IBM Corporation
Poughkeepsie, New York

SITE GRAVEL SUPPLEMENT TO FINAL GROUNDWATER REPORT: MAIN PLANT SITE

February 1985

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R.E. WRIGHT ASSOCIATES, Inc.
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CHAPTER 1.0

INTRODUCTION

This report summarizes the investigation into the hydrogeology and chemistry and the consideration of remediation at the main plant site gravel. The conclusion drawn from the investigation was that remediation of this chemical plume is not warranted. In keeping with the overall logic applied to the determination of the need for remediation, this report demonstrates that:

- The source of chemical in the site gravel is not locatable.
- The source is not recoverable.
- The site gravel is not a developable water resource, potable or otherwise.
- There is no impact of the chemicals, either on Spring Brook or the Hudson River.

The report format follows these four points, with some reference made to portions of the Final Groundwater Report: Main Plant Site (LMS et al. 1984).

CHAPTER 2.0

SOURCE NOT LOCATABLE

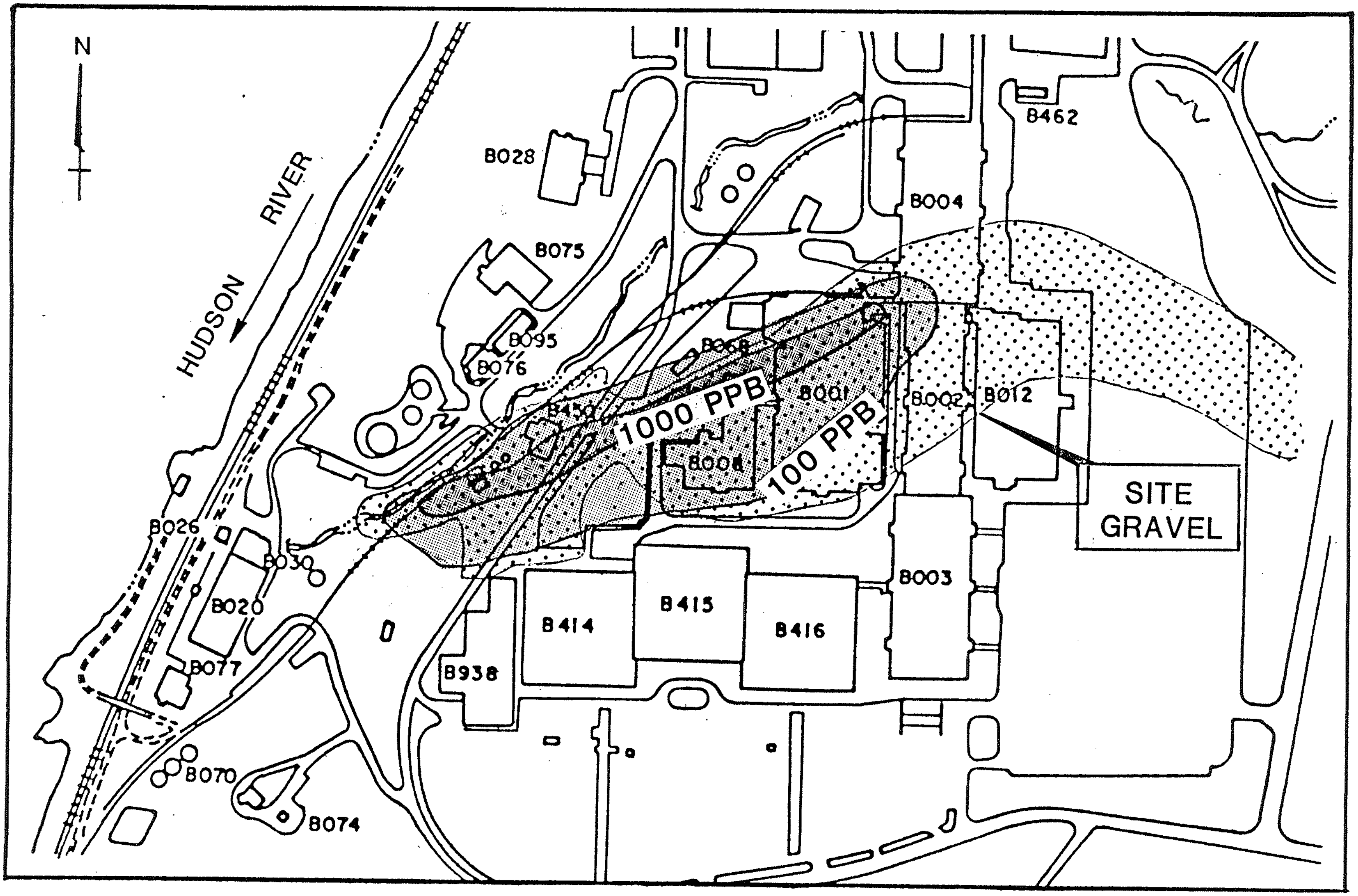
This section first discusses in generic terms the difficulty of locating the type of source causing the gravel chemical plume, and then follows with some specific characteristics of the site gravel that make its source especially difficult to locate.

As discussed in Appendix B of the final groundwater report on the main plant site (LMS et al. 1984), and further in Chapter 4.0 of this report, the flux of chemical (mainly trichloroethylene [TCE]) is conservatively (high) estimated to be less than 0.73 lb/day. It is presumed that the source of this chemical is dense non-aqueous phase liquid (DNAPL) TCE (as explained in Chapter 3.0 of LMS et al. [1984] and later in this report). At a flux rate of 0.73 lb/day, a 50-year supply of this flux (about 1000 gal, as DNAPL), with a porosity of sand and gravel of 0.2, could occupy a volume of soil as small as 10 x 10 x 7.5 ft deep. This is a specific example of the generality expressed in Chapter 3.0 of the final report: that it is highly improbable that a drilling program will find such a source.

Some specific characteristics of the site gravel and its presumed source make this source even more difficult to find than another of the same size might be. Figure 2.0-1 shows a map summarizing the site gravel chemistry, which is given in detail in Appendix A of the final report (LMS et al. 1984). The figure shows quite clearly, from the shape of the chemical plume, that the source of chemical is in the vicinity of the southwest corner of Building 004. Boring T-8 is drilled as close as practicable to the west wall of Building 004, and its TCE concentration is about 5000 parts per billion (ppb). The shape of the chemical plume coincides quite neatly with the delineation of the site gravel itself

FIGURE 2.0-1

SITE GRAVEL CHEMISTRY



based on the hydrogeological investigation, which is also shown on Figure 2.0-1. The trend of the site gravel is from northeast to southwest.

The known history of chemical use and handling in Building 004 supports the likelihood that the source is under the building. In the mid-1970s large quantities of TCE - in the order of millions of pounds per year - were used in its southern portion. A potential loss of thousands or even tens of thousands of pounds of TCE over a 2-3 year period would thus be insignificant from an inventory point of view. It is also noted that the IBM air permits allowed emissions of 150 lb/hr of TCE influent to the abatement system over this period; this again indicates that a loss of tens of thousands of pounds of chemical would be impossible to detect on an inventory basis, so that the time and place of loss cannot be pinpointed.

Because large quantities were used, the handling system included a TCE distillation unit for recovery and reuse of TCE. Part of this system was a gravity separation unit containing both TCE and an overlying layer of water, itself presumably saturated with TCE. This separation was a preliminary step in the recovery of TCE; the water (containing dissolved TCE) was decanted off the surface and directed to the industrial waste treatment plant (IWTP). In times of upset, however, pure product TCE would fill the vat, spill over the weir, and enter the pipe leading to the IW sewers. Because this pipe, under the slab of B004, was constructed of PVC, it deteriorated; this eventually led to its being taken out of service, but not before the opportunity for quantities of DNAPL TCE to be discharged into the soil under B004. The exact location of pipe break(s) is unknown.

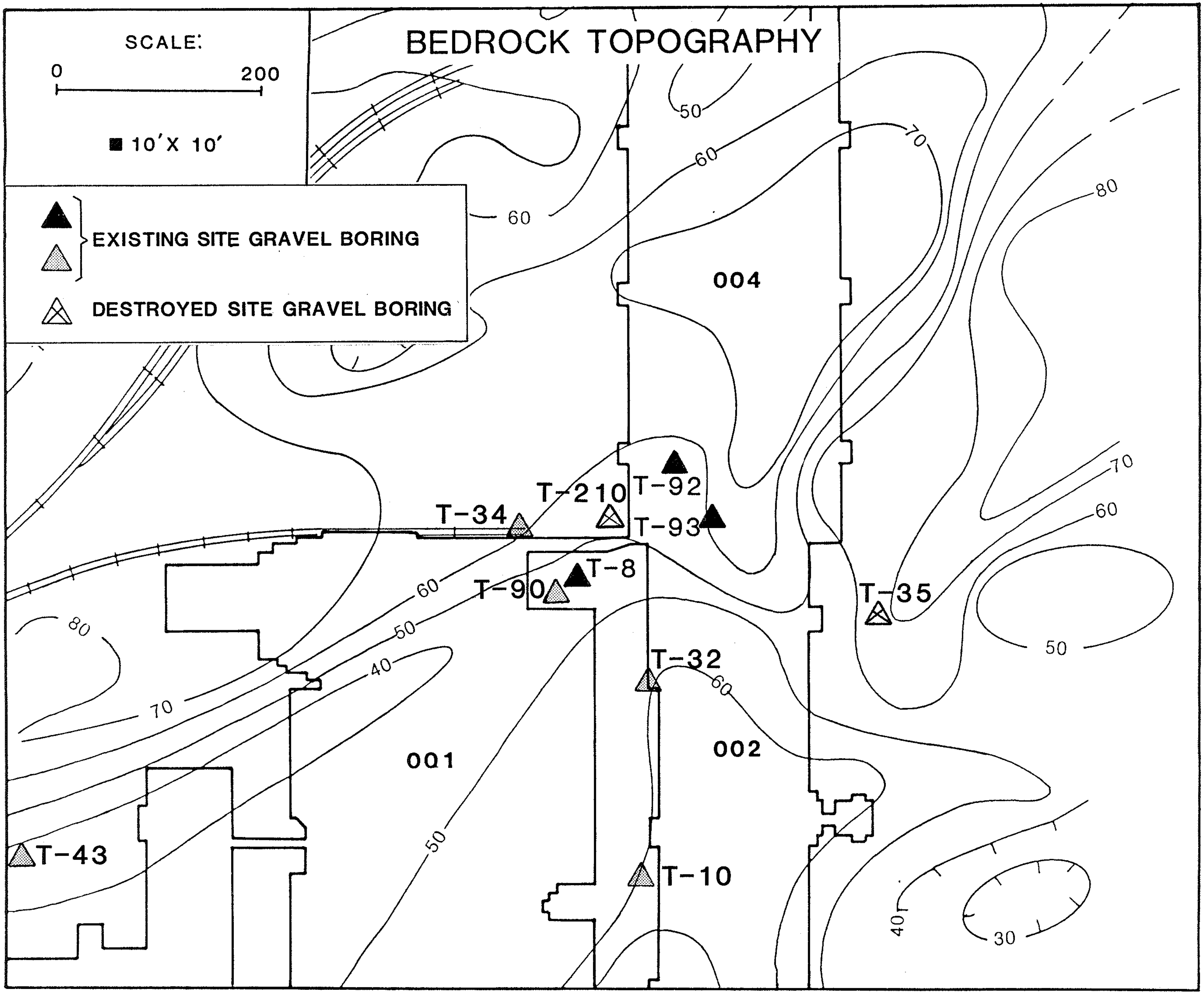
Besides being introduced to the subsurface soil by the known break in the pipe, chemical could also have penetrated through drains and cracks in the floor during spill events, which probably occurred. Therefore, it is likely that there is more than one source.

Based on the groundwater chemistry pattern, the areas of use of the chemical, and the fact that the TCE handling system under the B004 slab is known to have ruptured, we conclude that the site gravel chemical source is under the building, but that the exact location of the point(s) of introduction is not known.

It is difficult to operate drilling equipment inside any industrial building, even one not in use. When the building is in use - and, further, is being used for the manufacture of sensitive equipment such as computers - manufacturing needs control not only the location of a drilling rig, but also the amount of vibration that can be tolerated. Despite these problems, two borings were drilled through the floor slab of B004 into the underlying formations. These borings were drilled at what IBM and its consultants felt were the most likely locations of the source of the chemicals in the site gravel. The locations of these borings, T-92 and T-93, are shown on Figure 2.0-2. Referring back to Figure 2.0-1, it can be seen that these borings are in the line of the center of the plume of the site gravel, and in the southwest corner of Building 004. Logs of these borings (LMS 1983) show that boring T-92 penetrated 12 ft of the site gravel. T-93 hit bedrock 17 ft below floor slab, penetrating only 3 ft of the site gravel.

The chemistry results (LMS 1984) show that the concentration of priority organic chemicals at T-92 at the time of drilling totaled 141 ppb and at T-93 totaled 4 ppb, indicating that the source is probably downgradient of those borings. We have concluded that it would not be fruitful to continue to attempt to find the source by a drilling program because of the near impossibility of drilling a boring into the source chemical itself.

FIGURE 2.0-2


BEDROCK TOPOGRAPHY
SCALE:
0
200
■ 10'X 10'
▲ △ EXISTING SITE GRAVEL BORING
DESTROYED SITE GRAVEL BORING
50
60
70
80
60
004
T-92
T-210
T-93
T-34
T-8
T-90
T-35
60
50
70
60
80
50
40
70
T-32
60
001
002
50
T-43
T-10
40
30

Further characteristics of the subsurface in the vicinity of the southwest corner of B004 add to the near impossibility of locating the source of DNAPL. These include the irregular rock surface under B004, the fracturing of the rock, and the presence of relatively impermeable, discontinuous lenses of clay and/or silt above the site gravel.

Figure 2.0-2 shows the bedrock topography in this vicinity. As can be seen, there is a major trough in the bedrock, within which the site gravel is deposited, that trends generally from northeast to southwest, with a bend at the southern end of B004. This bend in the trough is caused mainly by the presence of a bedrock high under the central portion of B004, with a "nose" bulging toward the southern end of B004; this is close to the vicinity of the presumed break in the pipe under the floor slab, and the presumed source of the loss of DNAPL into the subsurface. Figure 2.0-2 indicates that within a 50-ft distance the direction of movement of DNAPL TCE down the slope of the bedrock/soil interface could vary from due west to due east. Therefore, a variance of only 10 ft could make a marked difference in direction of movement.

Fracturing of the bedrock surface, a phenomenom that can be expected to occur anywhere on the site, only adds to the unpredictable final resting place of the DNAPL chemical that sank through the overburden to the bedrock surface. Upon reaching the irregular, fractured bedrock surface, the chemical could either (1) flow down the slope of the bedrock surface to a local depression (not recognizable in existing data), (2) enter the fractured portion, or, if the particular location were unfractured, (3) could move a considerable distance along the bedrock surface until it reached one of the major depressions already identified. If the magnitude of the loss were sufficiently large, the chemical could do all three.

The final influence on the unpredictable behavior of chemicals under Building 004 is the relatively impermeable, discontinuous lenses of clay and slit above and within the gravel. These lenses were identified both in the drilling program conducted for the groundwater study and in the large-scale excavation for B012 (just to the east of B002) made in 1982. With these lenses, a leak or discharge of DNAPL chemical into the subsurface could proceed vertically downward through the building fill, reach an impermeable layer, spread out horizontally over this layer until a point of discontinuity was reached, and then proceed vertically downward once more. Therefore, the point at which the discharged DNAPL chemical reaches the bedrock surface is not necessarily vertically below the point of introduction into the overburden. This further shows the near impossibility of predicting where the chemical might have come to rest or of locating it with a drilling program.

The above discussion on the generic characteristics of DNAPL chemical, the specific characteristics of the site gravel, and the B004 situation at IBM indicates that the source of DNAPL chemical of the site gravel flux is not expected to be locatable. A drilling program specifically designed to find the source failed to do so, confirming the conclusion that the source is not locatable.

CHAPTER 3.0

SOURCE NOT RECOVERABLE

The most common method used for recovery of DNAPL chemicals in soil is excavation; in fact, this is the method IBM used at B025, the inactive waste disposal site, and the tank farm west of B004. The site gravel source, however, cannot be excavated because it is under B004, nor could this method remove that portion of the chemical in the fractured bedrock. Because this method is clearly impossible to apply, we considered the use of a purge well system, which is discussed in the remainder of this chapter.

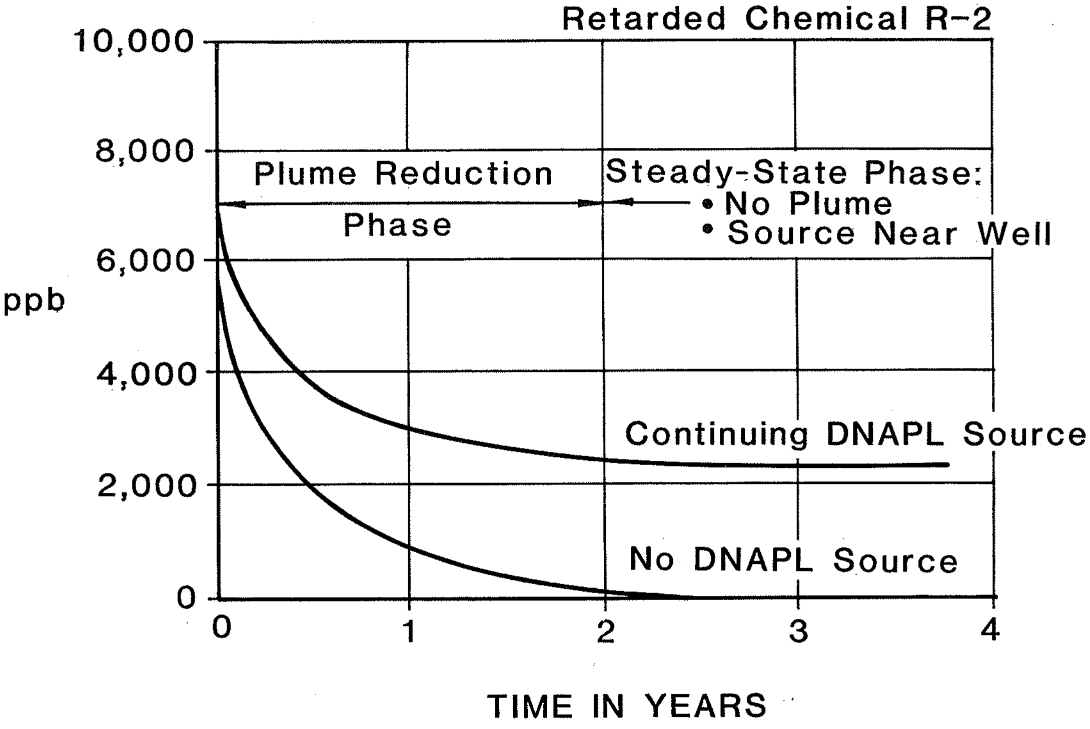
Appendix C of the Final Report (LMS et al. 1984) discusses DNAPL chemicals and their recovery from sand and gravel aquifers in a generic sense. Included in that appendix is a cell model that indicates the effect of pumping on a DNAPL chemical source. Appendix D of the Final Report discusses a case history of an experimental DNAPL chemical recovery system operated in a sand and gravel aquifer by IBM in Dayton, New Jersey. Both the hypothetical construction and the case history indicate that, although chemical concentrations at a distance from the source can be reduced significantly by a purging scheme, concentrations near the source will not be significantly reduced. Furthermore, assuming all DNAPL has not been removed and after purging ceases, it is likely that the plume will reestablish itself at the same concentrations and pattern that was exhibited before the purging project began. The purpose of the discussion herein is to show that a similar result would be expected if a purging scheme were established in the main plant site gravel; i.e., although it may be used to control the flux of chemical into Spring Brook, it would not be effective to recover the DNAPL source of the plume.

Figure 3.0-1 is taken from Appendix C, Final Report. It shows the results of the cell model for purging a sand and gravel aquifer of dissolved chemicals such as TCE. If there is no DNAPL, i.e., free product source of the dissolved chemical, the purging is relatively successful; here a purging well located near the source is shown to reduce chemicals to zero in about two years. If, however, a DNAPL source exists, a different pattern is observed: the chemical concentration at the pumping well is reduced relatively rapidly in the early operation, but eventually reaches a steady state well above zero concentration. This occurs after the plume of dissolved chemical has been drawn back into the well completely, and the only remaining source of chemical in the pumping well is the nearby DNAPL. In the numerical example presented in Appendix C, the pumping well was presumed to draw about 25% of its water through the DNAPL source; hence, the final concentration in the steady-state phase is 25% of the initial concentration at the recovery well near the source.

The principles applied in developing the cell model and the observations at the Dayton experiment can be used to generalize the pattern of chemical concentration in a purging well with relation to its distance from the DNAPL source. Even if the purge well is close to the DNAPL source, it still draws in a large amount of "clean water" relative to the volume of water that passes through the DNAPL source. As the purge well moves farther from the source, the radial angle covered by a given source diminishes, and the percentage of the total pumped water that passes through the DNAPL also diminishes. At the steady-state condition, therefore, one expects that the farther from the source the purge well is, the lower the equilibrium concentration at the purge well. This relationship was observed during the IBM experimental pumping at Dayton. For a given pumping rate, therefore, the rate of chemical purging, in mass per unit time, decreases as the

FIGURE 3.0-1

RESULTS OF PURGING IN A SAND AND GRAVEL AQUIFER



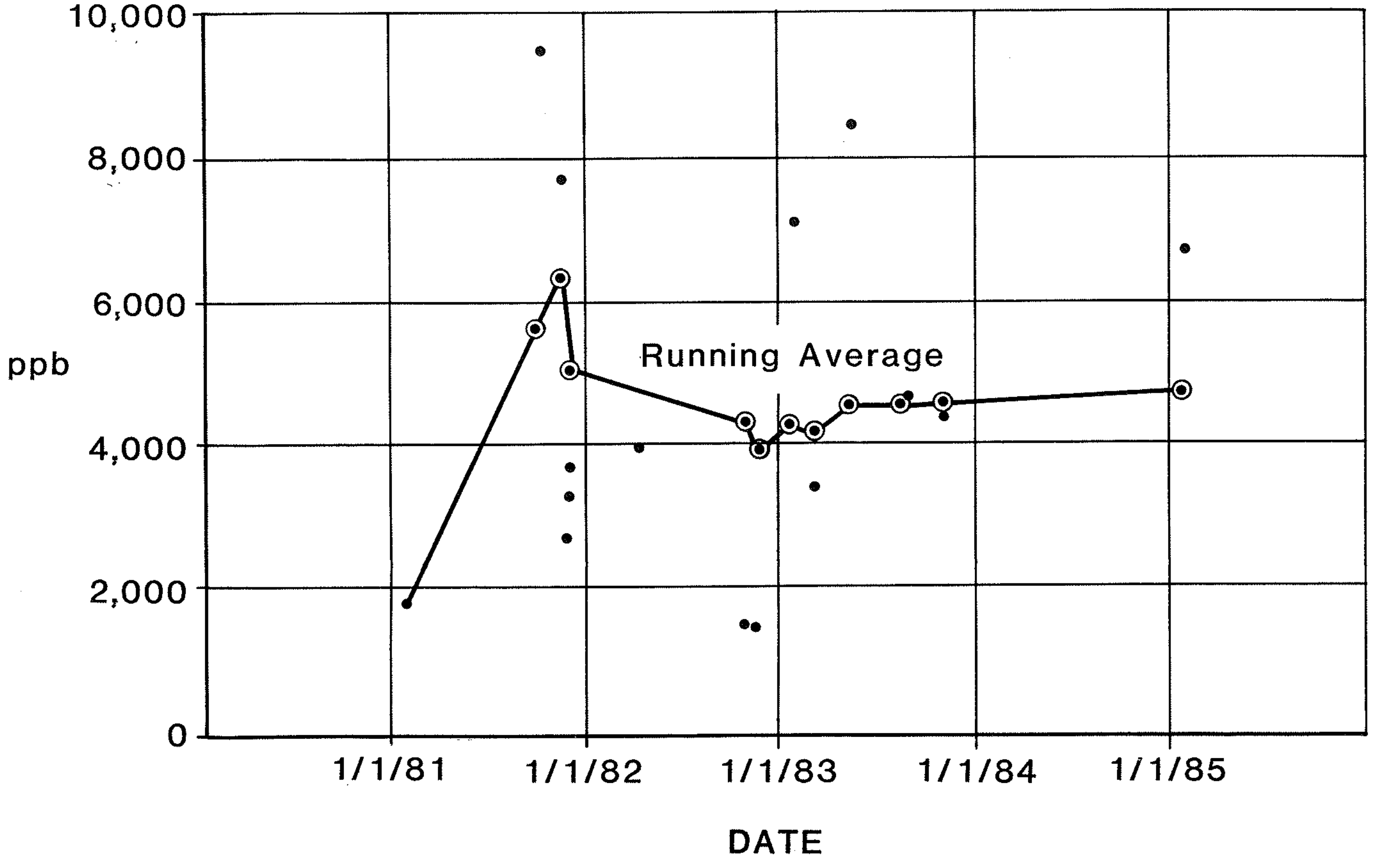
Source: LMS et al. 1984, Appendix C. These curves are the results of a specific numerical example explained in detail in that Appendix.

distance from purge well to source increases, i.e., the effectiveness of source recovery diminishes.

The closest that a purge well could be located to the site gravel source would be in the vicinity of T-8. Data collected at T-8 can be used to indicate that this is not close to the source, in the sense that the radial angle of the source will not be great at T-8. If it were, one would expect relatively high concentrations of dissolved TCE at T-8; however, the data show that the concentration is low in comparison to the 1,100,000 ppb saturation value of TCE, and is not dropping. These data in effect show that the trend of concentration in T-8 is already similar to that of a purge well location some distance from the source. Figure 3.0-2 plots all data collected at T-8, and also plots the running average of these data in order to reduce the fluctuations in individual analytical results normally found with this type of sample and chemical. As can be seen from that plot, the running average of the sampling results has been relatively steady for a two-year period, after some initial large fluctuation. The steady-state nature of the data indicates that there is a DNAPL source, and the relatively low concentrations of these data indicate that the water reaching T-8 is not efficiently purging the DNAPL source.

The discussion in Chapter 4.0 will show that, if the gravel were to be purged, purging flow would be about the same as that now discharging to Spring Brook. Therefore, with a purge well near the existing T-8, the flow through the DNAPL source would not be significantly different from that now prevailing. This means that the concentrations at a purge well near the existing T-8 might diminish somewhat at the onset of pumping, probably to about the level at the discharge to Spring Brook (1700 ppb). It would then exhibit a steady-state pattern at this concentration. In effect, the source would not be solubilized at a significantly faster rate than is now taking place, and therefore, such a purging scheme would not accomplish source removal.

FIGURE 3.0-2
TCE CONCENTRATIONS AT T-8



- – **Individual sampling report.**

◉ – **Running average.**

CHAPTER 4.0

SITE GRAVEL NOT A DEVELOPABLE WATER RESOURCE

The purpose of this chapter is to describe the calculations made regarding flow rate in the site gravel at the main plant site and to provide information on the potential yield to wells drilled into this geologic unit.

4.1 GROUNDWATER FLOW THROUGH THE SITE GRAVEL

This flow rate was calculated using Darcy's Law, which, simply stated is:

$$Q = kia$$

Where:

Q = flow rate, $L^3 T^{-1}$

k = permeability, $L T^{-1}$

i = gradient, $L L^{-1}$

a = cross-sectional area, L^2

The permeability (k) of the sediments in the area of the site gravel downgradient from the manufacturing buildings was determined by pulse tests performed in five borings and ranged from 17 to 27 ft/day.

The gradient (i) associated with groundwater flow in this area was determined by contouring static water level elevations for all borings completed in this unit. The results were published in the final report on main plant site hydrogeology and chemistry (LMS 1983). Plate 8 from that report is attached as Exhibit 1.

The cross-sectional area (a) through which this flow occurs was determined from cross sections constructed from logs of borings completed in this unit (LMS 1983).

The actual calculation of flow was performed based on these parameters in the area of cross section C-C' from Plate 5 (attached as Exhibit 2) of LMS (1983) (later changed to D-D' for the 21 February 1984 presentation and the final groundwater report). This cross section is drawn through two borings in the site gravel, T-43 and T-41. The resultant parameters are:

	k	i	a
T-41	17 ft/day	0.055	1700 ft^2
T-43	23 ft/day	0.040	3300 ft^2

With the application of Darcy's Law, flows are:

T-41: $Q = (17 \text{ ft/day})\ (0.055)\ (1700 \text{ ft}^2) = 1590 \text{ ft}^3\text{/day}$

T-43: $Q = (23 \text{ ft/day})\ (0.040)\ (3300 \text{ ft}^2) = 3040 \text{ ft}^3\text{/day}$

for a total flow through the gravel channel at section C-C' of 4630 ft^3/day or 34,630 gal/day.

These calculations indicate there is a 35,000 gal/day (24 gal/min) groundwater flow through the area associated with the chemical plume in the site gravel.

4.2 POTENTIAL WELL YIELDS

There is limited information on potential well yields in the area of the site gravel containing the chemical plume. Although some data are available from the dewatering performed for Building 012 construction, this site is upgradient from the area of concern in an area where the gravel deposits are apparently thicker, more extensive, coarser grained, and cleaner.

In the site gravel downgradient of the manufacturing buidings there was one attempt to perform a pumping test in the vicinity of boring T-43 at test well G-1. At this site a 6-in. test well was installed with 8 ft of 6-in. telescope-size well screen. After the well was drilled, using rotary equipment, the screen was installed (under the supervision of a geologist) and properly developed. Based on the gradation analyses for boring T-43, the yield of this well was expected to be on the order of 10 gpm.

A subsequent attempt to perform a pumping test at this location on 2 November 1982 produced disappointing results. After an initial rate of 5 gpm could not be sustained, the pumping rate was quickly valved back. The test was aborted after only 1 1/2 hrs when the pumping rate had decreased to less than 2 gpm.

In addition to the evidence from the pumping test, calculations of the probable maximum pumping rate for a well located in the vicinity of boring T-8 (where the highest k value was determined from pulse tests) indicate that this rate could not exceed the calculated flow-through rate of 25 gpm. Additionally, this calculated rate would be further reduced with time as negative boundaries associated with the irregular bedrock surface are encountered by the cone of depression.

4.3 CONCLUSIONS

Based on the calculated flow-through rate of groundwater in the site gravel, the low pumping rate for test well G-1, the low calculated maximum theoretical pumping rate at T-8, and the limited areal extent of the site gravel, we have concluded that this geologic unit does not represent a source of developable groundwater. This is particularly true considering the high water supply capacity requirements of this industrial site and the readily available sources for both industrial and potable supplies from the Hudson river.

CHAPTER 5.0

IMPACT ASSESSMENT

The potential impact on Spring Brook and the Hudson River was examined with respect to NYSDEC's Technical and Operational Guidance Series (TOGS) and by examining conditions in Spring Brook. This discussion presents the calculations of chemical flux from the site gravel, and summarizes the impact assessment that is contained in the final main plant site report (LMS et al. 1984).

5.1 FLUX CALCULATIONS

Section 3.1 has shown that the groundwater flow through the site gravel at borings T-41 and T-43 is 35,000 gpd. To account for flow into the gravel from the shale between section C-C' and Spring Brook, an additional 20% was added to obtain 42,000 gpd; finally, to provide a conservative estimate, this flow was rounded up to 50,000 gpd.

Chemical (total priority organics) concentrations are:

	BORING	CONCENTRATION (ppb)
Leading edge:		
	T-22	1,322
	T-38	3,270
	T-39	446
	T-40	1,108
	T-42	2,602
	Mean	1,750
Source area:	T-8	4,309

Fluxes are:

leading edge: 0.05 x 8.34 x 1.75 = 0.73 lb/day

maximum hypothetical: 0.05 x 8.34 x 4.309 = 1.797 lb/day

5.2 RECEIVING WATER ASSESSMENT

Details of the assessment of effects on Spring Brook and the Hudson River are contained in the final report (LMS et al. 1984).

For Spring Brook, a Class D water, there are no TOGS to assist in this assessment. Therefore, a site reconnaissance was conducted that showed:

- No fish habitat remaining over the entire (1 mile) length of Spring Brook, including the 700-ft stretch downstream of the site gravel discharge area. This destruction is a result of past construction activities on and off the IBM site and continuing urban runoff upstream of the IBM site.
- No fish observed and none expected because of the complete habitat loss.

We conclude that there is no impact of the site gravel chemicals on Spring Brook.

The potential impact on the Hudson River, a Class A water, was examined by use of a calibrated model and by chemical sampling in the river. Table 5.0-1 shows the results of modeling the input of all priority chemicals from the site, the major one of which is TCE. Concentrations given are at the two nearest water supply intakes, upstream (Poughkeepsie) and downstream (Chelsea). These may be compared to the TOGS limit for TCE of 5 ppb (5000 parts per trillion). At MA30CD/10 flow, concentrations would be about five times those on Table 5.0-1. Thus, the current concentration at Chelsea is 1/170 of the TOGS, and the maximum hypothetical is 1/25 of the TOGS.

TABLE 5.0-1

HUDSON RIVER MODEL SUMMARY OF TOTAL PRIORITY ORGANICS CONCENTRATIONS AT AVERAGE FLOW

		CONCENTRATIONS (PARTS PER TRILLION)			
		POUGHKEEPSIE		CHELSEA	
DISCHARGE	LB/DAY	MAX	MEAN	MAX	MEAN
Current	0.45	3	0.4	9	6
1 Times Current Discharge	0.57	4	1	14	9
Maximum Hypothetical	3.17	16	3	70	42

The sampling of the Hudson River revealed no pattern of chemical attributable to IBM, providing a "null" confirmation of the modeling: we did not expect to find chemicals and none were found.

We have concluded that there is no impact on the Hudson River.

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Lawler, Matusky & Skelly Engineers LMS. 1983. Final report: hydrogeology and chemistry of main plant site. Prepared for IBM, Poughkeepsie.

Lawler, Matusky & Skelly Engineers (LMS). 1984. Data update: hydrogeology and chemistry of main plant site. Prepared for IBM, Poughkeepsie.

Lawler, Matusky & Skelly Engineers, R.E. Wright Associates, Inc., Milton Chazin Associates, and Golden Associates (LMS et al.). 1984. Final groundwater report: main plant site. Prepared for IBM, Poughkeepsie.

EXHIBIT 1

PLATE 8

IBM CORPORATION
POUGHKEEPSIE, NEW YORK

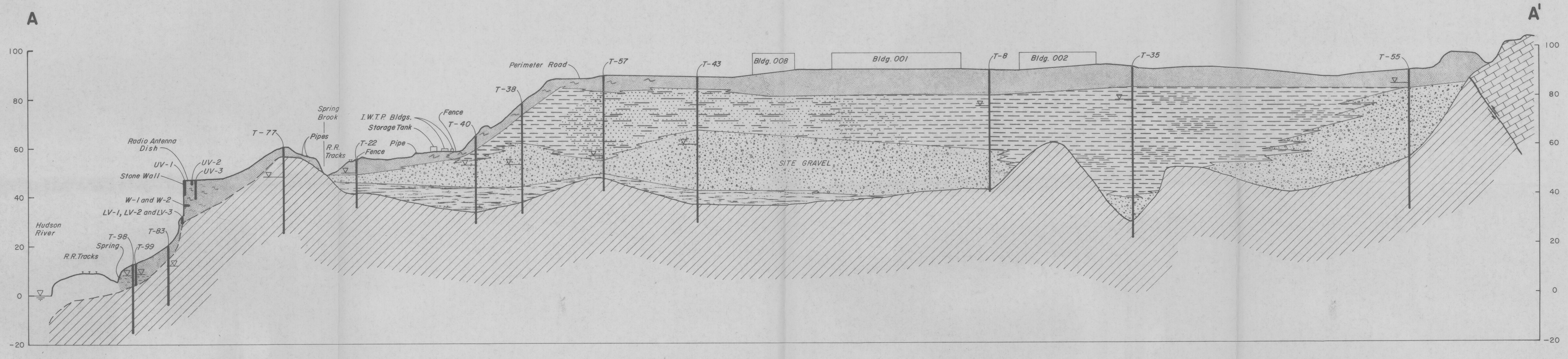
LAWLER, MATUSKY
AND SKELLY
ENGINEERS

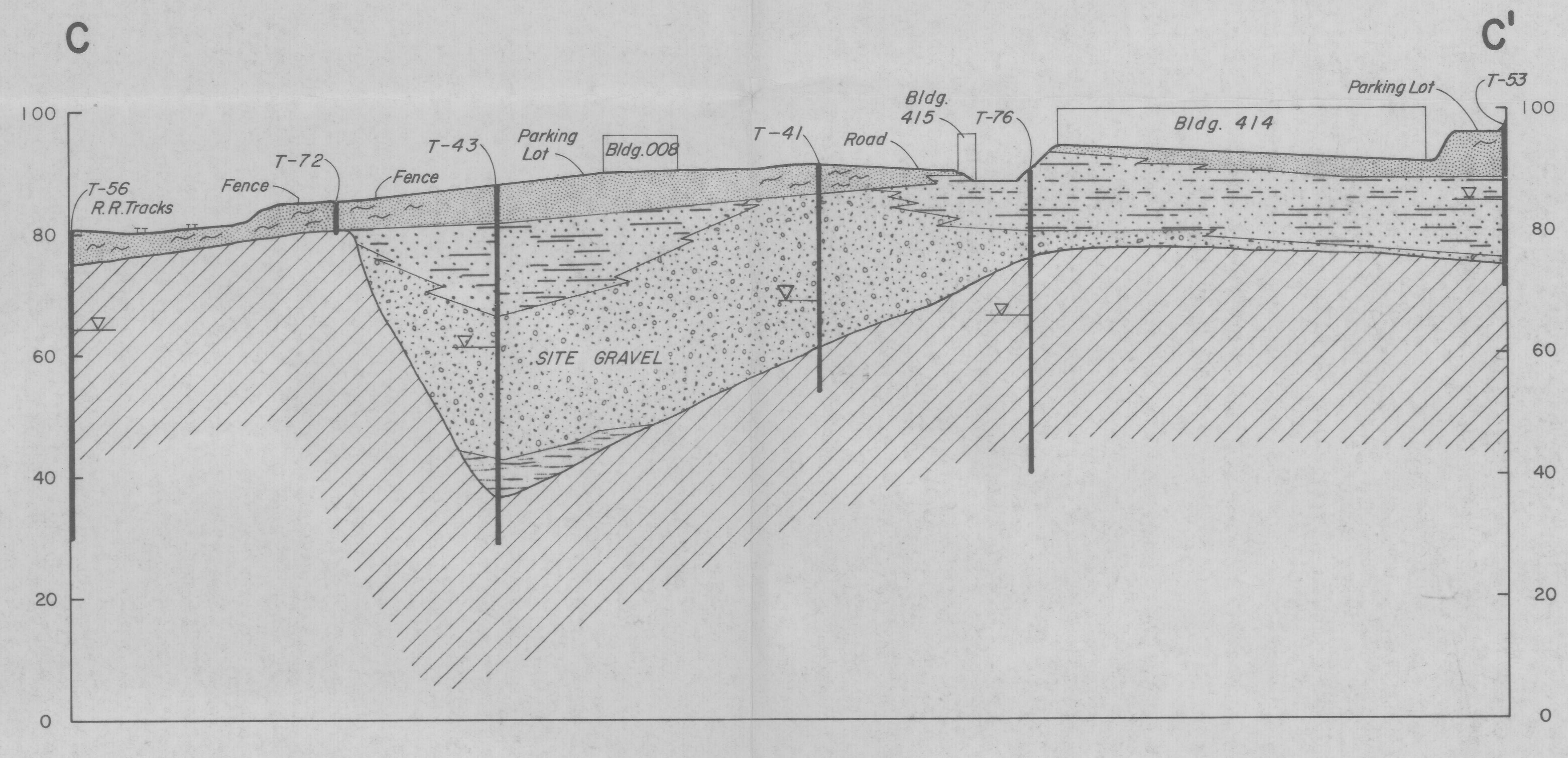
MAIN PLANT SITE
SOIL WATER LEVEL CONTOURS

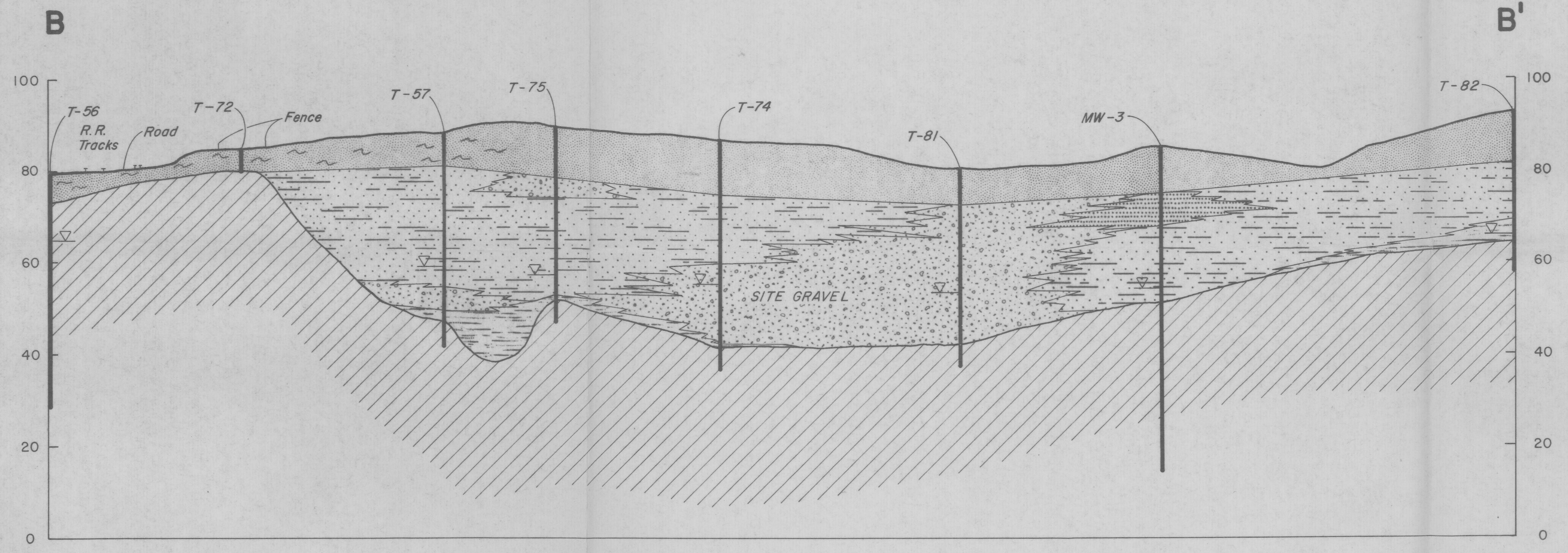
NO.	REVISIONS	BY	DATE
1	Extend Gravel Eastward	RMC	2/10/83

drawn RAM
approved
checked RMC
date
drawing no.
8061-022-D

r. e. wright associates, inc.
earth resources consultants
harrisburg pennsylvania







LEGEND

▨ SANDY LOAM	▨ MEDIUM COARSE SAND, GRAVEL
▨ SURFICIAL BROWN SAND	▨ TILL
▨ SAND	▨ SHALE
▨ SANDY SILT TO CLAYEY SILT	▨ LIMESTONE

VERTICAL EXAGGERATION 5 TIMES

EXHIBIT 2

100' 0 100' 200'
HORIZONTAL SCALE

PLATE 5

IBM CORPORATION POUGHKEEPSIE, NEW YORK	LAWLER, MATUSKY AND SKELLY ENGINEERS

MAIN PLANT SITE
CROSS SECTIONS A-A', B-B', C-C'

drawn RAM	approved CJL	drawing no.
checked SMS	date 5/11/82	8061-019-C

r. e. wright associates, inc.
earth resources consultants
harrisburg pennsylvania