Donohue

Additional Site Investigations and Remedial Action Recommendations

STA-RITE Industries
Water Equipment Division
Delavan Wisconsin

June 1984

Engineers & Architects

Donohue

July 2, 1984

Sta-Rite Industries, Inc.
293 South Wright Street
Delavan, WI 53115

Attn: Mr. Dick LaChapell
       Plant Manager

Re: Transmittal of Report Entitled
     "Additional Site Investigations and
       Remedial Action Recommendations"
     Donohue Project No. 12894.006

Dear Mr. LaChapell:

Attached is our report on additional site investigations and our remedial action recommendations related to groundwater contamination by chlorinated solvents at Plant 1 and Plant 2. During this investigation an extraction well was installed to intercept contaminates from the vicinity of the sump at Plant 2. We recommend the addition of another five extraction wells to intercept the plume from Plant 1.

If you have any questions concerning our investigations or remedial action recommendations, please contact us.

Very truly yours,

DONOHUE & ASSOCIATES, INC.

Michael L. Crosser
Project Manager

MLC/dlj

Attach: Report

cc: Allen Williams, Foley & Lardner, w/attach

Donohue & Associates, Inc.
4738 North 40th Street
Sheboygan, Wisconsin 53081
Engineers & Architects
414·458·8711

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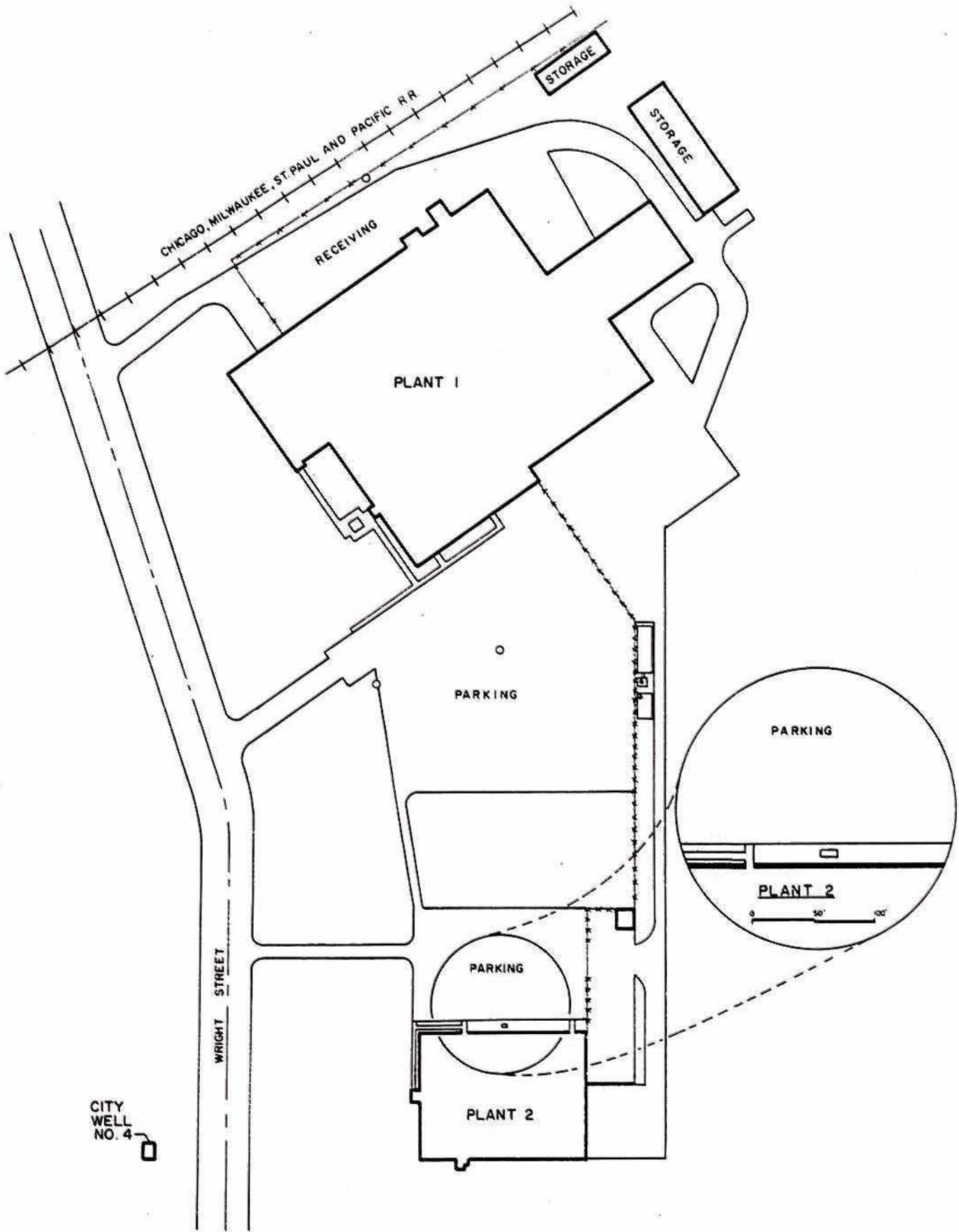# LIST OF TABLES

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CHAPTER 1

INTRODUCTION AND BACKGROUND

Since late 1982, investigations of chlorinated solvent contamination detected in City Well No. 4 in Delavan, Wisconsin have been underway. The Wisconsin Department of Natural Resources (DNR) suspected that the Sta-Rite Industries Water Equipment Division facilities, located approximately 1,000 feet east of City Well No. 4, was the source of the solvent contamination. A site plan showing Sta-Rite facilities and City Well No. 4 is shown on Figure 1. The City retained Warzyn Engineering, Inc., to investigate. With the cooperation of Sta-Rite Industries, Warzyn Engineering obtained soil and groundwater samples on Sta-Rite property. The samples were obtained in areas of potential contamination as identified by Sta-Rite and in areas between the potentially contaminated areas and City Well No. 4. Warzyn issued a preliminary report of their findings on February 16, 1983, which indicated solvent-contaminated water at the groundwater table surface near the southeast wall of Plant 1 and soil and near surface water contamination near the holding tank outside the north wall of Plant 2 (Warzyn, 1983). Wells near the Sta-Rite property line showed little or no contamination.

In January 1983, Sta-Rite retained Donohue to conduct further investigations. Donohue placed additional groundwater monitoring wells to obtain data covering greater areal and vertical distances and conducted a pump test to determine aquifer characteristics. The goals of the work were to determine whether the identified areas of contamination near Plants 1 and 2 could contribute to contamination of City Well No. 4 and to provide data for selecting remedial action if required. No definitive data collected during the investigation indicated a direct path of migration from the contaminated areas on Sta-Rite property to City Well No. 4. However, there was indication that solvents in the groundwater in the vicinity of Plant 1 were moving off-site to the northwest, the direction of groundwater flow. The data and results were reported in May, 1983 (Donohue & Associates, Inc., May 1983). Following evaluation of the results reported in May, 1983, Sta-Rite authorized additional investigations to determine groundwater and contaminant movement in the area and authorized the removal of the sump tank and contaminated soils near Plant 2. The remedial actions were completed in December, 1983. The report discussing the remedial actions was issued in January, 1984 (Donohue & Associates, Inc., January, 1984).

Concurrent with the implementation of the Plant 2 remedial actions and with the assistance of Thomas A. Prickett, Donohue modeled the groundwater flow system. The results of the groundwater modeling were discussed in a report issued in December, 1983 (Donohue & Associates, Inc., December, 1983). The results of the groundwater modeling program indicated that contamination in the vicinity of the sump at Plant 2 could impact the water quality of City Well No. 4, if City Well No. 4 is pumped at high rates. Furthermore, the modeling indicated that following the remedial actions at the Plant 2 sump, to the extent that the contamination is caused by sources on Sta-Rite property, the water quality at City Well No. 4 should gradually improve as the contaminant plume moves off to the northwest. Based on the results of the modeling program, the City of Delavan elected to shut down City Well No. 4

STORAGE

STORAGE

CHICAGO, MILWAUKEE, ST. PAUL AND PACIFIC R.R.

RECEIVING

PLANT 1

PARKING

PARKING

PLANT 2

WRIGHT STREET

CITY
WELL
NO. 4

PARKING

PLANT 2

0   50'   100'

Donohue

JUNE 1984

12894.000

Engineers & Architects

SITE PLAN

STA-RITE INDUSTRIES, INC. WATER EQUIPMENT DIVISION

DELAVAN, WISCONSIN

N

0   100'   200'
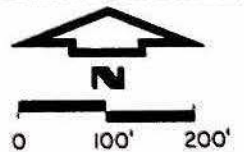
FIGURE 1

for several years to allow validation of the model. If the model is accurate, the groundwater system will clear and City Well No. 4 can be used without water treatment.

On March 9, 1984, the DNR sent a letter to Sta-Rite requesting that additional remedial action be conducted at the Plant 2 sump and that additional investigations be conducted on Sta-Rite property to determine the source of the contaminant plume that appears to be moving to the northwest from the Sta-Rite property. At that meeting, Sta-Rite agreed to conduct further site investigations and report the results by June 30, 1984. Sta-Rite also agreed to submit a report by April 30, 1984, addressing the following items:

1. Transmittal of boring and well logs and data.

2. Additional information concerning the direction of flow of the contaminant plume.

3. A proposal for additional remedial action at the Plant 2 sump.

4. A discussion of the appropriateness of further investigations under Plant 1.

The April 30, 1984, report discussed the feasibility of soil sampling beneath Plant 1 (Donohue & Associates, Inc., April, 1984). We concluded that a direct evaluation would be costly and would disrupt production operations. We outlined an alternative program to compare the relative contribution of sources outside Plant 1 with those beneath the building. We have completed this investigation and present the results in this report. We also discuss the implementation of additional remedial action at the Plant 2 sump and our evaluation of a boundary extraction system well to intercept solvents moving off-site in the groundwater.

CHAPTER 2

ADDITIONAL REMEDIAL ACTIONS AT PLANT 2

As discussed in our April 1984, report, additional excavation of contaminated soils in the vicinity of one Plant 2 sump is not practical because the excavation will put the foundation for Plant 2 in jeopardy unless costly reinforcing measures are taken. Furthermore, additional excavation of the soils will do nothing to remove the contamination already in the groundwater. As an alternative to excavation, Sta-Rite has installed a flushing system to extract the solvents from the soil. The contaminated groundwater will be removed using an extraction well. A portion of the water will be discharged to the storm sewer and a portion will be used for flushing water.

ESTIMATE OF EXTRACTION TIME AND EFFICIENCY

If the partition coefficient of a solute is known, the distribution of the solute in two solvent phases can be predicted and the number of extractions required to quantitatively remove the solute from one phase can be calculated (Berg, 1963). The fraction of solute remaining after n sequential liquid-liquid extractions is given by Equation 1:

$$(1) \qquad \frac{W_n}{W} = \left(\frac{V_w}{K_p V_o + V_w} \right)^n$$

Where:

V_w = Volume of raffinate (liquid from which chemical is extracted)

V_o = Volume of extractant (liquid used to extract chemical)

K_p = Partition coefficient

n = Number of extractions

W_n = Amount of solute remaining after n extractions

W = Total amount of solute

This equation can be modified to describe the extraction of chemicals from soil by water. The modification requires that the partition coefficient be expressed as the concentration of chemical in the water phase (mg/kg water) divided by the concentration in the soil (mg/kg soil).

For tetrachloroethylene, the partition coefficient is:

$$K_p = \frac{0.56 \text{ mg/l water}}{\text{mg/kg soil}} = \frac{0.56 \text{ mg/kg water}}{\text{mg/kg soil}}$$

which expresses the distribution between the water phase and soil phase for "natural aquifer" material (Schwarzenbach and Westfall, 1981).

For the Plant 2 sump area, Equation 1 can be modified as shown by Equation 2:

(2)   Fraction Solvent Remaining $= \dfrac{W_n}{W} = \left(\dfrac{W_s}{K_p V_o + W_s}\right)^n$

Where:

K_p = Partition coefficient (0.56)

W_s = Weight of soil (grams)

V_o = Weight of water (grams)

n = Number of extractions

For our approximation, n = number of pore volumes of water passing through the soil. Therefore, for a contaminated area with dimensions of 10 feet by 10 feet by 30 feet and for soil having a density of 100 pounds per cubic foot, and a pore volume of 25 percent, one pore volume of extractant will result in the fraction remaining given by,

$W_s = 3{,}000 \text{ ft}^3 \times 100 \text{ lb/ft}^3 \times \dfrac{454 \text{ g}}{\text{lb}} = 1.36 \times 10^8 \text{ grams}$

$V_o = 3{,}000 \text{ ft}^3 \times \dfrac{0.25 \text{ ft}^3 \text{ water}}{\text{ft}^3 \text{ soil}} \times \dfrac{7.48 \text{ gal}}{\text{ft}^3} \times \dfrac{3{,}780 \text{ g}}{\text{gal}}$

$= 2.12 \times 10^7 \text{ grams water}$

$\dfrac{W_n}{W} = \dfrac{1.36 \times 10^8}{0.56 \times 2.12 \times 10^7 + 1.36 \times 10^8} = \dfrac{1.36}{0.118 + 1.36} = 0.92$

The concentration of solvent remaining in the soil expressed as a function of the number of pore volumes extracted is shown in Table 1.

If we assume the conservative case in which we need 200 pore volumes to flush the soil, the total volume of flushing water required is:

$200 \text{ pore volumes} \times \dfrac{5{,}610 \text{ gal}}{\text{pore volume}} = 1{,}122{,}000 \text{ gal (total extract)}$

The time required to flush the soil system is given as a function of flushing rate in Table 2.

TABLE 1

CONCENTRATION OF SOLVENT REMAINING IN SOIL
AS A FUNCTION OF NUMBER OF PORE VOLUMES
OF WATER EXTRACTED

Number of Pore Volume Extractions	Initial Soil Concentration (µg/kg)	Percent Remaining in Soil	Concentration Remaining in Soil (µg/kg)
0	980,000	100	980,000
1	980,000	92	901,600
10	980,000	43	421,400
50	980,000	1.5	14,700
100	980,000	0.02	196
150	980,000	0.00036	4

TABLE 2

TIME REQUIRED TO FLUSH SOIL SYSTEM
AS A FUNCTION OF FLUSHING RATE

Flushing Rate		Pore Volumes Per Day	Days to Achieve Quantitative Removal
(gpm)	(gpd)		
5	7,200	1.28	160
10	14,400	2.56	80
15	21,600	3.85	52
20	28,800	5.13	39
25	36,000	6.41	31
30	43,200	7.70	26
35	50,400	8.98	22

The flushing rate depends on soil hydraulic conductivity and the system hydraulic gradient. Based on a vertical hydraulic conductivity of 200 gpd/ft^2 and a gradient of 1 foot/foot, we predicted we can flush at 15 to 30 gpm. Preliminary running of the flushing system indicated a flow rate less than 5 gpm. This lower rate indicates that a silty sand may be present and that saturation (mounding) has occurred in the area reducing the amount of water which can be added to the system. At this flushing rate, 160 days will be required to purge the system.

The calculation of flushing efficiency and rate depends on the following assumptions:

1. Extraction efficiency for soil/water is the same as for liquid-liquid system.

2. Equilibrium is rapid.

3. Sequential batch kinetics is the same as continuous column kinetics.

4. Partition coefficients are similar for other chlorinated organics.

To check the validity of our calculations, we conducted laboratory extractions of soil removed from the sump area in December 1983. We used the following procedure:

1. Weigh 500 grams of soil into a 1-quart extraction jar.

2. Add 500 ml of tap water at 50°F.

3. Shake the mixture for one minute.

4. Allow the mixture to settle for five minutes.

5. Decant the supernate and analyze it for trichloroethylene and 1,1,1-trichloroethane.

6. Repeat Steps 2 through 5 for 15 extractions.

Under this procedure, one extraction volume (500 ml) equals approximately 6.4 soil pore volumes. The concentration of trichloroethylene in the extraction water as a function of the number of the volumes extracted is shown on Figure 2. After 96 pore volumes have been extracted, the concentration of trichloroethylene decreased from the initial value of 57 mg/l to less than 1 mg/l. The rate of extraction is slightly less than predicted by the calculations; however, the rate is rapid enough to validate our assumption that quantitative removal will be achieved after 200 pore volumes are extracted.

DESCRIPTION OF EXTRACTION AND FLUSHING SYSTEM

An 8-inch well with a 20-foot screen intercepting the groundwater table surface was installed in the vicinity of Donohue monitoring well Nos. 18 and 19. The location is shown on Figure 3. Water is pumped from this well to intercept contaminants coming from the vicinity of the Plant 2 sump. Water is

LOG CONCENTRATION OF TRICHLOROETHYLENE MICROGRAMS / L

NUMBER OF PORE VOLUMES	LOG OF CONCENTRATION
6.4	4.76
25.6	4.78
38.4	4.07
64.0	3.60
96.0	2.95

5
4
3
2
1

10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200

CONCENTRATION AT 200 PORE VOLUMES = 7.9 MICROGRAMS / L

NUMBER OF PORE VOLUMES EXTRACTED

RESULTS OF EXTRACTION OF PLANT 2 SUMP SOIL WITH WATER

STA-RITE INDUSTRIES, INC. WATER EQUIPMENT DIVISION
DELAVAN, WISCONSIN

FIGURE 2

CHICAGO, MILWAUKEE, ST. PAUL AND PACIFIC R.R.

STORAGE

STORAGE

RECEIVING

• D-23

• D-24

D-6
D-5

PLANT 1

• B-11

• D-12

• B-13

D-14

TB-5

D-25
D-26
D-27

TW-4 • TB-4

TB-7

TB-8

TB-9

PARKING

PARKING

B-16 • • B-17
• D-15

TB-2

TB-1 • • TB-3

PLANT 2

0   10'   100'

TW-2A
TW-2

WRIGHT STREET

D-19 • D-18

D-4
D-3

EX.1

PARKING

TW-3

D-5

TW-1A

TW-1

PLANT 2

CITY
WELL
NO. 4

D-10 • D-9

LEGEND

D   DONOHUE WELL
B   DONOHUE BORING
TW   WARZYN WELL
TB   WARZYN BORING
EX. DONOHUE EXTRACTION WELL

pumped from this well to the vicinity of the sump where it is sprayed on the ground directly above and in the immediate vicinity of the Plant 2 sump. The sprayed water is contained in an area of approximately 120 square feet by a berm. The effectiveness of the flushing system will be monitored by measuring the concentration of solvents in existing monitoring wells in the vicinity.

CHAPTER 3

ADDITIONAL SITE INVESTIGATIONS

Based on information collected from site investigations and interviews of plant employees, we could not exclude the possibility that there are pockets of contamination in the soils under Plant 1. Plant 1 was constructed in phases over a period of years, with the last major expansion completed in 1974. There is a possibility that disposal of chlorinated solvents occurred somewhere under the 1974 addition prior to its construction. We also had information that soils in an area east of the existing chip storage area could be contaminated. Without further investigation, the groundwater contamination observed beneath Plant 1 and downgradient from Plant 1 could be explained by either of these potential sources.

Two general approaches were available for determining the importance of any contamination of soils under Plant 1. The first approach is direct and involves obtaining samples of soils beneath the building addition and analyzing the samples for the volatile chlorinated organics. This approach would require extensive concrete boring and soil sampling and would be disruptive to plant production. If the extent of contamination could be found, remedial action at the source would be significant. The actions would include relocation of production equipment, cutting concrete, concrete demolition and removal, soil excavation of a portion of the contaminated soils, backfilling, installation of a system of drains for flushing the remainder of the contaminated soils, and replacement of the concrete floor. Direct investigation and remedial action beneath Plant 1 would be a significant economic burden to Sta-Rite. The area of interest contains the motor assembly room which has a controlled environment to eliminate dust contamination. This production operation cannot be moved elsewhere on-site or transferred to other production facilities without substantial facilities renovation and interruption of production. The plant would have to stop production, resulting in hundreds of thousands of dollars in lost sales and potential loss of market share. A temporary plant closing would affect not only company performance, but also employment in the community. Furthermore, even with substantial additional investigation, the location of the sources might not be found precisely.

To minimize the adverse economic impacts, we evaluated the potential contamination under Plant 1 by an indirect method which consisted of a direct evaluation of the extent of contamination east and south of the chip storage area and additional groundwater monitoring wells to the north and west of Plant 1. In this chapter, we discuss the procedures in these additional site investigations and our conclusions.

EVALUATION OF SOILS IN THE VICINITY OF THE CASTING AND CHIP STORAGE AREA

We analyzed soils in the vicinity of the casting and chip storage area by excavating test pits with a backhoe. We then collected and analyzed soils from various depths. The test pits were located on a grid and covered the

entire area of potentially contaminated soils identified through plant interviews and prior soil boring results. The locations of the test pits are shown on Figure 4. This area was identified as a possible contamination source through employee interviews.

The following procedures were used at each test pit:

1. The backhoe operator excavated to the sample depth.

2. Approximately one pint of soil was collected in a wide-mouth quart jar from the bottom of the excavation or from the backhoe bucket.

3. The quart jar was immediately covered and shaken for two minutes.

4. After the two-minute shaking period, the air in the head space above the soil was analyzed using a Model PI-101 photoionization analyzer manufactured by HNU Systems, Inc. To analyze the head space gas, the detector probe was inserted through a hole in the jar cap. The instrument response is parts per million as benzene on a volume basis in the head space. Prior to analysis, the instrument was calibrated with calibration gas supplied by the manufacturer. The instrument detects organic and inorganic compounds by ionizing the chemical using ultra-violet radiation and measuring the current generated by the ions formed.

    The energy to the ultraviolet lamp is adjusted to provide a uniform response even though the lamp deteriorates with use. The instrument was calibrated three times per day with the calibration gas and also calibrated after significant positive response.

    The source of ultraviolet radiation is a lamp with a potential of approximately ten electron volts. Therefore, compounds with ionization potentials approximately ten electron volts or less are detected. The detection method is non-specific; however, it provides a valuable indication concerning the relative amounts of contamination from one soil sample to another. Because the results are obtained immediately, we were able to adjust the backhoe excavation operation in response to the data.

5. Samples that showed significant response using the photoionization detector were further analyzed using the Model OVA-108 Foxboro portable organic vapor analyzer. The OVA uses a flame ionization detector and provides a generally more sensitive response to those compounds with high ionization potentials. Furthermore, the OVA has a gas chromatograph mode which allows an approximation of the number of compounds present. The OVA was calibrated using a commercially prepared standard gas at least three times during a day. Also, the unit was calibrated when the analysis showed a positive result.

6. To correlate the field information with the more accurate laboratory determination of organics in the soils, we collected three samples of soils which had field instrument readings ranging from low to high for specific laboratory analysis.
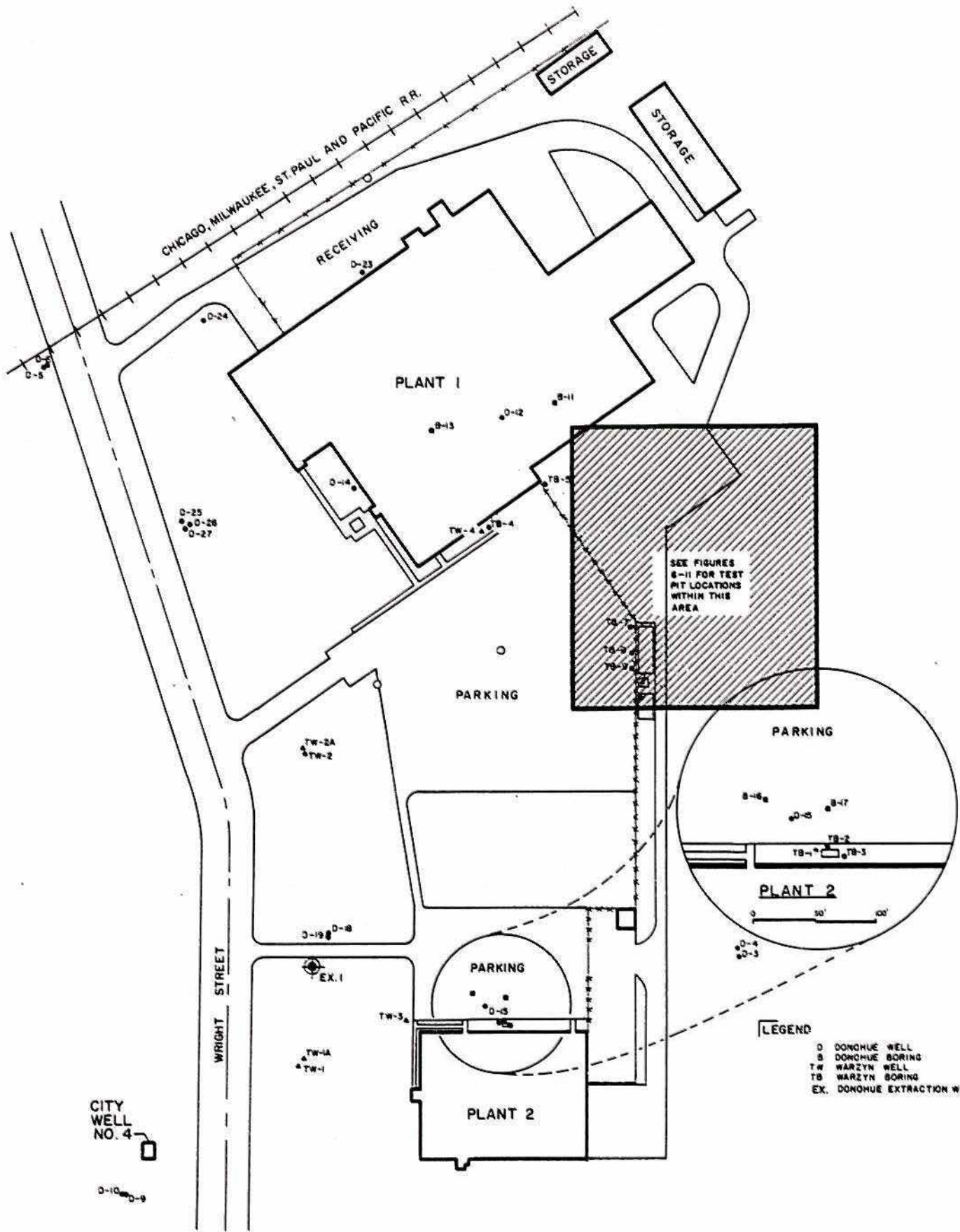
SOIL INVESTIGATION GENERAL LOCATION MAP
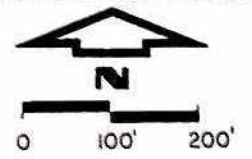
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DELAVAN, WISCONSIN

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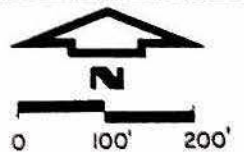
FIGURE   4

The correlation between field analysis using the photoionization detector and the laboratory analysis is shown in Table 3 and on Figure 5. Table 3 shows the listing of the HNU photoionization detector response from the field equipment and also the specific constituents and total concentration of organics in the soil samples. The correlation between the HNU readings and the total organics found in the laboratory samples is shown on Figure 5. There is a reasonably good correlation between the field instrument response and the total amount of organics in the soils as found in the laboratory. Because we have a good correlation, we can calculate the concentration of organics in the soil as a function of the field instrument readout. The results are listed in Table 4. The areal concentrations of solvents at various depths are shown on Figures 6 through 11. We obtained only limited OVA readings because a relatively small number of samples gave positive HNU readings. Therefore, no correlation of OVA and laboratory data was attempted.

The procedure for field analysis was evaluated prior to use at Sta-Rite to ensure that we would not have false positive reading. A clean soil sample that had been analyzed by a laboratory gas chromatograph which showed no contamination was introduced to our field methods. The field methods also showed no contamination. Therefore, there is little chance of recording a false positive or having the field instruments indicate contamination where there is none detectable.

We can estimate the amount of solvent in the soils based on the distribution of concentrations measured. To calculate the total weight of solvent, we assign an average concentration of solvents in the soils to an area and depth based on the analysis. By assuming a soil density of 100 pounds per cubic foot, we can calculate the amount of solvent. The results of the calculation are shown in Table 5. The total amount of organic solvents estimated in the soils in the vicinity of the chip storage area is 20.7 pounds. Most of the solvent is in a small area and at a depth of 6 to 10 feet below the surface. There is not sufficient contamination of the soils in the vicinity of the chip storage area to explain the groundwater contamination found in the monitoring wells near Plant 1. We conclude from this portion of the investigation that the contamination noted under Plant 1 is due to sources that are now covered by the building.

As discussed earlier, it is not feasible to conduct additional investigations or remedial action beneath Plant 1. We recommend the installation of extraction wells to intercept contaminants. The investigations related to the extraction system for the Plant 1 contaminants are presented in Chapter 4.

TABLE 3

COMPARISON OF HNU RESPONSE IN FIELD HEAD SPACE
ANALYSIS AND LABORATORY ANALYSIS OF SOILS

	HNU Reading ppm	Laboratory Analysis - mg/kg in soils					
Sample		Methylene chloride	Dichloro-ethane	1,1,1 Trichloro-ethane	TCE	Toluene	Total
2 (10 ft)	160	0.132	0.391	6.05	1.80	0.47	8.84
7 (6 ft)	<1	0.033	<0.01	0.015	0.011	0.19	0.25
9 (8 ft)	500	0.044	<0.01	0.049	2.40	20.8	23.3

600

500

400

HNU Response — ppm in head space

300

SLOPE = 21.5 ppm in head space
_____
mg / kg in soil

200

100

5   10   15   20   25

Laboratory Analysis Results — mg / kg in soil
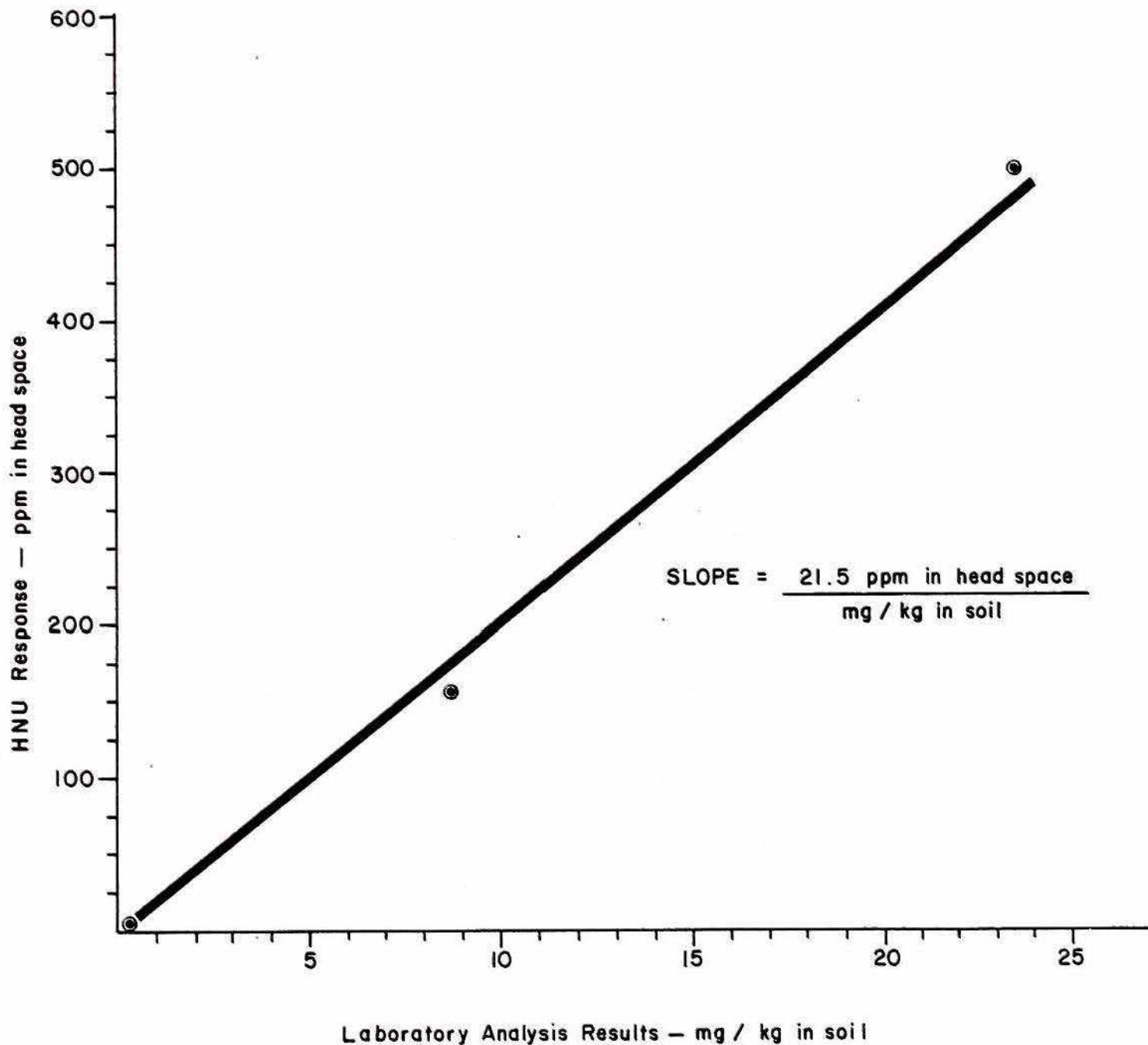
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**CORRELATION OF FIELD MEASUREMENT OF HEADSPACE
GAS AND LABORATORY ANALYSIS OF SOILS**

STA-RITE INDUSTRIES, INC. WATER EQUIPMENT DIVISION

DELAVAN, WISCONSIN   FIGURE 5

TABLE 4

FIELD HEAD SPACE ANALYSIS RESULTS AND CALCULATED
AMOUNT OF SOLVENT IN SOIL SAMPLES

Pit Number	Coordinate Location North/East	Sample Depth (feet)	HNU Response ppm as Benzene in Head Space	OVA Response ppm as Methane in Head Space	Amount of Solvent in Soil (mg/kg)
1	250/0	3	<1		<0.1
		6	<1		<0.1
		8	2		0.1
		10	<1		<0.1
2	230/0	1	3		0.15
		3	20		1.0
		6	18		1.0
		7	50		2.3
		10	160	1,600	7.4
3	230/-50	1	<5		<0.25
		3	<5		0.25
		6	<5		<0.25
		9	<5		<0.25
		11	<5		<0.25
4	220/0	3.5	<1		<0.1
		5	4		0.2
		7	34		1.6
		10	<1		<0.1
5	200/0	3	<1		<0.1
		5	3		0.2
		8	2		0.1
		10	<1		<0.1
6	190/10	3	<1		<0.1
		6	<1		<0.1
		9	<1		<0.1
		10	<1		<0.1
7	170/10	3	<1		<0.1
		6	<1		<0.1
		9	<1		<0.1
		10	<1		<0.1
8	170/100	2	<1		<0.1

TABLE 4
(Continued)

Pit Number	Coordinate Location North/East	Sample Depth (feet)	HNU Response ppm as Benzene in Head Space	OVA Response ppm as Methane in Head Space	Amount of Solvent in Soil (mg/kg)
9	150/40	3	<1		<0.1
		5	<1		<0.1
		7	14	0.02	0.7
		8	500	>10,000	23
		10	600	>10,000	28
		12	400	100	19
		14	600	500	28
10	120/40	1	8		0.4
		5	9	9	0.4
		8	130	30	6.0
		10	700	800	33
11	120/50	3	<1		<0.1
		6	<1		<0.1
		7	800	1,000	37
12	100/10	1	4		0.2
		5	5		0.3
		8	8		0.4
13	110/40	3	<1		<0.1
		5	<1		<0.1
		7	4		0.2
		10	6		0.3
		11	11		0.5
		12	7		0.4
14	130/40	1	<1		<0.1
		3.5	2		0.1
		5	900	4,000	42
		6	950	8,000	44
		7	50	20	2.3
		10	120	90	5.6
		12	30	30	1.4
		13.5	60	50	2.8
15	130/50	1	<1		<0.1
		3	5	5	0.25
		4	3	10	0.2
		6	30	40	1.4
		8	55	45	2.6
		9	50	45	2.3
		12	60		2.8

TABLE 4
(Continued)

Pit Number	Coordinate Location North/East	Sample Depth (feet)	HNU Response ppm as Benzene in Head Space	OVA Response ppm as Methane in Head Space	Amount of Solvent in Soil (mg/kg)
16	100/0	1	50		2.3
		5	3		0.1
		7	9		0.5
		10	30		1.4
17	260/40	3	<1		<0.1
		6	<1		<0.1
		10	<1		<0.1
18	240/30	3	<1		<0.1
		6	<1		<0.1
		10	<1		<0.1
19	220/40	3	<1		<0.1
		6	<1		<0.1
		10	<1		<0.1
20	310/60	1	<1		<0.1
		2	10		0.5
		7	20		1.0
		9	20		1.0
		10	5		0.25
21	Plant 2 Southeast Pavement Corner	0.5	<1		<0.1
		3	2		0.1
		6	2		0.1
		8	2.5		0.2
		10	3.2		0.3

NOTE: 21.5 ppm in head space = 1 mg/kg in soil. (See Figure 5 for empirical relationship)

20 (<1)

17 (<0.1)

250 — 1(<0.1) 18 (<0.1)

3 (<0.25) 2(0.15)

4
(<0.1) 19 (<0.1)

200 — 5 (<0.1)

6 (<0.1)

8 (<0.1)

7 (<0.1)

150 — 9 (<0.1)

(<0.1)14 15 (<0.1)

(0.4)10 11 (<0.1)

13 (<0.1)

16 (2.5)

100 — 12 (0.2)

TB-7

TB-8

50

TB-9

0

0   50   100   150   200

⌐LEGEND

⬣ WARZYN BORING

◉ DONOHUE TEST PIT

(N.N) CONCENTRATION IN
mg SOLVENT / kg SOIL
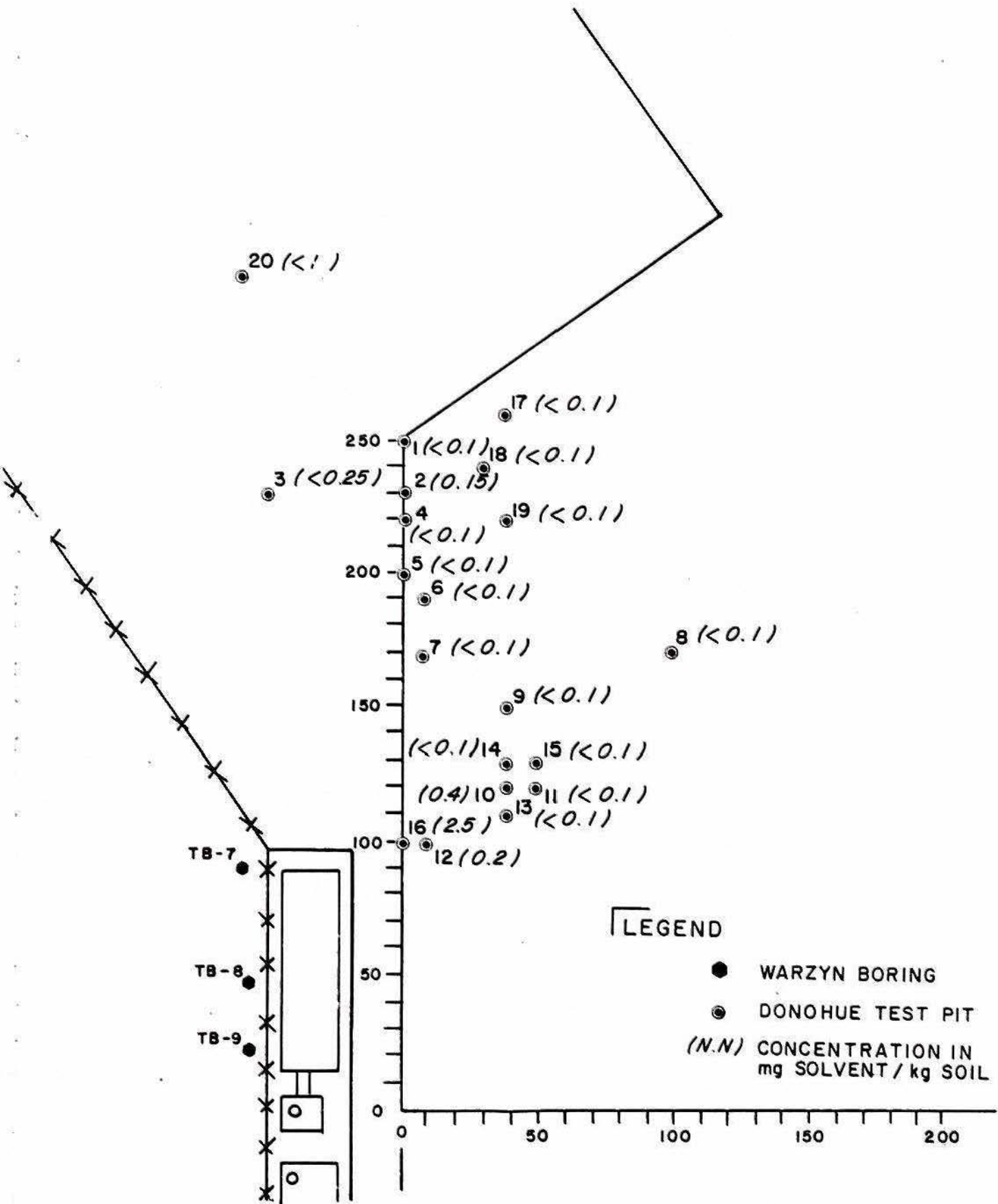
Donohue

JUNE 1984

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CONCENTRATION OF ORGANICS IN SOIL - 0-3 FEET

STA-RITE INDUSTRIES, INC. WATER EQUIPMENT DIVISION
DELAVAN, WISCONSIN

N

0   50'

FIGURE 6

20 (1.0)

17 (<0.1)

250 — 1(<.1) 18 (<0.1)

3(<0.25) 2(1)

4(0.2) 19 (<0.1)

200 — 5(0.2)

6(<0.1)

7(<0.1) 8 (<1)

150 — 9 (0.7)

(42)14 15 (1.4)

(0.4)10 11 (<0.1)

13 (0.2)

16 (0.1) 100 —

12 (0.3)

TB-7

TB-8 50 —

TB-9

0

0   50   100   150   200

LEGEND

● WARZYN BORING

◉ DONOHUE TEST PIT

(N.N) CONCENTRATION IN
mg SOLVENT / kg SOIL
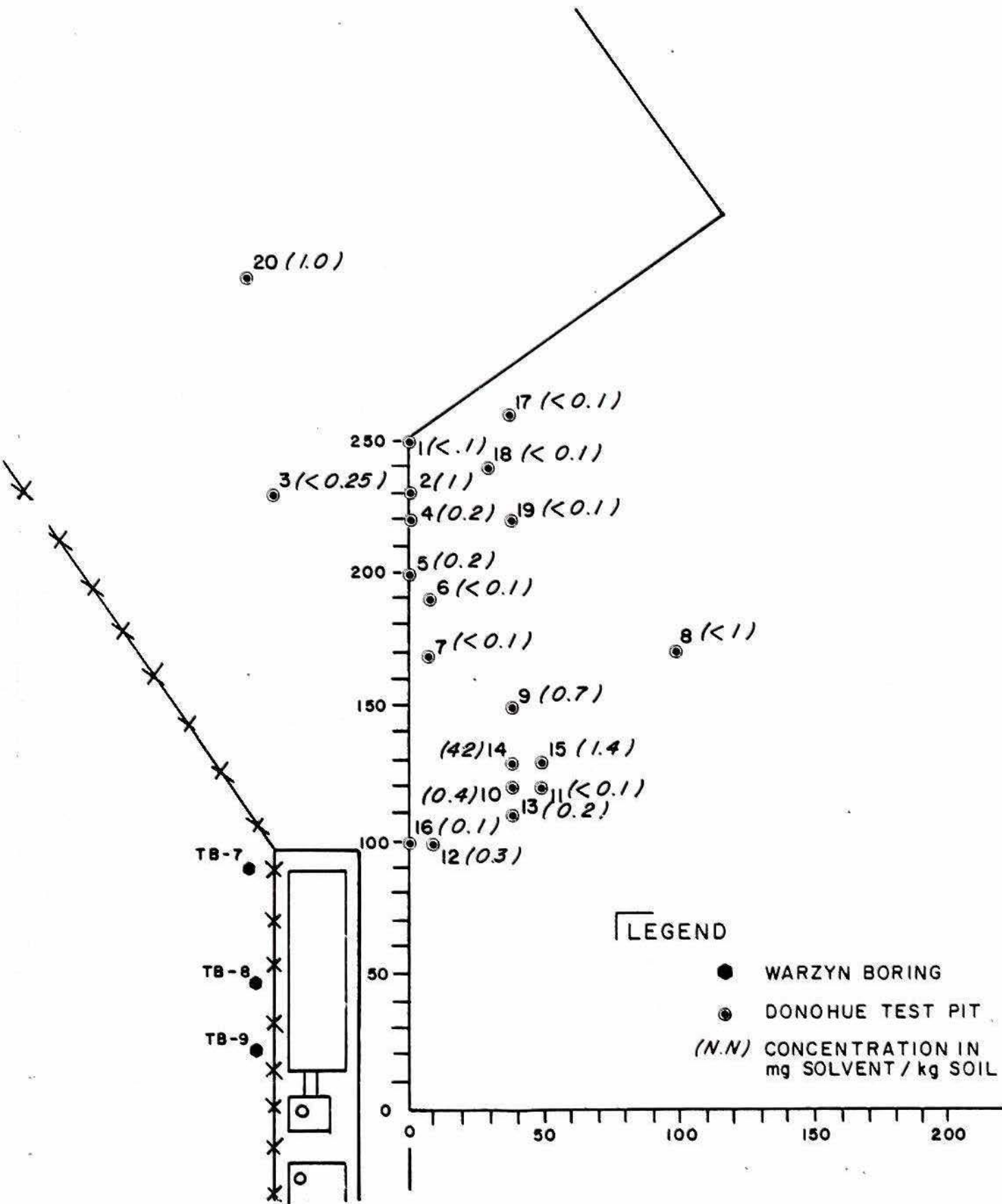
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CONCENTRATION OF ORGANICS IN SOIL - 3-6 FEET

STA-RITE INDUSTRIES, INC. WATER EQUIPMENT DIVISION

DELAVAN, WISCONSIN

N

0   50'

FIGURE 7

20 (1.0)

17 (< 0.1)

250 — 1 (0.1) 18 (< 0.1)

3 (< 0.25) 2 (2.3)

4 (1.6) 19 (< 0.1)

200 — 5 (0.1)
6 (< 0.1)

7 (< 0.1) 8 (< 1)

150 — 9 (24)

(2.0) 14 15 (2.3)

(6.0) 10 11 (37)
13 (0.3)

16 (0.5)

100 — 12 (0.4)

TB-7

50

TB-8

TB-9

0

0   50   100   150   200

LEGEND

● WARZYN BORING

⊙ DONOHUE TEST PIT

(N.N) CONCENTRATION IN
mg SOLVENT / kg SOIL
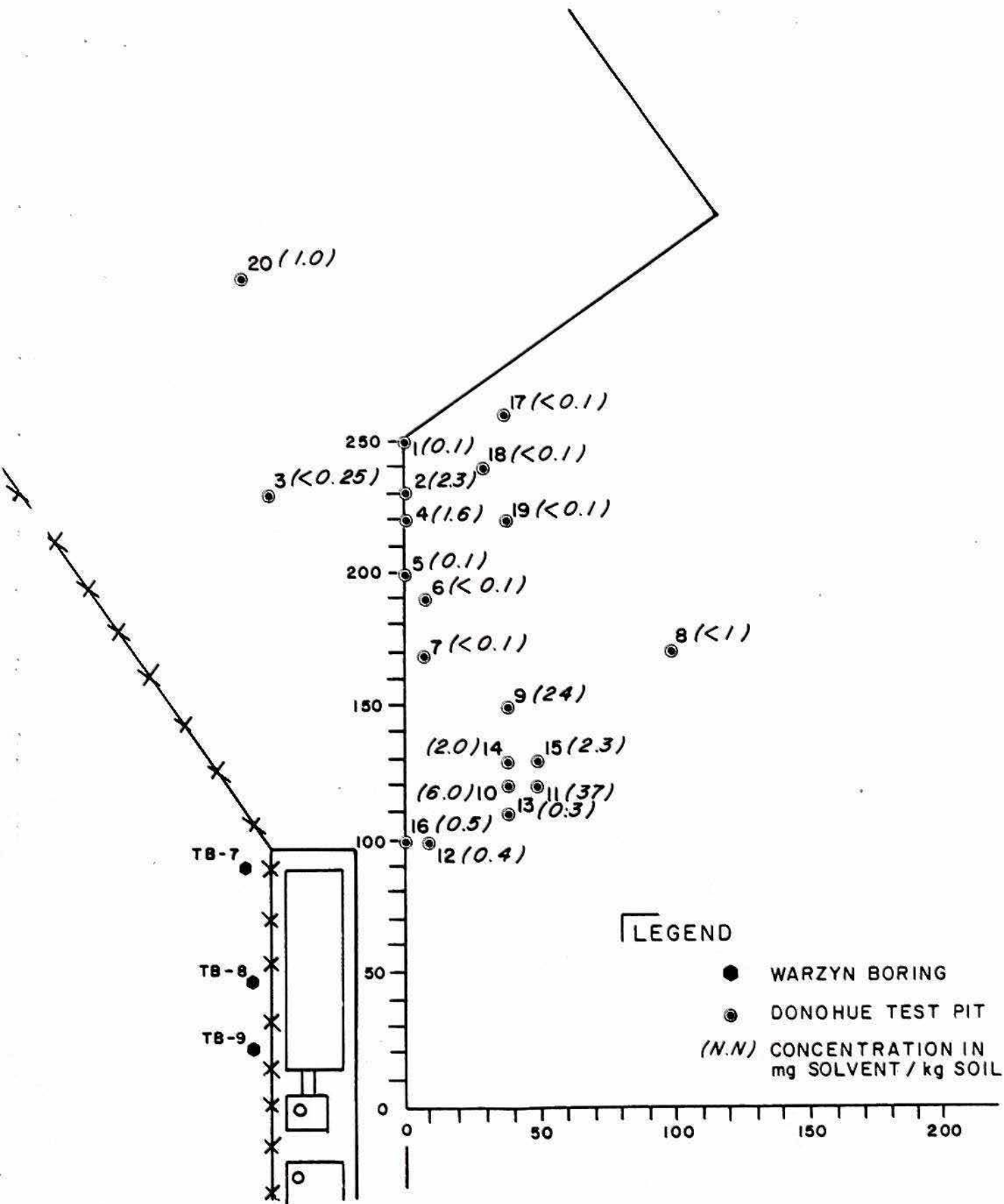
Donohue

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Engineers & Architects

CONCENTRATION OF ORGANICS IN SOIL - 6-9 FEET

STA-RITE INDUSTRIES, INC. WATER EQUIPMENT DIVISION
DELAVAN, WISCONSIN

N

0 ⌐⌐⌐⌐ 50'

FIGURE 8

20 (0.3)

17 (< 0.1)

250 — 1 (< 1)   18 (< 0.1)

3 (< 0.25)   2 (7.4)

4 (0.1)   19 (< 0.1)

200 — 5 (< 0.1)

6 (< 0.1)

7 (< 0.1)   8 (< 1)

150 — 9 (19)

(6) 14   15 (2.8)

(33) 10   11

13 (0.5)

16 (1.4)

100 — 12

TB-7 ●

LEGEND

⬢   WARZYN BORING

◉   DONOHUE TEST PIT

(N.N)   CONCENTRATION IN
        mg SOLVENT / kg SOIL

50 —

TB-8 ●

TB-9 ●

0 —

0   50   100   150   200
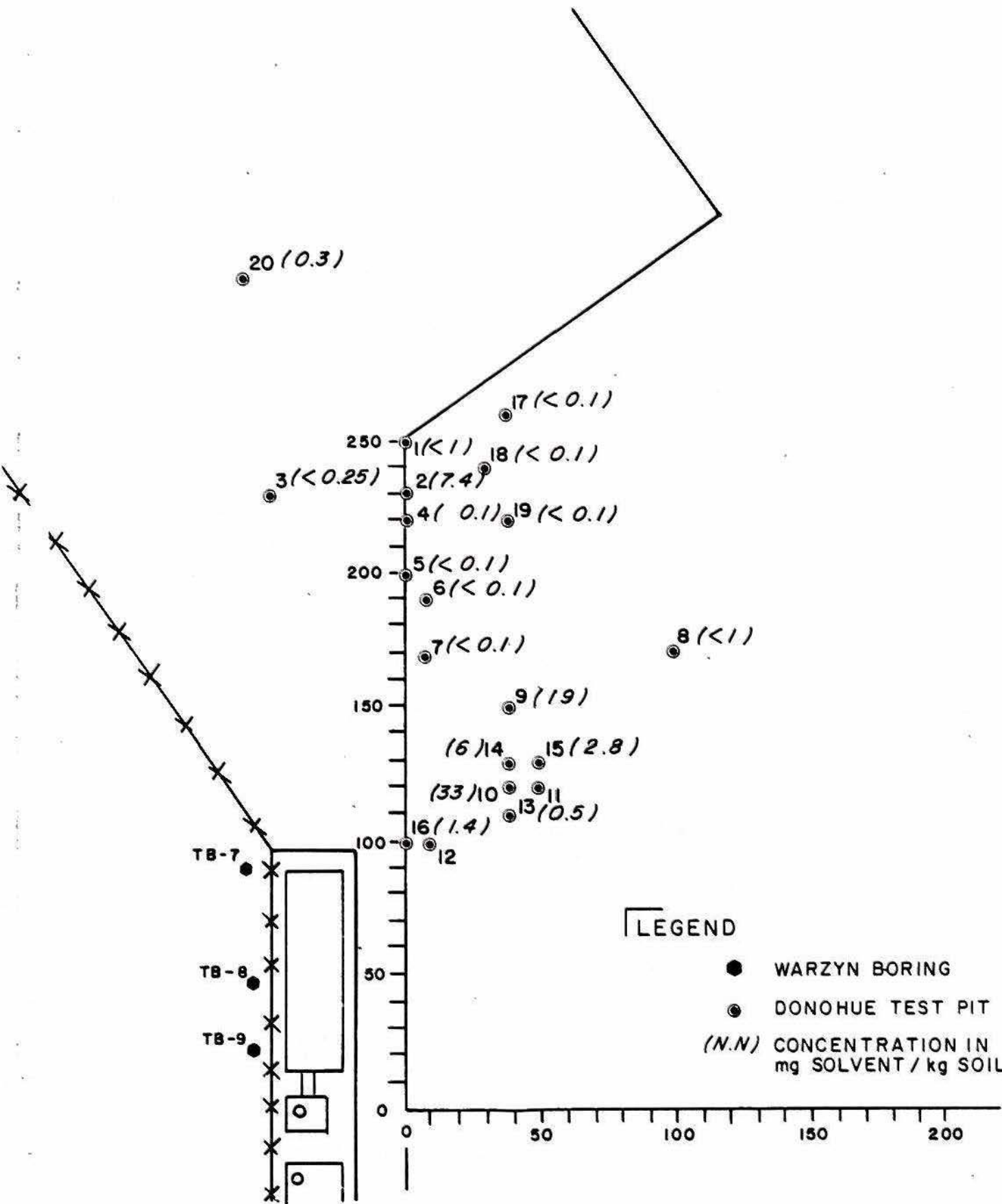
CONCENTRATION OF ORGANICS IN SOIL - 9-12 FEET

STA-RITE INDUSTRIES, INC. WATER EQUIPMENT DIVISION

DELAVAN, WISCONSIN

N

0   50'

FIGURE 9

20

17

250 — 1

3 (<0.25)   2

4

18

19

200 — 5

6

8 (<1)

7

9 (28)

150 —

(1.5) 14   15 (.3)

10   11

13 (<0.1)

100 — 16

12

TB-7

TB-8

50 —

TB-9

0

0   50   100   150   200

⌐ LEGEND

● WARZYN BORING

◉ DONOHUE TEST PIT

(N.N) CONCENTRATION IN
      mg SOLVENT / kg SOIL
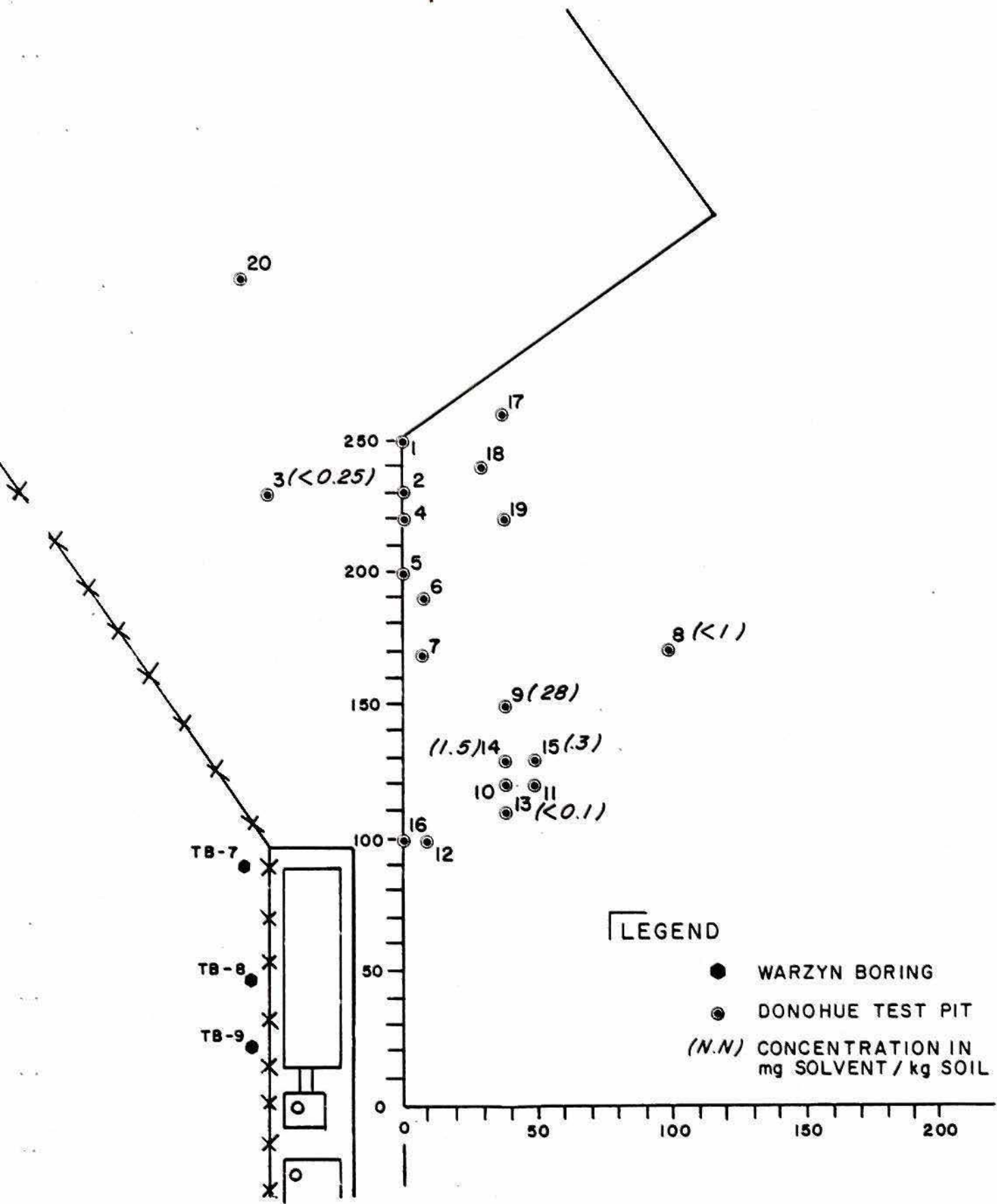
Donohue

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CONCENTRATION OF ORGANICS IN SOIL - 12 FEET

STA-RITE INDUSTRIES, INC. WATER EQUIPMENT DIVISION

DELAVAN, WISCONSIN

N

0   50'
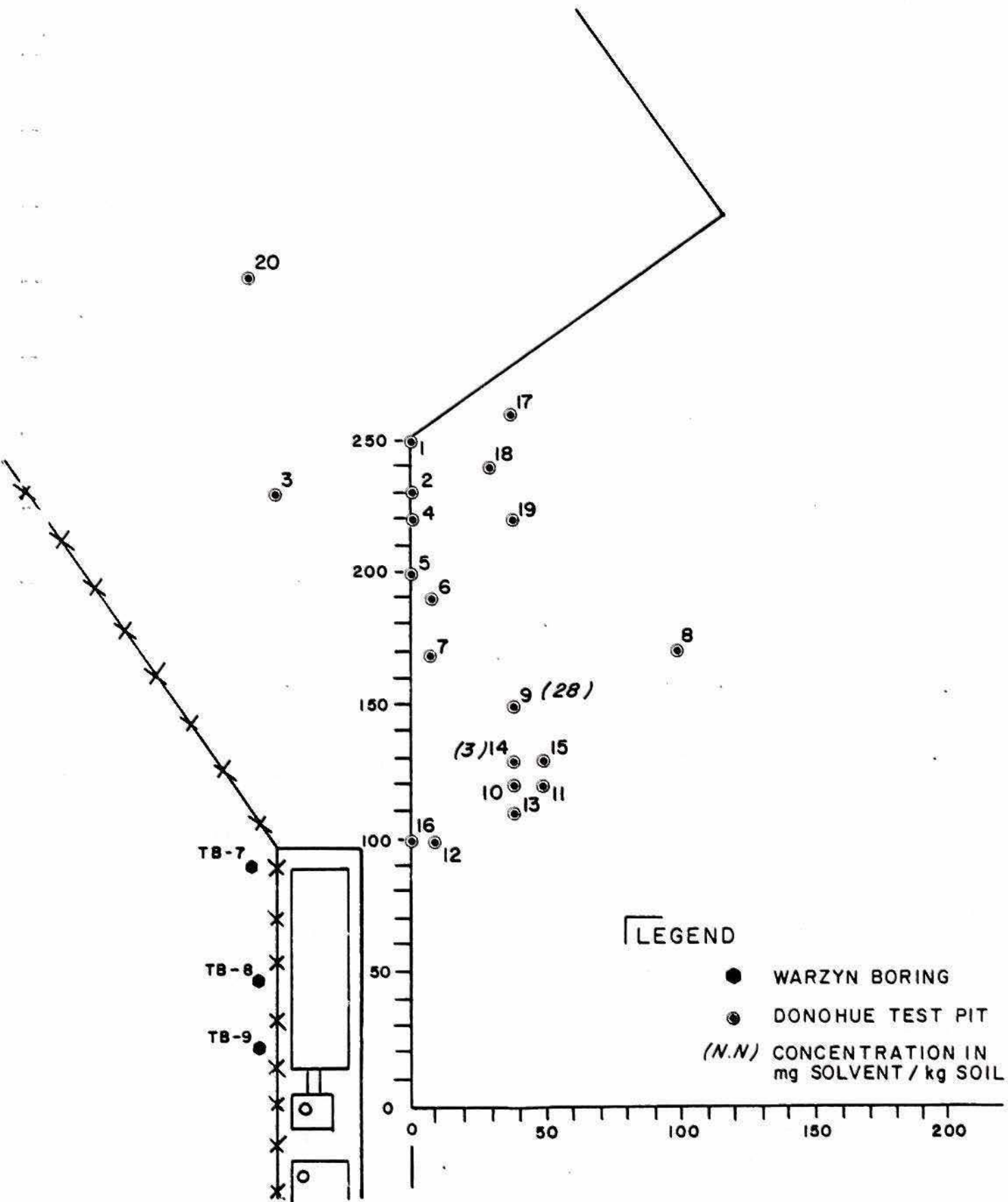
FIGURE 10

Donohue

JUNE 1984

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CONCENTRATION OF ORGANICS IN SOIL - 14 FEET

STA-RITE INDUSTRIES, INC. WATER EQUIPMENT DIVISION
DELAVAN, WISCONSIN

N

0   50'

FIGURE 11

TABLE 5

CALCULATED MASS OF SOLVENT IN SOIL IN
VICINITY OF CHIP STORAGE AREA

Depth (ft)	Area With Solvent (ft²)	Average Concentration (mg/kg)	Mass of Solvent (grams)	Mass of Solvent (lbs)
0 - 3	100	2.5	33	0.07
3 - 6	0	0	0	0
6 - 9	2,400	12.0	3,800	8.4
9 - 12	2,400	12.3	3,850	8.5
12 - 15	1,600	8.1	1,700	3.7
TOTAL				20.7

CHAPTER 4

GROUNDWATER EXTRACTION FOR
CONTROL OF THE PLANT 1 CONTAMINANT PLUME

INTRODUCTION

The Plant 1 plume boundaries and the effect of groundwater extraction wells on the Sta-Rite property were evaluated through installation of additional monitoring wells and analysis of the groundwater flow system. Groundwater information was collected to evaluate the vertical and lateral limits of the contaminant plume, fluctuations in groundwater flow direction, fluctuations in the elevation of the water table, and the cone of depression and cone of influence of proposed groundwater extraction wells. As discussed in Chapter 2, an extraction well was placed to intercept groundwater contamination originating from the Plant 2 sump area. A pump test was conducted on this extraction well to determine the expected radius of influence of the extraction wells on the contaminant plume. The data were used to design a groundwater interception system.

ADDITIONAL FIELD INVESTIGATIONS

Five additional monitoring wells were installed to define the extent of the contaminant plume. Three of these wells were constructed as observation wells and aided in the definition of the lateral extent of the plume. These wells included D-23 and D-24 which are located on the north side of Plant 1; they were used to define the eastern boundary of the plume. Well D-25, located west of Plant 1, aided in the definition of the southern extent of the plume from Plant 1. In addition, at D-25, two additional piezometers (D-26 and D-27) were installed to complete a well nest. This nest was used to define the depth of contamination in the aquifer. The location of the wells is shown on Figure 3 and installation information is provided in Table 6. Wells D-23, D-24, and D-25 are screened at the water table and extend approximately 5 to 8 feet below the water table. D-26 is 50 feet deep and D-27 is 75 feet deep. The observation wells have 10-foot slotted screen sections, while the piezometers have 5-foot screened sections.

An extraction well was installed directly south of D-18 to intercept contamination from the Plant 2 sump area. This well is approximately 48 feet deep and consists of 8-inch No. 40 slot PVC surrounded by a 2-inch gravel pack. The slotted section is 20 feet long and begins at or near the water table. This well is able to produce in excess of 80 gpm.

ADDITIONAL DATA COLLECTION

Additional geologic information was collected during drilling of the monitoring wells. The boring logs are contained in Appendix A. New information is consistent with previous subsurface investigations. A surface layer of sandy silt approximately 15 to 20 feet deep is underlain by sands and gravels. At D-27, a silt layer was encountered between a depth of 50 to 60 feet. This layer cannot be traced continuously over the site although it does appear in D-6, D-2, D-10, and TW-1A. D-23, D-24, D-25, and D-26 are all screened above this silt layer. At D-23 the formation contained a large thickness of rounded cobbles and gravel.

TABLE 6
BORING AND WELL INSTALLATION INFORMATION
STA-RITE INDUSTRIES
Delavan, Wisconsin

Well Boring No.	Installed By	Date Installed	Total Depth Feet	Screened Interval Feet	Ground Elevation	Top of Pipe Elevation	Elevation of Screened Interval
TB-1	Warzyn	12-14-82	10	-			
TB-2	Warzyn	12-14-82	15	-			
TB-3	Warzyn	12-14-82	10	-			
TB-4	Warzyn	12-14-82	10	-			
TB-5	Warzyn	12-14-82	10	-			
TB-7	Warzyn	12-14-82	10	-			
TB-8	Warzyn	12-14-82	10	-			
TB-9	Warzyn	12-14-82	10	-			
TW-1	Warzyn	12-09-82	44	24-44	939.2	942.39	915.2-895.2
TW-1A	Warzyn	12-10-82	85	75-85	939.4	942.60	864.4-854.4
TW-2	Warzyn	12-02-82	51	31-51	942.5	944.38	911.5-891.5
TW-2A	Warzyn	12-03-82	90	80-90	942.5	945.50	862.5-852.5
TW-3	Warzyn	12-08-82	48	28-48	943.5	946.67	915.5-895.5
TW-4	Warzyn	12-06-82	49	29-49	948.0	951.06	919.0-900.0
D-1	Donohue - Wis. Testing Lab.	02-15-83	50	30-50	948.71	950.10	918.7-898.7
D-2	Donohue - Wis. Testing Lab.	02-09-83	110	100-110	948.8	952.52	848.8-838.8
D-3	Donohue - Wis. Testing Lab.	02-17-83	50	30-50	947.2	949.75	917.2-897.2
D-4	Donohue - Wis. Testing Lab.	02-17-83	80	70-80	947.4	950.50	877.4-867.4
D-5	Donohue - Wis. Testing Lab.	02-22-83	50	30-50	944.0	946.45	914.0-894.0
D-6	Donohue - Wis. Testing Lab.	02-21-83	110	100-110	944.1	946.39	844.1-834.1
D-9	Donohue - Wis. Testing Lab.	02-23-83	50	30-50	935.3	936.96	905.3-885.3
D-10	Donohue - Wis. Testing Lab.	03-02-83	110	100-110	935.4	938.33	835.4-825.4
B-11	Donohue - Wis. Testing Lab.	06-28-83	35	-			
D-12	Donohue - Wis. Testing Lab.	06-30-83	36	26-36	948.56	948.56	922.6-912.6
B-13	Donohue - Wis. Testing Lab.	07-01-83	35.5	-			
D-14	Donohue - Wis. Testing Lab.	07-12-83	35	25-35	948.18	950.09	923.2-913.2
D-15	Donohue - Wis. Testing Lab.	07-07-83	38	28-38	943.69	945.55	915.7-905.7
B-16	Donohue - Wis. Testing Lab.	07-08-83	32.5	-			
B-17	Donohue - Wis. Testing Lab.	07-11-83	27.5	-			
D-18	Donohue - Wis. Testing Lab.	10-10-83	37	34.5-37	942.08	944.25	907.6-905.1
D-19	Donohue - Wis. Testing Lab.	10-10-83	29.5	19.5-29.5	941.86	943.11	922.4-912.4
D-23	Donohue - Giles Engineering Associates	05-02-84	38	28.5-38	944.47	946.01	916.0-906.5
D-24	Donohue - Giles Engineering Associates	05-18-84	34	24.5-34	942.84	944.88	918.3-908.8
D-25	Donohue - Giles Engineering Associates	05-16-84	35	25.5-35	943.22	945.76	917.7-908.2
D-26	Donohue - Giles Engineering Associates	05-14-84	50	45-50	943.27	945.30	898.3-893.3
D-27	Donohue - Giles Engineering Associates	05-04-84	75	70-75	943.22	945.71	873.2-868.2

Additional water level elevations were taken and are contained in Table 7. Water table maps have been constructed from data collected on May 23, and June 8, 1984. These are depicted on Figures 12 and 13. Maximum fluctuation of the water table has been 8 feet at TW-1 with an average fluctuation of 5 feet at the site. The 8-foot fluctuation at TW-1 is probably a result of measurements taken while City Well No. 4 was pumping. The water table constructed from the May 23, and June 8, water level measurements indicates a groundwater flow to the west and northwest. Rainfall occurred between the two days, causing the water level to rise approximately one-half foot. A low groundwater elevation was found at TW-2. This is inconsistent with expected hydrogeologic conditions and may be caused by changes in the integrity of the well or a slower response time of the well to changing water levels.

A pump test was conducted on the extraction well to aid in the design of an extraction system for Plant 1. Data were collected over a 4,500-minute time span from June 4, through June 6. These data are contained in Appendix B. The data were matched to Thies-type curves for delayed yield from storage. Computed transmissivity values were then corrected for effects of partial penetration of the pumping and observation wells. These values ranged from a low of 22,000 gallons/day/foot (gpd/ft) at TW-1 to a high of 42,000 gpd per foot at TW-3 and D-19. City Well No. 4 was on for a portion of the pump test and may have caused the low transmissivity value calculated at TW-1 where the effects from City Well No. 4 would be the greatest. The cessation of pumping at City Well No. 4 is shown in the data by a rise in the water levels. A second rise in the water levels was seen during the latter stages of the pump test after rainfall had occurred. None of the other surrounding wells were monitored for groundwater fluctuations, therefore where this occurred during the pump test the data could not be used in the analysis. A rough estimate of the transmissivity based on the specific capacity of the pumping well results in a value of 20,000 gpd per foot. This is consistent with the calculated transmissivities. These transmissivities reflect conditions in the upper portion of the aquifer and do not reflect the entire saturated thickness. The transmissivity for the entire aquifer is estimated at 150,000 gpd per foot (Donohue, December 1983).

The analysis of water from the new monitoring wells and other monitoring wells is provided in Table 8. The data provides the following information:

1. The contaminant plume extends to the north side of Plant 1 where it was detected in D-23.

2. The depth of the plume near the Sta-Rite western boundary is approximately 20 feet from the top of the groundwater table.

3. Downward movement of the contaminants is probably restricted by the low permeability silt layer found between 50 and 60 feet. This information is reflected in the data collected from D-25, D-26, and D-27.

TABLE 7

WATER TABLE ELEVATIONS
MEASUREMNT DATA

Well Number	Top of PVC Elevation	12/13/82	1/07/83	3/11/83	4/07/83	4/08/83	4/11/83	10/17/83	1/25/84	5/23/84	6/8/84
TW-1	942.39	917.35	916.67	917.76	918.52	918.65	919.51	913.95	915.21	915.35	915.61
TW-1A	942.6	915.76	915.48	917.81	918.55	918.71	919.58	912.33	914.63	914.83	915.71
TW-2	944.38	915.43	915.68	915.94	916.47	916.59	918.71	913.17	913.57	913.67	913.77
TW-2A	944.5	915.91	916.01	916.49	916.96	917.2	919.71	913.42	914.02	914.18	914.35
TW-3	946.67	917.19	917.25	917.82	917.25	918.62	919.46	914.48	915.37	915.55	915.63
TW-4	951.06	916.43	916.92	917.09	917.49	917.57	918.32	915.06	914.67	914.76	914.76
D-1	950.1				920.57		921.02	918.1			917.61
D-2	952.52				921.34		921.78	918.81	918.03		918.83
D-3	949.75					919.59	920.32	915.67	916.72	916.85	917.26
D-4	950.5					921.44	921.03	917.15	916.58	916.85	917.23
D-5	946.45				916.94		917.59	914.45	914	914.3	914.42
D-6	946.34				917.15		917.76	914.37	914.22	914.1	914.43
D-9	936.96				917.22		919.25	913.46	915.02	915.12	915.49
D-10	938.33				915.17		920.75	911.5	915.81	916.93	917.34
D-12	948.56							916.56	914.88	914.26	915.43
D-14	950.09								914.15		
D-15	945.55							914.64	915.41	915.68	915.81
D-18	944.25							914.17	915.02	915.17	915.23
D-19	943.11							913.12	915.02	915.14	915.18
D-23	946.01									914.51	915.14
D-24	944.88									914.52	914.73
D-25	945.76									914.36	914.73
D-26	945.3									914.3	914.69
D-27	945.71									914.73	914.97

4-4

CHICAGO, MILWAUKEE, ST. PAUL AND PACIFIC R.R.

STORAGE

STORAGE

RECEIVING

914.51
D-23

D-24
914.52

D-5
914.30

PLANT 1

914.26
8-41
D-12

8-13

D-14

TB-5

914.36
D-25
D-26
D-27

914.76
TW-4 TB-4

TB-7
TB-8
TB-9

914

PARKING

PARKING

8-16   8-17
D-15

TB-2
TB-1   TB-3

PLANT 2

0   50'   100'

915

916

TW-2A
TW-2
913.67

915.14 D-18
D-19B

D-4
D-3
916.85

EX.1

915.55
TW-3

915.59
D-13

PLANT 2

LEGEND

LEGEND

D   DONOHUE WELL
B   DONOHUE BORING
TW   WARZYN WELL
TB   WARZYN BORING
EX. DONOHUE EXTRACTION WELL

TW-4A
TW-1
915.35

CITY
WELL
NO. 4

D-10 915.12
D-9

WRIGHT STREET

Donohue

JUNE 1984

12894.000

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GROUNDWATER TABLE ELEVATIONS - MAY 23, 1984

STA-RITE INDUSTRIES, INC. WATER EQUIPMENT DIVISION

DELAVAN, WISCONSIN

N

0   100'   200'
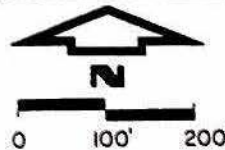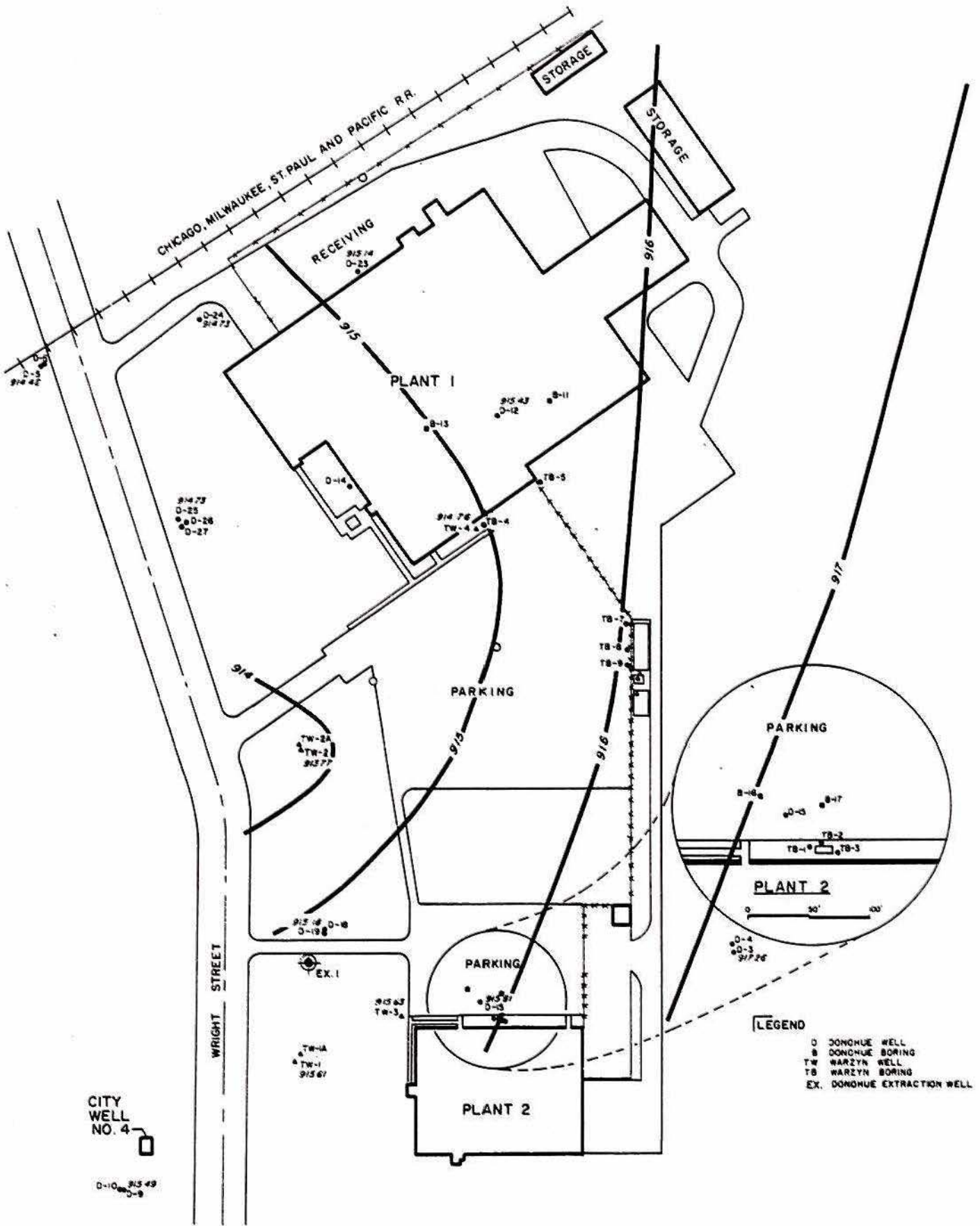
FIGURE 12

Donohue

JUNE 1984

12894.000

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GROUNDWATER TABLE ELEVATIONS - JUNE 8,1984

STA-RITE INDUSTRIES, INC. WATER EQUIPMENT DIVISION

DELAVAN, WISCONSIN

N

0   100'   200'
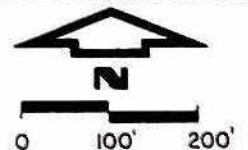
FIGURE 13

TABLE 8

GROUNDWATER QUALITY DATA
STA-RITE INDUSTRIES
Delavan, Wisconsin

Well No.	Date Sampled	Methylene chloride	1,1-Dichloro-ethylene	Trans 1,2-dichloroethylene	1,1,1-Trichloro-ethane	Trichloro-ethylene	Tetrachloro-ethylene	Toluene
TW-1	01-07-83				ND	7		
TW-1A	01-07-83	ND	ND	ND	ND	ND	ND	ND
TW-2	01-07-83	ND	ND	ND	ND	ND	ND	ND
TW-2A	01-07-83	ND	ND	ND	ND	ND	ND	ND
TW-3	01-07-83			7	8	81	7	
TW-4	01-07-83		250	<500	13,750	2,035		
D-1	04-08-83	<1	<1	<1	<1	<1	<1	<1
D-2	04-08-83	<1	<1	<1	<1	<1	<1	2
D-3	04-08-83	<1	<1	<1	<1	<1	<1	<1
D-4	04-08-83	<1	<1	<1	<1	<1	<1	<1
D-5	04-08-83	<25	150	19	1,800	500	<1	<1
D-6	04-08-83	<1	<1	<1	<1	<1	<1	<1
D-9	04-08-83	<1	<1	<1	10	2	<1	<1
D-10	04-08-83	<1	<1	<1	<1	<1	<1	<1
TW-1	04-08-83	<1	<1	<1	3	3	<1	2
TW-1A	04-08-83	<1	<1	<1	<1	<1	<1	<1
TW-2	04-08-83	<1	<1	<1	<1	<1	<1	<1
TW-2A	04-08-83	<1	<1	<1	<1	<1	<1	<1
TW-3	04-08-83	<1	<1	<1	4	32	<1	<1
TW-4	04-08-83	<100	1,100	<100	12,500	3,400	<100	<100
D-12	07-13-83	140	4,080		16,200	3,870		85
D-15	07-13-83	860				110,000	1,830	85
TW-1	10-18-83	<1	<1	<1	6	7	1	<1
TW-1A	Not Sampled							
TW-2	10-18-83	<1	<1	<1	<1	<1	<1	<1
TW-2A	10-18-83	<1	<1	<1	<1	<1	<1	<1
TW-3	10-18-83	2	4	4	17	199	12	2
TW-4	Not Sampled							
D-1	10-18-83	<1	<1	<1	<1	<1	<1	<1
D-2	10-18-83	<1	<1	<1	<1	<1	<1	<1
D-3	10-18-83	1	<1	<1	<1	<1	<1	<1
D-4	10-18-83	<1	<1	<1	<1	<1	<1	<1
D-5	10-18-83	<1	250	23	2,120	588	10	<1
D-5A	10-18-83	1	195	19	1,920	340	4	2
D-6	10-18-83	<1	<1	<1	11	4	<1	<1
D-9	10-18-83	<1	<1	<1	<1	<1	<1	<1
D-10	10-18-83	<1	<1	<1	<1	<1	<1	<1
D-12	10-18-83	9	1,010	55	9,820	1,190	<1	<1
D-14	10-18-83	2	773	<1	7,640	954	5	<1
D-15	10-18-83	1,180	8	10	26	17,400	2,950	11
D-18	10-18-83	<1	<1	<1	<1	517	254	2
D-19	10-18-83	<1	<1	2	<1	518	67	<1
TW-1	01-25-84	1	<1	<1	<1	<1	<1	<1
TW-1A	01-25-84	<1	<1	<1	<1	<1	<1	<1
TW-2	01-25-84	<1	<1	2	<1	6	<1	<1
TW-2A	01-25-84	<1	<1	<1	<1	20	<1	<1
TW-3	01-25-84	<1	5	5	38	500	27	<1
TW-4	01-25-84	5	2,330	57	20,400	5,360	<1	1
D-1	01-25-84	**	**	**	**	**	**	**
D-2	01-25-84	**	**	**	**	**	**	**
D-3	01-25-84	**	**	**	**	**	**	**

TABLE 8
(Continued)

:ll No.	Date Sampled	Methylene chloride	1,1-Dichloro-ethylene	Trans 1,2-dichloroethylene	1,1,1-Trichloro-ethane	Trichloro-ethylene	Tetrachloro-ethylene	Toluene
D-4	01-25-84	**	**	**	**	**	**	**
D-5	01-25-84	<1	91	14	1,150	404	<1	1
D-6	01-25-84	<1	<1	<1	6	3	<1	<1
D-9	01-25-84	<1	<1	<1	<1	<1	<1	<1
D-10	01-25-84	<1	<1	<1	<1	<1	<1	<1
D-12	01-25-84	<50	1,570	100	18,300	3,600	<50	<50
D-14	01-25-84	<1	140	6	1,720	363	<1	<1
D-15	01-25-84	<50	<50	<50	<50	29,200	1,100	<50
D-18	01-25-84	2	1	1	6	2,290	150	<1
D-19	01-25-84	Dry						
TW-1	05-25-84	<4	<4	<4	6	<4	<4	<4
TW-1A	05-25-84	<4	<4	<4	<4	<4	<4	<4
TW-2	05-25-84	<4	<4	<4	<4	<4	<4	<4
TW-2A	05-25-84	<4	<4	<4	6	<4	<4	<4
TW-3	05-25-84	<4	<4	<4	30	180	44	<4
TW-4	05-25-84	<50	3,450	<50	31,200	13,700	<50	<4
D-5	05-25-84	<4	<4	<4	4,150	650	<4	<4
D-6	05-25-84	<4	<4	<4	16	<4	<4	<4
D-9	05-25-84	<4	<4	<4	6	<4	<4	<4
D-10	05-25-84	<4	<4	<4	<4	<4	<4	<4
D-12	05-25-84	<10	990	<10	10,600	2,050	<10	<4
D-14	05-25-84	<10	233	<10	2,580	530	<10	<4
D-15	05-25-84	<50	<50	<50	<50	41,800	2,670	<4
D-18	05-25-84	<4	<4	<4	<4	660	117	<4
D-19	05-25-84	<4	<4	<4	<4	4,780	980	<4
D-23	05-25-84	<4	56	<4	692	<4	<4	<4
D-24	05-25-84	--	--	--	--	--	--	<4
D-25	05-25-84	--	--	--	--	--	--	<4
D-26	05-25-84	<4	84	<4	957	328	<4	<4
D-27	05-25-84	<4	<4	<4	<4	<4	<4	<4

Note: All analysis results are microgram/liter

*Warzyn Analysis
**No Analysis

EXTRACTION WELL SYSTEM

Donohue applied and calibrated a contaminant transport model describing plume movement which is explained in "Groundwater Modeling of Solvent Contamination near City of Delavan Well No. 4", by Donohue & Associates, Inc., December, 1983. The general aquifer characteristics were defined from field data including water level information, topography, and pump tests. The aquifer is unconfined with a storage coefficient of 0.1, a porosity of 35 percent, a transmissivity of 150,000 gpd/ft, and a hydraulic conductivity of 1,250 gpd/ft². The high transmissivity and hydraulic conductivity of the aquifer results in a rapid groundwater velocity of approximately 2 feet/day and a fairly narrow plume. The high transmissivity does not allow nearby pumping wells to have a profound effect on contaminant movement even though their cone of depression is large. Although the cone of depression is large, drawdowns away from the well are very small, resulting in a small cone of influence.

This knowledge of the groundwater system was used to aid the design of and extraction well system. The purpose of the extraction wells is to intercept the majority of contaminants moving off-site from the pump area and from beneath Plant 1. Extraction Well No. 1 currently intercepts contamination from the pump area. Additional extraction wells are required to intercept the plume from Plant 1.

The estimated plume boundaries and location of extraction wells are shown on Figure 14. These well locations were chosen for three reasons. First, extraction wells should be placed in a line perpendicular to groundwater flow to maximize the interception of the cones of depression from each of the wells. This placement maximizes drawdown and causes movement of contaminants towards the wells. Secondly, the extraction wells are placed as close to the suspected source as possible to intercept the contaminants where less downward dispersion of the contaminants has occurred. Lastly, the cone of influence of each well was assumed to be slightly less than a 100 foot radius, resulting in the wells being placed on approximately 200 foot centers. The wells will extend 20 feet below the water table and pump at approximatley 80 gpm. This depth is recommended to withdraw water as close to the water table as possible since most of the contamination stays in the upper portion of the aquifer. This depth is also needed to allow for sufficient drawdown at the required pumping rates.

After preliminary placement of the extraction wells, our previous model was re-run to estimate the amount of contaminants which would be captured by the extraction wells. However, a number of the parameters in the model were changed. Specifically, the model was changed to account for the three-dimensional problems in the two-dimensional model. We reduced the aquifer thickness and increased the transmissivity to 20 feet and 40,000 gpd/ft respectively. The aquifer thickness was reduced because the depth of the wells is 20 feet. The effect of this reduction is to increase the amount of contamination entering the wells. Actually less contamination will be captured because the wells will be withdrawing water from a depth greater than 20 feet. To compensate for this partial penetration affect, the transmissivity was increased from 25,000 gpd/ft (Donohue & Associates, Inc., 1983; corrected pump test results, this report) to 40,000 gpd/ft (uncorrected

STORAGE

STORAGE

CHICAGO, MILWAUKEE, ST.PAUL AND PACIFIC R.R.

PROPOSED
EX.6

RECEIVING

D-23

D-24

EX.5
PROPOSED

D-6
D-5

PROPOSED
EX.4

PLANT 1

B-11

D-12

B-13

PROPOSED
EX.3

D-14

D-25
D-26
D-27

PROPOSED
EX.2

TB-5

TW-4 TB-4

TB-7

TB-8

TB-9

PARKING

TW-2A
TW-2

PARKING

B-16   B-17
D-15

TB-2
TB-1   TB-3

PLANT 2

0   50'   100'

D-19 D-18

D-4
D-3

WRIGHT STREET

EX.1

PARKING
D-13

TW-3

CITY
WELL
NO. 4

PLANT 2

TW-1A
TW-1

D-10 D-9

LEGEND

D   DONOHUE WELL
B   DONOHUE BORING
TW   WARZYN WELL
TB   WARZYN BORING
EX. DONOHUE EXTRACTION WELL
——— PLUME BOUNDARY

Donohue

JUNE 1984

12894.000

Engineers & Architects

PLUME BOUNDARY AND LOCATION OF EXTRACTION WELLS

STA-RITE INDUSTRIES, INC. WATER EQUIPMENT DIVISION

DELAVAN, WISCONSIN

N

0   100'   200'

FIGURE 14

results). Increasing the transmissivity decreases the influence of the wells. The gradient was changed to .005 ft/ft and flow direction was 75° west of north.

When the model was re-run with these modifications, the majority of contaminants were intercpeted by the extraction system. The model was run with various pumping rates and with four and five extraction wells. It was found that five wells were necessary to intercept substantially all of the contamination.

Darcy's law was applied as a rough check to determine if the five extraction wells were adequate to capture the contaminants. The estimated flow from the upper 20 feet of the aquifer across the plume is calcuated from:

$$Q = KIA \text{ where:}$$

$$Q = \text{groundwater discharge}$$
$$K = \text{hydraulic conductivity}$$
$$I = \text{gradient}$$
$$A - \text{cross-section area}$$

and is equal to,

$$120 \text{ gpd/ft}^2 \text{ x .005 x 20 ft x 1,000 ft} = 125,000 \text{ gal/day.}$$

For the entire acquifer thickness the flow estimate is:

$$1,250 \text{ gpd/ft}^2 \text{ x .005 x 120 ft x 1,000 ft} = 750,000 \text{ gal/day}$$

With six wells pumping at 80 gpm 691,000 gal/day of water would be withdrawn from the system. This analysis indicates these wells would be adequate to capture substantially all of the contaminants. Actual pumping rates will be adjusted after well placement to ensure maximum containment capture.

Limitations of this model must be recognized. A large model is required to precisely account for three-dimensional components to the contaminant movement in this system. We compensated for this by changing the transmissivity. By doing this, it may be necessary to also change the dispersivities. This could be checked by recalibrating the model. Because of insufficient data including the uncertainty of the source area, this was not done. However, the model worked well to approximate conditions, Darcy's law was consistent with the model results, and the cost of a larger model or recalibration is not justified. Therefore, the recommended approach is to install the wells and adjust the pumping rate as required.

The extracted water will be discharged to the city storm sewer system. The storm sewer along the west boundary of Sta-Rite is a 54-inch pipe with a 0.3 percent slope. The expected flow from the extraction system, including the extraction well at Plant 2, 1 cfs, is less than 1 percent of the sewer design flow. There should be no problems with sewer flooding during design rain events. The concentration of chlorinated organics in the water discharge

to the storm sewer is expected to be less than 1.0 mg/l. This estimate is based on the concentration found in nearby monitoring wells and the fact that some dilution will occur as clean water is pulled into the wells. The effluent guidelines for the metal finishing industry permit a discharge of 2.13 mg/l.

Since the source for the contaminants in this area is suspected to be beneath Plant 1, the pumping life of the wells cannot be determined. Periodic monitoring of the downgradient monitoring wells and extraction wells can be used to determine the required pumping period.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

Since our April 1984 submittal to the Department of Natural Resources, we have completed additional site investigations and evaluation of the remedial action requirements to address the groundwater contamination on Sta-Rite property in Delavan, Wisconsin. We conclude the following:

1. Soils contaminated with chlorinated solvents can be cleaned by extraction with water. Laboratory evaluations confirm the partition coefficients reported in the literature.

2. If the soils in the vicinity of the Plant 2 sump are flushed at a rate of approximately 5 gpm, approximately 160 days will be required to substantially remove the contaminants.

3. The extent of contamination of soils in the vicinity of the casting and chip storage area is relatively small and cannot explain the concentration of solvents in the groundwater beneath and downgradient from Plant 1. We therefore conclude that the primary source of contamination of groundwater downgradient from Plant 1 is beneath Plant 1.

4. At the Plant 1 west boundary, the contaminants are confined to the top 20 feet of the aquifer.

5. A total of six extraction wells including the extraction well for the Plant 2 sump, will substantially reduce the off-site movement of the contaminants when the wells are pumped at approximately 80 gpm each. The effectiveness of the extraction well system will be monitored using existing groundwater monitoring wells downgradient of the extraction system. The water from the extraction wells should be discharged to the storm sewer system.

Based on the results of these investigations, we recommend that Sta-Rite install the groundwater extraction system with a discharge to the 54-inch storm sewer along the plant boundary. A portion of water from the extraction well at Plant 2 should continue to be used for flushing soils in the vicinity of the Plant 2 sump until monitoring wells in the immediate vicinity of the sump indicate substantial removal of contaminants. No further site remedial actions or investigations are recommended.

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APPENDIX A

BORING LOGS

RECORD OF SUBSURFACE EXPLORATION

GILES ENGINEERING ASSOCIATES, INC.

Consulting Soil and Foundation Engineers

Boring No. **23**

Project: **Sta Rite Industries**   Date: **5-17-84**

Delevan, Wisconsin   GEA Project No.: **840417**

Crew Chief: **Duane Drewicz**

DESCRIPTION Ground Surface Elevation	Depth Below Surface	Sample No. & Type	N	q_u	q_p	q_s	w	REMARKS
Light Brown Silty very fine Sand, trace coarse Sand, trace fine Gravel (Damp) (SM)								
	5'	1-SS	15					
Tan fine Sand, trace coarse Sand, some fine Gravel (Damp), Cobbles at 7.5' (SP) Trace Silt	10'	2-SS	63					
Tan fine to coarse Sand, fine to coarse Gravel, trace Silt (Damp to Wet) (SW)	15'	3-SS	64					
	20'	4-SS	69					
	25'	5-SS	110					
	30'	6-SS	42					▼ Water at 30' upon completion
	35'	7-SS	18					
Boring Terminated at 38' Well Set at 38'	40'							
	45'							

Changes of strata indicated by the lines are approximate boundary between soil types. The actual transition may be gradual and may vary considerably between boring locations.

RECORD OF SUBSURFACE EXPLORATION

GILES ENGINEERING ASSOCIATES, INC.

Consulting Soil and Foundation Engineers

Boring No. ____24____

Project: ___Sta Rite Industries___   Date: _5-17-84_

___Delevan, Wisconsin___   GEA Project No.: _840417_

Crew Chief: Duane Drewicz

DESCRIPTION Ground Surface Elevation	Depth Below Surface	Sample No. & Type	N	q_u	q_p	q_t	w	REMARKS
Light Yellow-Brown Silty Clay(Fill) (Damp)- (ML-CL)								
	5'	1-SS	8					
Note A Probable old Topsoil Layer	10'	2-SS	4					
Light Brown fine Clayey Sandy Silt, little to some medium to coarse Sand, trace fine Gravel (Moist) (SM)	15'	3-SS	17					
Tan to Dark Brown fine to coarse Sand, fine to coarse Gravel, trace Silt(Damp) (SW)	20'	4-SS	65					
	25'	5-SS	102					
								▼ Water at 27' upon completion
Tan fine Sand, trace medium to coarse Sand, trace fine Gravel(Wet) trace Silt (SP)	30'	6-SS	24					
Tan fine to coarse Sand, some fine to coarse Gravel, trace Silt (Wet) (SW)	35'	7-SS	12					
Boring Terminated at 36' Well Set at 36' Note A: Dark Brown Silty Clay to Clayey Silt, trace Organic Matter (Roots), (OL)	40'							
	45'							

Changes of strata indicated by the lines are approximate boundary between soil types. The actual transition may be gradual and may vary considerably between boring locations.

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RECORD OF SUBSURFACE EXPLORATION

GILES ENGINEERING ASSOCIATES, INC.

Consulting Soil and Foundation Engineers

Boring No. 25

Project: Sta-Rite Industries

Date: 5-15-84

Delevan, Wisconsin

GEA Project No.: 840417

Crew Chief: Duane Drewicz

DESCRIPTION Ground Surface Elevation	Depth Below Surface	Sample No. & Type	N	q_u	q_p	q_s	W	REMARKS
Auger advanced to 35' casing set and cleaned 4" well set at 35'	5'							
	10'							
	15'							
	20'							
	25'							
	30'							
	35'							
Boring Terminated at 35'	40'							
	45'							

Changes of strata indicated by the lines are approximate boundary between soil types. The actual transition may be gradual and may vary considerably between boring locations.

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RECORD OF SUBSURFACE EXPLORATION

GILES ENGINEERING ASSOCIATES, INC.

Consulting Soil and Foundation Engineers

Boring No. __26__

Project: __Sta Rite Industries__   Date: __5-10-84__

__Delevan, Wisconsin__   GEA Project No.: __840417__

Crew Chief: __Duane Drewicz__

DESCRIPTION Ground Surface Elevation	Depth Below Surface	Sample No. & Type	N	q_u	q_p	q_s	w	REMARKS
Auger advanced to 50' Casing set and cleaned 4" Well set at 50'	10'							
	20'							
	30'							
	40'							
	50'							
Boring Terminated at 50'	60'							
	70'							
	75'							

Changes of strata indicated by the lines are approximate boundary between soil types. The actual transition may be gradual and may vary considerably between boring locations.

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RECORD OF SUBSURFACE EXPLORATION

GILES ENGINEERING ASSOCIATES, INC.

Consulting Soil and Foundation Engineers

Boring No. **27A**

Project: **Sta. Rite Industries**

Delevan, Wisconsin

Date: **5-2-84**

GEA Project No.: **840417**

Crew Chief: **Duane Drewicz**

DESCRIPTION Ground Surface Elevation	Depth Below Surface	Sample No. & Type	N	q_u	q_p	q_s	w	REMARKS
Yellow Brown Silty Clay (Damp) (ML-CL)	5'	1-SS	11					
Tan Silty fine Sand, trace little medium to coarse Sand, trace fine Gravel (Damp) (SM)	10'	2-SS	7					
Tan Silty very fine Sand, trace to little medium to coarse Sand, trace fine Gravel, trace Clay, (DAMP) (SM)	15'	3-SS	29					
Tan fine to coarse Sand, fine Gravel, trace Silt(Damp to Wet) (SW)	20'	4-SS	63					▼ Water at 18' upon completion
	25'	5-SS	85					
	30'	6-SS	37					
	35'	7-SS	26					
	40'	8-SS	32					
	45'	9-SS	39					

Changes of strata indicated by the lines are approximate boundary between soil types. The actual transition may be gradual and may vary considerably between boring locations.

RECORD OF SUBSURFACE EXPLORATION

GILES ENGINEERING ASSOCIATES, INC.
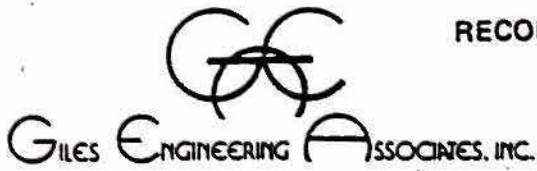
Consulting Soil and Foundation Engineers

Boring No. _____27B_____

Project: __Sta Rite Industries__   Date: __5-2-84__
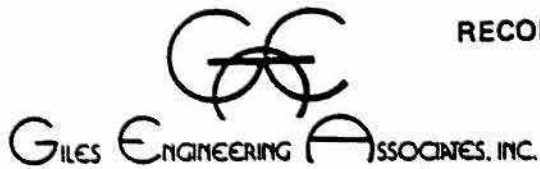
__Delevan, Wisconsin__   GEA Project No.: __840417__

Crew Chief: Duane Drewicz

DESCRIPTION Ground Surface Elevation	Depth Below Surface	Sample No. & Type	N	q_u	q_p	q_s	W	REMARKS
Tan very fine Sandy Silt to Silty Sand, trace coarse Sand, some Clay (Damp) (ML-SM)	50'	10-SS	25					
interbedded fine Sand Seams	55'	11-SS	68					
Tan very fine Sandy Silt, some Clay, trace to little medium to coarse Sand, trace fine to coarse Gravel-Damp (SM)	60'	12-SS	34					
Tan fine Sand, little medium to coarse Sand,, trace Gravel (Wet) (SP)	65'	13-SS	2					
	70'	14-SS	54					
Tan fine to coarse Sand, trace Gravel (Wet)	75'	15-SS	67					
Boring Terminated at 76' Well Set at 75'	80'							
	85'							
	90'							

Changes of strata indicated by the lines are approximate boundary between soil types. The actual transition may be gradual and may vary considerably between boring locations.

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APPENDIX B
PUMP TEST DATA

STA-RITE
PUMP TEST DATA
JUNE 4,1984   WELL NO. D-15
EX-1 PUMPING@ 84GPM
STATIC WATER LEVEL=30.73   TAPE FACTOR=-0.1FT

TIME	ELAPSED TIME	WATER ELEV.	DRAWDOWN
10.28	0	30.73	0
	0.5	30.75	0.02
	1	30.79	0.06
	1.5	30.79	0.06
	2	30.79	0.06
	2.5	30.79	0.06
	3	30.79	0.06
	3.5	30.79	0.06
	4	30.81	0.08
	4.5	30.83	0.1
	5	30.83	0.1
	5.5	30.83	0.1
	6	30.83	0.1
	6.5	30.83	0.1
	7	30.83	0.1
	7.5	30.83	0.1
	8	30.85	0.12
	9	30.85	0.12
	10	30.85	0.12
	11	30.85	0.12
	12	30.88	0.15
	13	30.88	0.15
	14	30.88	0.15
	15	30.88	0.15
	16	50.88	0.15
	17	30.92	0.19
	18	30.92	0.19
	19	30.92	0.19
	20	30.92	0.19
	22	30.92	0.19
	24	30.92	0.19
	26	30.94	0.21
	28	30.94	0.21
	30	30.94	0.21
	32	30.96	0.23
	34	30.96	0.23
	36	30.98	0.25
	40	30.98	0.25
	45	30.98	0.25
	50	31	0.27
	55	31	0.27
	60	31	0.27
	65	31	0.27
	70	30.92	0.19
	75	30.92	0.19
	80	30.88	0.15
	90	30.88	0.15
	100	30.88	0.15

110	30.88	0.15
120	30.85	0.12
130	30.85	0.12
140	30.85	0.12
150	30.85	0.12
160	30.85	0.12
170	30.85	0.12
180	30.85	0.12
190	30.85	0.12
200	30.85	0.12
220	30.85	0.12
240	30.85	0.12
260	30.85	0.12
280	30.85	0.12
300	30.85	0.12
320	30.83	0.1
340	30.83	0.1
360	30.83	0.1
420	30.84	0.11
480	30.84	0.11
540	30.87	0.14
600	30.85	0.12
690	30.85	0.12
780	30.86	0.13
900	30.86	0.13
1080	30.9	0.17
1260	30.9	0.17
1440	30.9	0.17
1680	30.9	0.17
1920	30.93	0.3
2220	30.93	0.2
2520	30.93	0.2
2820	30.95	0.22
3180	30.91	0.18
3540	30.98	0.25
4020	30.98	0.25
4500	30.92	0.19

STA-RITE
PUMP TEST DATA
JUNE 4,1984   WELL NO.TW-2
EX-1 PUMPING@ 84GPM
STATIC WATER LEVEL=30.55

TIME	ELAPSED TIME	WATER LEVE	DRAWNDOWN
10.28	0	30.55	0
	0.5	30.55	0
	1	30.56	0.01
	1.5	30.56	0.01
	2	30.56	0.01
	2.5	30.56	0.01
	3	30.56	0.01
	3.5	30.56	0.01
	4	30.56	0.01
	4.5	30.56	0.01
	5	30.56	0.01
	5.5	30.56	0.01
	6	30.56	0.01
	6.5	30.56	0.01
	7	30.56	0.01
	7.5	30.56	0.01
	8	30.56	0.01
	9	30.56	0.01
	10	30.56	0.01
	11	30.56	0.01
	12	30.56	0.01
	13	30.56	0.01
	14	30.56	0.01
	15	30.56	0.01
	16	30.56	0.01
	17	30.56	0.01
	18	30.56	0.01
	19	30.56	0.01
	20	30.56	0.01
	22	30.56	0.01
	24	30.56	0.01
	26	30.56	0.01
	28	30.57	0.02
	30	30.57	0.02
	32	30.57	0.02
	34	30.57	0.02
	36	30.57	0.02
	40	30.57	0.02
	45	30.57	0.02
	50	30.58	0.03
	55	30.58	0.03
	60	30.58	0.03
	65	30.58	0.03
	70	30.58	0.03
	75	30.58	0.03
	80	30.58	0.03
	90	30.57	0.02
	100	30.57	0.02

110	30.57	0.02
120	30.57	0.02
130	30.57	0.02
140	30.57	0.02
150	30.57	0.02
160	30.58	0.03
170	30.58	0.03
180	30.58	0.03
190	30.58	0.03
200	30.58	0.03
220	30.59	0.04
240	30.59	0.04
260	30.59	0.04
280	30.59	0.04
300	30.59	0.04
320	30.59	0.04
340	30.59	0.04
360	30.59	0.04
420	30.61	0.06
480	30.61	0.06
540	30.63	0.08
540	30.63	0.08
600	30.64	0.09
690	30.68	0.13
780	30.67	0.12
900	30.71	0.16
1080		
1260	30.49	-0.06
1440		
1680	30.49	-0.06
1920		
2220	30.53	-0.02
2520		
2820	30.55	0
3180	30.53	-0.02
3540	29.57	-0.98
4020		
4500	30.53	-0.02
		-30.55
		-30.55
		-30.55

STA-RITE
PUMP TEST DATA
JUNE 4,1984   WELL NO. D-19
EX-1 PUMPING@ 84GPM
STATIC WATER LEVEL=28.81   TAPE FACTOR=-0.05ft

TIME	ELAPSED TIME	WATER LEVEL	DRAWDOWN
10.28	0	28.81	
	0.5	28.92	0.06
	1	28.95	0.09
	1.5	28.97	0.11
	2	28.99	0.13
	2.5	29.01	0.15
	3	29.01	0.15
	3.5	29.01	0.15
	4	29.01	0.15
	4.5	29.01	0.15
	5	29.03	0.17
	5.5	29.04	0.18
	6	29.04	0.18
	6.5	29.05	0.19
	7	29.06	0.2
	7.5	29.06	0.2
	8	29.07	0.21
	9	29.07	0.21
	10	29.07	0.21
	11	29.07	0.21
	12	29.06	0.22
	13	29.09	0.23
	14	29.1	0.24
	15	29.1	0.24
	16	29.11	0.25
	17	29.11	0.25
	18	29.12	0.26
	19	29.13	0.27
	20	29.13	0.27
	22	29.14	0.28
	24	29.15	0.29
	26	29.15	0.29
	28	29.17	0.31
	30	29.17	0.31
	32	29.18	0.32
	34	29.2	0.34
	36	29.2	0.34
	40	29.2	0.34
	45	29.22	0.36
	50	29.23	0.37
	55	29.25	0.39
	60	29.26	0.4
	65	29.26	0.4
	70	29.23	0.37
	75	29.23	0.37
	80	29.24	0.38
	90	29.24	0.38
	100	29.24	0.38

110	29.24	0.38
120	29.25	0.39
130	29.25	0.39
140	29.25	0.39
150	29.25	0.39
160	29.25	0.39
170	29.25	0.39
180	29.26	0.4
190	29.26	0.4
200	29.26	0.4
220	29.27	0.41
240	29.28	0.42
260	29.3	0.44
280	29.31	0.45
300	29.31	0.45
320	29.31	0.45
340	29.31	0.45
360	29.31	0.45
420	29.32	0.46
480	29.33	0.47
540	29.34	0.48
600	29.35	0.49
690	29.39	0.53
780	29.35	0.49
900	29.35	0.49
1080		
1260	29.19	0.33
1440	29.19	0.33
1680	29.2	0.34
1920	29.22	0.36
2220	29.25	0.39
2520		
2820	29.25	0.39
3180	29.22	0.36
3540	29.28	0.42
4020		
4500	29.23	0.37

STA-RITE
PUMP TEST DATA
JUNE 4,1984   WELL NO. TW-3 corner bldg.#2
EX-1 PUMPING@ 84GPM
STATIC WATER LEVEL=30.74   TAPE FACTOR=-0.2ft

TIME	ELAPSED TIME	WATER LEVEL	DRAWDOWN
10.28	0	30.74	
	0.5	30.76	0.02
	1.	30.78	0.04
	1.5	30.8	0.06
	2	30.84	0.1
	2.5	30.84	0.1
	3	30.85	0.11
	3.5	30.85	0.11
	4	30.86	0.12
	4.5	30.86	0.12
	5	30.86	0.12
	5.5	30.86	0.12
	6	30.86	0.12
	6.5	30.86	0.12
	7	30.86	0.12
	7.5	30.9	0.16
	8	30.9	0.16
	9	30.9	0.16
	10	30.91	0.17
	11	30.91	0.17
	12	30.92	0.18
	13	30.94	0.2
	14	30.95	0.21
	15	30.95	0.21
	16	30.96	0.22
	17	30.97	0.23
	18	30.97	0.23
	19	30.97	0.23
	20	30.97	0.23
	22	30.98	0.24
	24	31	0.26
	26	31	0.26
	28	31.01	0.27
	30	31.02	0.28
	32	31.02	0.28
	34	31.03	0.29
	36	31.04	0.3
	40	31.04	0.3
	45	31.05	0.31
	50	31.07	0.33
	55	31.09	0.35
	60	31.09	0.35
	65	31.07	0.33
	70	31.07	0.33
	75	31.05	0.31
	80	31.05	0.31
	90	31.03	0.29
	100	31.03	0.29

110	31.03	0.29
120	31.03	0.29
130	31.02	0.28
140	31.01	0.27
150	31.02	0.28
160	31.03	0.29
170	31.03	0.29
180	31.02	0.28
190	31.02	0.28
200	31.02	0.28
220	31.02	0.28
240	31.02	0.28
260	31.04	0.3
280	31.04	0.3
300	31.04	0.3
320	31.03	0.29
340	31.03	0.29
360	31.03	0.29
420	31.03	0.29
480	31.03	0.29
540	31.05	0.31
600	31.05	0.31
690	31.08	0.34
780	31.05	0.31
900	31.07	0.33
1080		
1260	31.09	0.35
1440	31.11	0.37
1680	31.11	0.37
1920	31.15	0.41
2220	31.15	0.41
2520		
2820	31.16	0.42
3180	31.14	0.4
3540	31.2	0.46
4020		
4500	31.14	0.4

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STA-RITE
PUMP TEST DATA
JUNE 4,1984            WELL NO. TW-1
EX-1 PUMPING@ 84GPM
STATIC WATER LEVEL=27.30    TAPE FACTOR=-0.1FT
TIME            ELAPSED TIME        WATER LEVEL         DRAWDOWN
    10.28            0               27.3                    0
                     0.5            27.3                    0
                     1              27.31                0.01
                     1.5            27.31                0.01
                     2              27.32                0.02
                     2.5            27.32                0.02
                     3              27.32                0.02
                     3.5            27.33                0.03
                     4              27.33                0.03
                     4.5            27.33                0.03
                     5              27.33                0.03
                     5.5            27.34                0.04
                     6              27.35                0.05
                     6.5            27.35                0.05
                     7              27.35                0.05
                     7.5            27.35                0.05
                     8              27.35                0.05
                     9              27.35                0.05
                     10             27.35                0.05
                     11             27.35                0.05
                     12             27.35                0.05
                     13             27.35                0.05
                     14             27.35                0.05
                     15             27.35                0.05
                     16             27.36                0.06
                     17             27.36                0.06
                     18             27.37                0.07
                     19             27.37                0.07
                     20             27.38                0.08
                     22             27.38                0.08
                     24             27.39                0.09
                     26             27.39                0.09
                     28             27.39                0.09
                     30             27.39                0.09
                     32             27.4                 0.1
                     34             27.4                 0.1
                     36             27.41                0.11
                     40             27.42                0.12
                     45             27.44                0.14
                     50             27.45                0.15
                     55             27.45                0.15
                     60             27.35                0.05
                     65             27.29               -0.01
                     70             27.24               -0.06
                     75             27.2                -0.1
                     80             27.16               -0.14
                     90             27.12               -0.18
                     100            27.08               -0.22
```

110	27.06	-0.24
120	27.04	-0.26
130	27.02	-0.28
140	27	-0.3
150	26.99	-0.31
160	26.98	-0.32
170	26.98	-0.32
180	26.95	-0.35
190	26.95	-0.35
200	26.95	-0.35
220	26.94	-0.36
240	26.94	-0.36
260	26.93	-0.37
280	26.86	-0.44
300	26.87	-0.43
320	26.87	-0.43
340	26.86	-0.44
360	26.86	-0.44
420	26.83	-0.47
480	26.83	-0.47
540	26.81	-0.49
600	26.84	-0.46
630	26.84	-0.46
780	26.84	-0.46
900	26.83	-0.47
1080		
1260	26.6	-0.7
1440	26.6	-0.7
1680	26.6	-0.7
1920	26.6	-0.7
2220	26.65	-0.65
2520		
2820	26.65	-0.65
3180	26.61	-0.69
3540	26.73	-0.57
4020		
4500	26.59	-0.71