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NWS EARLE
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LETTER REPORT OF RESULTS FOR MAIL-DOWN TEST CONDUCTED AT BUILDING R-12 NWS EARLE NJ

2/25/1999

TETRA TECH

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C-51-2-9-42

February 25, 1999

Mr. Brian Helland, Code 1812
Senior Environmental Engineer
Northern Division
Naval Facilities Engineering Command
10 Industrial Highway Mail Stop 82
Lester, Pennsylvania 19113

Reference: Contract No. N62472-90-D-1298(CLEAN)
Contract Task Order No. 206

Subject: Letter Report of Results
Building R-12 Bail-down Test
NWS Earle - Colts Neck, New Jersey

Dear Mr. Helland:

Tetra Tech NUS (TtNUS) is pleased to provide this letter report of results for the bail-down test conducted at Building R-12, at the Naval Weapons Station Earle. You will note that we performed the work between February 10 and February 15, 1999.

Background Information:

TtNUS installed 3 recovery wells, R12-RC-01, R12-RC-02, and R12-RC-03, in early June, 1998. The well locations were selected based on the results of a remedial investigations performed by TtNUS that delineated the extent of contamination and free-phase product within the immediate vicinity of the abandoned-in-place UST at the northeast side of Building R-12. Refer to Figure 1 in Attachment A, for the well locations, and a summary of the results for soil and groundwater samples from the previous investigations. Refer to Figures 2, 3, and 4 in Attachment A for copies of the well construction diagrams.

Previous investigations have indicated that the abandoned UST at Building R-12 lies in Cretaceous sediments of the Englishtown Formation, which consists of tan and gray, fine- to medium-grained sand with local clay beds. Site borings describe the soils as mainly silty, clayey fine-grained sand and silty fine-grained sand with some silty clay layers. The depth to groundwater in the UST vicinity was 9 to 11 feet below grade. Additional details regarding the remedial investigations are included in the following New Jersey Department of Environmental Protection (NJDEP)-approved reports:

- TtNUS, September 1998, Final Report – "Phase I Remedial Investigation Report for the Group 3 Underground Storage Tank Sites."

- TtNUS, November 1998 Final Report – "Remedial Action Work Plan and Classification Exception Area Documents for Buildings R-6/7 and R-12."

Bail-down Test Summary:

The purpose of the bail-down test was to characterize the product recovery rate in the recovery wells and to estimate the true product thickness in the formation around the UST. This information can be used to make conclusions and recommendations regarding further testing (e.g., pilot tests, bailing) and the selection of appropriate product removal methods.

The bail-down test was initiated on February 10, 1999. Pre bail-down product and groundwater levels were recorded at each well. Available free product was then extracted from each well with a peristaltic pump. Immediately following extraction, product and groundwater levels were recorded at increasing time intervals over a 123-hour period.

During the first 5 hours after the initial bail-down, product and groundwater level measurements were recorded in the 3 recovery wells at increasing minute and hourly intervals. Figure 5 in Attachment A presents a plot of the free product recovery data for this period. Table 1 in Attachment B identifies product and groundwater level measurements recorded during the initial 5-hour recovery period. Two additional product and groundwater level measurement events were conducted approximately 21-hours and 123-hours respectively, after the initial bail-down. Table 2 in Attachment B identifies and compares key measurements throughout the duration of the test.

Weather conditions during the bail-down and measurement events were dry and cold, with temperatures ranging between the 30°F and 50°F. Note that all product, groundwater, and decontamination liquids were containerized at the site and delivered to the bilge-water oil-water separator for final disposal. It should also be noted that based on the well construction diagrams, the depth to product in all three recovery wells was at least four feet below the elevation of the top of the well screen.

The following table summarizes the observed free product recoveries at each well and provides an estimated daily recovery rate for the noted time intervals following the bail-down:

Measurement Event	Product Thickness (ft.)	% Recovery (of static thickness)	Estimated Daily Recovery Rate(gal/day)
(Pre-bail-down)			
RC-01	1.1	N/A	N/A
RC-02	1.97	N/A	N/A
RC-03	2.38	N/A	N/A
RC-01 (+5 hours)	0.26	24	0.82
RC-02 (+4 hours)	0.43	22	1.7
RC-03 (+3 hours)	0.43	18	2.2
RC-01 (+21 hours)	0.36	33	0.26
RC-02 (+20 hours)	0.53	27	0.41
RC-03 (+19 hours)	0.52	22	0.43
RC-01 (+123 hours)	0.8	73	0.1
RC-02 (+122 hours)	0.68	36	0.09
RC-03 (+121 hours)	0.63	26	0.08

The EPA (1996) suggests that the daily recovery rate applicable to skimming type recovery systems can be estimated from the time it takes to achieve 80 percent of the maximum recovered thickness (following bail down). For wells RC-01 and RC-02 approximately 80 percent of the maximum recovered thickness (e.g., 0.53 ft of 0.68 ft for well RC-02) occurred at about 20 hours after bailing. Therefore, expected recovery rates for RC-01 and RC-02 are about 0.4 gallons per day as shown in the above table. For RC-01 the 80 percent recovery level occurred between 21 and 123 hours after bailing and a skimming recovery rate between 0.26 to 0.1 gallons per day is expected.

Product Thickness in the Formation:

The product bail-down test data were used to estimate the true thickness of the mobile hydrocarbon layer in the formation based on the methods of Hughes, et al (1988). Using this method the thickness of the mobile free product in the formation is graphically determined as the distance between the point of the initial product recovery rate change and the static depth to the top of the hydrocarbon layer prior to bailing (see Figures 6,

7, and 8 in Attachment A). The Hughes method test results estimate true product thicknesses of 0.27 ft., 0.34 ft., and 0.29 ft., at wells RC-01, RC-02, and RC-03, respectively.

Aeral Extent of Free Product Plume:

The estimated areal extent of free product floating on top of the water table surface is outlined on Figure 1 in Attachment A. The lateral limits of the product plume were interpolated based on the relatively low concentration of dissolved VOCs and TPH in soils and the absence of free product in monitoring wells surrounding the abandoned UST location. The limits of the plume are shown to encompass the three recovery wells that display product accumulation and to be slightly skewed to the northwest, in the general direction of groundwater flow. The free product plume outlined on Figure 1 has an approximate area of 560 square feet, or 0.01 acres.

The following site conditions are expected to limit the lateral extent of free product plume:

- Low groundwater gradient in the area, estimated to be 0.005 ft/ft during previous investigations;
- Higher viscosity of fuel oil compared to water;
- Fine-grained nature of the site soils;
- Thin accumulation of product in the formation.

Volume of Free Product:

The volume of free product in the formation was calculated based on the area of the product plume and the estimates of the true product thickness in the formation derived from the bail down tests. In addition, a percentage of the volume of product that fills the pore space will not be recovered due to residual saturation of the product, therefore a recoverable volume of product was also estimated. The details of these calculations are provided in Attachment C. The results estimate the total volume of free product to be 471 gallons and the recoverable volume to be 421 gallons. In practice, because many of the physical variables can not be predicted or accurately accounted for in the calculations, the actual recovery efficiency may be only 50 percent (i.e., 236 gallons) or less of the total volume present.

Conclusions:

TtNUS concludes that the passive recovery rates (i.e., no induced groundwater gradient) in each well are likely to be low (<0.4 gallons per day). The thickness of product floating on the water table is thin (<0.35 ft.) and the volume of product in the formation is expected to be less than 500 gallons. Site conditions suggest that the product plume is unlikely to migrate much further than the present established limits.

Aggressive product recovery schemes involving groundwater depression and dual phase extraction or total fluids recovery are not warranted based on the observed site conditions. In particular, due to the thin layer of product, the physical barrier created by the UST, and the fine-grained nature of the soils, groundwater depression is likely to result in product immobilization due to smearing and residual saturation of product in the cone of depression.

Site conditions appear amenable to bioslurping, mechanical skimmers, or passive skimmers. The main differences between these methods are indicated by cost and the time frame for completion. Higher technology designs such as bioslurping and mechanical skimmers include higher costs for design, equipment, installation, operation and maintenance, and may necessitate treatment or disposal of contaminated groundwater or air discharge permits. These technologies, on the other hand, are expected to increase the overall rate of recovery and may provide overall greater effectiveness. Passive skimming is a low cost, low design, simple installation approach that will require low maintenance. This technology does

however require frequent labor input to remove product from the skimming devices and will likely result in a longer period of recovery.

Recommendations:

Since further migration of the observed free-product plume appears to be limited, and since an accelerated regulatory agency mandated time frame for product recovery is not being pursued, TtNUS recommends mechanical or passive skimmer-technology. However, this recommendation does not consider the Navy's plans for future use and disposition of the site. If the Navy requires an accelerated final disposition regarding free product at the site, active product removal methods, which would be more costly, could be considered. Further recommendations regarding the selection of the appropriate equipment, operating, and maintenance scenarios would require additional input form the Navy regarding target costs, time-frames, and site use planning and management.

In addition, given the close proximity of Building R-12 with the free-product plume, and the observed groundwater flow direction, TtNUS recommends periodic inspection of the sub-grade rooms in R-12 for vapors and/or the presence of product in floor drains or around foundations.

As always, TtNUS appreciates the opportunity to provide technical services to the Navy. Please contact me if you have additional questions or comments, or if you need additional copies of the report.

Sincerely

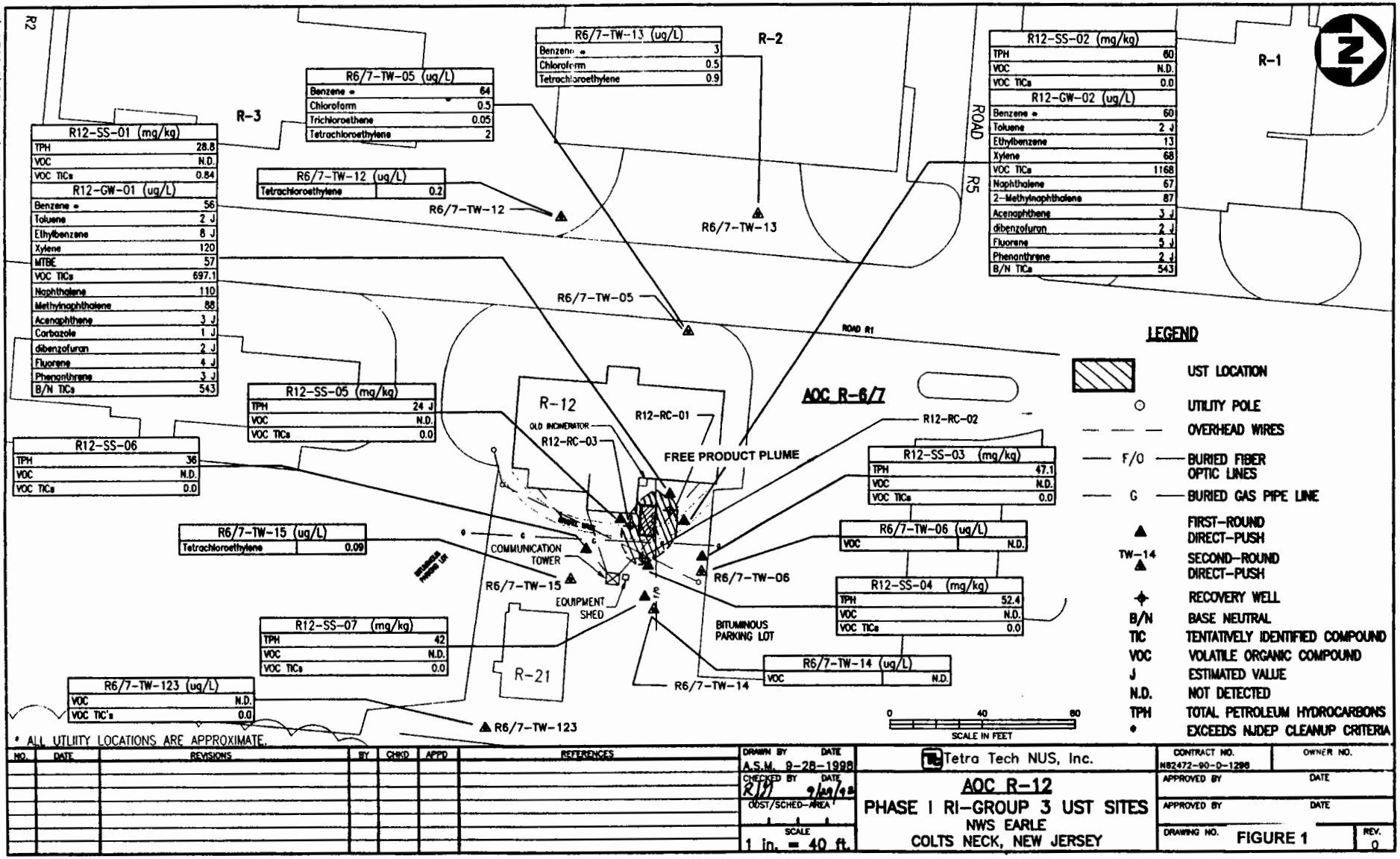
Richard J. Gorrell
Project Manager

RJG/ejc

c: Lawrence Burg, Navy - NWS Earle
John Trepanowski, P.E. - TtNUS
Garth Glenn - TtNUS
Russ Turner - TtNUS

ATTACHMENT A

MAPS and FIGURES



* ALL UTILITY LOCATIONS ARE APPROXIMATE.

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY A.S.M. DATE 9-28-1998
CHECKED BY R.J.T. DATE 9/29/98
COST/SCHED-AREA
SCALE 1 in. = 40 ft.

Tetra Tech NUS, Inc.

AOC R-12
PHASE I RI-GROUP 3 UST SITES
NWS EARLE
COLTS NECK, NEW JERSEY

CONTRACT NO. N62472-90-D-1298
OWNER NO.
APPROVED BY DATE
APPROVED BY DATE
DRAWING NO. FIGURE 1
REV. 0

L:\AUTOCAD\PROJECTS\5085\5085036B

PLOT DATE: 9/29/98 CADD FILE NO. L:\AUTOCAD\ELECTRICAL\BORDERS\ANSI_B.DWG

RC-01

ADVANCED DRILLING, INC.	PROJECT: Navel Weapons Station Earl	CLIENT: Tetra Tech NUS, Inc.	PROJECT NO.: ADV 562	HOLE NUMBER: R12MW3

MUNICIPALITY	COUNTY	STATE	COORDINATES	WELL PERMIT NO.
Colts Neck	Monmouth	New Jersey	29 : 22: 327	29 38464

START DATE	COMPLETION DATE	DRILLER	DRILLER LICENSE NO.	BORING DIA.	TOTAL DEPTH
6-1-98	6-1-98	Roger Logel	M 1166	10.25	19 Ft.

LOT	BLOCK	DRILLING METHOD	SAMPLE TYPE	DEPTH OF GROUNDWATER
N/A	N/A	Hollow Stem Augers	From Cuttings	5 Feet

PROTECTIVE CASING	NOTES
Flush	

Soil Boring Cross-Reference R12MW3
Town and City Colts Neck
County and State Monmouth, New Jersey

Installation Date (s) 6-1-98

Drilling Method Hollow Stem Augers
Driller Roger Logel
Drilling Fluid None

Static water level after drilling ft.
Well developed for _____ hours at _____ gpm
Method of development Not recorded

Well Purpose Monitoring

Remarks

Prepared By Roger Logel
Date Prepared 7-13-98

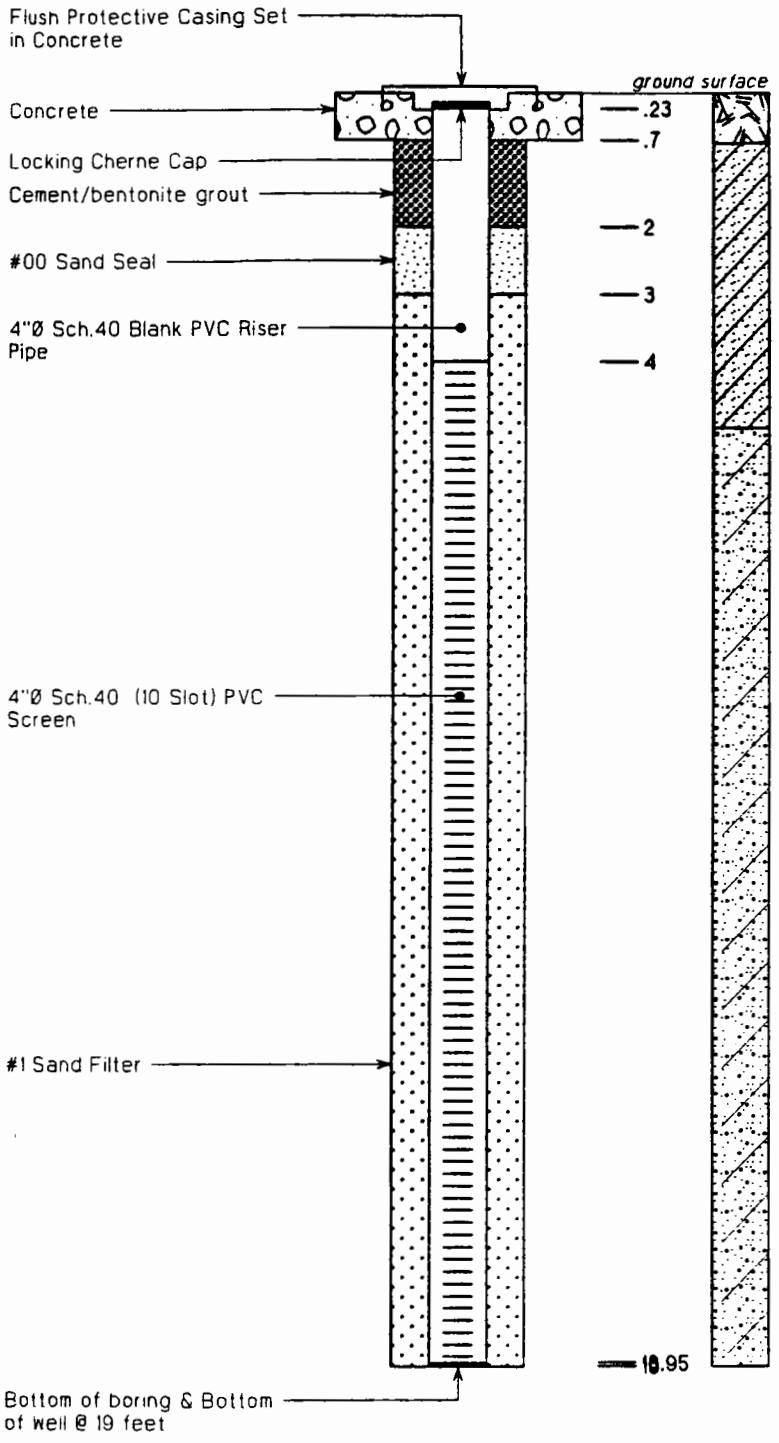


FIGURE 2

ADVANCED DRILLING, INC.	PROJECT: Navel Weapons Station Earl	CLIENT: Tetra Tech NUS, Inc.	PROJECT NO.: ADV 562	HOLE NUMBER: R12MW2

MUNICIPALITY	COUNTY	STATE	COORDINATES	WELL PERMIT NO.
Colts Neck	Monmouth	New Jersey	29 : 22: 327	29 38463

START DATE	COMPLETION DATE	DRILLER	DRILLER LICENSE NO.	BORING DIA.	TOTAL DEPTH
6-2-98	6-2-98	Roger Logel	M 1166	10.25	19 Ft.

LOT	BLOCK	DRILLING METHOD	SAMPLE TYPE	DEPTH OF GROUNDWATER
N/A	N/A	Hollow Stem Augers	From Cuttings	5 Feet

PROTECTIVE CASING	NOTES
Flush	

Soil Boring Cross-Reference R12MW2
Town and City Colts Neck
County and State Monmouth, New Jersey

Installation Date (s) 6-2-98

Drilling Method Hollow Stem Augers
Driller Roger Logel
Drilling Fluid None

Static water level after drilling ft.
Well developed for _____ hours at _____ gpm
Method of development Not recorded

Well Purpose Monitoring

Remarks

Prepared By Roger Logel
Date Prepared 7-13-98

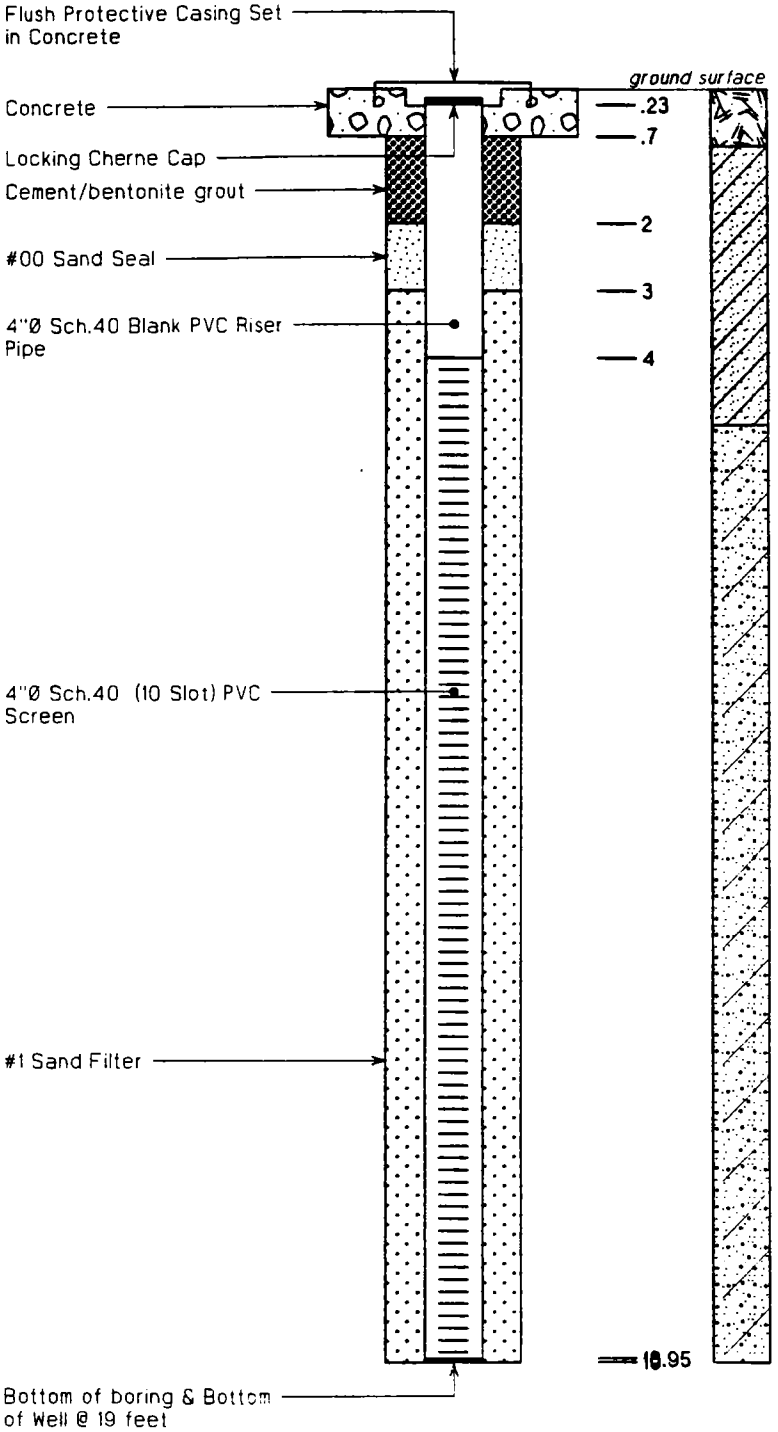


FIGURE 3

ADVANCED DRILLING, INC.	PROJECT: Navel Weapons Station Earl	CLIENT: Tetra Tech NUS, Inc.	PROJECT NO.: ADV 562	HOLE NUMBER: R12MW1

MUNICIPALITY	COUNTY	STATE	COORDINATES	WELL PERMIT NO.
Colts Neck	Monmouth	New Jersey	29 : 22: 327	29 38462

START DATE	COMPLETION DATE	DRILLER	DRILLER LICENSE NO.	BORING DIA.	TOTAL DEPTH
6-2-98	6-2-98	Roger Logel	M 1166	10.25	19 Ft.

LOT	BLOCK	DRILLING METHOD	SAMPLE TYPE	DEPTH OF GROUNDWATER
N/A	N/A	Hollow Stem Augers	From Cuttings	5 Feet

PROTECTIVE CASING	NOTES
Flush	

Soil Boring Cross-Reference *R12MW1*
Town and City *Colts Neck*
County and State *Monmouth, New Jersey*

Installation Date (s) *6-2-98*

Drilling Method *Hollow Stem Augers*
Driller *Roger Logel*
Drilling Fluid *None*

Static water level after drilling *ft.*
Well developed for _____ hours at _____ gpm
Method of development *Not recorded*

Well Purpose *Monitoring*

Remarks

Prepared By *Roger Logel*
Date Prepared *7-13-98*

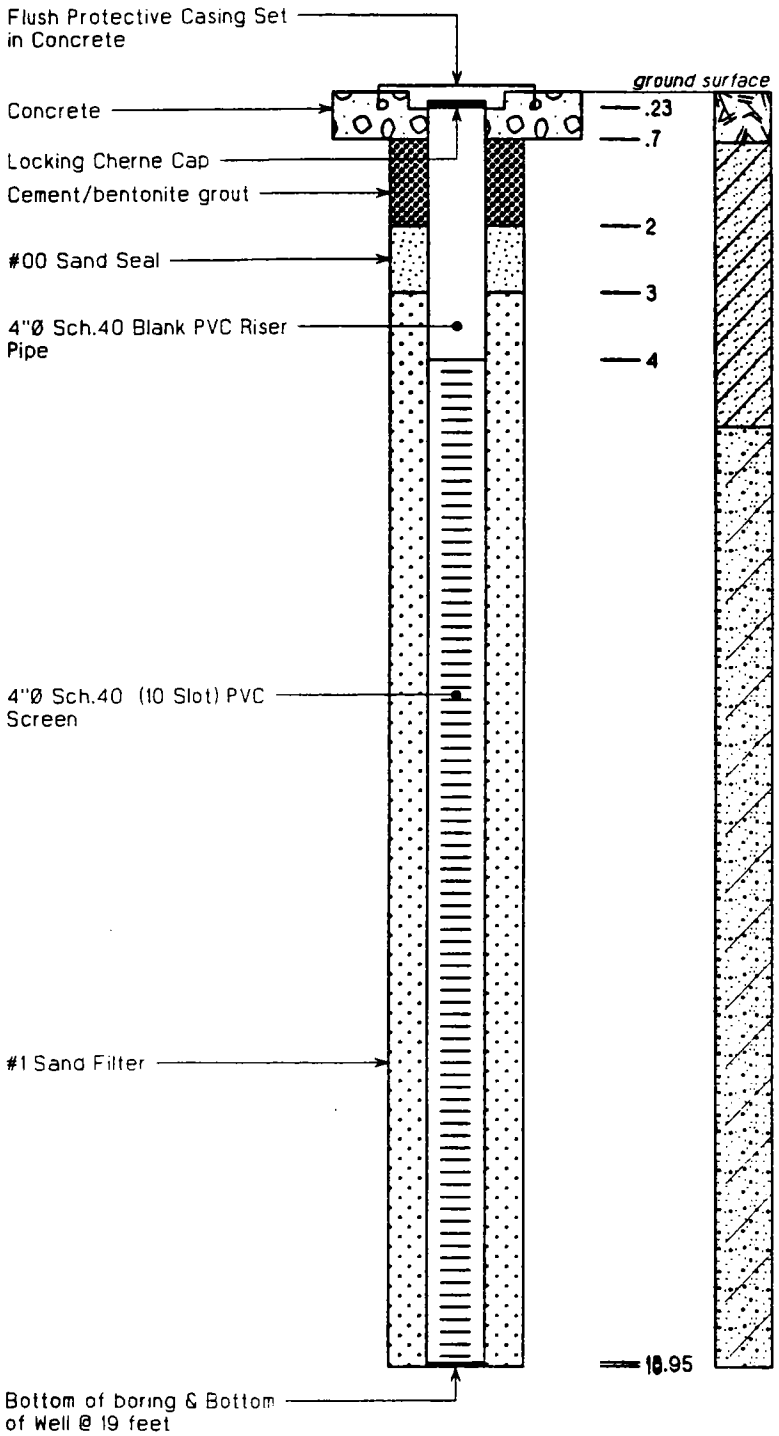
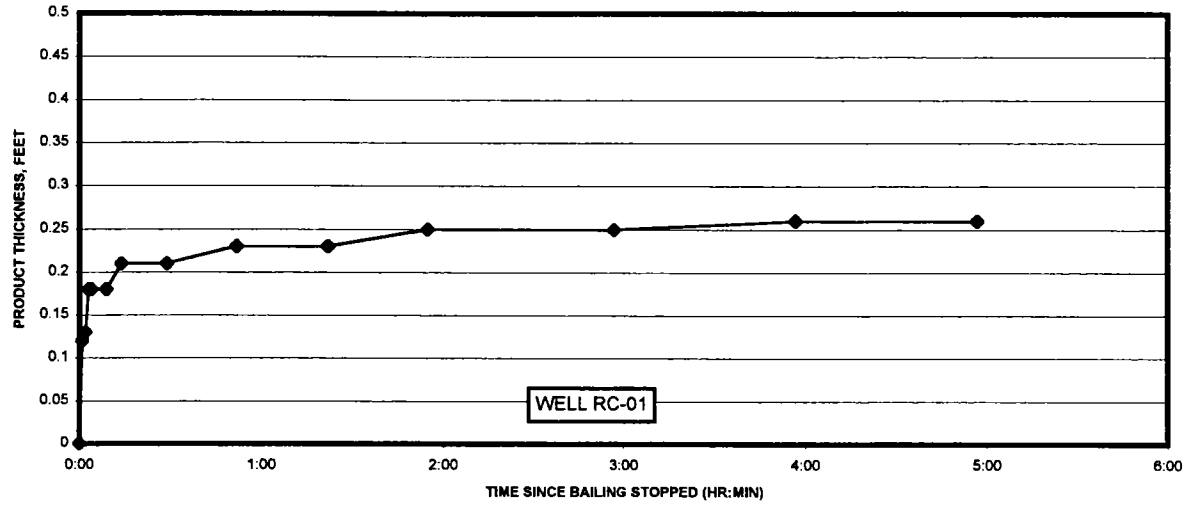
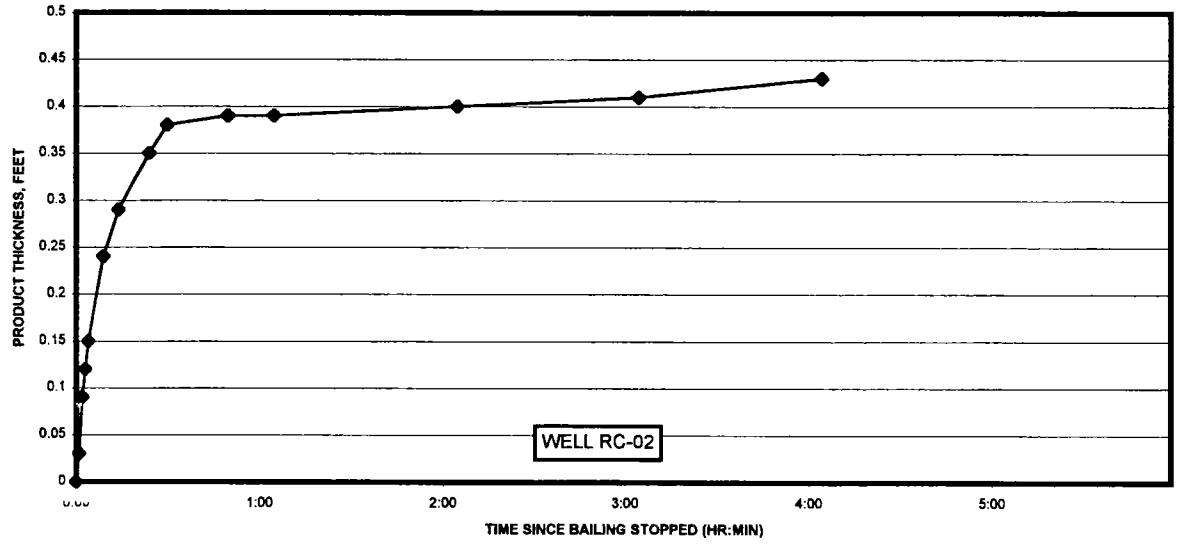
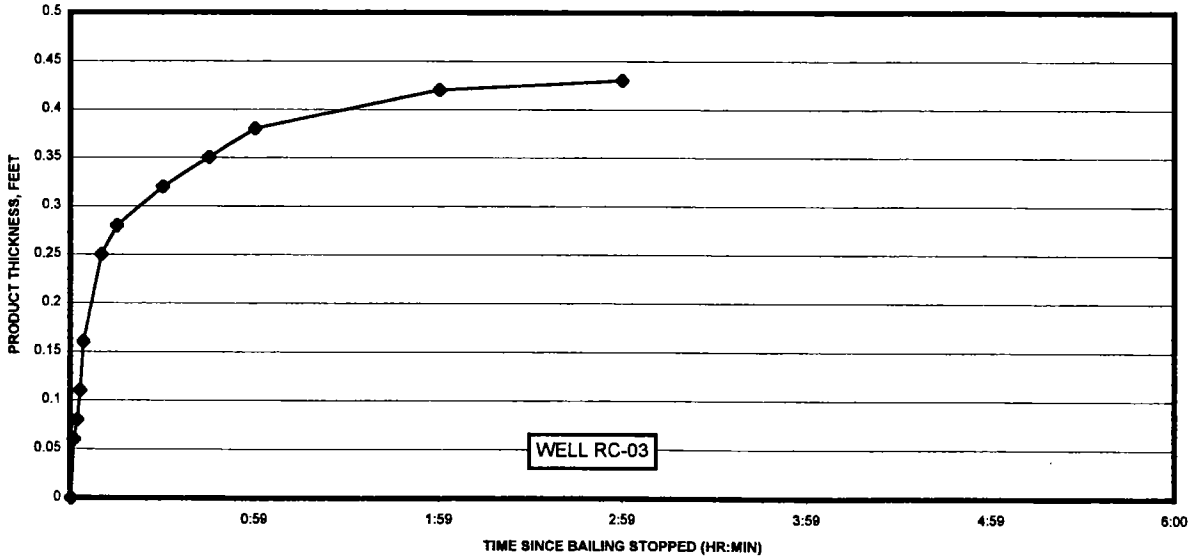


FIGURE 4

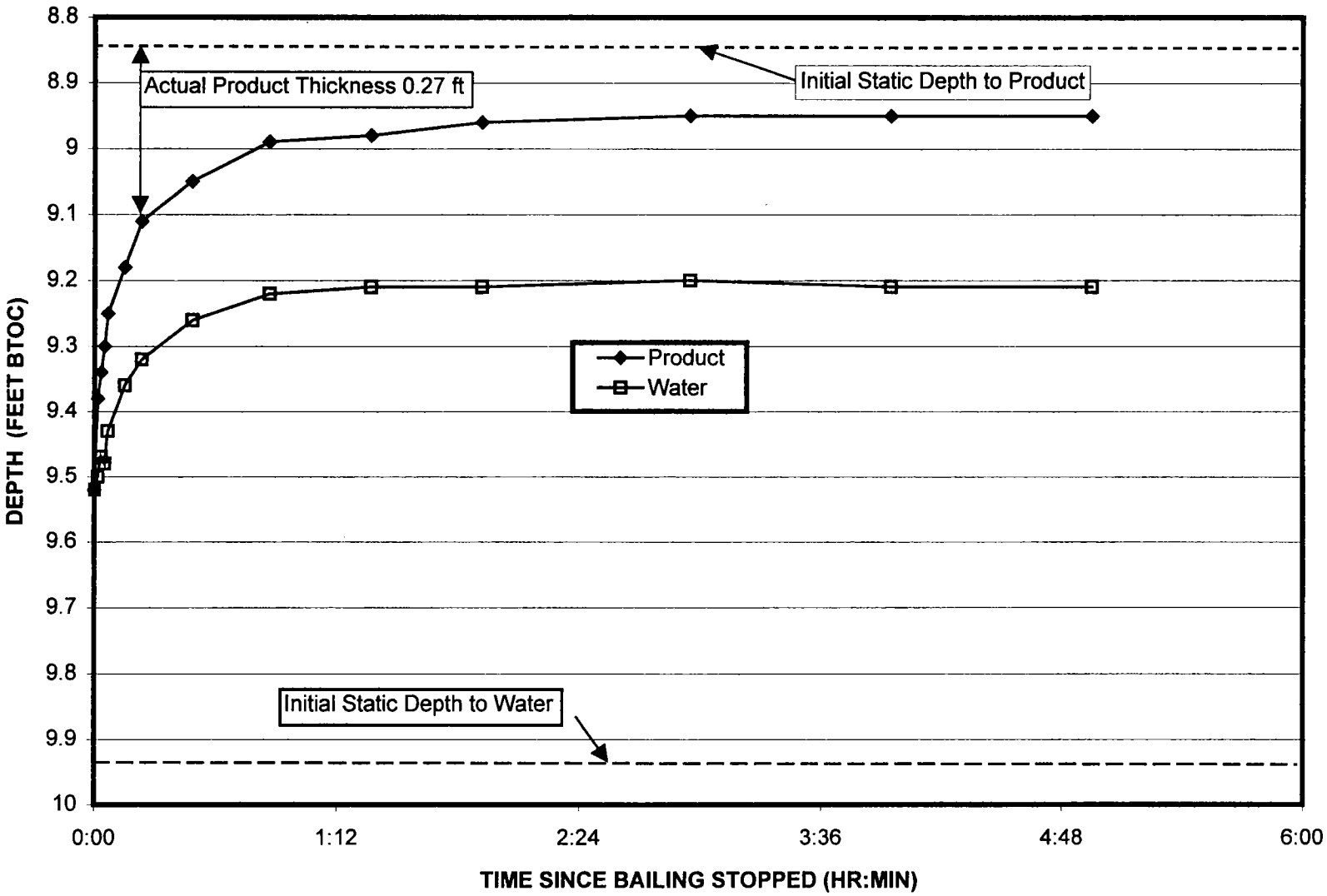
ATTACHMENT A
Figure 5
Product Recovery Thickness vs. Time
Building R-12
NWS Earle Colts Neck, New Jersey



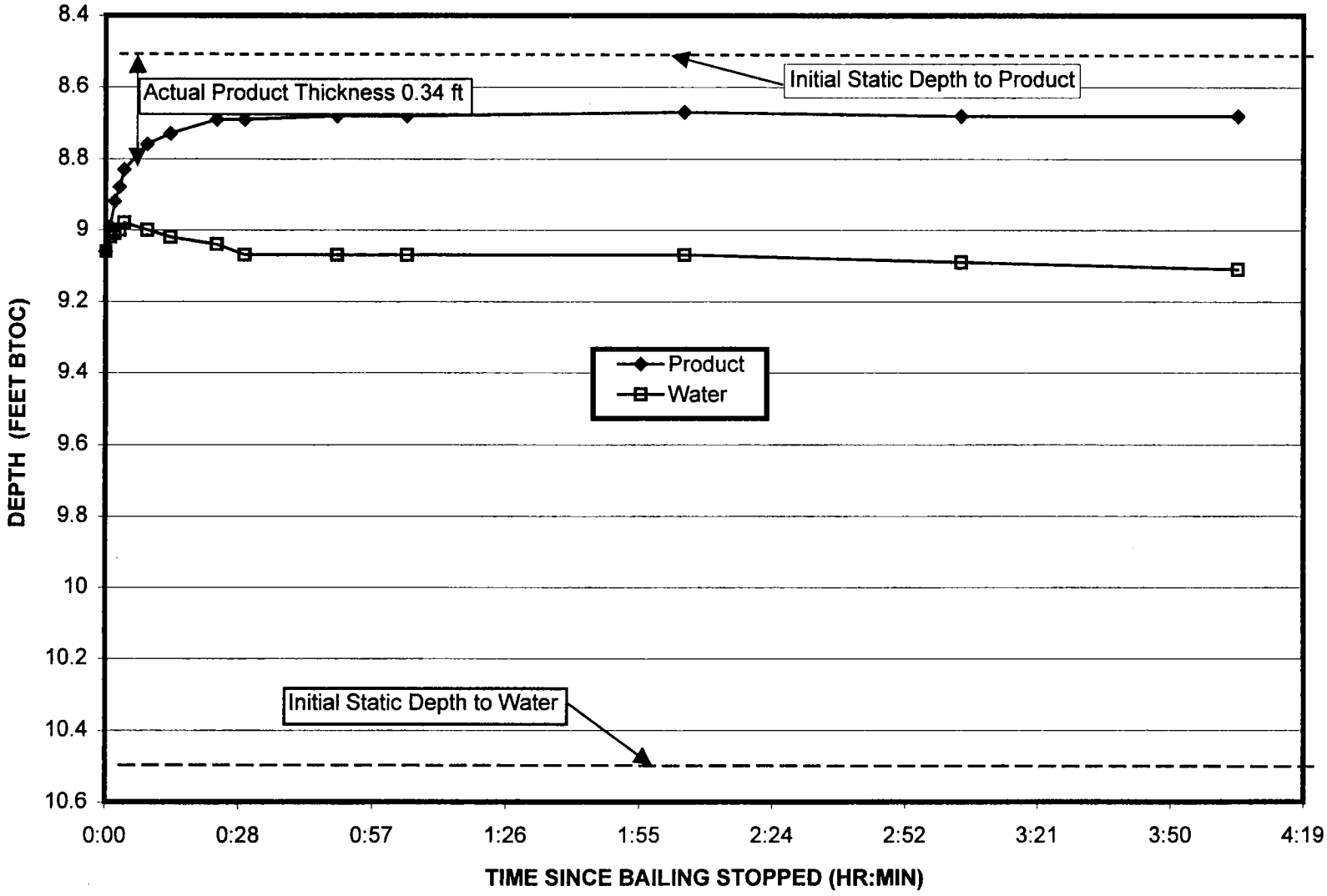




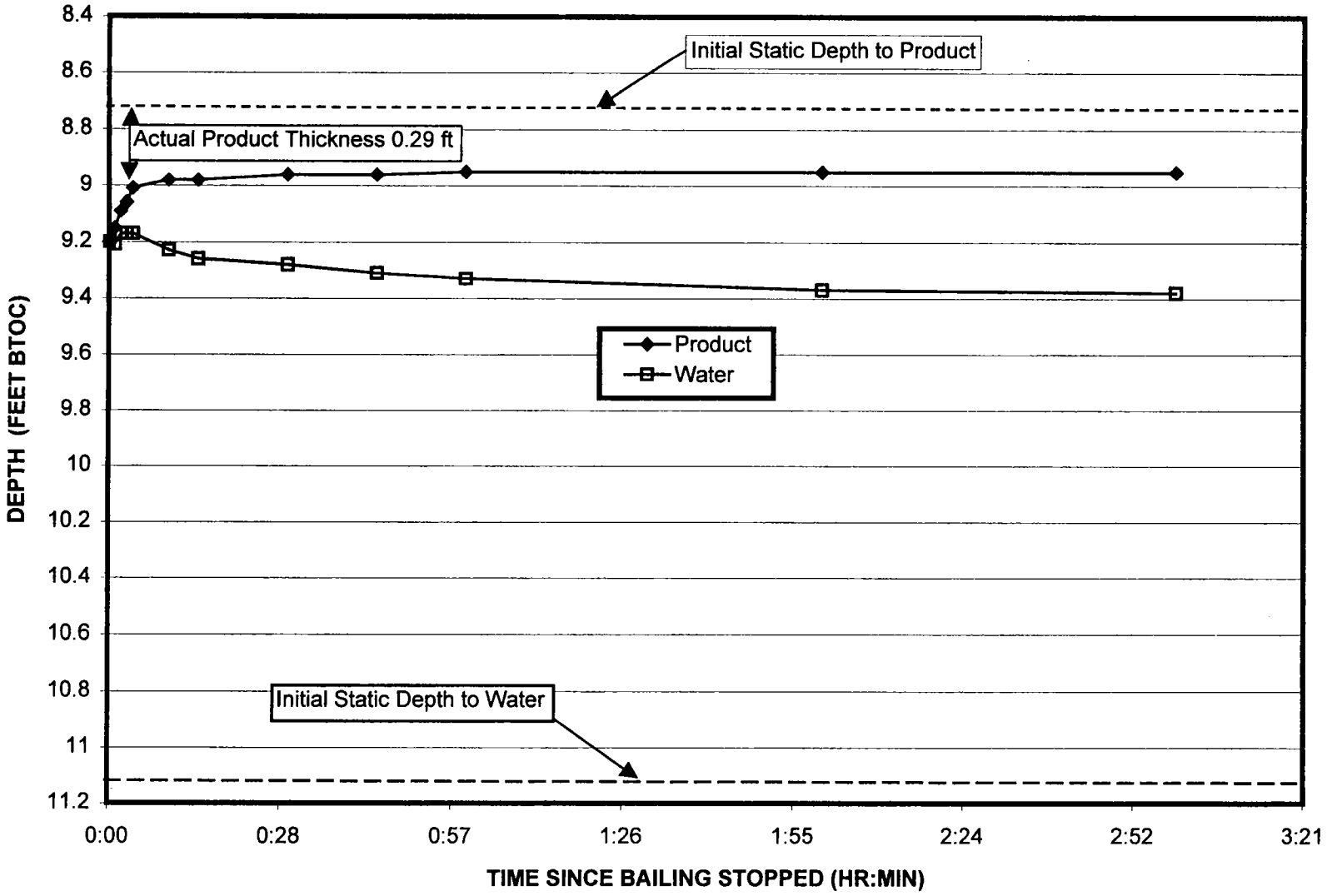
ATTACHMENT A
Figure 6
Depth to Product/Water vs. Time Ater Bailing
Recovery Well RC-01, Building R-12
NWS Earle Colts Neck, New Jersey



ATTACHMENT A
Figure 7
Depth to Product/Water vs. Time Ater Bailing
Recovery Well RC-02, Building R-12
NWS Earle Colts Neck, New Jersery



ATTACHMENT A
Figure 8
Depth to Product/Water vs. Time Ater Bailing
Recovery Well RC-03, Building R-12
NWS Earle Colts Neck, New Jersery



ATTACHMENT B

DATA SUMMARY TABLES

ATTACHMENT B
Table 1
Bail-down Test Measurements
Building R-12
NWS Earle Colts Neck, New Jersey

Well/Time	Depth to Product(1)	Depth to Groundwater (2)	Product Thickness
RC-01/11:23	N/A	9.52	0
11:24	9.38	9.50	0.12
11:25	9.34	9.47	0.13
11:26	9.30	9.48	0.18
11:27	9.25	9.43	0.18
11:32	9.18	9.36	0.18
11:37	9.11	9.32	0.21
11:52	9.05	9.26	0.21
12:15	8.99	9.22	0.23
12:45	8.98	9.21	0.23
13:18	8.96	9.21	0.25
14:20	8.95	9.20	0.25
15:20	8.95	9.21	0.26
16:20	8.95	9.21	0.26
RC-02/12:25	N/A	9.06	0
12:26	8.99	9.02	0.03
12:27	8.92	9.01	0.09
12:28	8.88	9.00	0.12
12:29	8.83	8.98	0.15
12:34	8.76	9.00	0.24
12:39	8.73	9.02	0.29
12:49	8.69	9.04	0.35
12:55	8.69	9.07	0.38
13:15	8.68	9.07	0.39
13:30	8.68	9.07	0.39
14:30	8.67	9.07	0.40
15:30	8.68	9.09	0.41
16:30	8.68	9.11	0.43
RC-03/13:30	N/A	9.20	0
13:31	9.15	9.21	0.06
13:32	9.09	9.17	0.08
13:33	9.06	9.17	0.11
13:34	9.01	9.17	0.16
13:40	8.98	9.23	0.25
13:45	8.98	9.26	0.28
14:00	8.96	9.28	0.32
14:15	8.96	9.31	0.35
14:30	8.95	9.33	0.38
15:30	8.95	9.37	0.42
16:30	8.95	9.38	0.43

Notes:

(1) Depth to product measured in feet, with a Kech Interface Probe, from top of inner PVC casing to surface of free product.

(2) Depth to groundwater was measured in feet from the top of the inner PVC casing, to the surface of the water below the free-product.

ATTACHMENT B
Table 2
Bail-down Test Measurements
Building R-12
NWS Earle Colts Neck, New Jersey

Measurement Event	Depth to Product[1]	Depth to Groundwater[2]	Product Thickness (ft.)
2/10/99 (Pre-bail-down)			
RC-01	8.84	9.94	1.1
RC-02	8.49	10.46	1.97
RC-03	8.72	11.1	2.38
2/10/99			
RC-01 (+5 hours)	8.95	9.21	0.26
RC-02 (+4 hours)	8.68	9.11	0.43
RC-03 (+3 hours)	8.95	9.38	0.43
2/11/99			
RC-01 (+21 hours)	8.97	9.33	0.36
RC-02 (+20 hours)	8.69	9.22	0.53
RC-03 (+19 hours)	8.98	9.5	0.52
2/15/99			
RC-01 (+123 hours)	8.89	9.69	0.8
RC-02 (+122 hours)	8.62	9.03	0.68
RC-03 (+121 hours)	8.91	9.54	0.63

Notes:

(1) Depth to product measured in feet, with a Kech Interface Probe, from top of inner PVC casing to surface of free product.

(2) Depth to groundwater was measured in feet from the top of the inner PVC casing, to the surface of the water below the free-product.

ATTACHMENT C

CALCULATIONS

CLIENT NWS Earle – Colts Neck, New Jersey		JOB NUMBER CLEAN Task Order No. 206
SUBJECT Building R-12, Calculation of the Volume of Free Product Around Abandoned UST		
BASED ON Product Bail Down Testing		DRAWING NUMBER ATTACHMENT C
BY Allan Jenkins, TtNUS	CHECKED BY R. Gorrell	DATE 2/22/99

PROBLEM

Calculate the Volume of Free Product and of Recoverable Free Product floating on the water table surface in the vicinity of the abandoned 2,000 gallon UST.

GIVEN

Free product bail-down testing was conducted on the three recovery wells, RC-01, RC-02, and RC-03, that contained a measurable accumulation of free product. The results of the bail-down testing were interpreted using the methodology of Hughes, et.at. (1988) to estimate the true product thickness in the formation and the results are summarized in the following table. No other wells at the site demonstrated the presence of free phase hydrocarbons.

Well	Test Date	Static Product Thickness in the Well (Feet)	Estimated Product Thickness in the Formation (Feet)	Exaggeration Factor
RC-01	2/10/99	1.1	0.27	4.1
RC-02	2/10/99	1.97	0.34	5.8
RC-03	2/10/99	2.38	0.29	8.2

Free product in the formation at the site is interpreted to lie on top of the capillary fringe above the water table. Fine grained silty to clayey sand that exists at the site is expected to have a generally thick capillary fringe (14 to 59 inches, Testa and Paczkowski, 1989). The accumulated product in the well also depresses the water level in the well, thus the exaggeration factor is expected to be relatively high as shown in the above table.

CALCULATION

Volume of Formation Containing Free Product:

The volume of the formation that contains free product is defined as the area of the free product plume multiplied by the estimated true product thickness in the formation. The areal extent of the free product plume was estimated to be 560 square feet (as described in the Bail Down Test letter report). Because of the small plume size and the narrow range of the true product thickness estimates no attempt was made to contour the thickness data within the plume area. The area was therefore multiplied by the average thickness to obtain the volume of the formation containing free product, Vf, as shown below:

True Product Thickness, ft.	Area, sq. ft.	Formation Volume, cu. ft. Vf
Average = 0.30	560	168

Total Volume of Free Product in the Formation:

The volume of free product in the formation is limited to the pore space in the formation that is open to fluid migration minus the volume of residual water (the original wetting fluid) that occupies a portion of the pore space. For calculation purposes the total available porosity and the field capacity for a typical fine grained sand were used for this calculation (as referenced below):

Total Porosity for fine sand (EPA 1994) = 0.457
Field Capacity for fine sand (EPA 1994) = 0.083
Available Pore Space = 0.457 - 0.083 = 0.374

The Total Volume of Free Product, Vt, is then,

Vt = Formation Volume x Available Pore Space = 168 cu.ft. X 0.374 = 63 cu.ft., or
= 471 gallons of product

Total Volume of Recoverable Free Product in the Formation:

The recoverable volume of free product is less than the total volume of free product because a portion of the product will not drain from the pores under the influence of gravity. In general, as the viscosity of the hydrocarbon increases and the grain size decreases the specific retention of the free product (i.e., residual hydrocarbon) increases. A typical oil retention capacity for kerosene (i.e., assume similar for fuel oil) for a fine sand to silt formation is 8 gallons / cubic yard of formation (Testa and Paczkowski, 1989). Applying this retention factor to the total volume of free product calculated above results in the following estimate for the total volume of recoverable free product, Vr, as shown below:

Vr = Vt - (Vf cu.yd. x 8 gal/cu.yd.) = 471 – (6.2 cu.yd. X 8 gal/cu.yd.) = 421 gallons

INTERPRETATION OF RESULTS

The calculations provided above are predicated on many factors for which significant errors in the data area possible, such as:

- difficulty in obtaining representative thickness measurements in wells during nonequilibrium conditions
- few number of monitoring wells containing free product
- determination of true vs. apparent product thickness based on well measurements only
- extrapolation of geologic and hydrogeologic information between monitoring points
- estimation or assumption of key factors including porosity, specific yield or oil retention values
- averaging of estimated true product thickness between data points
- effects of residual trapped hydrocarbons

Because of these factors the total and recoverable free product volumes provided above should be used only for estimating the scope and level of effort associated with developing remedial alternatives. In addition, active recovery of free product hydrocarbons and natural water level variations can cause significant volumes of residual free product to occur in the formation that can not be recovered by conventional methods. The relatively thin free product thickness in the formation coupled with the higher viscosity of fuel oil (compared to water) and the likelihood of some water level fluctuation suggests that the recovery efficiency will be tend to be low.

REFERENCES

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CLIENT NWS Earle – Colts Neck, New Jersey		JOB NUMBER CLEAN Task Order No. 206
SUBJECT Building R-12, Calculation of the Volume of Free Product Around Abandoned UST		
BASED ON Product Bail Down Testing		DRAWING NUMBER ATTACHMENT C
BY Allan Jenkins, TtNUS	CHECKED BY R. Gorrell	DATE 2/22/99

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