off the site to the east, indicating a possible migration of the original plume away from the extraction system. It is not known how the migration occurred, but this makes a good geologic characterization of the aquifer critical to effective remediation.

Groundwater Panel of Experts:

To assess the availability, quality, and interpretation of the existing groundwater data, the University of Minnesota Sea Grant Program and the Leech Lake Tribal Council convened a national panel of groundwater experts. The panel was made up of the following members:

Dr. Michael E. McDonald, UM Sea Grant, Chair
Dr. Rob Striegl, US Geological Survey
Dr. Howard Mooers, UM Duluth Geology Dept.
Ms. Mary Manydeeds, Bureau of Indian Affairs
Dr. Joseph D'Lugosz, US EPA
Mr. Richard Soule, MN Dept. Health*
Mr. Don Rosenberry, USGS*

* Panel members providing written comments

For a list of all attendees of the Groundwater Panel meeting, see Table 1.

Panel Findings:

The groundwater panel has identified a number of problems based on analysis of data in the consultant's reports. We feel that these problems are due to an inadequate geological assessment (poor conceptual model) of the site and surrounding area. This causes subsequent problems with the computer simulations of groundwater flow and its interpretation. The problems are identified below, but are not necessarily in order of importance.

Geology and Sampling

1. It was noted in reports (Remedial Investigation/Alternatives Report Cass Lake Sites, April 1985, prepared for Champion International by Barr Engineering) that pumping of city well #3 caused fluctuation in deep well 302 but not deep well 306. It was suggested that well 306 was beyond the influence of pumping. The two deep wells are roughly the same distance from the city well, and the extent of a cone of influence in coarse sandy material is large. The suggestion that well 306 is beyond the influence is unfounded. An alternative is that city well #3 and well 302 are in the same unit, and well 306 lies in a different sand and gravel unit that is isolated from the effects of city well #3 (i.e., different aquifers). Thus pumping from the city well

could have changed the groundwater flow direction and pulled contaminants from the site back into the city's well field. This could have subsequently contaminated the city's water supply (see also Panel Finding #6, page 4). However, well #3 was sold to Champion and is currently being used as a monitoring well (MW3). City wells #1 and #2 were abandoned around 1990 when city well #5 was installed. Cass Lake city well #5 is currently non-detect for PAHs, VOCs, and PCP (MPCA personal communication).

2. In the reports (e.g., Remedial Investigation/Alternatives Report, 1985, figures 23, 24, 26, 27) hydraulic heads and contaminant concentrations suggest that groundwater flow is west to east. Such a flow direction explains high contaminant concentrations in wells 118 (very high concentration) and 104. However, the analytic modeling suggests the flow is to the southeast from the treating facility site. That is about a 30^{o} to 45^{o} difference in flow direction as calculated by the model, relative to that determined from actual well head and contaminant data. The model's predicted direction is contradicted by Champion's own extraction well locations, which were apparently based on a hydraulic gradient determined from contaminant concentration and well head data. Also, a southeast flow component does not account for the high contaminant concentrations in wells 118 and 104. Therefore, either the interpretation of the subsurface geology or the model is in error. There are no wells to the south and southeast of the treating facility to verify contaminant levels or the depth to groundwater that might help determine the correct interpretation.

3. The erratic sampling schedule is a cause of concern. Numerous modifications have been made to sampling intervals, protocol, and detection limits without written agreement of all the parties. For example, well 118 was sampled annually through 1991 and PAH levels were rather erratic (Table 2). The well was not sampled again until 1997 and contaminant levels had dropped below detection limits. Although a drop to non-detect may be possible, it seems rather unlikely, especially since detection limits for PCP and PAHs have increased 10-fold and >50-fold, respectively in 1996 and 1997. The absence of sample analyses for several years adds to the skepticism. There are numerous other examples of nonconformity with the mandated sampling protocols. There is also a lack of documentation regarding quality assurance procedures used for the samples.

4. High PCPs at wells 215 and 220 (Table 3) suggest that contaminants may be moving to the east and east-southeast from the treating facility. Well 220 was only installed recently, but data from it suggest that the extraction wells are not containing the contaminants. There are no other wells available in this area to confirm this finding. The southern extent of the contaminant plume from the treating facility site is unknown and needs to be determined.

5. PAHs across the channel at well 219 (Table 2) suggest the potential for flow from west to east under the channel, but the source of the PAHs are unknown. If these PAHs are from the site, the groundwater flow simulation model cannot account for these levels. A possible scenario for this is that in building the railroad grade all the

organic material was removed and replaced with coarse ballast. The grade then would act like a pipeline for movement of groundwater and contaminants. Further investigation of the area around well 219 is required.

6. The Leech Lake Tribal Division of Resource Management (DRM) fish hatchery is located to the west of all identified contaminated sites, although it is near the containment vault. DRM wells pump 300-500 gpm from February through June. Contaminants are detected during the active pumping season, even though the wells are screened in the lower aquifer. This indicates that there is interaction between the deep aquifer and the more shallow aquifer. Well logs from the hatchery and other locations suggest there is not a continuous confining layer between the two aquifers. It is possible that pumping the DRM wells at 300-500 gpm is drawing the contaminants from the east and into the water pumped from the well. It is unknown whether this condition has existed elsewhere, such as city well #3, because of poor geological understanding of the area, including the extent and continuity of the confining till layer.

7. Are there available data for As, Cu, and Cr? We understand that other contaminants have been deemed more useful for determining transport. However, we also believe it is essential to document the fate of chemicals associated with the copper-chromium-arsenate wood preservation operation, especially since they were in a water-soluble solution.

Panel Comments:

After 14 years of study and remediation at this site, its geological and geochemical characterization is still remarkably poor. Without a better, more comprehensive conceptual model of this site, the quality of future decisions may be flawed and unsupportable.

Problems Associated with the Groundwater Modeling Efforts

Assumptions

1. The reports are contradictory when referring to the nature of the confining layer between the surficial aquifer (upper aquifer in contact with the soil and air) and the upper confined aquifer (deeper aquifer, isolated from the surficial aquifer by a "confining layer.") There are numerous references to the "continuous confining layer" but also numerous instances where gaps in the confining till are noted (e.g., the DRM fish hatchery and near the city dump site). It is the nature of melt-out tills to have interspersed discontinuous layers of sands and gravels (interstratified glaciofluvial sediments) within, and contacting, aquifers. The model assumes a continuous confining layer between aquifers, which has been shown to be inaccurate. The three-dimensional complexities of the till deposits in this area are not accounted for in the conceptual or analytic model.

2. In the analytic model the hydrogeologic boundaries for the site are specified heads (or fixed head - the head in a well is fixed at a certain level in the model) at Fox Creek, Pike Bay, and the channel. The specified head at the channel precludes modeled transport of contaminants to the east of the channel. However, well 219 located to the east of the channel has PAHs. The origin of these PAHs remains unknown, but they have been consistently present. The specified head at Fox Creek results in essentially southerly flow from the city dump site to the creek. Yet on some report figures, there is a sense that the plume at the dump site is moving to the east. This suggests that specified (fixed) heads at the boundaries are not good assumptions for the model.

Predictions

3. The model predicts a northwest - southeast flow, approximately 30◦- 45^{o} southward from a due east - west line. This is not supported by well head data in pumping wells prior to extraction. We do not know where the plumes are, particularly to the south of the treating facility. New test wells in this area could add credibility to the model.

4. The current model does not explain contaminants in DRM wells. The fish hatchery's deep wells pump at 300-500 gpm from February - June. This is not accounted for. If the fish hatchery wells can change the flow gradient, did city wells influence the gradient enough to become contaminated prior to their removal from service? We know the influence of pumping at deep monitoring well 302 is substantial and is within the capture zone of the city wells.

Panel Recommendations:

1. There needs to be a better interpretation of existing data and better use of all available data.

2. There needs to be a more complete geologic site characterization. This becomes especially important for understanding and modeling the transport of DNAPLs by gravity flow.

Options

- Possibly use Ground Penetrating Radar (GPR) or seismic investigations to improve geologic site characterization.

- Drill additional test holes for geologic characterization and additional sampling wells (particularly to the south of the treating facility) for better contaminant plume definition. If high concentrations are found in the initial wells, we suggest using an exploratory Geoprobe to determine locations for subsequent permanent wells. Because of the current poor plume definition, the simulated capture zones for the extraction wells are based on inadequate information.

- We recommend screening additional private wells in the area for contaminants.

- The source of contaminants in the DRM fish hatchery's well needs to be determined. The contaminants may be coming from the containment vault, and, if so, then the containment vault is leaking. Alternatives include: 1) the draw down of groundwater during peak pumping may be pulling contaminants in from a greater distance (this has possible implications for the city wells) or 2) the bore hole for the hatchery's well may be improperly sealed.

- Locations for any additional wells (but especially deep wells) need to be agreed upon and approved by all parties.

- There is a need for better hydraulic conductivity values (how fast water moves through the glacial deposits). Also a better understanding of the three dimensional complexity of the glacial deposits is needed in order for modeled predictions to more accurately depict actual field conditions. Stratigraphy could be better understood by geophysical investigations.

3. Based on additional well and geologic information, the conceptual model and, subsequently the analytical model, should be re-evaluated.

   - For the analytical model, at a minimum we suggest a change from specified (fixed) heads at the boundaries to a fluctuating head at the boundaries that is based on flow measurements, especially for Fox Creek. Possibly one specified head at Cass Lake or some other downstream location could be used, and then Fox Creek, Pike Bay, and the channel could be included in the model's calibration. This would allow a more realistic modeling assessment of whether the contaminants could migrate into Fox Creek and the channel, rather than just assuming they will not, and setting a specified (fixed) head at these sites.

   - The complexity of this geological environment is greater than has been realized, and more realistic 3-D modeling is required.

4. The model must be calibrated to agree with existing data on well head and contaminant concentration levels.

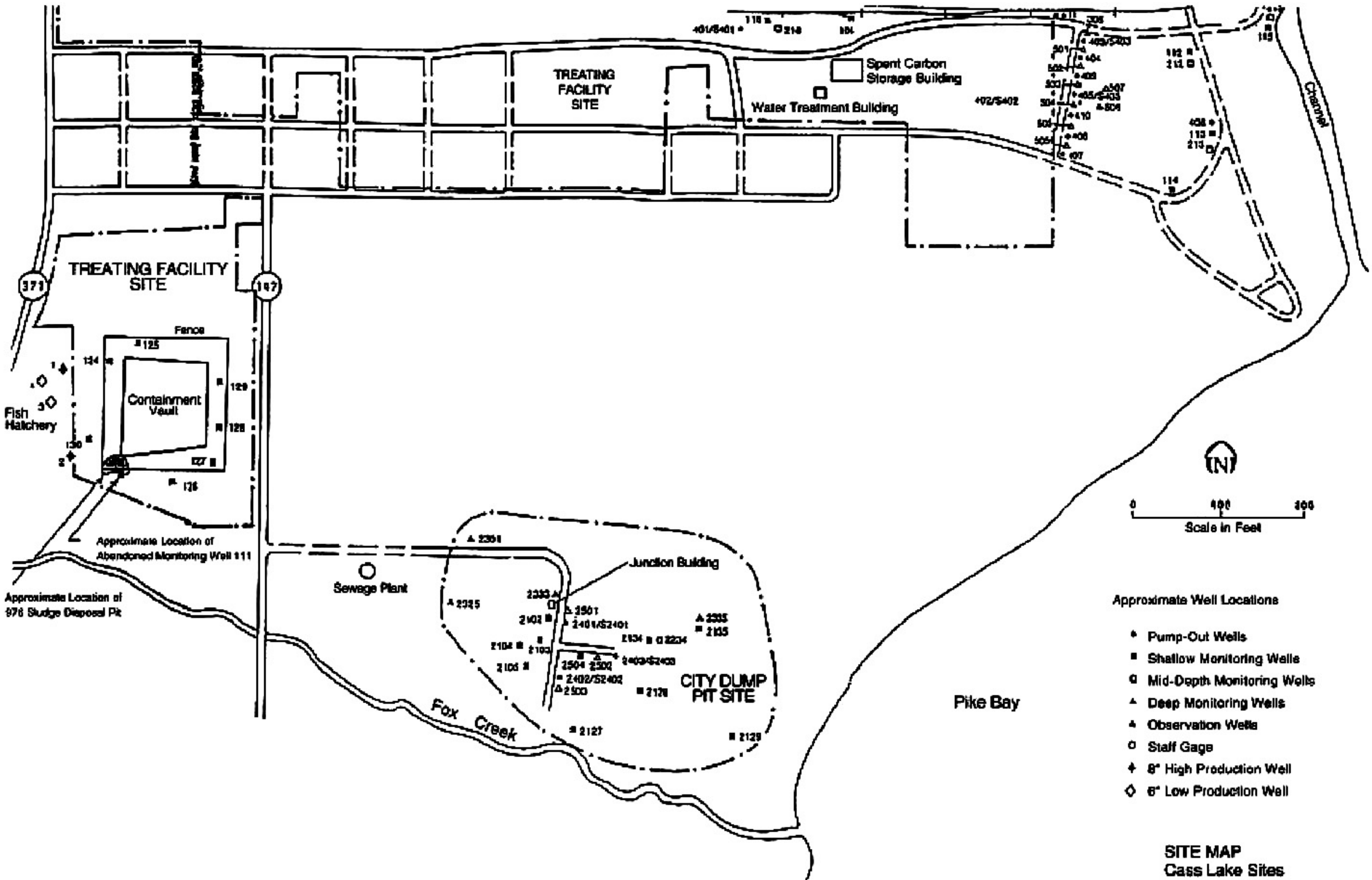
   - The model should then be tested on an independent data set, not used in calibration. Levels of contaminants in new wells could be used as a possible check on the recalibrated model.

5. Finally, all sampling and well drilling activities should follow standardized and technically acceptable protocols for contaminant investigations. All parties, including the Tribe, governmental agencies, and an independent expert as determined by the Tribe should approve these.

- Because there are two types of contaminant plumes (sinking DNAPLs and floating LNAPLs), there is obvious concern about the potential for cross-contamination of wells, especially in the construction of new wells. Extreme care should be taken in drilling new wells and in sampling all wells. We recommend that dedicated sampling equipment be established for each individual well (if this is not currently occurring) to prevent sample cross-contamination.

- All parties must agree upon any changes in the well contaminant sampling scheme. (Well 118 was sampled for PAHs in 1991 and then never sampled again. Values in 1991 were 1500 $\mu g\ l^{-1}$ /45000 $\mu g\ l^{-1}$ for list 1/and list 2 PAHs. Well 118 was sampled for PCP in 1991 (60,000 $\mu g\ l^{-1}$) and again in 1996 (<50$\mu g\ l^{-1}$)).

- All affected parties must agree upon any changes in analytical laboratories or detection limits.



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Map Reference: Barr Engineering, March 1956

FIGURE 1

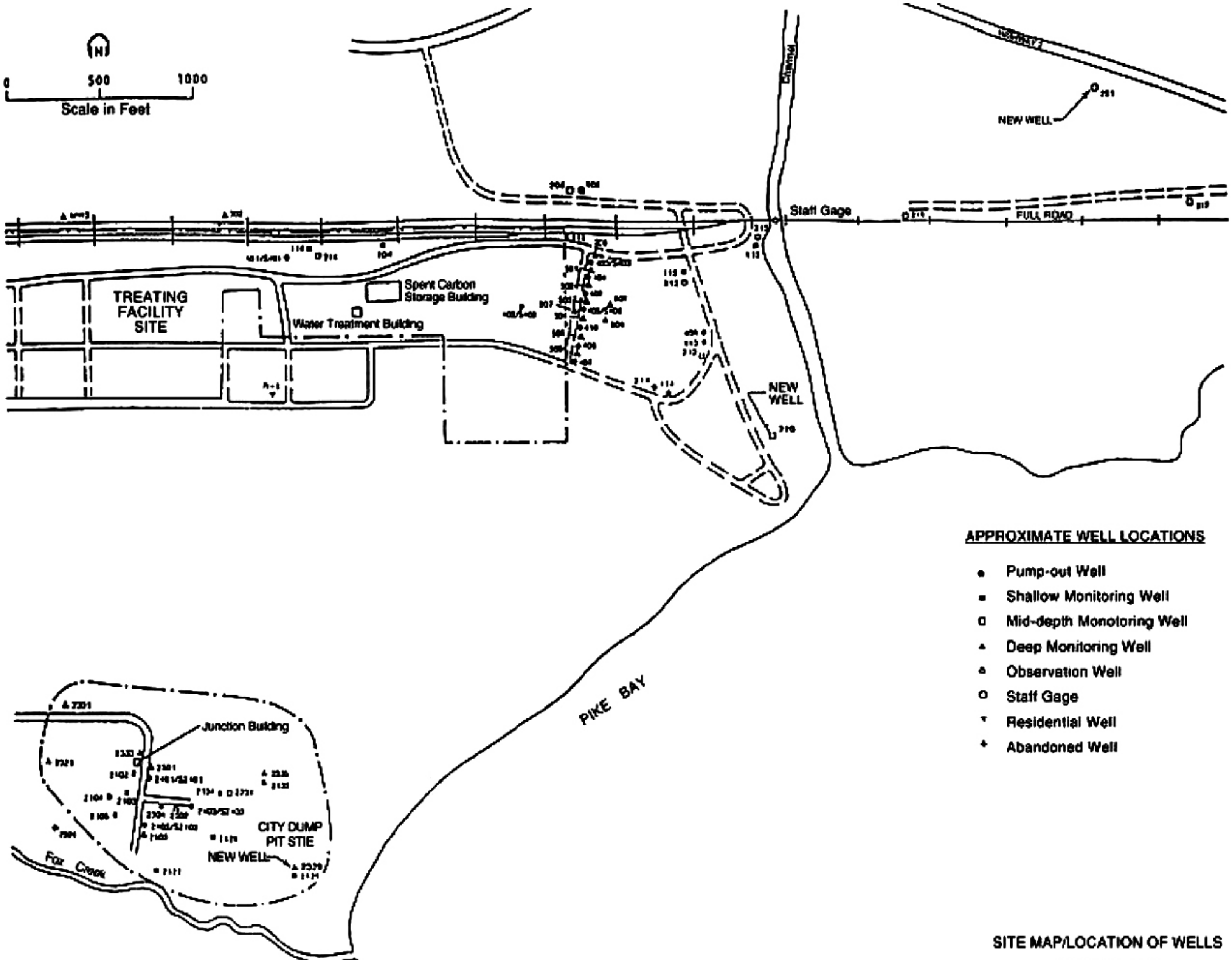

FIGURE 1 (con't)

TABLE 1
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*Panel Members

Table 2

PAH Data
Treating Facility Site
1986-1996 (concentration in µg/L)

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Shallow Surficial Aquifer											
W104	<0.6/24	<6/14	<6/61	<10/<10	<10/53	<10/2	<10/<10	<0.432/15.5	<0.8/19.7	<4/69	--
W112	0.0096/0.20	0.012/0.29	0.0091/0.24	0.03/0.36	0.013/0.24	<0.12/0.25	<0.006/0.17	<0.006/0.107	0.019/0.202	0.010/0.18	--
W113	<0.0043/0.048	6.3/6.6	0.012/0.058	<0.0017/0.01	0.0022/0.017	<0.098/1.9	0.066/0.80	<0.012/0.101	<0.2/<0.35	--	--
W114	<0.0043/0.068	<0.0017/0.063	<0.0017/0.048	<0.0017/0.001	<0.0017/0.011	<0.003/0.031	<0.012/<0.012	<0.006/0.0132	<0.02/0.036	<0.02/0.007	<10/<1 0
W115	<0.0017/0.0091	0.0086/0.05	0.0025/0.034	<0.0017/0.017	<0.0017/0.033	<0.003/0.0030	<0.006/0.037	<<0.006/0.0205	<0.02/0.009	<0.02/0.003	<10/<1 0
W118	--	<1,200/29,000	<600/51,000	360/5,900	470/5,300	1500/45,000	--	--	--	--	--
Base of Surficial Aquifer											
W212	47/1,500	<120/740	<6/920	<20/380	<10/150	<100/28	<150/<150	<10/42	<10/46a	<750/750	<10/27
W213	1,700/2,600	1,000/4,600	160/2,100	700/2,000	19/1,100	<40/1,100	<10/330	<10/250	<20/240a	<10/150a	<10/90
W215	<0.0017/0.020	<6/59	<6/63	<10/20	<10/66	<100/22	<75/16	<10/29	<10/46a	<500/<500	<10/29
W217	<0.0043/0.13	0.0018/0.052	<0.0017/0.026	<0.0017/0.013	<0.0017/0.0047	<0.003/0.0037	0.0038/0.042	<0.006/0.00305	<0.04/0.025	<0.02/<0.035	--
W218	--	0.26/11	<0.0017/8.3	<<0.068/13	<0.24/17	<0.006/3.4	<0.048/0.39	0.0215/0.858	<0.4/0.355	<0.08/0.37	--
W219	<0.034/1.2	<6/8.6	<6/9.7	<0.068/18	<10/16	<10/8	<10/8	<0.192/6.21	<2.4/8.27	<3.0/7.0	--
W220	--	--	--	--	--	--	--	--	<20/527	<200/250a	<10/12 0
W221	--	--	--	--	--	--	--	--	<0.4/0.008	<0.02/<0.035	--
Lower Aquifer											
W302	0.0019/0.026	0.0053/0.11	0.13/0.21	0.0022/0.091	0.013/0.070	0.016/0.059	.0032/0.24	<0.006/0.0170	<0.08/0.883	<0.02/0.059	--
W308	<0.0017/0.0035	0.0044/0.13	0.010/0.050	<0.0017/0.011	<0.0017/0.0064	<0.003/0.34	<0.012/0.016	<0.006/<0.006	0.023/0.022	<0.02/0.018	<10/<1 0
MW3	<0.0017/0.005	0.0036/0.073	<0.0017/0.018	<0.0017/0.017	0.0022/0.050	<0.003/0.012	<0.006/0.050	<0.003/0.0092	0.010/0.014	<0.02/0.048	--

List l/List 2 PAH compounds.
If <, all compounds in list were below that detection limit.
If value, it is the sum of detected values.
* LNAPL present in this well.
a = Estimated value, calculated using some or all values that are estimates.

Table 7 from *Annual Monitoring Report January 1996 through December 1996 Groundwater and Surface Water Monitoring St. Regis Paper Company Site Cass Lake, Minnesota*
Prepared for Champion International by
Barr Engineering, Minneapolis, MN

2311005\47946-1/YMH

Table 3

Pentachlorophenol Data
Treating Facility Operable Unit
1986-1996
(concentration in µg/L)

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Shallow Surficial Aquifer											
W104	670	1,000	990	330	820	200	84	250	110	590	—
W112	<6	<6	<6	<6	<6	<6	<6	<6	<3	<3	—
W113	<5	100	<6	<6	<6	<6	<6	<6	<3	—	—
W114	<5	<6	<6	<6	<6	<6	<6	<6	<3	<3	—
W115	<6	<6	<6	<6	<6	<6	<6	<6	<3	<3	<50
W118	—	150,000	49,000	46,000	54,000	60,000	—	—	—	—	<50
Base of Surficial Aquifer											
W212	8,900	4,000	3,800	3,500	5,100	2,200	2,200	2,900	3,900	2,300	1,300
W213	20,000	12,000	4,800	13,000	5,800	830	300	<10	<20	<10	<50
W215	<6	27,000	4,400	2,700	4,200	2,800	1,900	2,200	3,400	1,600	1,100
W217	<6	<6	<6	<6	<6	<6	<6	<6	<3	3	—
W218	—	3,000	860	78	570	170	14	26	13	26	—
W219	<6	<6	<6	16	<10	<10	<10	<6	<3	<3	—
W220	—	—	—	—	—	—	—	—	1,000	570	180
W221	—	—	—	—	—	—	—	—	<3	<3	—
Lower Aquifer											
W302	<6	<6	<6	<6	<6	<6	<6	<6	<3	<3	—
W308	<6	<6	<6	<6	<6	<6	<6	<6	<3	<3	<50
MW3	<5	<6	<6	<6	<6	<6	<6	<6	<3	<3	—

— Not analyzed.

Table 8 from *Annual Monitoring Report*
January 1996 through December 1996
Groundwater and Surface Water Monitoring
St. Regis Paper Company Site
Cass Lake, Minnesota
Prepared for Champion International by
Barr Engineering, Minneapolis, MN

Table 3 cont.

Pentachlorophenol Data
Extraction Wells
1987-1996
(concentration in μg/L)

Extraction Wells	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
401	3,000	2,000	56	1,500	3,900	1,500	970	2,000	890	—
402	1,600	1,300	1,200	700	1,600	1,100	810	2,200	1,200	—
403	9,300	2,200	1,500	790	1,200	560	300	320	190	—
404	17,000	6,300	9,900	—	—	—	—	—	—	—
405	8,000	4,500	7,000	5,500	1,500	840	6,400	6,500	5,300	—
406	<6	12	<5	—	<10	—	—	<5	<5	—
407	<6	<5	—	—	—	—	—	<5	<5	—
408	9,900	5,000	5,600	4,800	9,100	3,800	4,400	3,100	1,300	2,000
409	21,000	18,000	8,900	5,800	11,000	5,400	4,800	3,700	2,100	—
410	<6	280	130	39	<10	<5	<5	8	14	—
2401	—	16,000	—	—	—	—	3,100	3,800	1,800	—
2402	—	17,000	2,500	700	820	580	450	280	220	—
2403	—	6,900	4,500	2,600	3,800	3,400	2,800	1,900	1,600	—

— Not analyzed.

Table 21 from *Annual Monitoring Report*
January 1996 through December 1996
Groundwater and Surface Water Monitoring
St. Regis Paper Company Site
Cass Lake, Minnesota
Prepared for Champion International by
Barr Engineering, Minneapolis, MN