BOEING

PHASE 2 GROUNDWATER STUDY
PLANT 1 FACILITY
BOEING MILITARY AIRPLANES
WICHITA, KANSAS
PROJECT NO. 52905009

SEPTEMBER 17, 1990

RECEIVED

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Terracon
ENVIRONMENTAL, INC.
2111 West Harry Street
Wichita, Kansas 67213
(316) 262-0171

James A. Cunningham, P.E.
John F. Hartwell, P.E.
Robert L. Sholar
Douglas A. Aldrich, P.E.

September 17, 1990

Boeing Military Airplanes
P. O. Box 7730
M/S K11-65
Wichita, Kansas 67277-7730

Attn: Mr. John Clarke

Re: Phase 2 Groundwater Study
Plant 1 Facility
Boeing Military Airplanes
Wichita, Kansas
Project No. 52905009

Dear Mr. Clarke:

As requested, Terracon Environmental has performed a Phase 2 Groundwater Study of the referenced site. The purpose of this study was to further evaluate the extent of groundwater contamination encountered during the Phase 1 Groundwater Study, submitted with our report dated April 25, 1990.

The results of the Phase 2 Groundwater Study appears to indicate the contaminant source is located in the vicinity of Building 310C. The plume stretches from Building 310C to the southwest. A smaller contaminant lobe is indicated to the northwest of Building 310C, apparently the result of bedrock and groundwater divides in this area. The highest contaminant levels were ~~15,000~~ 150,000 ppb trichloroethylene, measured at MW-63 in the Phase 1 Groundwater Study.

A surface drainage swale, and underlying depression of the shale interface, were located west of the PMS Building. Although further work would be required to evaluate the nature and extent of this

depression, it does not appear to have significantly affected contaminant distribution at this time. However, the presence of sand/sandstone seams within the depression may result in increased contaminant migration in the future.

Based on the contaminant levels encountered, it is anticipated that the KDHE will require groundwater recovery and treatment. Included with this report are recommendations for further work required for the design of groundwater recovery and treatment systems.

Should you have any questions regarding the enclosed report, or if we may be of further service to you in any other way, please let us know.

Sincerely,

TERRACON ENVIRONMENTAL, INC.

John R. Hoaglund

John R. Hoaglund III
Project Hydrogeologist

Douglas A. Aldrich

Douglas A. Aldrich, P.E.
Principal

JRH/DAA:gmf(3)
Attachments

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BORING LOGS -

B-1 through B-7

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ATTACHMENT A: FIELD PROCEDURES
PHASE 2 GROUNDWATER STUDY
PLANT 1 FACILITY
BOEING MILITARY AIRPLANES
WICHITA, KANSAS
PROJECT NO. 52905009
SEPTEMBER 17, 1990

INTRODUCTION

The Phase 1 Groundwater Study comprised a preliminary evaluation of the groundwater quality in the general area of Plant 1 facility. Phase 1 included the installation of 4-inch diameter monitor/recovery wells at 10 separate locations. At three of these locations, shallow groundwater was observed and 2-inch diameter monitor wells were installed next to the 4-inch wells, in cluster configuration. The results of the Phase 1 study, including contaminant concentration contours and groundwater table contours, were transmitted with our report dated April 25, 1990.

The results of the Phase 1 study indicated groundwater flow was generally to the west-southwest in the deeper/fully screened wells. The shallow monitor wells indicated a south-southwest flow direction based on a limited number of data points (3 wells). Solvent contamination (notably trichloroethylene) was encountered in the groundwater, with maximum levels on the order of ~~15,000~~ 150,000 ppb TVOC at MW-63. Contaminant contours indicated a plume oriented in a northeast to southwest direction. The area of highest concentration was between the Plant 1 Warehouse and Building 310C. However, the source of the contamination could not be determined within the Phase 1 work scope.

To further evaluate the plume source and extent, eight additional 2-inch monitor wells, MW-71 through MW-78, were installed as part of the Phase 2 study, at the locations shown on Figure 2. Most of

these wells were installed in the vicinity of the Plant 1 Warehouse to evaluate the source of the contamination.

Evaluation of aerial photographs indicated that a drainage swale had previously drained the general area of Plant 1. The drainage swale, now covered due to more recent construction activities, was considered as a potential preferential pathway for groundwater flow (and dissolved contaminants). Therefore, as part of the Phase 2 study, seven soil borings were performed west of the PMS Building to locate the channel, based on lithology and contaminant distribution. The information from these borings was used to locate a 5-inch monitor/recovery well (MW-79) in this area (Figure 2).

FIELD PROCEDURES

Monitor Wells

Eight 2-inch diameter monitor wells were installed at the approximate locations indicated by Boeing in the vicinity of Plant 1 (see Figure 2). These 2-inch diameter monitor wells were designated MW-71 through MW-78 and were installed to fully screen the aquifer, except for MW-72. The field observations indicated shallow/perched water conditions at one of the locations, MW-72. Therefore, as authorized by Boeing, a shallow observation well, MW-72A, was installed to form a cluster configuration with the deeper well, MW-72 (Figure 2).

Attachment A: Field Procedures
Phase 2 Groundwater Study
Plant 1 Facility
Boeing Military Airplanes
Wichita, Kansas
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Monitor well MW-79 was constructed west of the PMS Building with 5-inch diameter casing, to facilitate potential conversion to a recovery well. MW-79 was located in the area of the preferential drainage path indicated by the seven soil borings performed (B-1 through B-7, Figure 2).

The monitor wells were performed with a cleaned, truck-mounted CME-75 auger drill rig using 4 1/4-inch I.D. hollow-stem augers fitted with a continuous hollow-stem sampler (CHSS). The subsurface soils were continuously sampled, in 5-foot increments.

Representative portions of the soil samples obtained from the continuous hollow-stem sampler were composited over 5-foot intervals, placed in appropriate glass containers, and transported to Boeing for chemical analysis using chain-of-custody procedures. Other representative portions of the samples obtained were composited over 5-foot intervals, placed in appropriate glass containers, allowed to stabilize, and subjected to an ambient field headspace vapor analysis using a Thermo-Environmental photoionization detector (PID). The PID qualitatively measures most organic vapors, in ppm, relative to an internal instrument calibration standard. The PID readings were used to provide field screening information, to adjust the field program, to potentially select soil samples for chemical analysis, and to supplement the chemical analyses results.

Representative portions of the samples obtained were examined by the field geologist, classified in accordance with the Unified Soil Classification System, based on visual and tactual observations. Monitor/recovery well MW-79 was performed with 8 1/4-inch I.D. hollow-stem augers fitted with a center bit. Since MW-79 was located only a few feet away from B-6, a continuously sampled soil boring, discrete soil samples were not obtained. The subsurface materials shown in the boring log for MW-79 were based on the classifications developed from the continuous samples at B-6, as confirmed by the visual observation of disturbed auger cuttings at MW-79.

The monitor/recovery well borings were advanced to a depth slightly below the observed interface of the weathered shale bedrock material, encountered at depths on the order of 40 to 50 feet. Upon completion of the borings to the required depth, the monitor/recovery wells were constructed through the hollow-stem augers. The monitor wells were constructed of 2-inch diameter, Schedule 40 PVC flush-joint well casing and screens (.010-inch slot), however, MW-79 was constructed of 5-inch diameter well casing and screen (.020-inch slot).

The screened interval of the wells typically extended from the bottom of the borings to a level a couple of feet above the water table indicated by the field observations. However, where apparent perched water conditions were indicated at MW-72, a cluster of two wells was constructed in a manner to separately screen both the

shallow and deep "aquifers". Coarse grade silica sand was placed in the annular space around the well screen to a level approximately 1 to 2 feet above the top of the well screen. A bentonite-pellet plug, approximately 1 to 2 feet thick, was constructed on top of the sand pack. The remainder of the well annulus was filled with bentonite-cement grout to a level about 2 feet below grade.

The 2-inch wells were fitted with a rubber expansion plug and a PVC slip cap was fitted on the 5-inch casing of MW-79. Metal protective covers with hinged lids were placed over the well casings and set in the grout. Matching padlocks were provided on the hinged lids to reduce the potential for unauthorized entry. Concrete pads with four barrier posts were constructed around the monitor wells for further protection. Prior to installation of barrier posts, monitor well MW-71 was damaged by truck traffic, but repaired under separate agreement.

Soil Borings

The soil borings west of the PMS Building were performed using 3 1/4-inch I.D. hollow-stem augers fitted with a continuous hollow-stem sampler (CHSS). Soil samples were collected, contained, and transported as discussed above for monitor wells. Portions of the soil samples were subjected to ambient headspace vapor analyses and other portions provided to Boeing for chemical analysis, using procedures previously outlined.

Attachment A: Field Procedures
Phase 2 Groundwater Study
Plant 1 Facility
Boeing Military Airplanes
Wichita, Kansas
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Cleaning

To reduce the potential for cross-contamination, the auger drill rig and downhole drilling/sampling equipment were cleaned prior to entry into the site; the augers and downhole drilling/sampling equipment were also cleaned prior to the performance of each monitor well/soil boring. Cleaning procedures consisted of a high-pressure, hot-water detergent (Alconox) wash followed by a clean-water rinse. The cleaning was performed using a portable washer at the site. As requested by Boeing, auger cuttings were transported (by sub-contractor) to the Boeing Landfill on MacArthur Road for disposal.

Surveying

The locations and elevations of the monitor/recovery wells and borings were determined by a licensed land surveyor. The coordinates of the monitor/recovery wells are summarized in Table 1. The coordinates of the borings are summarized in Table 2. The elevations of the ground surface and top of casing for the monitor/recovery wells are summarized in Table 3. The ground surface elevations of the borings are summarized on the attached boring logs.

Development/Sampling

All monitor wells were developed using cleaned PVC hand bailers and/or centrifugal pump; the wells were considered developed

following removal of a minimum of five well casing volumes of water. Well development fluids were containerized in a 55-gallon drum (provided by Boeing); we understand Boeing has arranged for the appropriate disposal of these fluids. Boeing also arranged sampling of the monitor wells and subsequent chemical analysis.

Water Level Measurements

Following development, the monitor wells were allowed to stabilize for approximately eight days. The depth to water was measured in each well on June 28, 1990 using an ORS hydrocarbon interface probe, capable of measuring free product to the nearest .01 foot. Free product was not detected in any of the monitor wells installed. The depths to groundwater are included in Table 3.

SITE GEOLOGY

Regional Geology

As discussed in the Phase 1 report, the subject site is located near the Arkansas River valley (Figure 1). However, the Plant 1 facility is located in a shale upland area, which generally consists of residual soils weathered from the underlying Wellington shale. The transition between the residual soils and the underlying shale is gradual, primarily dependent on the degree of weathering of the bedrock material. The overburden soils are typically cohesive lean to fat clays, with shale fragments and

lamination in the less weathered materials at greater depths. The residual soils are generally red-brown to gray in coloration, generally becoming olive-brown to olive-gray with depth, underlain by dark gray relatively unweathered shale.

Several layers of sand/sandstone have often been encountered in other portions of the Boeing facility, above the dark gray, relatively unweathered shale bedrock. Compilation of boring logs from other projects in the Boeing facility, and field observation of sandstone out-croppings near K-15 highway, indicates that one sandstone seam may be consistent at approximate elevation 1300 feet MSL. The sand/sandstone appears to range in thickness from a few inches to a few feet. The borings in which this sandstone is encountered generally occur in the western portion of the Boeing facility. Since the unweathered shale bedrock interface slopes down to the west, it is possible that the sand/sandstone layer may be encountered within the unweathered shale further east, however, the previous monitor well borings were terminated near the unweathered shale interface.

The Wellington shale has been geologically interpreted[1] as the result of Permian shallow marine and coastal flat deposition "with relic puddles, ponds, and even small scale lakes" that may have

[1]"Periodicity in the Wellington Formation of Kansas and Oklahoma", Paul Tasch, 1964.

been in-filled with sand. This suggests that the sand/sandstone seams may be part of the original Permian age deposition of the bedrock, which is supported by observations indicating a bedded nature and high degree of sorting.

Variations in composition of the apparent material and degree of weather often results in zones of varying permeability and separation of "aquifers". Although these aquifer separations are often localized, they can result in perched water and confined conditions. Overall, permeability is relatively low, with corresponding slow groundwater velocity and low well yields. The Phase 1 study indicated a shallow perched water condition flowing generally to the south-southwest, based on limited data. The information from the deeper wells in Phase 1 indicated the deeper "aquifer" flows generally to the west-southwest.

SITE AND SUBSURFACE CONDITIONS

The subject area is slightly to moderately sloped, with surface drainage generally towards the west. A drainage ditch is currently located on the south side of the Master Model Building, flowing to the west and eventually draining into the Arkansas River.

Evaluation of aerial photographs also indicated that a drainage swale had previously drained the Plant 1 facility, before being covered by construction activities. The location of this drainage swale is indicated in Figure 2. As indicated therein, the drainage

swale originated near Plant 1, drained into a pond near the northwest corner of the Nacelle Building, and continued toward the PMS Building, then further west. Although this drainage channel is no longer visible due to filling/regrading, it was considered that coarser deposits associated with this drainage swale could act as a preferential pathway for groundwater with dissolved contaminants. Accordingly, seven soil borings were performed west of the PMS Building to located the drainage swale, and to subsequently install a monitor/recovery well near its center (Figure 2).

As indicated on the attached boring logs, and those previously submitted with the Phase 1 study, the overburden soils encountered generally consist of cohesive lean to fat clays which extended to depths on the order of 35 to 50 feet, underlain by dark gray, relatively unweathered shale bedrock. These cohesive soils were generally dark brown to red-brown near the surface, becoming olive-gray to gray with greater depth. Shale fragments and lamination were also observed in these residual soils with greater depth. Although not indicated on the boring logs, the deeper cohesive soils with shale fragments and lamination could also be sub-classified as highly weathered shale. As previously discussed, the distinction between residual soils and the underlying shale is subtle and subjective, dependant primarily upon the degree of the weathering.

Figure 4 shows a cross-section across the Plant 1 site, including Phase 1 and Phase 2 borings. As indicated therein, many discrete

beds of sandstone, limestone, or gypsum encountered in the section do not consistently trace from one boring to another. However, stratigraphic breaks were commonly encountered at consistent subsurface elevations, suggesting that the strata may trace its sedimentary characteristics laterally, although individual sedimentary components may be discontinuous. The cross-section of Figure 4 shows that the bedrock surface generally slopes from northeast to southwest. One stratum of massive to blocky to red-brown fat clay was consistently observed between elevation 1330 and 1340 feet. This unit was relatively unweathered, compared to overlying and underlying strata, suggesting a zone of relatively low groundwater flow. The red-brown fat clay may be acting as a confining unit.

To locate the drainage swale west of the PMS building, a cross-section was constructed with the data obtained from borings B-1 through B-7, as shown in Figure 5. As indicated therein, the cross-section shows the fill is thickest at borings B-5, B-3, and B-7 and the central part of the cross-section. It appears that the thicker fill corresponds to the surface drainage swale indicated on aerial photographs prior to more recent facility construction.

As indicated in Figure 5, a depression in the shale interface was encountered in the vicinity of B-3, B-6, and B-7. Several sand/sandstone seams were observed in boring B-6, including one which occurred at approximate elevation of 1300 MSL. The origin of these sand beds are not positively identified at this time, but appears to be part of the sand/sandstone seam observed in the western por-

tion of the Boeing facility, as described above. Although absent in some borings, the general continuity of this strata, and the presence of apparent residual soils above and below the sand/ sandstone seams, indicates the sand/sandstone seams were not a recent alluvial deposit, but were an original member of the Permian bedrock. Therefore, the depression in the shale interface does not appear to be an in-filled erosional surface, but an area of accelerated weathering of the shale. In-place weathering of the cemented sandstone would account for the sand seams currently encountered in some locations. However, further work would be required including performance of deeper borings which penetrate through unweathered shales above elevation 1300.

In Figure 3, the surface drainage swale previously indicated by the 1938 aerial photographs has been overlain on the unweathered shale bedrock contours. As indicated therein, the surface drainage swale generally correspond to the depression encountered in the shale bedrock surface. It appears that the depression in the shale interface is probably a reflection of accelerated weathering of the shale bedrock, due to increased recharge of groundwater from the surface drainage swale. The flatter surface of the unweathered shale near the northeast corner of the Nacelle Building may be due to a greater amount of recharge water in this area from the pond.

If the observed sand/sandstone seam at elevation 1300 is generally continuous, then it is likely that it will be overlain by unweathered shale bedrock materials further to the east. Therefore,

the sand/sandstone seams observed at B-6 and MW-79 would represent a preferential pathway for contaminant migration only for a limited distance east of the PMS Building. However, further work would be required to evaluate the extent of the sand/sandstone exposed above the unweathered shale interface.

GROUNDWATER

Observations were made by the drill crew while drilling to determine the presence of free water. At monitor well MW-72, a red-brown fat clay was observed from about 14 to 17 feet below grade. It appeared that water in the overlying sandy clays could result in a perched water condition above the fat clay. Therefore, monitor wells MW-72 and MW-72A were installed in a cluster configuration to separately screen the observed "aquifers".

Free water was not observed while drilling monitor wells MW-71 and MW-78, but was observed in the remainder of the Phase 2 monitor wells at depths ranging from 13 to 38 feet. However, longer-term observations indicated that water levels in these monitor wells had risen to depths on the order of 4 to 10 feet below grade. Although the cohesive soils would yield water slowly into a well boring, the absence of observed water in some of the overlying seams, together with the observed rise in water levels, may suggest artesian potential of a confined aquifer.

The depths to groundwater measured on June 28, 1990 are summarized in Table 3. The groundwater elevations for the deeper/fully screened wells are contoured in Figure 6. Assuming horizontal flow, homogeneous materials, and isotropic conditions, the contours indicate a groundwater gradient generally to the west, consistent with earlier observations from the Phase 1 study. However, a relative high groundwater potential is indicated in the vicinity of Building 310C, suggesting a groundwater divide in this area. Groundwater appears to flow to the northwest near the Plant 1 Warehouse and to the southwest under Plant 1.

Fluctuations in the groundwater should be anticipated due to variations in hydrological conditions and other conditions not apparent at the time of this report. Also, longer-term observations would be required to more accurately evaluate the groundwater conditions.

CONTAMINANT DISTRIBUTION

As discussed above, Continental Analytical Services sampled and analyzed the newly installed monitor wells. The results of those analyses, provided to us by Boeing, are summarized in Table 4. As indicated therein, the detected contaminants were primarily solvents, particularly trichloroethylene, chloroform, and carbon tetrachloride. High concentrations of trichloroethylene were encountered in the wells located near Building 310C, ranging from 6.5 ppb to 4,100 ppb. The highest concentration for all wells was

150,000 ppb at MW-63 in the Phase 1 study. Only trace levels were observed east and north of the Plant 1 Warehouse. High concentrations of both trichloroethylene and carbon tetrachloride were encountered in MW-74, south of the Tooling Building.

The data set from the February sampling of the Phase 1 wells was combined with the results of the June 21 sampling of the Phase 2 monitor wells. The total volatile organic compound (TVOC) contaminant concentration contours were drawn for the composite data set, as shown in Figure 7. The logarithmic contours shown therein indicate a relatively high concentration around MW-63, but this concentration decreases sharply to the northeast. The contaminant distribution shown in Figure 7 suggests the contaminant plume is migrating in a southwesterly direction, from Building 310C. However, contaminants in the area of Building 310C also indicate a northwesterly trend, possibly in response to the groundwater divide previously discussed. In addition, a second area of relatively high concentration is indicated around the MW-74, south of the Tooling Building, although additional wells may indicate the two areas of relatively high concentrations are connected.

The bedrock contours of Figure 3 indicated a relative bedrock high in the vicinity of Plant 1. Bedrock slopes down to the north in the vicinity of the Plant 1 Warehouse and slopes down to the southwest generally to the west of Plant 1. As discussed below, it appears that this bedrock divide may influence groundwater and contaminant movement.

Only relatively low levels of trichloroethylene, 4.0 ppb, were encountered at MW-79, located in the depression of the shale interface west of the PMS Building. Although continued monitoring of this well should be performed, it appears that this shale depression has not yet significantly affected contaminant migration. This may be due to the anticipated absence of sand/sandstone exposed above the unweathered shale interface east of the PMS Building. This appears to be supported by the absence of sand/sandstone seams above the shale at MW-74 (6,820 ppb TVOC). However, further work would be required to evaluate the extent of the shale depression.

It appears that the leading edge of the contaminant plume is approaching the sand/sandstone seams encountered in the shale depression west of the PMS Building. Although current contaminant levels in this depression are relatively low, it is possible that increased levels of contaminants could occur in the future, as solvent contaminants pass through the relatively less permeable residual clay soils to the east and enter the more permeable sand/sandstone seams in the vicinity of the PMS Building.

SUMMARY

The overburden soils encountered consist of generally cohesive clays to depths on the order of 35 to 50 feet, underlain by relatively unweathered shale bedrock. The overburden soils are apparently residual clays derived from weathering of the underlying

shale. The surface of the unweathered shale generally slopes down to the southwest through most of the study area, but slopes down generally to the north in the vicinity of Building 310C and the Plant 1 Warehouse.

Soil borings performed west of the PMS Building appear to locate a surface drainage swale indicated in this area by the 1938 aerial photographs. Below the surface drainage swale, a depression was encountered in the surface of the unweathered shale. This shale depression appears to have developed by accelerated weathering of the shale due to increased recharge water from the surface drainage swale. Seams of sand/sandstone were encountered within the "shale drainage feature", approximately elevation 1300. Although further work would be required for verification, it appears the sand/sandstone seams at elevation 1300 may be generally continuous throughout most of the western portion of the Boeing facility, although potentially discontinuous on a localized basis. Since it appears that the sandstone seams are relatively flat, relative to the somewhat steeply sloped weathered shale bedrock interface, it is possible the sand/sandstone seams are below the shale interface east of the PMS Building.

Longer-term observations in the monitor wells indicated water levels on the order of 4 to 10 feet below existing grade. Although further work would be required for verification, a stratum of red-brown fat clay may act as a confining layer, resulting in artesian potential. A generally west-southwesterly gradient was indicated

for the deeper monitor wells. However, an apparent groundwater divide is indicated in the vicinity of Building 310C, with a northwesterly gradient in the vicinity of the Plant 1 Warehouse. Groundwater velocities in the cohesive overburden soils are anticipated to be relatively low, although higher groundwater velocities could be anticipated in the sand/sandstone seams observed west of the PMS Building. Aquifer stress tests would be required to more accurately evaluate aquifer transmissivity, velocity, and other parameters.

The contaminants encountered were primarily solvents, primarily trichloroethylene, and carbon tetrachloride. The highest levels of trichloroethylene were measured in Phase 1 at MW-~~62~~ 63 (~~15,000~~ 150,000 ppb), while the highest levels of carbon tetrachloride were measured in Phase 2 at MW-74 (3,300 ppb). The contaminant distribution developed from the Phase 1 and Phase 2 sampling indicated a contaminant plume oriented from the northeast to the southwest. Higher contaminant concentrations were indicated near Building 310C and the southeast corner of the Tooling Building. Although it is possible that these areas represent separate sources of contamination, it appears more probable that a common source of trichloroethylene occurs in the vicinity of Building 310C. However, the data indicates a source of carbon tetrachloride may be located near the southeast corner of the Tooling Building. Additional monitor wells would be required between Building 310C and the Tooling Building to evaluate whether there are more than one source of contaminants.

Although most of the contamination appears to extend to the southwest from Building 310C, a secondary contaminant lobe to the northwest is also indicated in the vicinity of Building 310C and Plant 1 Warehouse. It appears this secondary lobe of contaminant migration is a reflection of the bedrock and groundwater divides observed in the area of Building 310C.

A depression in the shale bedrock interface was encountered west of the PMS Building. Seams of sand/sandstone were encountered above the shale interface within this depression. However, the residual nature of the overlying and underlying clay soils, and other information developed, indicates that the sand/sandstone seams are not of alluvial origin, but were originally within the Permian shale. Although these sand/sandstone seams will likely be a preferential pathway for movement of groundwater and contaminants, it is anticipated that their extent would be relatively limited east of the PMS Building. Since the leading edge of the observed contaminant plume appears to be just reaching the PMS Building area, this preferential pathway does not appear to have significantly affected the contaminant plume at this time. However, further work would be required to verify that the sandstone seams are part of Permian bedding and limited in extent east of the PMS Building.

RECOMMENDATIONS

As outlined above, it appears that the contamination may be advectively moving to the northwest in the vicinity of the Plant 1

Warehouse. To evaluate contaminant migration in this direction, it is recommended that monitor wells be installed at the northwest and southwest corners of the Plant 1 Warehouse. As indicated by the contaminant contours in Figure 7, other suggested locations for monitor wells would be west of MW-59, south of MW-57, and northeast of MW-64. If possible, a monitor well should be installed within the northwest portion of Plant 1, to indicate whether the relatively high contaminant concentrations indicated near the Tooling Building represent a separate source of contamination. The source facility should be evaluated to identify potential sources and to make appropriate repairs.

Only relatively low levels of contaminants were measured in the shale depression west of the PMS Building, where sand/sandstone seams were encountered above the shale interface. However, it is recommended that further work be performed to further evaluate the nature and extent of these features with respect to the observed contaminant plume, and potentially, other sources.

Based on the contaminant levels encountered, it is anticipated that KDHE will require groundwater recovery and treatment. Design of groundwater recovery and treatment would require further information regarding radius of influence and well yield. To develop this information, we suggest the performance of constant rate pump test at the 4-inch wells installed in Phase 1. This information will be used to determine whether separate shallow recovery wells will be required, as well as to determine the radius of influence

for recovery wells in this area. Slug tests could also be performed in the 2-inch diameter monitor wells installed in Phase 2, to evaluate aquifer consistency.

Information from the pump tests and other field data could be used to model the groundwater recovery with the "random walk" solute transport model (Prickett et al, 1981). This model can use groundwater potentials modeled from either the PLASM flow model (Prickett and Lonquist, 1971) or the MODFLOW groundwater flow model (USGS, McDonald and Harbough, 1983). Modeling would aid in the design and most efficient use of multiple recovery wells and estimate the time required to develop plume control. The model results would be used to determine location and configuration of recovery wells and develop information required for design of groundwater treatment systems. Also, it is recommended that a total toxic organics analysis, plus metals, be performed for design of the groundwater treatment system.

Since the measured contaminant levels are in excess of the Kansas Action Levels, the results of this report should be forwarded to the KDHE for their review. A copy of this report could be forwarded to Mr. Kyle Parker, KDHE, 1919 N. Amidon, Suite 130, Wichita, Kansas 67203. If desired, Terracon Environmental would forward a copy of this report to Mr. Parker, but only upon your specific request.

Attachment A: Field Procedures
Phase 2 Groundwater Study
Plant 1 Facility
Boeing Military Airplanes
Wichita, Kansas
Project No. 52905009
September 17, 1990

GENERAL COMMENTS

The above discussion of contaminants and recommendations for further action were based on the results of the monitor wells at the locations installed. Different conditions should be anticipated at other locations and at other times.

This report has been prepared for the exclusive use of our client for specific application to this project, within the constraints of the client's directives. This report has been prepared in accordance with generally accepted environmental engineering practices; no other warranty is expressed or implied.

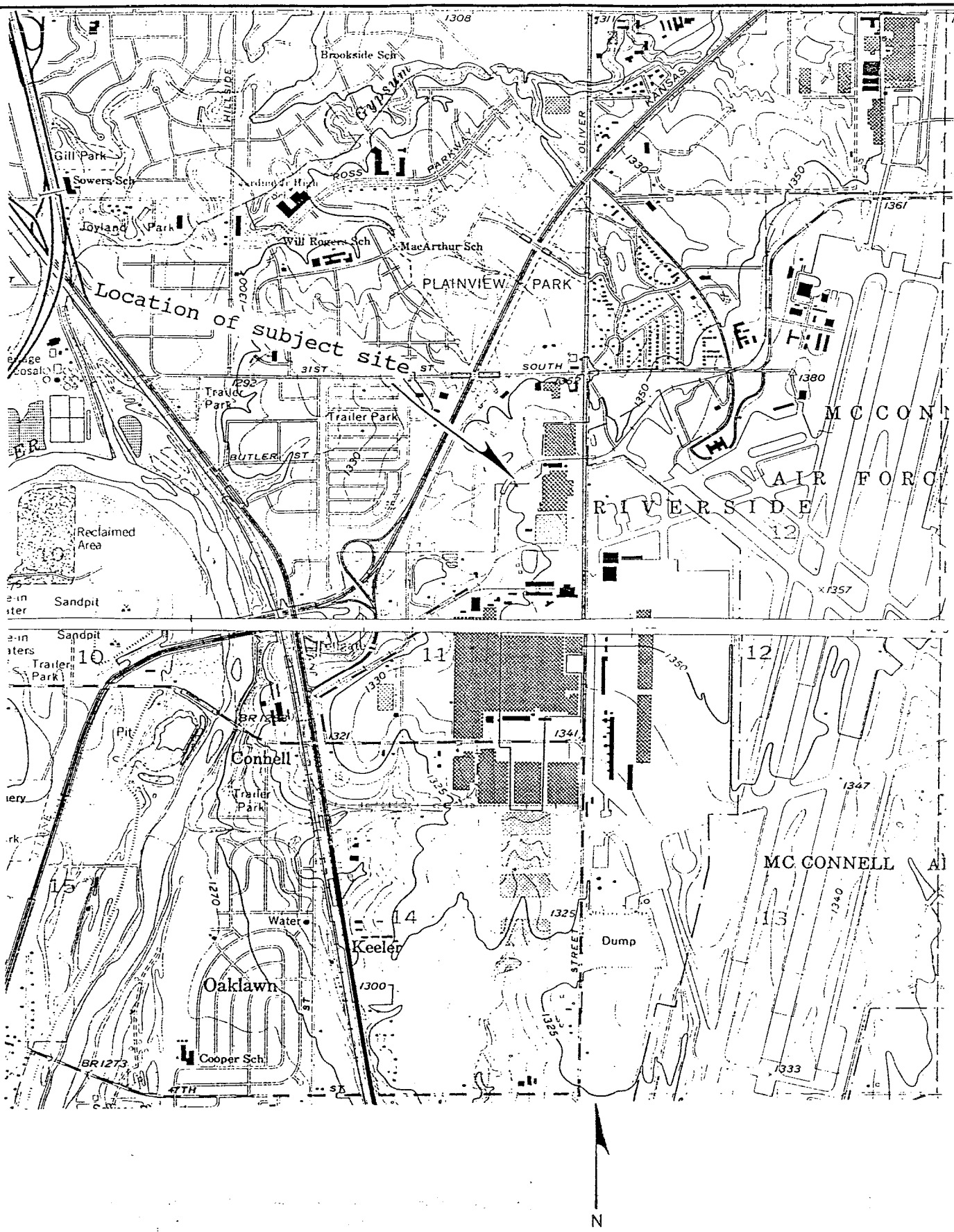


FIGURE 1. SITE LOCATION DIAGRAM
PLANT 1 FACILITY
BOEING MILITARY AIRPLANES
WICHITA, KANSAS

Job # 52905009	Date March 1990	Drawn JRH/nts

Terracon

Form 104 - 6.85

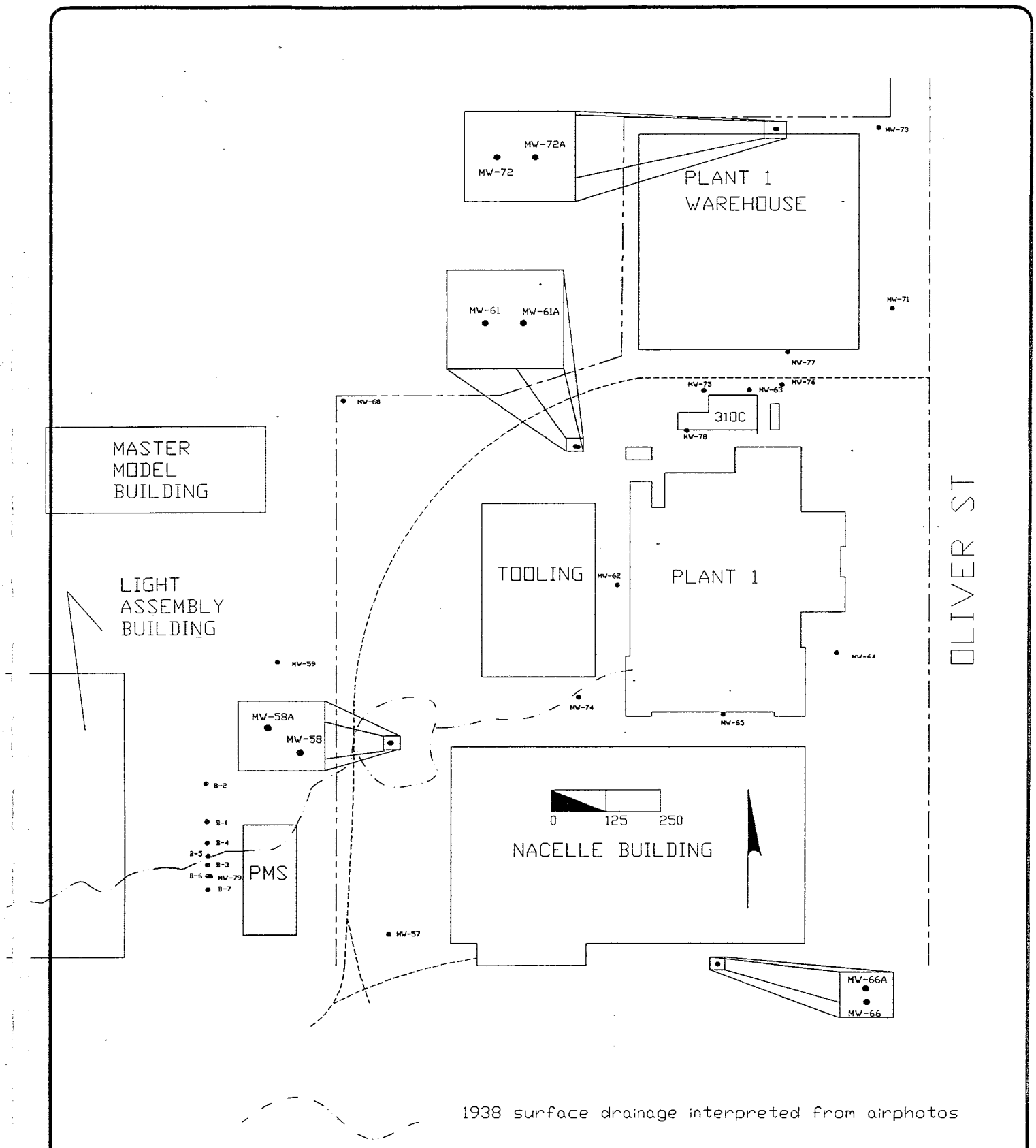
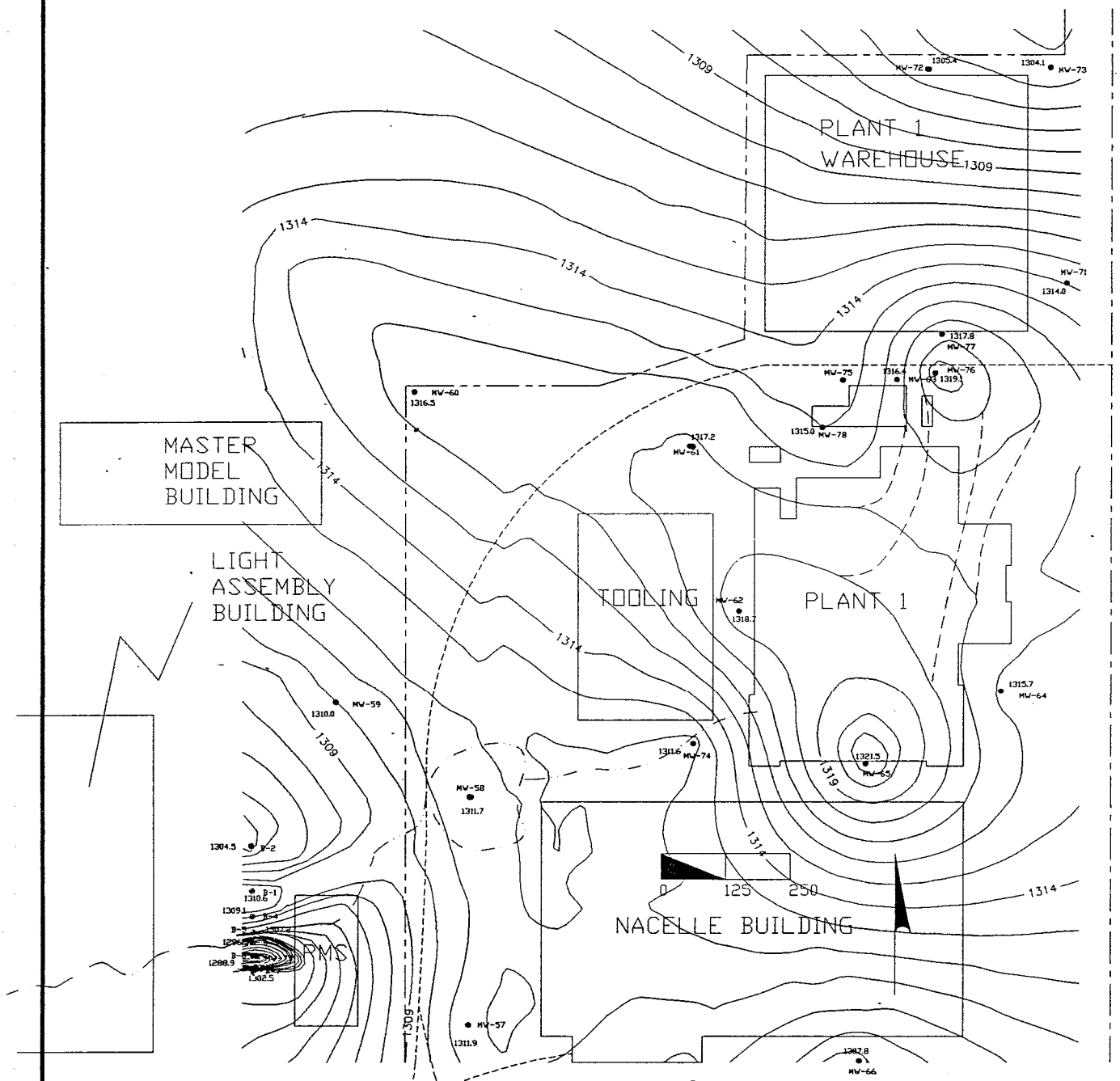


FIGURE 2. MONITOR WELL/BORING LOCATION DIAGRAM
PLANT 1 FACILITY
BOEING MILITARY AIRPLANES
WICHITA, KANSAS

Job # 52905009	Date Sept. 1990	Drawn JRH

Terracon

Form 104—6-85



Contours shown are based on computer-assisted interpolation between data points. Contours extrapolated beyond data points should be considered subjective.

Contour interval: 1 foot

1938 surface drainage interpreted from airphotos

FIGURE 3. SHALE INTERFACE CONTOURS
PLANT 1 FACILITY
BOEING MILITARY AIRPLANES
WICHITA, KANSAS

Job # 52905009	Date Sept. 1990	Drawn JRH

Terracon

Form 104—6-85

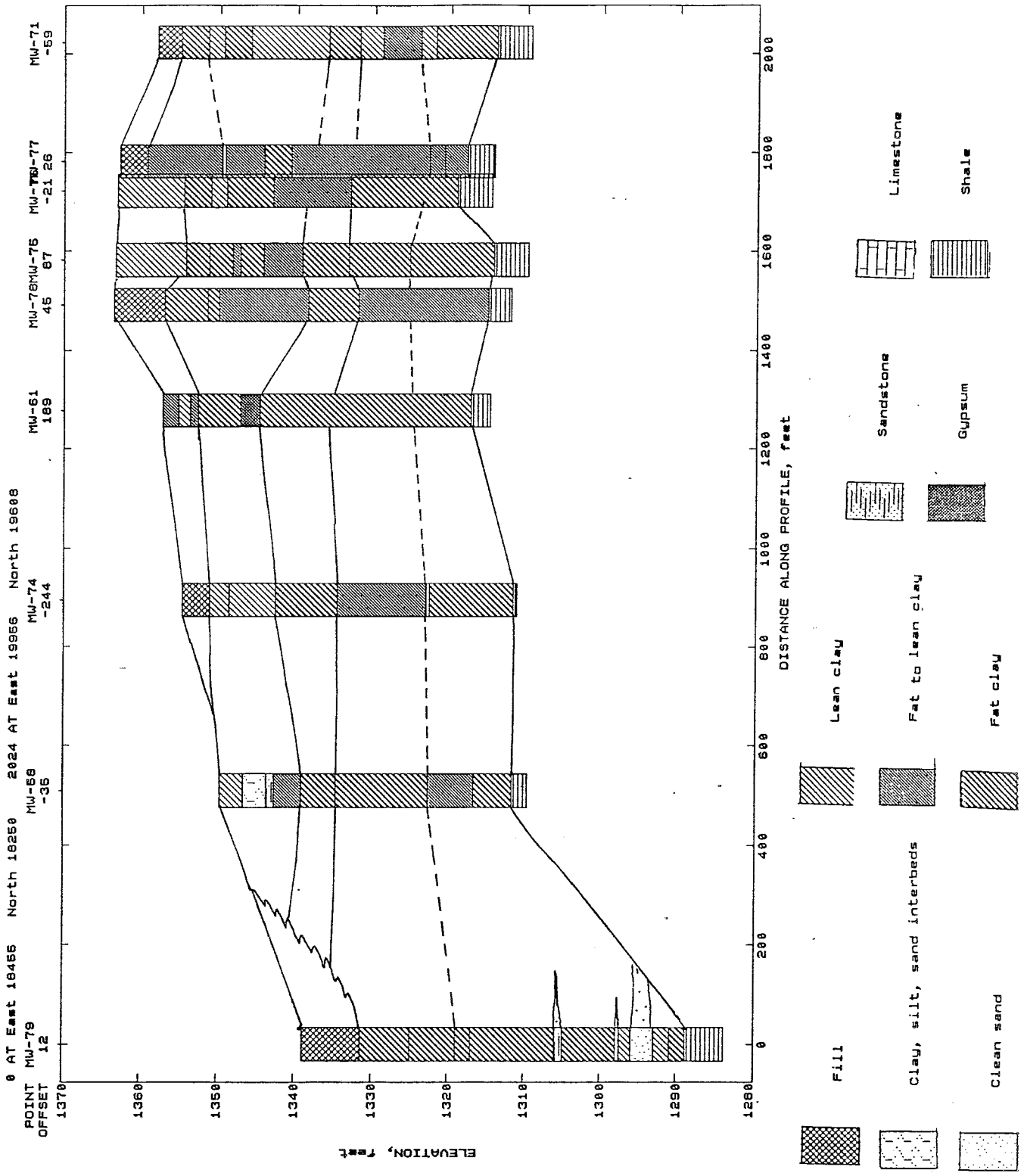


FIGURE 4. CROSS SECTION: NORTHEAST/SOUTHWEST, THROUGH PLANT 1 STUDY AREA
PLANT 1 FACILITY
BOEING MILITARY AIRPLANES
WICHITA, KANSAS

Job # 52905009	Date Sept. 1990	Drawn JRH nts	Terracon

Form 104—6-85

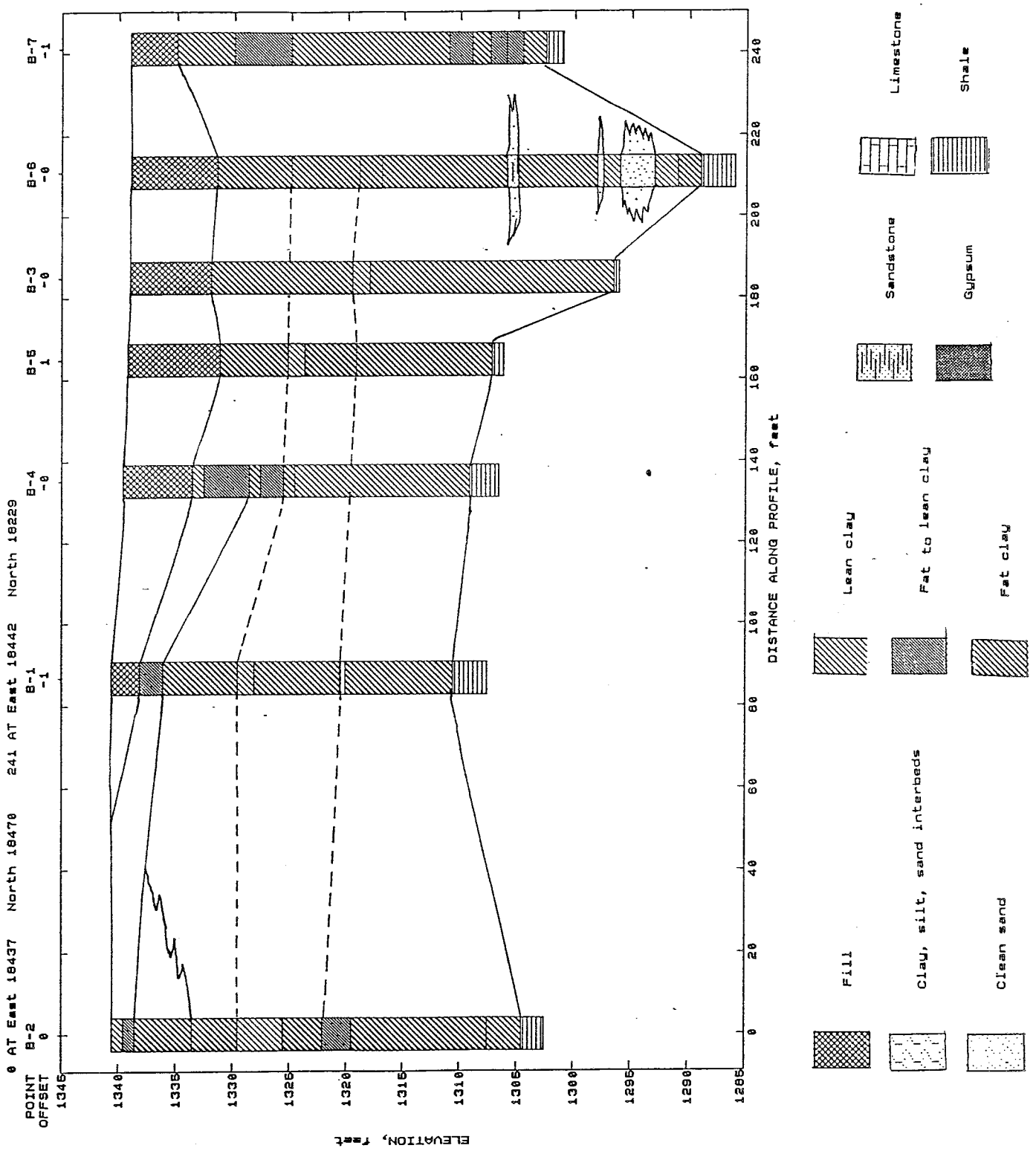
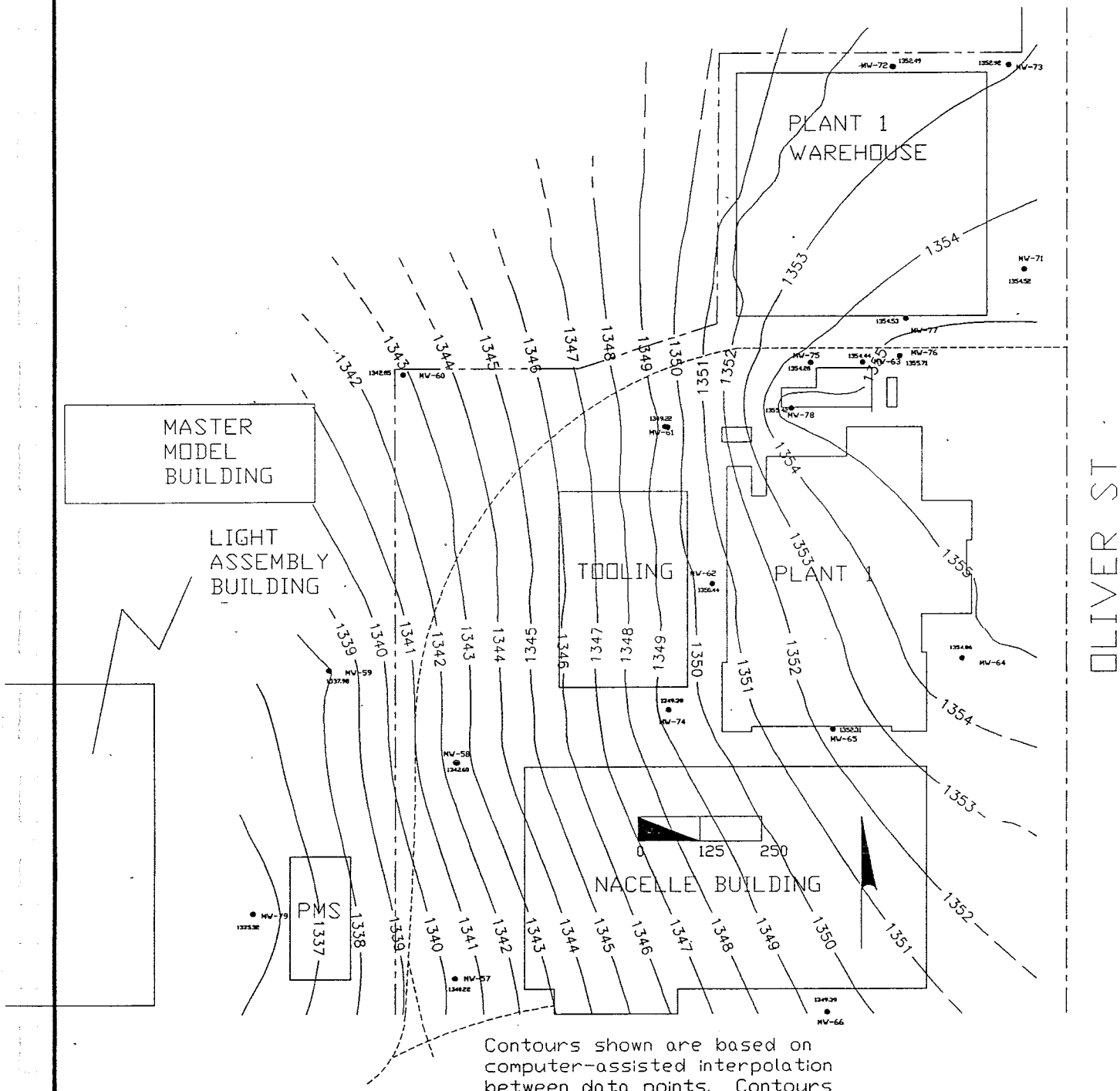


FIGURE 5. CROSS SECTION: NORTH/SOUTH, WEST OF PMS BUILDING
PLANT 1 FACILITY
BOEING MILITARY AIRPLANES
WICHITA, KANSAS

Job # 52905009	Date Sept. 1990	Drawn JRH/nts

Terracon

Form 104—6-85



Contours shown are based on computer-assisted interpolation between data points. Contours extrapolated beyond data points should be considered subjective

Contour interval: 1 foot

FIGURE 6. GROUNDWATER CONTOURS: DEEP/FULLY SCREENED WELLS
PLANT 1 FACILITY
BOEING MILITARY AIRPLANES
WICHITA, KANSAS

Job # 52905009	Date Sept. 1990	Drawn JRH	Terracon

Form 104—6-85

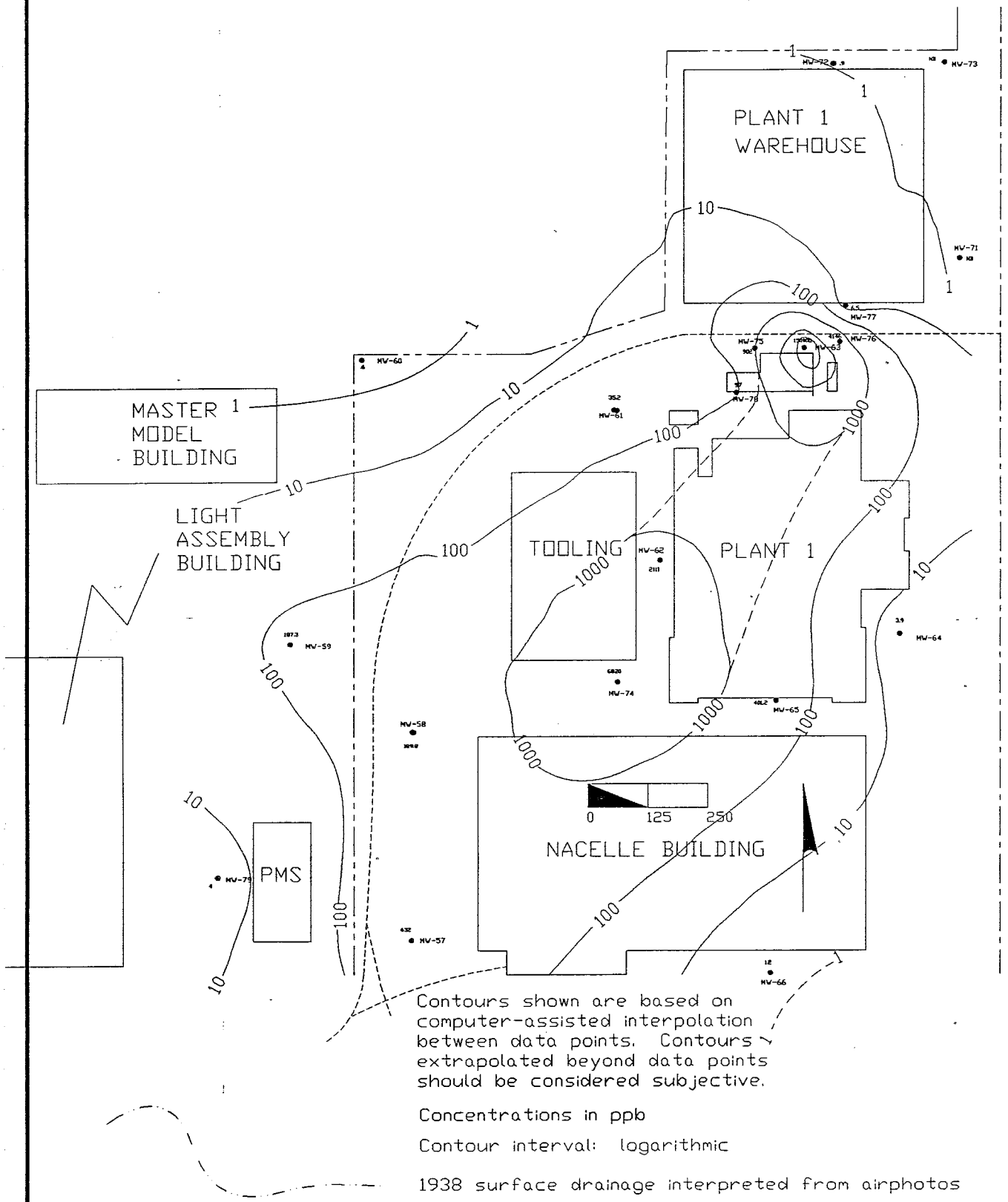


FIGURE 7. TVOC CONCENTRATIONS: DEEP/FULLY SCREENED WELLS
PLANT 1 FACILITY
BOEING MILITARY AIRPLANES
WICHITA, KANSAS

Job # 52905009	Date Sept. 1990	Drawn JRH	Terracon

Form 104—6-85

TERRACON ENVIRONMENTAL, INC.

PROJECT: Plant 1 Warehouse Facility
Boeing Military Airplanes
Wichita, Kansas

PROJECT NO.: 52905009

TABLE 1. APPROXIMATE COORDINATES OF MONITOR WELLS

LOCATION	NORTH	EAST
MW-57	18126.8	18851.7
MW-58	18564.5	18855.9
MW-58A	18565.0	18853.1
MW-59	18749.9	18597.9
MW-60	19353.6	18747.3
MW-61	19247.1	19275.9
MW-61A	19246.2	19281.5
MW-62	18927.6	19371.2
MW-63	19377.0	19672.7
MW-64	18773.1	19872.0
MW-65	18630.2	19614.2
MW-66	18058.7	19602.8
MW-66A	18063.5	19602.8
MW-71	19564.1	19996.0
MW-72	19977.6	19731.7
MW-72A	19977.6	19733.7
MW-73	19980.6	19964.5
MW-74	18669.6	19282.6
MW-75	19376.2	19569.6
MW-76	19389.6	19746.7
MW-77	19465.0	19759.1
MW-78	19283.8	19530.8
RW-79	18258.9	18447.1
REF. POINT A	20702.6	20047.8
REF. POINT B	18055.4	20056.0

REFERENCE: Coordinates determined by Baughman Company, P.A. a 2647.22 foot baseline bearing S 00, 10', 41", from reference point A to reference point B corresponding to the northeast and southeast corner of the NE 1/4 of Section 11, Township 28 South, Range 1 East, respectively.

TERRACON ENVIRONMENTAL, INC.

PROJECT: Plant 1 Warehouse Facility
Boeing Military Airplanes
Wichita, Kansas

PROJECT NO.: 52905009

TABLE 2. APPROXIMATE COORDINATES OF BOREHOLES

LOCATION	NORTH	EAST
B-1	18383.0	18438.9
B-2	18469.7	18437.1
B-3	18284.9	18440.5
B-4	18334.6	18439.6
B-5	18304.9	18441.3
B-6	18258.9	18441.1
B-7	18228.5	18441.4
REF. POINT A	20702.6	20047.8
REF. POINT B	18055.4	20056.0

REFERENCE: Coordinates determined by Baughman Company, P.A. a 2647.22 foot baseline bearing S 00, 10', 41" from reference point A to reference point B corresponding to the northeast and southeast corner of the NE 1/4 of Section 11, Township 28 South, Range 1 East, respectively.

TERRACON ENVIRONMENTAL, INC.

PROJECT: Plant 1 Warehouse Facility
Boeing Military Airplanes
Wichita, Kansas

PROJECT NO.: 52905009

TABLE 3. SURFACE/GROUNDWATER ELEVATIONS (Feet)

WELL NO.	GROUND SURFACE	DEPTH TO GROUNDWATER BELOW GROUND SURFACE	TOP OF WELL CASING	DEPTH TO GROUNDWATER BELOW TOP OF WELL CASING	GROUNDWATE
MW-57	1346.9	6.7	1350.04	9.82	1340.22
MW-58	1349.7	7.1	1352.58	9.98	1342.60
MW-58A	1349.7	4.5	1352.85	7.69	1345.16
MW-59	1345.5	7.5	1348.47	10.49	1337.98
MW-60	1348.0	5.2	1350.67	7.82	1342.85
MW-61	1357.2	8.0	1360.06	10.84	1349.22
MW-61A	1357.2	5.8	1360.23	8.83	1351.40
MW-62	1355.7	5.3	1358.92	8.48	1350.44
MW-63	1363.4	9.0	1366.89	12.45	1354.44
MW-64	1362.7	7.8	1366.07	11.21	1354.86
MW-65	1361.5	9.2	1364.63	12.32	1352.31
MW-66	1357.3	7.9	1360.30	10.91	1349.39
MW-66A	1358.1	6.8	1361.22	9.94	1351.28
MW-71	1358.0	3.5	1362.00	7.48	1354.52
MW-72	1362.4	9.9	1365.59	13.10	1352.49
MW-72A	1362.4	9.6	1365.63	12.80	1352.83
MW-73	1357.6	4.7	1360.62	7.70	1352.92
MW-74	1354.6	5.2	1357.55	8.16	1349.39
MW-75	1363.3	9.0	1366.25	11.97	1354.28
MW-76	1363.1	7.4	1665.05	10.34	1355.71
MW-77	1362.8	8.3	1365.61	11.08	1354.53
MW-78	1363.5	8.1	1366.47	11.05	1355.42
MW-79	1338.9	3.6	1342.66	7.34	1335.32

NOTES:

1) Elevations determined by Baughman Company, P.A. using standard leveling procedures and a benchmark of 1342.03 feet (MSL) for the intersection of the center-line joint of the concrete drive with the east of the concrete pavement on the east side of the MASTER MODEL BUILDING.

2) Depths to groundwater determined June 28, 1990 using an ORS Hydrocarbon Interface Probe (free product was not detected).

TERRACON ENVIRONMENTAL, INC.

PROJECT: Plant 1 Warehouse Facility
Boeing Military Airplanes
Wichita, Kansas

PROJECT NO.: 52905009

TABLE 4. DETECTED VOLATILE ORGANICS: GROUNDWATER SAMPLES
(June 21, 1990)

	MW-71	MW-72	MW-72A	MW-73	MW-74	MW-75	MW-76	MW-77	MW-78	MW-79	KNL	KAL
Vinyl Chloride	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.2	2.0
Trichlorofluoromethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	800.0	8000.0
Trichloroethylene	ND	0.9	1.9	ND	3300.0	870.0	4100.0	6.5	47.0	4.0	0.5	5.0
Trans-1,3,-Dichloropropylene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.2	2.0
Toluene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	200.0	2000.0
Tetrachloroethylene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.7	7.0
Methylene Chloride	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	5.0	50.0
Ethylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	68.0	680.0
Dichlorodifluoromethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	560.0	5600.0
Dibromochloromethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.7	100.0
Cis-1,2-Dichloropropylene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.2	2.0
Chloromethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.019	0.190
Chloroform	ND	ND	ND	ND	ND	9.7	ND	ND	7.7	ND	0.5	100.0
Chloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	3.7	37.0
Chlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	6.0	60.0
Carbon Tetrachloride	ND	ND	ND	ND	3300.0	22.0	46.0	ND	40.0	ND	0.5	5.0
Bromomethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.019	0.190
Bromoform	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.5	100.0
Bromodichloromethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.5	100.0
Benzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.5	5.0
2-Chloroethylvinyl Ether	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	-	-
1,4-Dichlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	7.5	75.0
1,3-Dichlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	62.0	620.0
1,2-Dichloropropane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.6	6.0
1,2-Dichloroethylene (total)	ND	ND	ND	ND	220.0	ND	ND	ND	2.3	ND	7.0	70.0
1,2-Dichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.5	5.0
1,2-Dichlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	62.0	620.0
1,1-Dichloroethylene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.7	7.0
1,1-Dichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.5	5.0
1,1,2-Trichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.610	6.100
1,1,2,2-Tetrachloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.170	1.700
1,1,1-Trichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	20.0	200.0
TVOC*	0	0.9	1.9	0	6820.0	901.7	4146.0	6.5	97.0	4.0	-	-

NOTES: Units = ug/l (ppb)
ND = not detected
KNL = Kansas Notification Levels
KAL = Kansas Action Levels
*TVOC = Total Volatile Organic Compound