ASSESSMENT OF NAPL MIGRATION VIA UNDERGROUND UTILITY BEDDING

S-Area Remedial Program

CRA 5-0038771

JUNE 1988
Ref. No. 1769

CONESTOGA-ROVERS & ASSOCIATES

TABLE OF CONTENTS

LIST TABLES

LIST OF FIGURES

LIST OF PLANS

1.0 INTRODUCTION

As required by the Stipulation and Judgment Approving Settlement Agreement, Addendum I, Paragraph B(6)(e), an underground utility bedding investigation was completed for utilities in and around the S-Area Landfill Site including the 003 Outfall, the Industrial Intake Trench and the bedding of 53rd Street and the Robert Moses Parkway. Procedures followed during the excavations are outlined in the report entitled "Information Summary Report, S-Area Remedial Program". The purpose of this report is to summarize the information gathered in the study and discuss the conclusions regarding Non-Aqueous Phase Liquid (NAPL) migration along the bedding of the underground utilities.

The area of the study is outlined on Figure 1 and includes the utilities in the immediate vicinity of the Site Barrier Wall, Northern System Barrier Wall and the utilities along the Robert Moses Parkway extending from the eastern property line of the City of Niagara Falls Water Treatment Plant (WTP) to a point approximately 800 feet west of the S-Area Landfill Site.

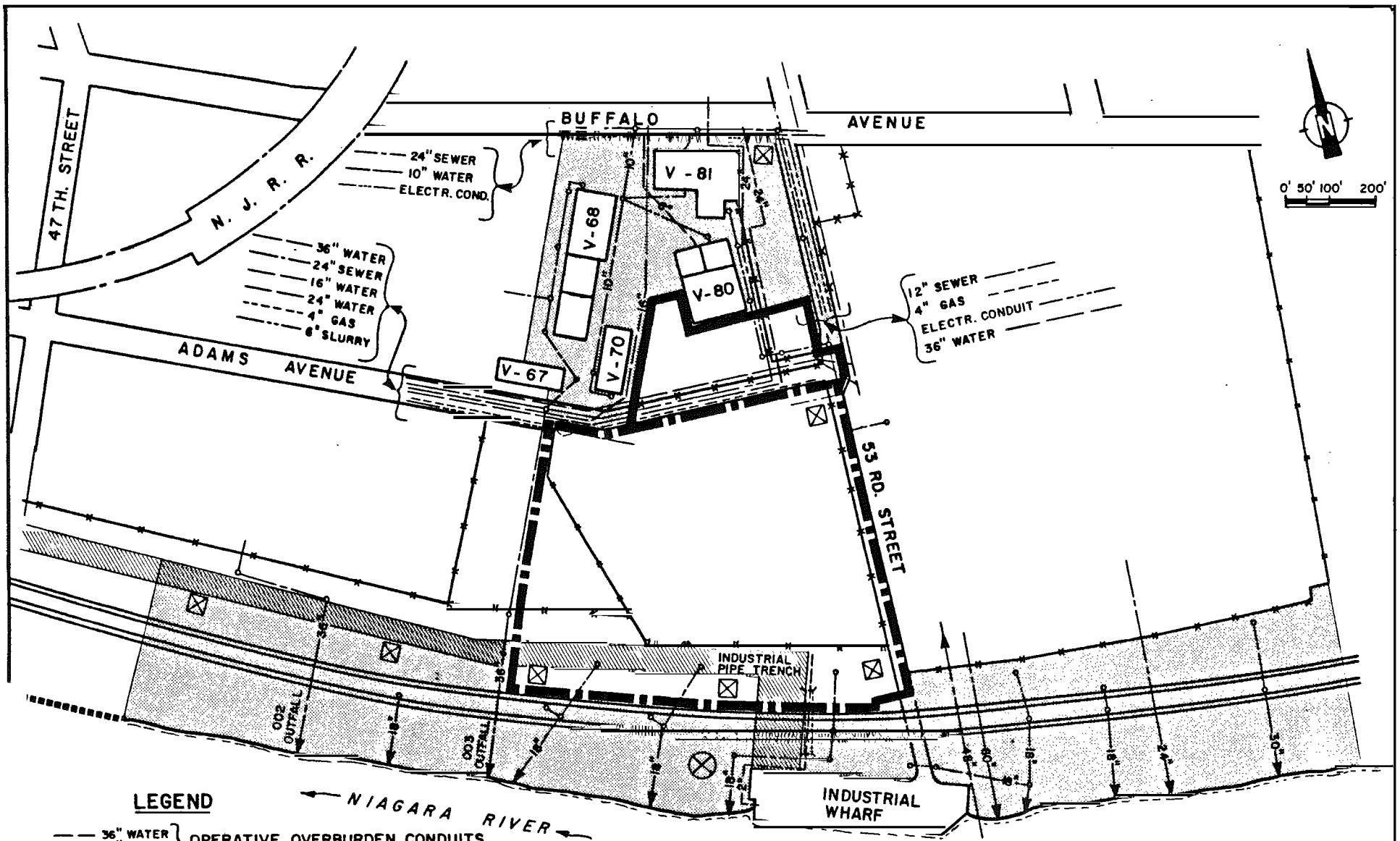


figure 1

STUDY AREAS
S-AREA REMEDIAL PROGRAM
Occidental Chemical Corporation

CRA

1769-18/05/88-24-D-0

CRA 5-0038775

2.0 WORK COMPLETED

A total of 30 excavations and boreholes were completed as part of this investigation. Excavation procedures and protocols including methodology for preparation, excavation and trenching, backfilling, waste disposal, health and safety and air monitoring are presented in the Information Summary Report referenced in Section 1.0.

Excavations were conducted to assess the influence of the utility and roadway beddings on NAPL migration. Excavations consisted of digging with a backhoe, perpendicular to the utility of concern, to a depth below the pipe invert elevation. The utility bedding material at each location was then sampled, photographed and examined for visual and olfactory indications of the presence of NAPL. Excavated materials were backfilled and compacted. Imported fill material was placed in each excavation for the last 6-12 inches of backfill and the area was restored to its original condition.

Boreholes were installed in lieu of excavations at B-9, B-32, C-4a and C-4b due to anticipated high groundwater levels in those areas. A truck-mounted drill rig was to complete the boreholes. In conjunction with

the augering of the boreholes, continuous split spoon samples of the materials encountered were collected from the ground surface to the bottom of the bedding material. All waste materials generated were drummed and stored for future disposal in the S-Area.

Pertinent information on NAPL presence was also obtained during the installation of overburden survey wells and boreholes which were part of the Overburden Survey Well Installation Program. All of the completed excavations and boreholes utilized for information discussed in this report are shown on Plan 1.

Test excavations located within the WTP property have yet to be completed and are therefore not discussed as part of this report. The WTP test excavations are planned to be completed at a later date. In addition, some of the shallow excavations in the vicinity of the Industrial Intake Pipe Trench have been postponed (i.e. B-10, B-11, B-15, C-3 and C-5), although the Subsurface Investigation boreholes (BH181, 182, 184, 185 and 187) were installed within the trench limits to the bedding depth. The completion of all of the remaining excavations is contingent on the EPA/State approval of the S-Area's Solid Waste Management Plan; and the City of Niagara Falls Contingency Plan for the WTP; and OCC's completion of all utility relocations and the development of methods for excavation of critical service lines (see Table 1).

TABLE 1
UTILITY INVESTIGATION SUMMARY
UNCOMPLETED EXCAVATIONS

Excavation No.	Utility to be Investigated	Remarks
B-7	8-inch diameter sanitary sewer	To be completed after realignment construction.
B-10	2-inch diameter gas main	To be completed after realignment construction.
B-11	8-inch diameter caustic line	To be completed when line is out of service.
B-15	8-inch diameter caustic line	To be completed when line is out of service.
B-17	2-inch diameter gas main	To be completed after realignment construction
C-2	electrical conduit	To be completed after realignment construction
C-3	electrical conduit	To be completed after realignment construction
C-5	electrical conduit	To be completed after realignment construction
TE1 thru 11-86	City of Niagara Falls Water Treatment Plant lines	To be completed subsequent to necessary plan approvals, relocation and development of excavation procedures for critical service lines.

3.0 EXCAVATION INFORMATION

The geologic stratigraphy encountered at each excavation was logged as it was uncovered and identified. This information, including excavation identification number, utility investigated, bedding material and depth of excavation is summarized in Table 2.

In most instances, the "bedding" material found around the utility of concern consisted of a heterogeneous mix of fill materials including gravel, sand and silt as well as occasional bricks, cinder and metal fragments. This fill material was essentially identical to the surrounding material indicating that no imported material was used as bedding and the pipes were simply installed and backfilled with the material originally removed from the excavation.

At only seven locations (B-9, B-12, B-13, B-25, B-27, B-28 and B-33) was it apparent that actual pipe bedding material was used. The bedding material consisted of gray, fine to medium crushed stone. All of the utilities with imported stone bedding are located south of the Robert Moses Parkway near the River's edge.

TABLE 2
UTILITY INVESTIGATION SUMMARY
S-AREA SUBSURFACE INVESTIGATION

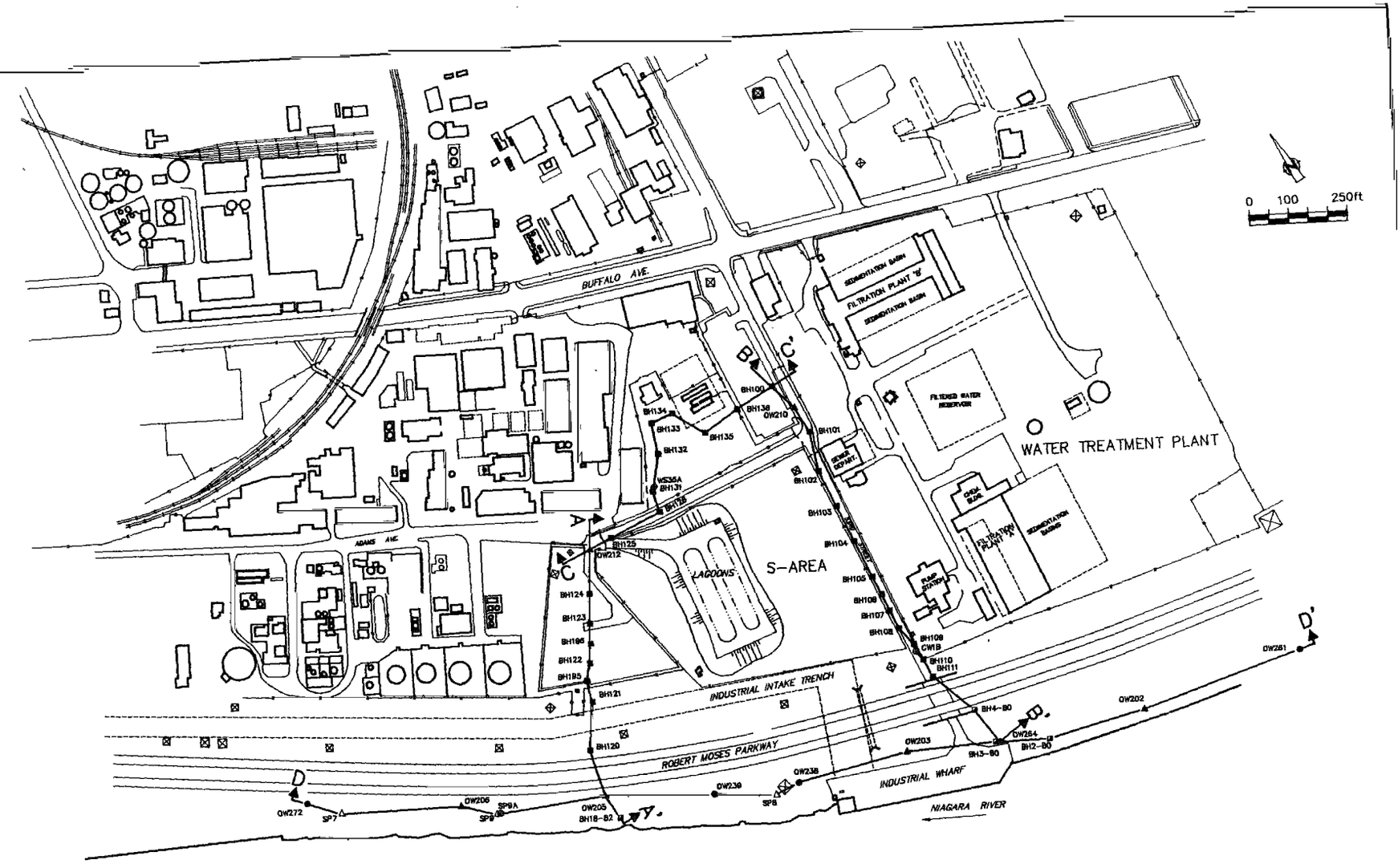
Excavation Number	Utility Investigated	Bedding Material	NAPL Presence	Sampled Depth	Total Excavate Depth
	Roadway				
A-1	53rd Street	Fill-Gravel/Sand	No	2.0 ft.	2.0 ft.
A-2	53rd Street	Fill-Gravel/Sand/Silt	No	2.0 ft.	2.0 ft.
A-3	Adams Avenue	Fill-Silt/Sand/Gravel	No	0.8 ft.	0.8 ft.
	Pipes				
B-1	24" diameter watermain east of V-80	Fill-Silt/Sand/Gravel	(6-8 ft.)	8.0 ft.	8.0 ft.
B-1A	24" diameter watermain east of V-80	Fill-Gravel/Sand/Silt	No	7.0 ft.	7.0 ft.
B-2	24" diameter wastewater sewer east of V-80 (Outfall 003)	Fill-Silt/Sand/Gravel	(6-8 ft.)	8.0 ft.	8.0 ft.
B-2A	24" diameter wastewater sewer east of V-80 (Outfall 003)	Fill-Gravel/Sand/Silt	No	7.0 ft.	7.0 ft.
B-3	6" diameter sanitary sewer east of V-80	Fill-Silt/Sand/Gravel	No	8.0 ft.	8.0 ft.
B-5	4" diameter gas main on 53rd Street	Fill-Gravel/Sand	No	3.5 ft.	4.5 ft.
B-6	36" diameter watermain at 53rd Street and Adams Avenue	Fill-Clay/Gravel	No	6.5 ft.	6.5 ft.
B-8	42" diameter high service discharge line (west pipe)	Fill-Gravel/Clay	No	10.5 ft.	10.5 ft.
B-9	18" diameter storm sewer on Robert Moses Parkway	Bedding Gravel	No	0-10.5 ft.	10.5 ft.
B-12	18" diameter storm sewer	Bedding Gravel	No	12.0 ft.	12.0 ft.
B-13	24" diameter storm sewer	Bedding Gravel	No	11.5 ft.	14.0 ft.
B-14	42" diameter storm sewer	Fill-Sand	No	14.5 ft.	14.5 ft.
B-16	10" diameter wastewater sewer from S-Area Lagoons	Fill-Gravel/Sand/Clay	No	4.5 ft.	4.5 ft.
B-18	6" diameter slurry line to S-Area Lagoons	Fill-Gravel/Sand/Clay	No	4.5 ft.	4.5 ft.
B-19	4" diameter gas main on Adams Avenue	Fill-Gravel/Sand/Clay	No	4.0 ft.	4.0 ft.

TABLE 2
UTILITY INVESTIGATION SUMMARY
S-AREA SUBSURFACE INVESTIGATION

Excavation Number	Utility Investigated	Bedding Material	NAPL Presence	Sampled Depth	Total Excavated Depth
	Pipes				
B-21	16" diameter U.W.F. watermain on Adams Avenue	Fill-Sand/Clay/Gravel	(5-6.5 ft.)	7.0 ft.	7.0 ft.
B-22	24" diameter wastewater sewer on Adams Avenue (Outfall 003)	Fill-Clay/Gravel	(5-6.5 ft.)	6.5 ft.	6.5 ft.
B-24	16" diameter U.W.F. watermain east of V-70	Fill-Gravel/Sand	No	8.0 ft.	8.0 ft.
B-25	30" diameter storm sewer	Bedding Gravel	No	10.5 ft.	10.5 ft.
B-26	24" diameter City of Niagara Falls Water Treatment Plant discharge	Fill-Gravel/Sand	No	10.5 ft.	10.5 ft.
B-27	18" diameter storm sewer	Bedding Gravel	No	6.5 ft.	6.5 ft.
B-28	24" diameter storm sewer	Bedding Gravel	No	6.0 ft.	6.0 ft.
B-31	18" diameter storm sewer	Fill-Gravel/Silt	No	9.5 ft.	9.5 ft.
B-32	36" diameter storm sewer (Outfall 002)	Fill-Sand/Gravel	No	0-16.0 ft.	16.0 ft.
B-33	24" diameter storm sewer	Bedding Gravel	No	9.5 ft.	11.0 ft.
	Utility Trench				
C-4A	Utility Trench of Industrial Intake Pipes	Fill-Sand/Gravel	No	0-28.0 ft.	28.0 ft.
C-4B	Utility Trench of Industrial Intake Pipes	Fill-Sand/Silt	No	0-28.0 ft.	28.0 ft.
OW269-87	Utility Trench of Industrial Intake Pipes		No	---	33.2 ft.
BHW270-87	Utility Trench of Industrial Intake Pipes		No	---	29.8 ft.
BHW273-87	Utility Trench of Industrial Intake Pipes		No	---	26.7 ft.

Several of the overburden survey wells installed as part of the Overburden Survey Well Installation Program intersect the bedding of the Industrial Intake Piping Trench. Boreholes BH181, BH182, BH184, BH185, BH187 and wells OW269 and OW270 were determined to be located within the limits of the original trench excavation. This determination was made by comparison of stratigraphic information from these installations with information from other nearby wells. Based upon stratigraphic information obtained from nearby boreholes and wells (BH183, BH186, BH188 and OW273), the elevation of the top of the undisturbed till was identified to be at approximately elevation 546. However, wells within the trench area located the native undisturbed till elevation at approximately 543.5, which is two feet below the pipe invert elevations of 545.5.

In order to better appreciate the correlations between the stratigraphic units and the pipe bedding material elevations, a series of cross-sectional drawings have been prepared. The alignments of the cross-sections shown are presented in Figure 2 and Figures 3 through 6 present the actual cross-sections.



LEGEND

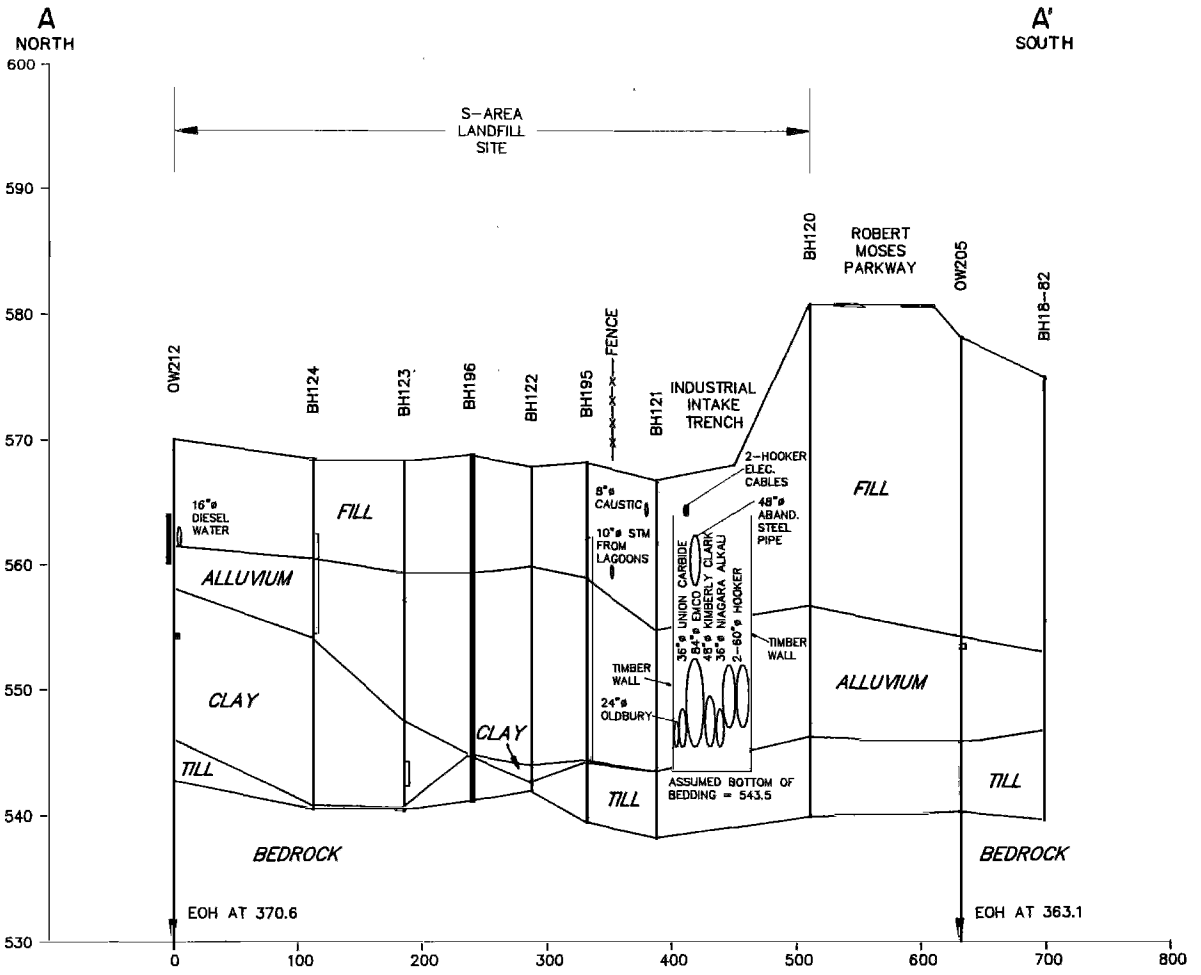
A A' CROSS-SECTION LOCATIONS

figure 2
CROSS-SECTION LOCATIONS
S-AREA REMEDIAL PROGRAM
Occidental Chemical Corporation

CRA

1769-26/05/88-24-D-0 (P-16)

CRA 5-0038783



LEGEND

- MONITORING INTERVAL
- SHEEN
- NAPL

SCALE: 1"=10' VER.
1"=100' HOR.

ALL ELEVATIONS BASED ON 1986 OCC DATUM
(REF. DWG. A-11-19200)

figure 3
CROSS-SECTION A-A'
S-AREA REMEDIAL PROGRAM
Occidental Chemical Corporation

CRA

1769-18/05/88-24-D-0(X-43)

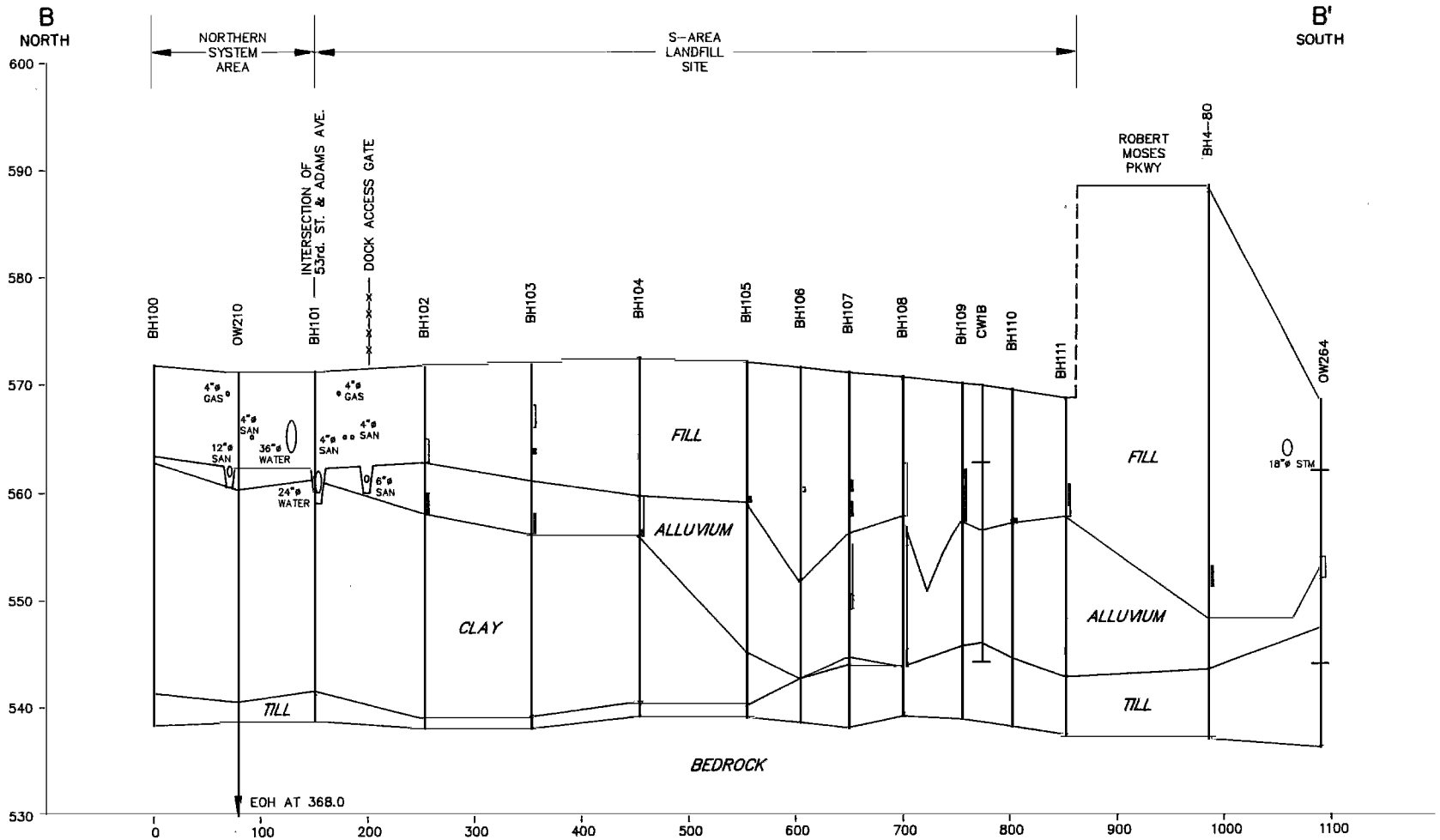


figure 4

CROSS-SECTION B-B'
S-AREA REMEDIAL PROGRAM
Occidental Chemical Corporation

CRA

1769-16/05/88-24-D-0(X-47)

CRA 5-0038785

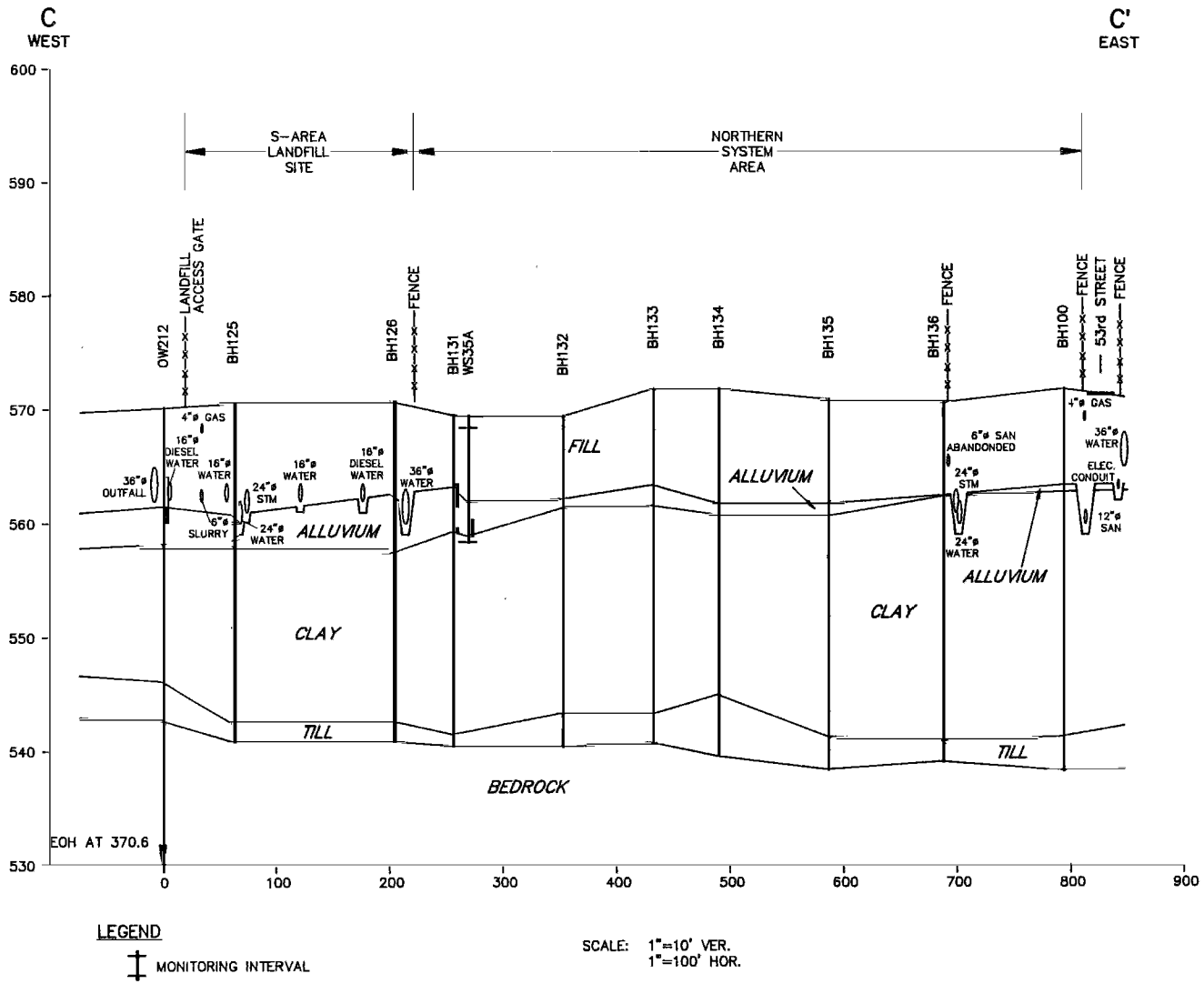


figure 5
CROSS-SECTION C-C'
S-AREA REMEDIAL PROGRAM
Occidental Chemical Corporation

CRA

1769-18/05/88-24-D-0(X-42)

CRA 5-0038786

4.0 RESULTS

Of the 30 excavations and boreholes completed during the Utility Bedding Investigation, the presence of NAPL was identified in only four. Excavations B-1, B-2, B-21 and B-22 all contained NAPL along the utility line.

4.1 EXCAVATIONS B-1 AND B-2 (NORTHERN AREA)

Excavations B-1 and B-2 are located along a 24-inch diameter watermain and a 24-inch diameter wastewater sewer (Outfall 003) respectively. They were installed north of the S-Area Landfill Site, east of former Building V-80 near 53rd Street. The total depth of each excavation was 8 feet. The bedding material appeared to be composed of fill materials similar to the surrounding overburden material and therefore was non-distinct. An interspersed layer of NAPL was identified in the fill excavated at a depth of 6 to 8 feet below ground surface. The utility lines are located at a depth of 8 feet to invert elevation. This coincides with the elevation of the top of the confining clay layer in this area. The NAPL found at these locations was black with a strong chemical odor.

4.2 EXCAVATIONS B-21 AND B-22 (ADAMS AVENUE)

Excavations B-21 and B-22 were located on Adams Avenue near the northwest corner of the S-Area Landfill Site boundary south of Building V-67. The utilities being investigated include the 16-inch diameter watermain and the 24-inch diameter wastewater sewer (Outfall 003) under Adams Avenue. The depths of excavations B-21 and B-22 were 7.0 feet and 6.5 feet respectively. Once again, the lines were situated in material which was a composite of sand, clay and gravel comparable to surrounding overburden material and no distinct bedding material was identified. The invert elevations of the utility lines were at a depth of 7.0 feet for the 24-inch sewer (B-22) and 6.5 feet for the 16-inch (B-21) watermain. NAPL was identified in an interspersed layer of soil at a depth of between 5.0 and 6.5 feet.

4.3 INDUSTRIAL INTAKE PIPE TRENCH

Boreholes C-4a and C-4b, installed within the limits of the industrial intake trench are located approximately 300 feet south of the S-Area Landfill Site and 100 feet north of the Niagara River shoreline. Boreholes were installed in lieu of trench excavations due to the depth of the bedding materials, 28 feet, and concern over the volume of groundwater that potentially may have been required to be handled. NAPL was not located in either borehole.

In addition to the previously mentioned boreholes, several boreholes and one overburden survey well have been installed and located within the limits of the Industrial Intake Pipe Trench (BH181, BH182, BH184, BH185, BH187 and OW269). All of the boreholes installed in this area (which is located approximately 150 feet south of the S-Area Landfill Site) uncovered evidence of NAPL migration southward. In general, there were two depths at which NAPL is located in this area, 8 to 14 feet and 18 to 29 feet below ground.

4.4 ROADWAY BEDDING

All of the roadway bedding investigations were completed by the excavation of trenches across the roadway. Trenches A-1 and A-2 were completed for 53rd Street and A-3 for Adams Avenue. Trenches A-1 and A-2 were completed to a depth of 2 feet while A-3 was completed to a depth of 0.8 feet. All of the bedding materials observed consisted of a mixture of gravel, sand and silt. NAPL was not identified at any of the roadway bedding excavations.

4.5 SECONDARY EXCAVATIONS

Following the identification of NAPL at survey locations B-1 and B-2, secondary excavations (B-1a and B-2a) were completed at a location 100 feet north of B-1 and B-2 upstream of the 24-inch diameter watermain and 24-inch diameter wastewater sewer (Outfall 003). These excavations were intended to determine the lateral extent of NAPL migration from the B-1, B-2 test areas, along the alignment of the utilities in a northerly direction away from the existing landfill. The excavations were completed to a depth of 7.0 feet which is immediately below the depth of the lines. The bedding materials were, as before, a composite of clay, sand and gravel. However no NAPL was observed at these sites.

Secondary excavations were not completed at B-21 and B-22. Based upon the assessment of NAPL presence discussed in Section 5.0 of this document, secondary excavations were not required at these locations.

5.0 DISCUSSION

5.1 EXCAVATIONS B-1 AND B-2 (NORTHERN AREA)

A study of nearby overburden wells and boreholes (OW233, BH135 and BH136) indicate that wells adjacent to the north of excavations B-1 and B-2 were free of NAPL throughout the entire overburden regime. One borehole located south of B-1 and B-2, however, did show the presence of NAPL at approximately the depth of the top of the clay stratum (BH-129, 8.6-12.9 feet BGS). The elevation of the lines investigated by B-1 and B-2 are at the depth where the utilities intersect the top of the clay stratum (approximately 8.0 feet BGS). Due to the slope of the utility lines as they progress in a southerly direction and the relatively level surface of the clay layer, the installation of the utilities would have cut into the confining clay layer. Thus NAPL located on either side of the utility trench may have been drawn toward the lower elevation offered by the trench's cut into the clay (see Figure 7). The fact that NAPL was not observed at locations B-1a and B-2a is consistent with NAPL migration characteristics which prevent NAPL flow uphill. Since the cut into the clay initially excavated for the installation of the lines is sloped toward the south, the preferential flow direction for NAPL entering the clay cut would also be

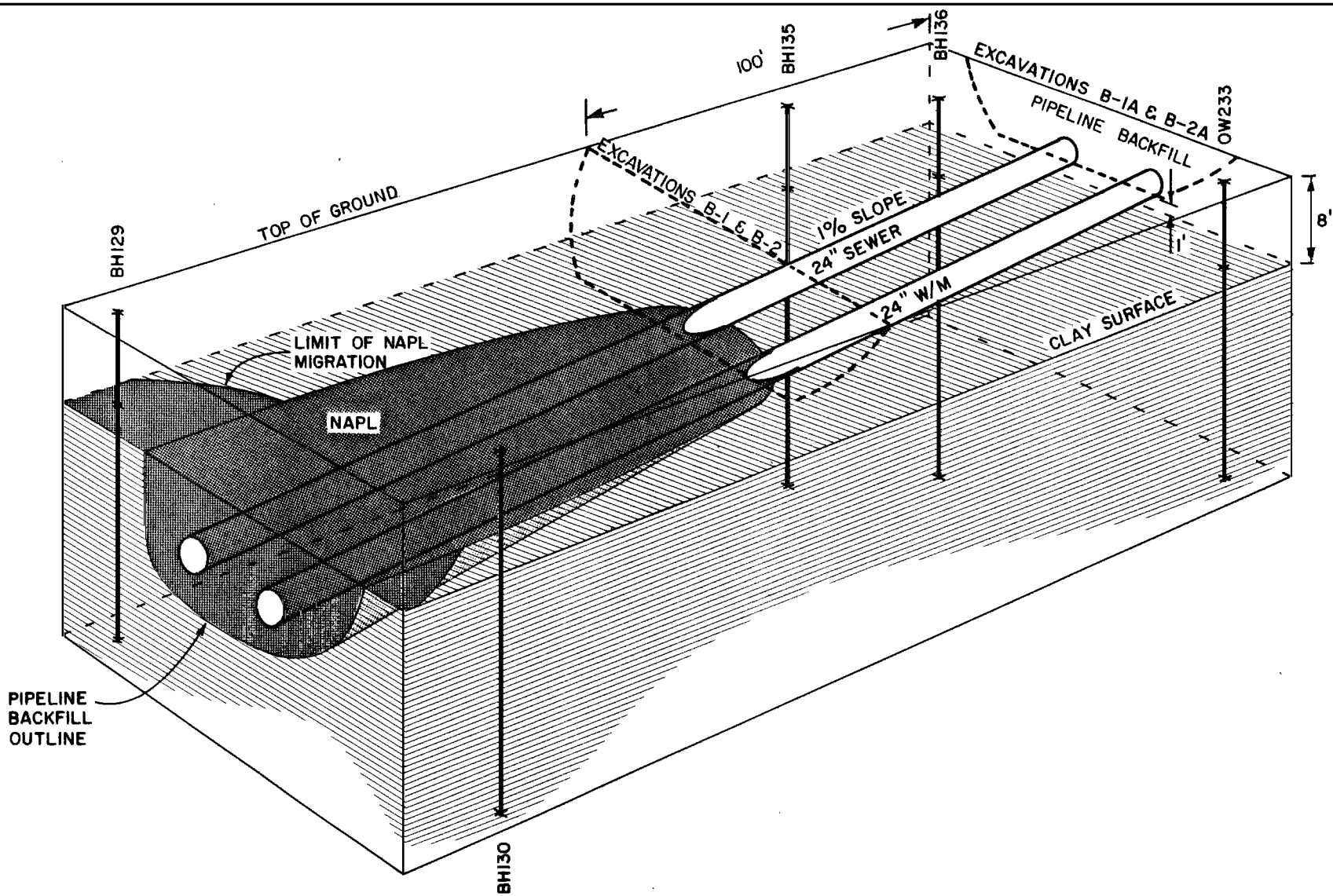


figure 7

UNDERGROUND UTILITY BEDDING INVESTIGATION
EXCAVATIONS B-1, B-2, B-1A, AND B-2A
S-AREA REMEDIAL PROGRAM
Occidental Chemical Corporation

CRA

1769-18/05/88-24-D-0

southerly back towards the S-Area Landfill Site. Consequently, once beyond the northern limits of the cut into the clay, the bedding (or more correctly, the excavation) for the lines no longer offers a preferential pathway for NAPL migration.

5.2 EXCAVATIONS B-21 AND B-22 (ADAMS AVENUE)

At excavations B-21 and B-22, NAPL was identified in the fill at a depth of 5.0 to 6.5 feet. Adjacent excavations, B-18, B-19 and A-3, did not identify NAPL, however the excavations for these utilities were relatively shallow, 4.5 feet, 4.0 feet and 0.8 feet. A review of information from overburden wells and boreholes installed in the immediate area did show NAPL presence at depths similar to the excavations at B-21 and B-22 (BH-125, 6-12.5 feet BGS; OW-212, 8.6-10 feet BGS and 15.8 feet BGS; and OW-230, 6.7-10 feet BGS). Although the utility lines are installed approximately 6 feet above the top of the clay stratum, it appears that they lie in a general NAPL plume which is also situated at approximately the 6.0 foot depth. This plume is a result of gravity flow of NAPL from the S-Area Landfill Site and cannot be attributed to preferential flow through the utility bedding.

5.3 INDUSTRIAL INTAKE PIPE TRENCH

The overburden wells installed within the boundary of the Industrial Intake Pipe Trench exhibited evidence of NAPL at various points generally grouped at the 8 to 14 feet and 18 to 29 feet depths. These depths can be correlated with the interfaces between the various strata found in the area (i.e. depth to alluvium approximately 11.5 to 14 feet BGS and depth to till approximately 22 to 31.5 feet BGS). These elevations of NAPL presence are also confirmed in other boreholes located nearby (BH142, 8-12 feet BGS; BH143, 6-14 feet BGS and 21-26 feet BGS; BH146, 10-21 feet BGS and 24-27 feet BGS).

The NAPL identified in the Industrial Intake Pipe Trench appears to be a result of a general NAPL plume migrating in a southward direction. The trench excavation and construction affected the local geologic stratigraphy thereby influencing the southerly migration of NAPL. In order to install the industrial intake pipes, an open cut trench (approximately 50 feet in width) was excavated to an elevation of approximately 543.5 feet AMSL (1986 OCC datum). The walls of the excavation were vertical and supported by 10-inch by 10-inch timbers laid horizontally atop one another. Vertical bracing was pile driven to refusal to maintain the vertical position of the timbers. Observation made in a test pit excavation in 1982 indicated that the

timber walls were not removed as the trench was backfilled and remain in place today. Consequently, not only do the timber walls sever the connection of geologic limits across the trench, but the type of material used as backfill will also serve as a discontinuity. Once NAPL enters the intake trench, the preferential path of migration would be along the intake pipe trench timber walls or bedding material to the west or east and then south to the intake structure on the edge of the River. A detailed discussion of the impact of the Industrial Intake Trench on chemical migration in the surrounding overburden is presented in the report "Assessment of Extent of APL/NAPL Migration from the S-Area in the Overburden Toward the Niagara River".

5.4 EXCAVATIONS WITH NO NAPL

In the majority of excavations conducted as part of the Utility Bedding Investigation, there was no evidence of NAPL presence. There are three possible explanations for the absence of NAPL in these bedding materials. The majority of the "clean" excavations were located outside of the general NAPL plumes present around the S-Area Landfill Site (i.e. B-5, B-25, B-33). Other utility bedding excavations were completed at shallow depths, consistent with the invert elevations of the bedding materials, thereby not encountering the NAPL which is present at greater depths (i.e. B-18, B-19 and A-3).

Lastly, the method by which the backfilling of native materials used as bedding is performed may reduce the potential for the bedding to act as a preferential pathway for NAPL migration. As the original materials are excavated from the trench and then replaced around the pipe and in the utility trench, they are mixed. Consequently, the original layering of soils is disturbed in the trench and results in the creation of discontinuities of the soil layers from one side of the trench to the other. Thus, the more permeable strata through which NAPL would preferentially migrate would effectively be severed. Consequently, the trench with its more homogeneous backfill would serve to reduce continued NAPL migration across the trench. The homogenization created by the reuse of native materials for backfill and bedding together with the compactive effort used to place these materials may in fact reduce the overall permeability of the bedding in comparison to the surrounding undisturbed areas and therefore results in a less preferential pathway for NAPL migration. It is possible that a poor compactive effort could lead to an increased overall permeability and a more preferential pathway, however this was not identified to be the case.

6.0 SUMMARY AND CONCLUSIONS

From the information gathered in the Utility Bedding Investigation to date, it can be concluded that the degree of influence of the utility bedding on NAPL migration is minimal. The reasons for this are:

- many of the utilities are located above the elevation of the NAPL found in the overburden and are therefore above the plume of NAPL migration;

- many of the utilities are remote and do not intersect the NAPL plume;

- most of the utility trenches have been backfilled with the originally excavated soil rather than coarser bedding material. Consequently, having been disturbed and compacted, it is possible that the bedding material may even be less conducive to NAPL migration than the surrounding undisturbed soils.

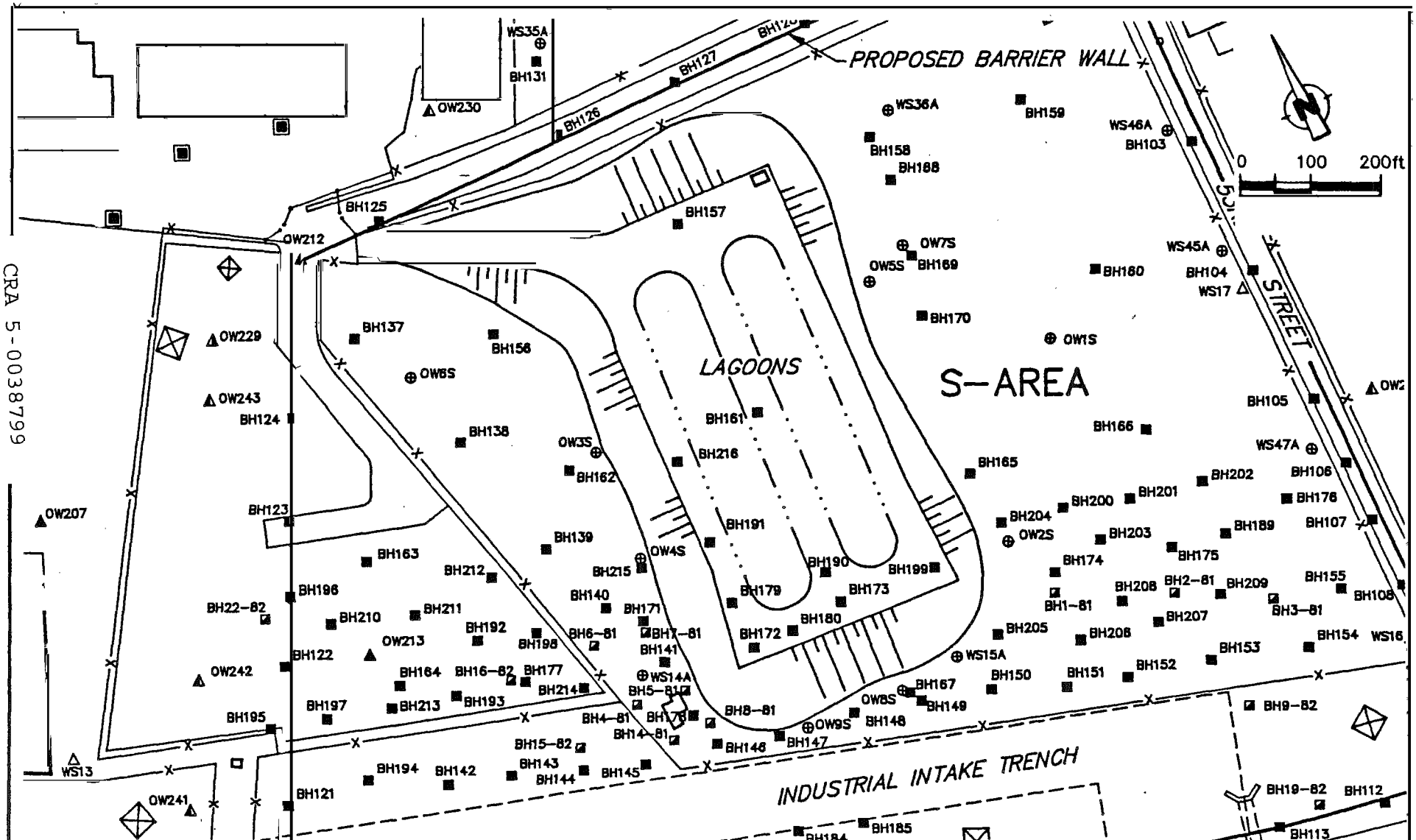
Due to the above mentioned factors, the bedding of the following underground utilities are not pathways of NAPL migration:

A-1, A-2, A-3
B-3, B-5, B-6, B-8, B-9, B-12, B-13, B-14, B-16, B-18, B-19, B-24, B-25, B-26,pB-27, B-28, B-31, B-32, B-33
C-4A, C-4B

The intersection of the 24-inch watermain and 24-inch wastewater sewer (Outfall 003) with the underlying clay layer has caused some localized NAPL migration. This effect, however, is expected to direct NAPL back towards the S-Area Landfill Site since the line cuts into the native clay and slopes back toward the S-Area Landfill Site.

In addition, the NAPL which was identified at B-1 and B-2 will be within the perimeter of, and would be contained by, the proposed Northern System Barrier Wall and is therefore of no concern. A slight modification of the Northern Barrier Wall alignment will be necessary to accommodate this identified area of NAPL presence.

The presence of NAPL at B-21 and B-22 does not appear to be related to bedding material. This is simply a general area of NAPL presence and as a result will require further investigation prior to finalizing the appropriate alignment of the Site Barrier Wall. In order to finalize this aspect of the study, it is proposed that three additional boreholes be completed at the locations shown in Figure 8. Each borehole will extend to the top of the confining layer and will include continuous split spoon sampling.



LEGEND

▲ ▲ ◪ ■ ⊕ EXISTING WELLS/BOREHOLES

▣ PROPOSED ADDITIONAL BOREHOLES

CRA

figure 8

PROPOSED ADDITIONAL BOREHOLES
S-AREA REMEDIAL PROGRAM
Occidental Chemical Corporation

CRA 5-0038799

1769-18/05/88-24-D-0

While the bedding of the Industrial Intake Pipe Trench could be expected to be a preferential pathway to westward and southward NAPL migration, the investigation of the bedding near the Niagara River (locations C-4A and C-4B) and west of the S-Area (locations OW269, BHW270 and BHW273) indicate that this has not occurred.

The results of the investigation of the outstanding bedding surveys will be reported as completed.