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HYDROGEOLOGY OF AMMUNITION BURNING GROUNDS ASH PILE,
NAVAL WEAPONS SUPPORT CENTER, CRANE, INDIANA

by
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PREFACE

This report is the first of six studies performed by personnel of the Geotechnical Laboratory (GL) of the U. S. Army Engineer Waterways Experiment Station. Funding for this study was authorized by Order for Work and Services-NAVCOMPT Form 2275 (2-81) Number N0016483WROG185 dated 17 May 1983 and amended 9 and 16 September 1983.

The field work was conducted during the periods 7 June 1983 to 11 October 1983. Data reduction was performed from October 1983 to February 1984 and report preparation was accomplished during this same period. The drilling was performed by the Exploration Group (EG), Engineering Geology and Rock Mechanics Division (EGRMD), GL, under the supervision of Mr. Joseph B. Dunbar, Site Characterization Unit (SCU), Engineering Geology Applications Group (EGAG) of the EGRMD. Mr. Dunbar prepared the report and Mr. Dale L. Barefoot assisted in data compilation.

The study was conducted under the direct supervision of Mr. Jerald D. Broughton, Acting Chief, SCU, and under the general supervision of Mr. John H. Shamburger, Chief, EGAG, Mr. Mark A. Vispi, Chief, EG, Dr. Don C. Banks, Chief, EGRMD, and Dr. William F. Marcuson III, Chief, GL.

Special acknowledgment is extended to Ms. Cathy Andrews and Mr. Jim Hunsicker of the Naval Weapons Support Center for their assistance during the study.

Commander and Director of WES during the conduct of the study was COL Tilford C. Creel, CE. The Technical Director was Mr. F. R. Brown.

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BACKGROUND

1. The Waterways Experiment Station (WES) conducted a previous investigation in 1981 at the Ammunition Burning Grounds (ABG) valley to define the hydrogeology of the area. Eight borings with monitoring wells were installed in the ABG valley to monitor ground-water flow from the disposal facility and provide basic information about the soils and geology. In addition, a boring was drilled and sampled in the ash pile for chemical analysis of ash composition. Information on previous ABG work is contained in the WES draft report "Hydrogeologic Investigation of Waste Disposal Sites at the Naval Weapons Support Center, Crane, Indiana" (Dunbar, 1982).

PURPOSE AND SCOPE

2. The purpose of this investigation was to define the direction of ground-water flow and the geology beneath the ash pile at the ABG (see Figure 1). Activities during this study include drilling, well installation, and data analysis.

DRILLING AND WELL INSTALLATION

3. Field work consisted of drilling and installing one monitoring well upslope and three monitoring wells downslope from the ash pile as shown by Figure 2. Drilling at the ABG was done by a truck-mounted Failing 1500 drill rig with a 5-5/8-in. tricone roller bit and air to remove drill cuttings. Boring advance was terminated 10 ft below the water table. Soil or rock samples were not taken during the drilling operations, but soil and rock cuttings were field classified to identify soil or rock type, color, hardness, and estimate water content. Field logs from these borings are presented in Appendix A. Appendix B graphically summarizes this information.

4. Monitoring wells were installed in each boring following drilling. Well construction and installation are identical to the wells installed during the previous ABG study and are not discussed here. The report on the previous ABG work describes well installation procedures. Well completion diagrams for the four wells are presented in Appendix C. Water levels were measured daily

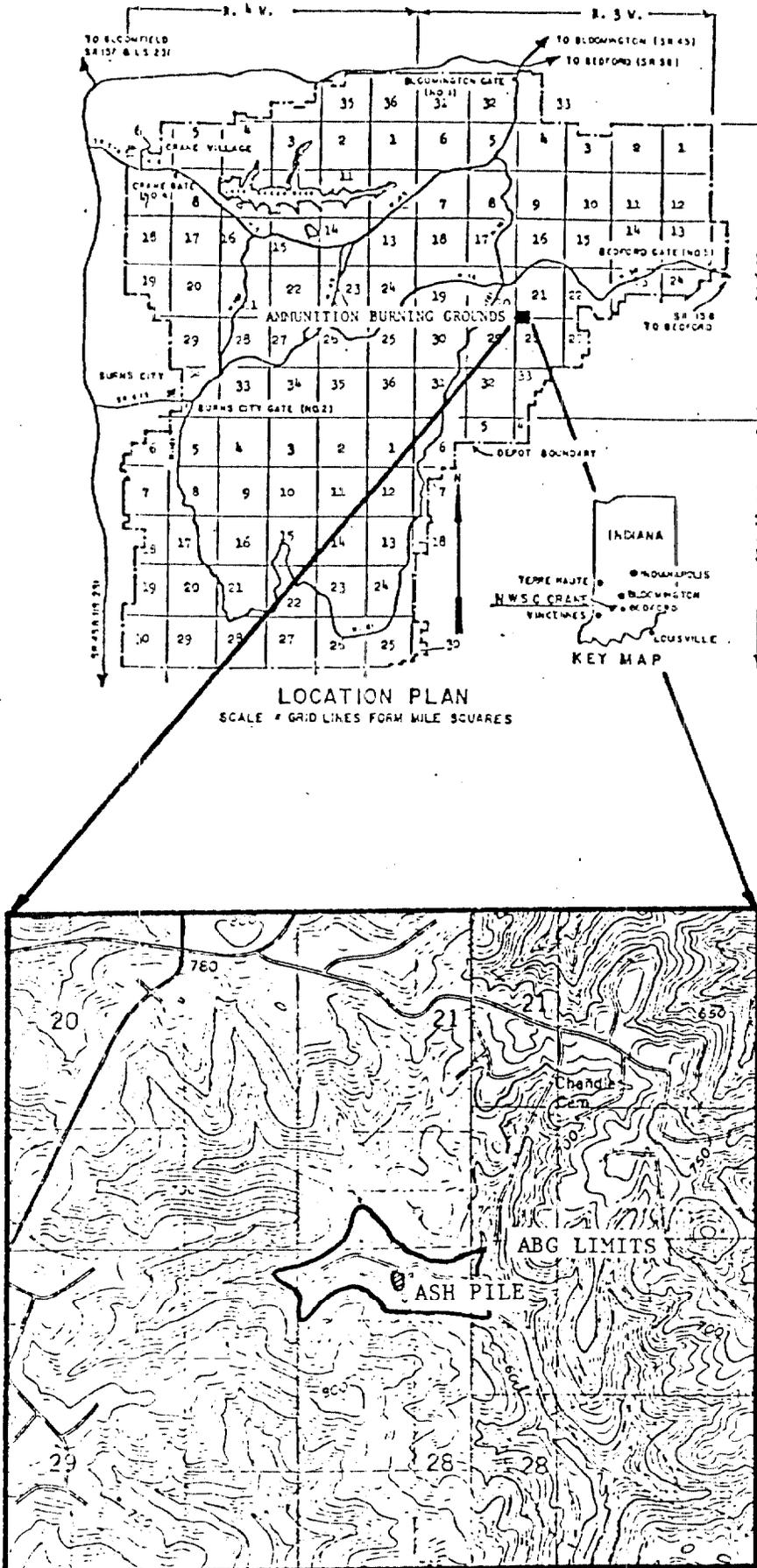


Figure 1. Ammunition Burning Grounds Location

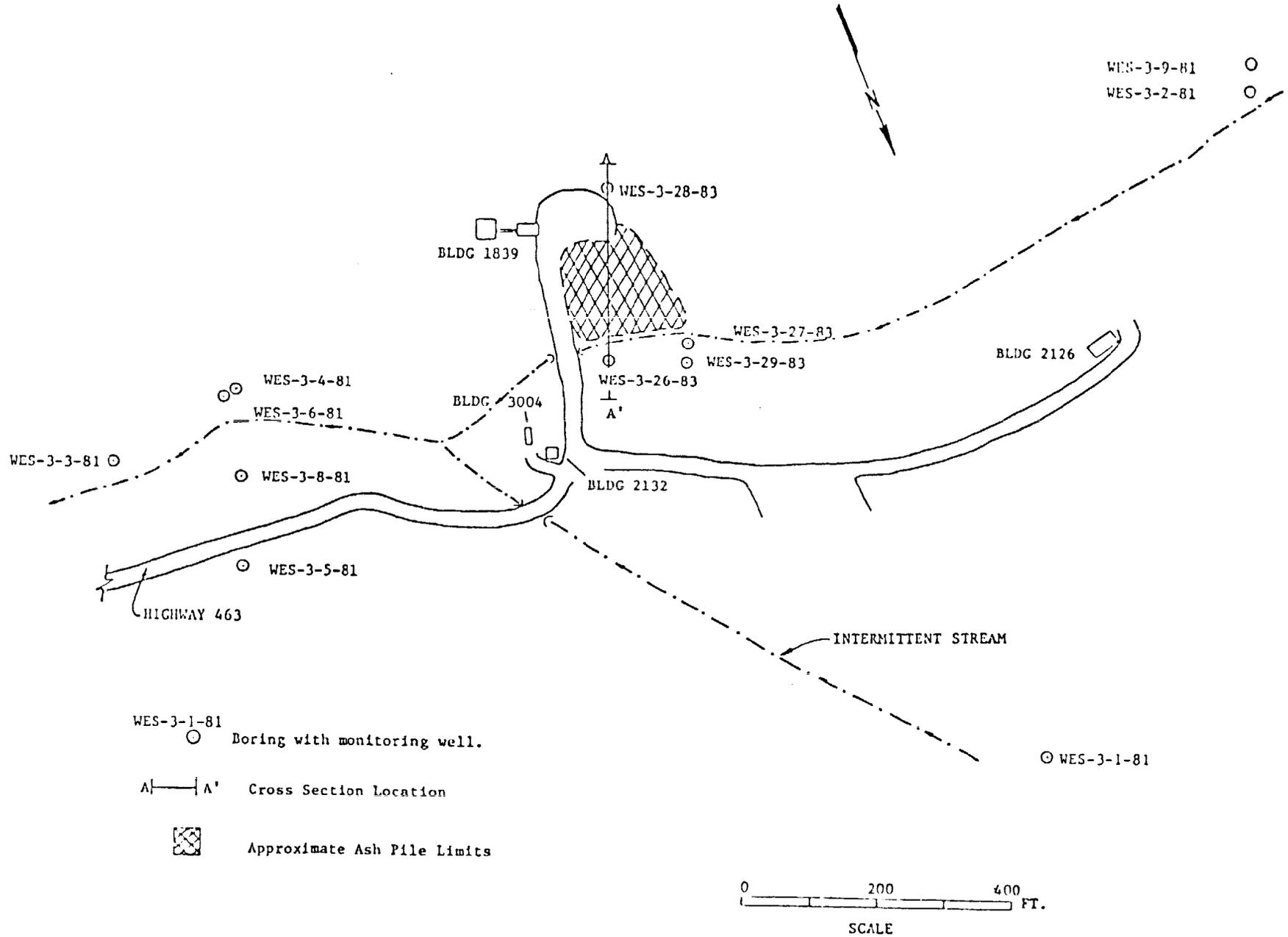


Figure 2. Ammunition Burning Grounds Boring and Cross Section Location

for approximately seven days following well completion. Water level measurements are presented in Appendix D.

DATA ANALYSIS

Geology

5. The geology of the ABG consists of residual soils underlain by Mississippian age Stephensport Group Sedimentary Rocks from the Hardinsburg Formation and Golconda Limestone Formation. The geology underlying the ABG ash pile is shown in Figure 3 (see Figure 2 for location). Soil in the four ash pile borings averages 6.7 ft in thickness and consists of sandy and gravelly clay. The sedimentary sequence underlying the soil is the Hardinsburg Formation consisting of sandstone, shale, and sandstone. Boring WES-3-28-83, located upslope from the ash pile, encountered a tan to reddish brown sandstone composed of very fine-grained, quartz sand which is approximately 15 ft thick. The sandstone is underlain by a soft, dark grey shale beginning at the 610-ft Mean Sea Level (MSL) elevation. At the base of the slope from the ash pile this upper sandstone and shale is absent and Borings WES-3-26-83, WES-3-27-83, and WES-3-29-83 encountered a sandy clay overlying a lower sandstone. This sandstone is a very fine-grained, quartz sandstone ranging from tan to reddish brown and white to light grey and is approximately 40 ft thick. The Hardinsburg Formation is underlain by the Golconda Limestone Formation, a grey, very fine-grained, semicrystalline, fossiliferous, hard limestone, at approximately the 548-ft MSL elevation.

Ground water

6. Ground water at the ABG as defined in the 1981 study is flowing down valley or towards the east in rock fractures with the water table in the ABG valley at an average depth below ground surface of approximately 50 ft. The water table depth at the ash pile averages 31.7 ft below ground surface. Ground-water flow at the ABG is shown by the ground-water contour map in Figure 4, with flow to the north under the ash pile and to the east for the entire ABG valley. The installation of four additional wells at the ash pile has not altered previous findings. The water table gradient is fairly steep as shown by the cross section (Figure 3) and the ground-water contour map (Figure 4), reflecting the steep topographic relief between the valley and

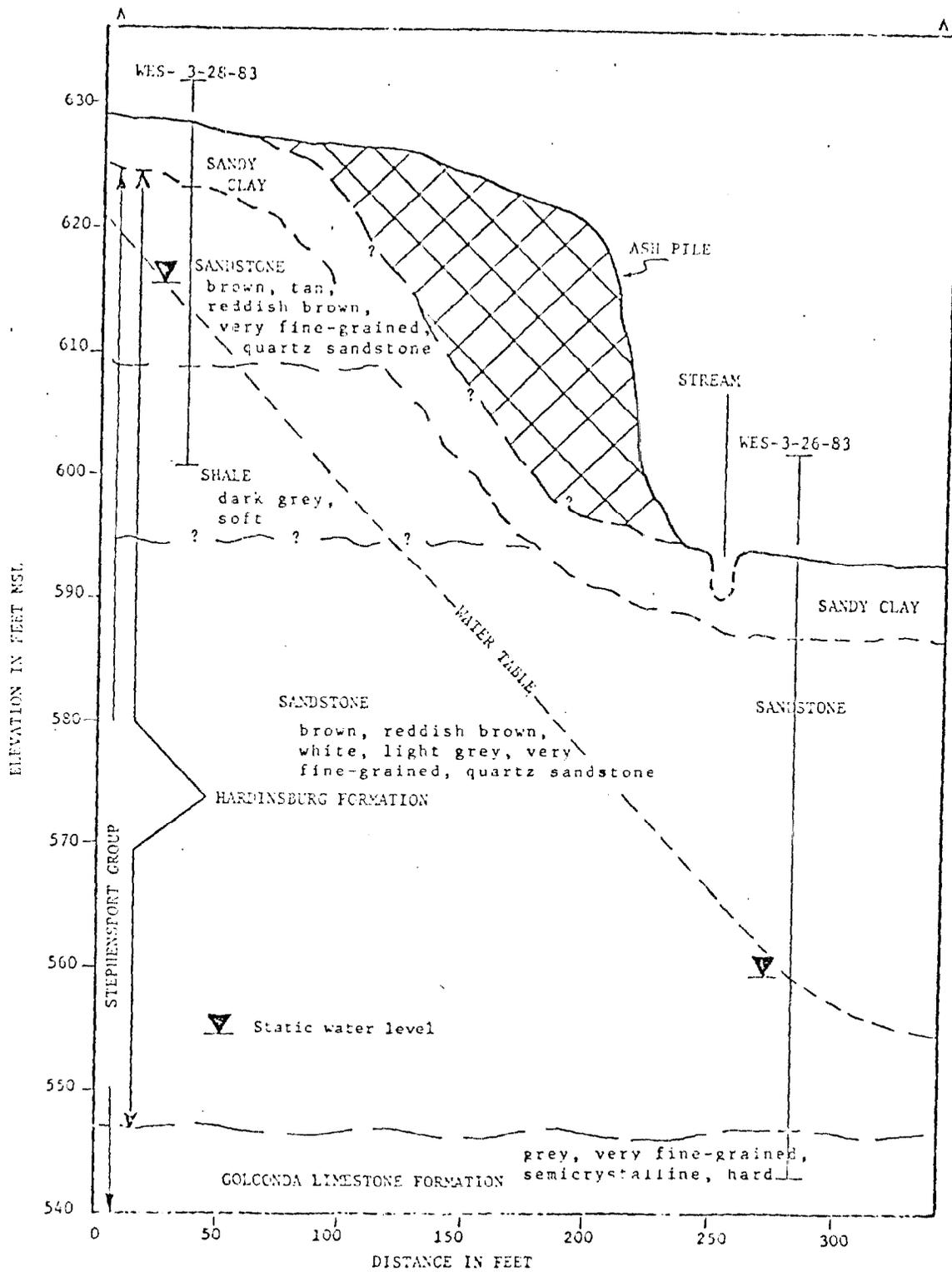


Figure 3. Ammunition Burning Grounds Geological Cross Section A - A'

- LEGEND
- 559.05
 - WES-3-26-83 ○ MONITORING WELL WITH GROUND-WATER ELEVATION IN FEET MSL (WATER LEVELS MEASURED ON 17 OCTOBER 1983)
 - 545 --- GROUND-WATER CONTOUR IN FEET MSL
 - WES 3-27-83 ● DRY WELL - BOTTOM AT 563.54 FEET MSL

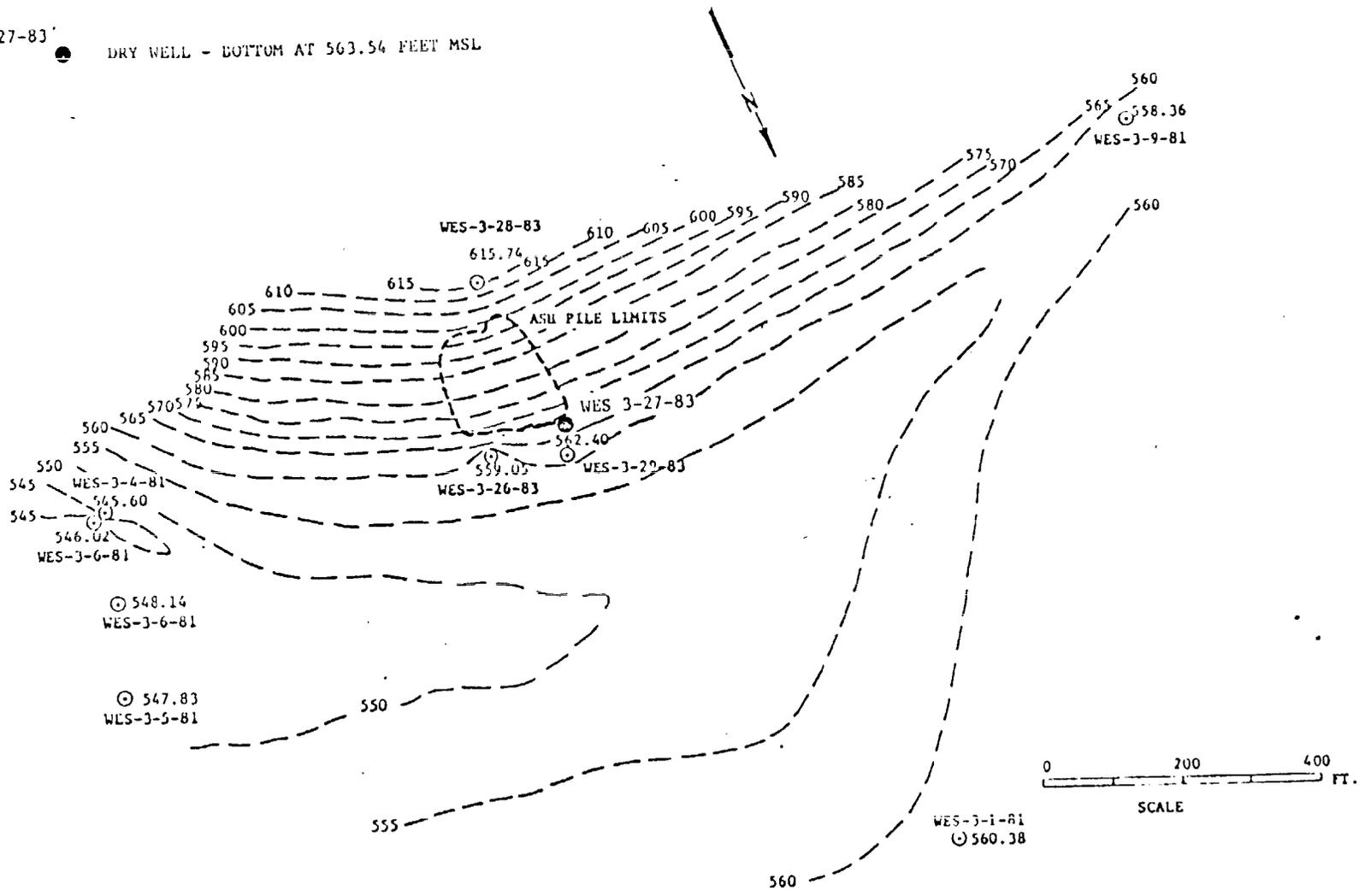


Figure 4. Ammunition Burning Grounds Ground-water Contour Map

surrounding uplands (see Figure 1). Ground-water elevations differ by approximately 55 ft between wells WES-3-28-83 and wells WES-3-26-83 and WES-3-29-83. Monitoring well WES-3-27-83 was dry and was not used in map construction in Figure 4.

SUMMARY

7. The four monitoring wells installed at the ABG ash pile have defined the geology and ground water at the ash pile. Soil adjacent to the ash pile consists of sandy and gravelly clay which averages 6.7 ft in thickness and is believed to underlie the ash pile. Rock beneath the ash pile to a depth of about 50 ft consists of Mississippian age sandstone, shale, sandstone, and limestone of the Stephensport Group. Ground water under the ash pile is in rock fractures and flows to the north into the ABG valley where ground-water flow changes to an easterly direction.

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APPENDIX A: FIELD BORING LOGS

BORING LOG
FIELD DATA

Project NWSC Ground-Water Study Site Crane, IN Date October 1983
 Location Ammunition Burning Grounds Job No. 441-G150.14GR21/22
 Drill Rig Failing Inspector J. Dunbar Operator C. Drake Surface El 593.39 Boring No. WES-3-26-83

SAMPLE NUMBER	DATE TAKEN	STRAIUM		DRIVE		SAMPLE		TYPE OF SAMPLER		CLASSIFICATION AND REMARKS
		FROM	TO	FROM	TO	FROM	TO			
	1 Oct	0.0	6.5	0.0	50.4			5-5/8 Rock Bit		Sandy clay (CL): brown and grey, soft to stiff, dry, sandy - very fine grained.
		6.5	20.5							Sandstone: brown, reddish brown, soft, very fine-grained, uniform quartz sand.
		20.5	46.5							Sandstone: white to light grey, soft, very fine-grained, uniform quartz sand. Water at 38 ft.
		46.5	50.4							Limestone: medium grey, hard, very fine-grained.
	3 Oct									Installed well - water level at 33.9 ft.

**BORING LOG
FIELD DATA**

Project NWSC Ground-Water Study Site Crane, IN Date 3 October 1983
 Location Ammunition Burning Grounds Job No. 441-G150.14GR21/22
 Drill Rig Failing Inspector J. Dunbar Operator B. Harried Surface El 597.54 Boring No. WES-3-27-83

SAMPLE NUMBER	DATE TAKEN 1983	STRATUM		DRIVE		SAMPLE		TYPE OF SAMPLER		CLASSIFICATION AND REMARKS
		FROM	TO	FROM	TO	FROM	TO			
	3 Oct	0.0	6.0	0.0	11.0			5-5/8 Rock Bit		Fill (sandy clay): brown, moist, soft, sandy- very fine-grained.
		6.0	9.3							Fill (sandy clay): grey, moist, soft, sandy - very fine-grained.
	4 Oct			0.0	9.0			6" Rock Bit		Cleanout for 6-in. casing - caving at 3 ft, casing to 9.0 - stick up 1.0 ft
		9.3	19.3	9.0	34.0			5-5/8 Rock Bit		Sandstone: brown, reddish brown, uniform, very fine-grained, quartz sandstone, soft.
		19.3	34.0							Sandstone: white to light grey, uniform, very fine-grained quartz sandstone. Wet at 23 ft.

BORING LOG
FIELD DATA

Project NWSC Ground-Water Study Site Crane, IN Date 6 October 1983
 Location Ammunition Burning Grounds Job No. 441-G150.14GR21/22
 Drill Rig Falling Inspector J. Dunbar Operator B. Harried Surface El 628.31 Boring No. WES-3-28-83

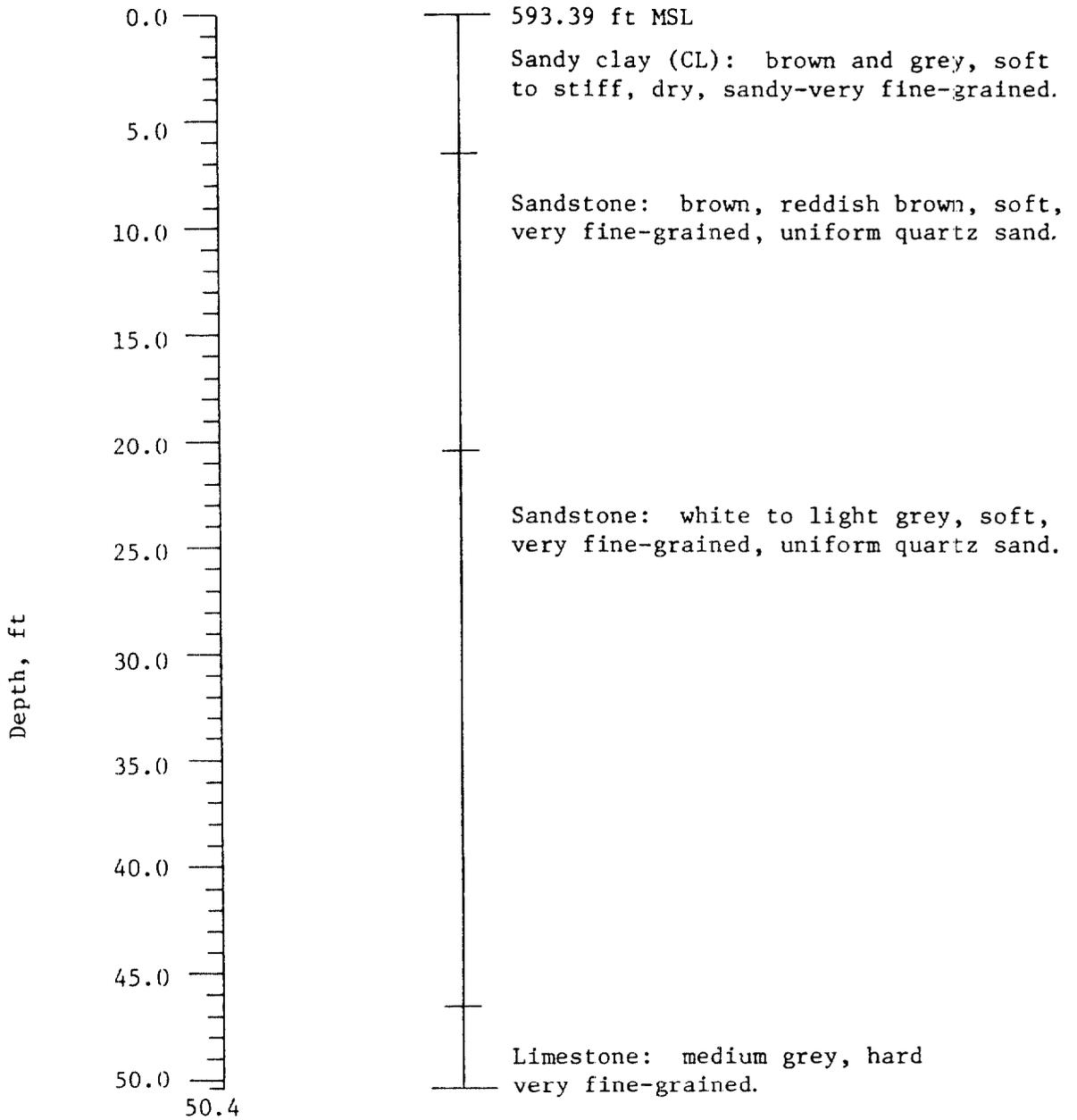
SAMPLE NUMBER	DATE TAKEN 1983	STRATUM		DRIVE		SAMPLE		TYPE OF SAMPLER		CLASSIFICATION AND REMARKS
		FROM	TO	FROM	TO	FROM	TO			
	6 Oct	0.0	5.2	0.0	27.5			5-5/8 Rock Bit		Sandy clay (CL): brown, soft to stiff, damp, organic matter.
		5.2	20.0							Sandstone: brown, reddish brown, and tan, very fine-grained, uniform quartz sandstone, water at 16 ft.
		20.0	27.5							Shale: dark grey, soft, uniform, dry.
	7 Oct									Blew water from boring and installed monitoring well.

**BORING LOG
FIELD DATA**

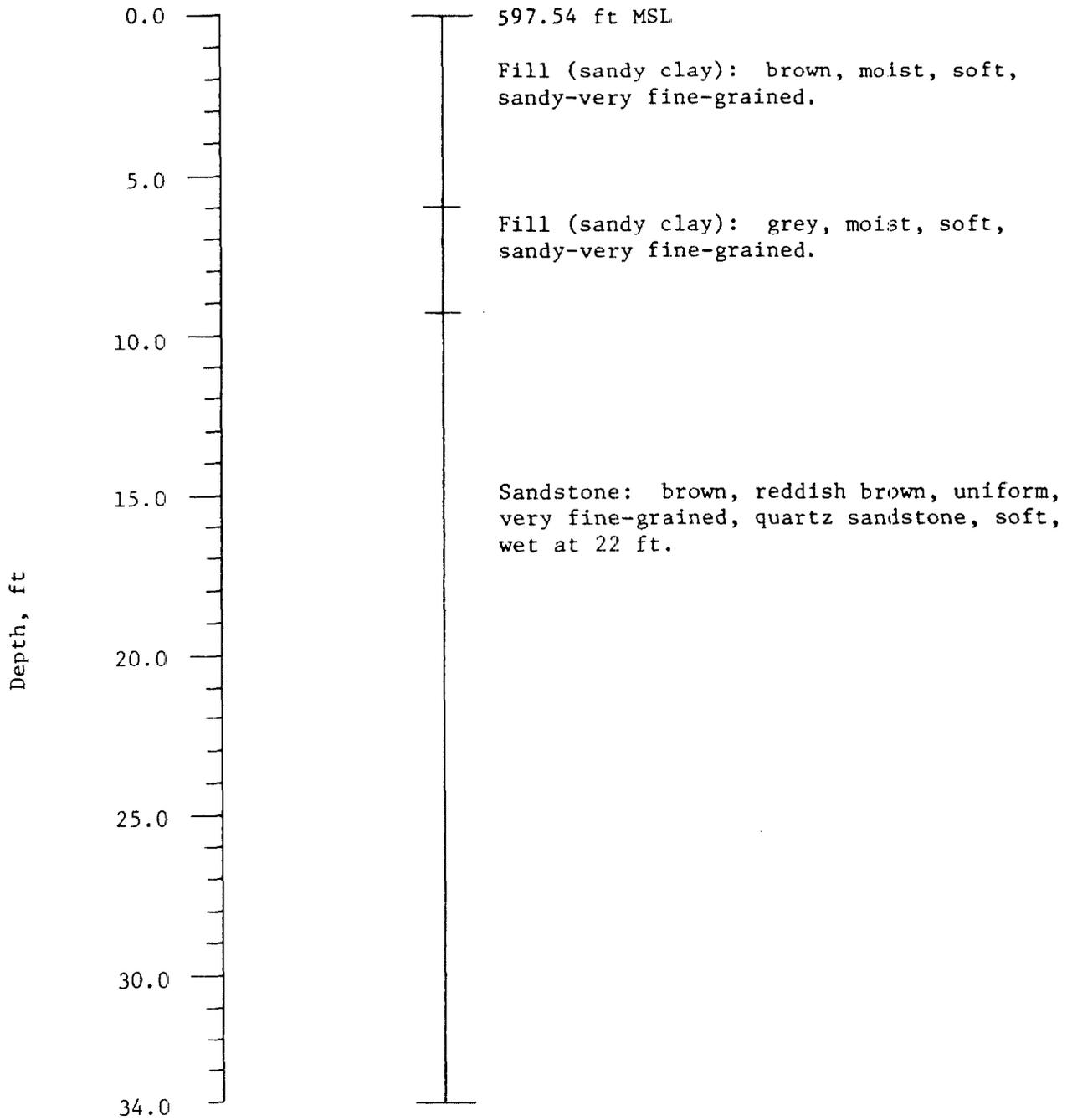
Project NWSC Ground-Water Study Site Crane, IN Date 8 October 1983
 Location Ammunition Burning Grounds Job No. 441-G150.13GR21/22
 Drill Rig Failing Inspector J. Dunbar Operator C. Drake Surface El 596.78 Boring No. WES-3-29-83

SAMPLE NUMBER	DATE TAKEN 1983	STRATUM		DRIVE		SAMPLE		TYPE OF SAMPLER		CLASSIFICATION AND REMARKS
		FROM	TO	FROM	TO	FROM	TO			
	8 Oct	0.0	2.1	0.0	51.0			5-5/8" Rock Bit		Sandy clay (CL): brown, soft to stiff, damp, sandy - very fine-grained.
		2.1	9.1							Sandy clay (CL) and sandstone: brown, reddish brown, thinly bedded (soft and hard), weathered, slightly damp, very fine-grained sandstone.
		9.1	14.1							Sandstone: brown, reddish brown, very fine-grained, quartz sandstone, soft, weathered.
		14.1	30.1							Sandstone: light grey, very fine-grained quartz sandstone, soft.
		30.1	45.5							Sandstone: brown to reddish brown

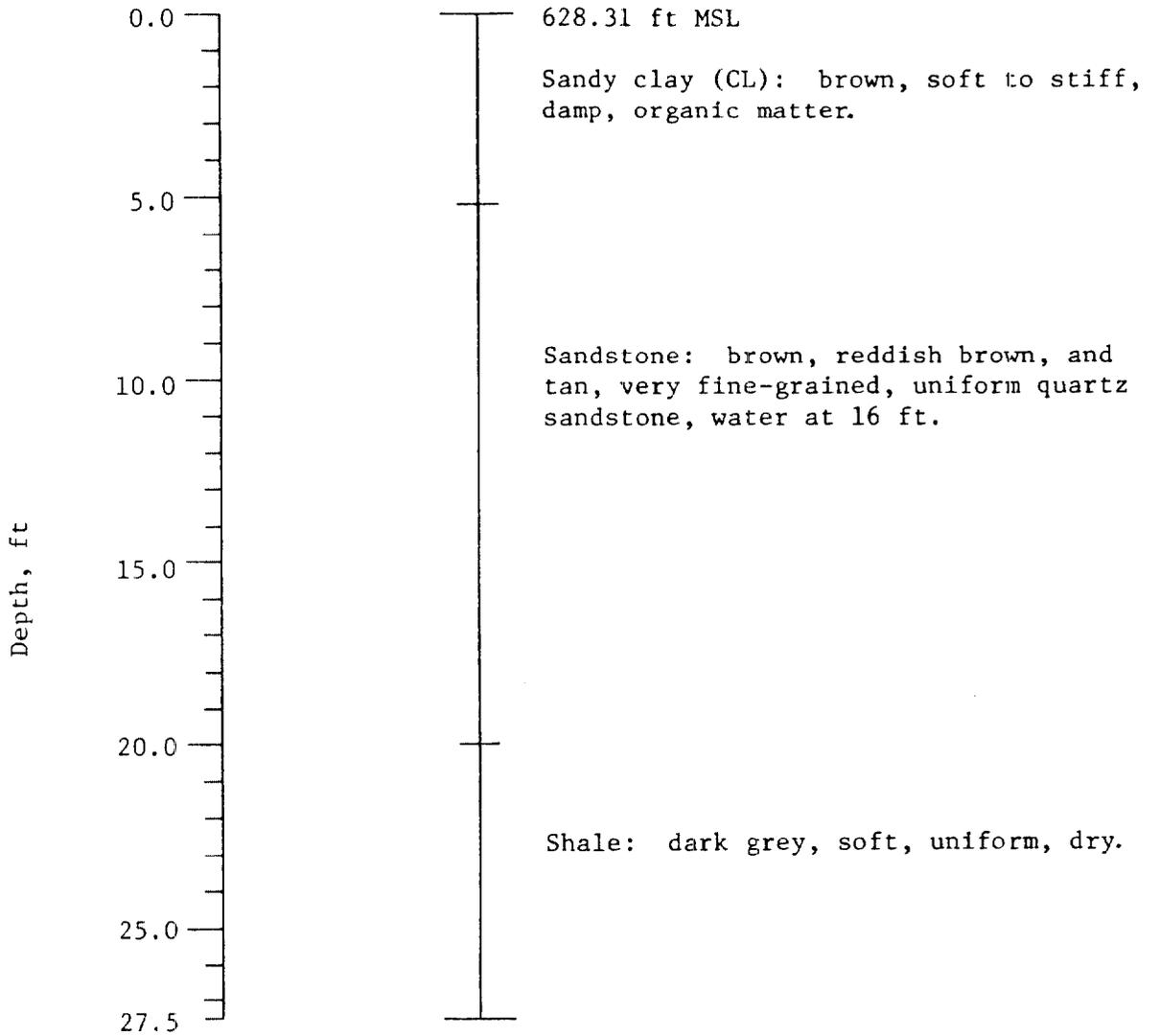
APPENDIX B: GRAPHIC FIELD LOGS



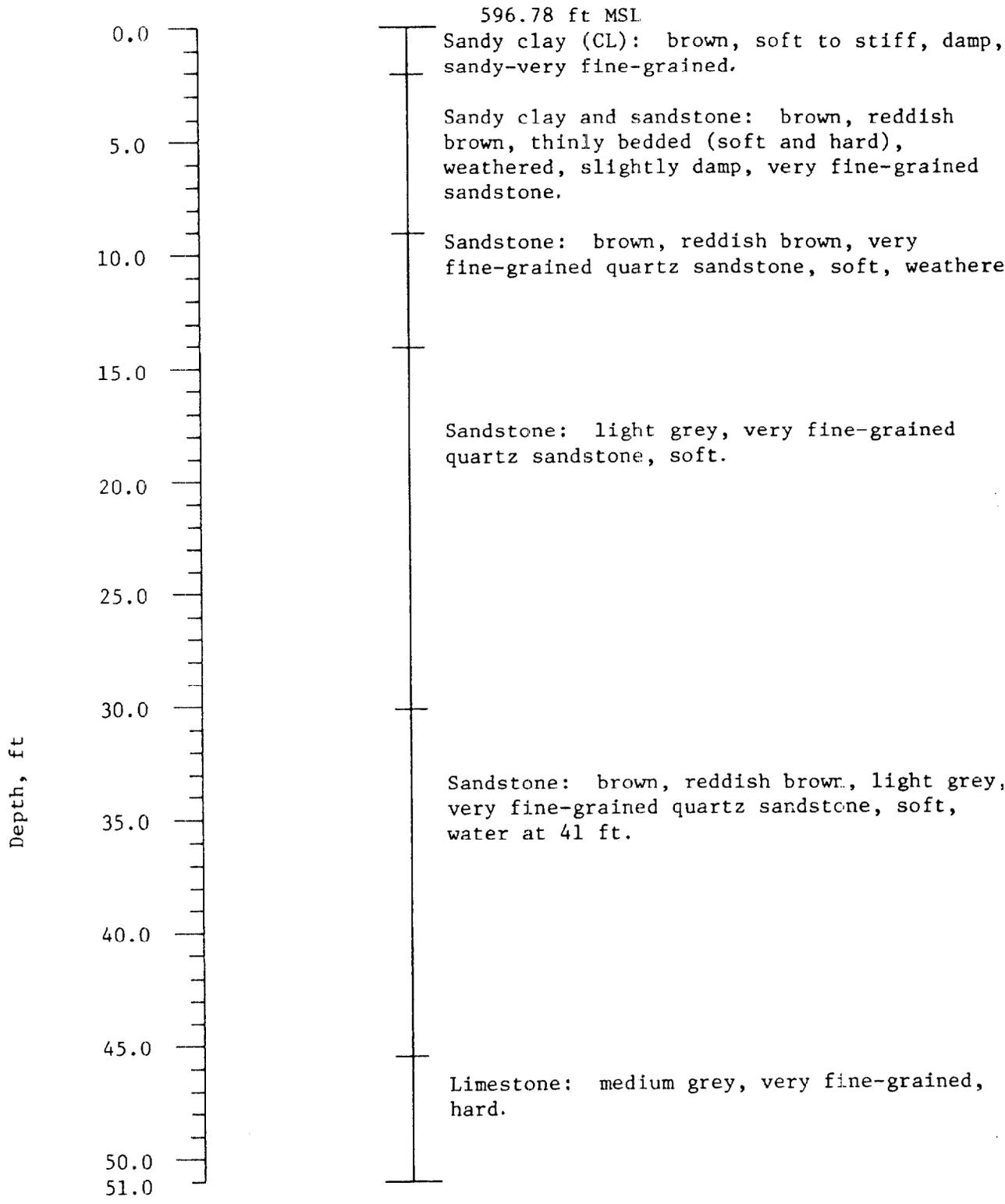
NWSC, Crane, Indiana
 Ammunition Burning Grounds
 Lithology
 Boring Number: WES-3-26-83



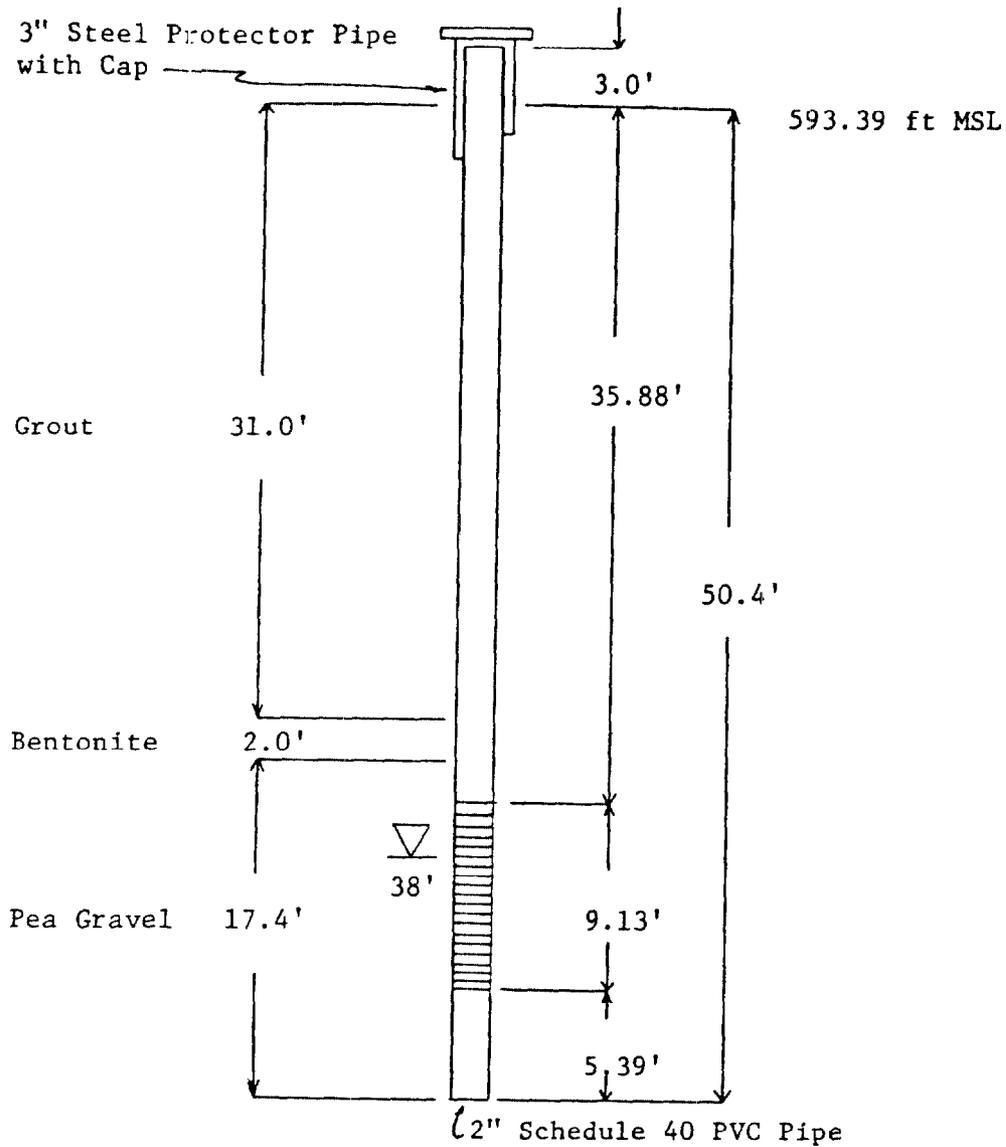
NWSC, Crane, Indiana
Ammunition Burning Grounds
Lithology
Boring Number: WES-3-27-83



NWSC, Crane, Indiana
 Ammunition Burning Grounds
 Lithology
 Boring Number: WES-3-28-83



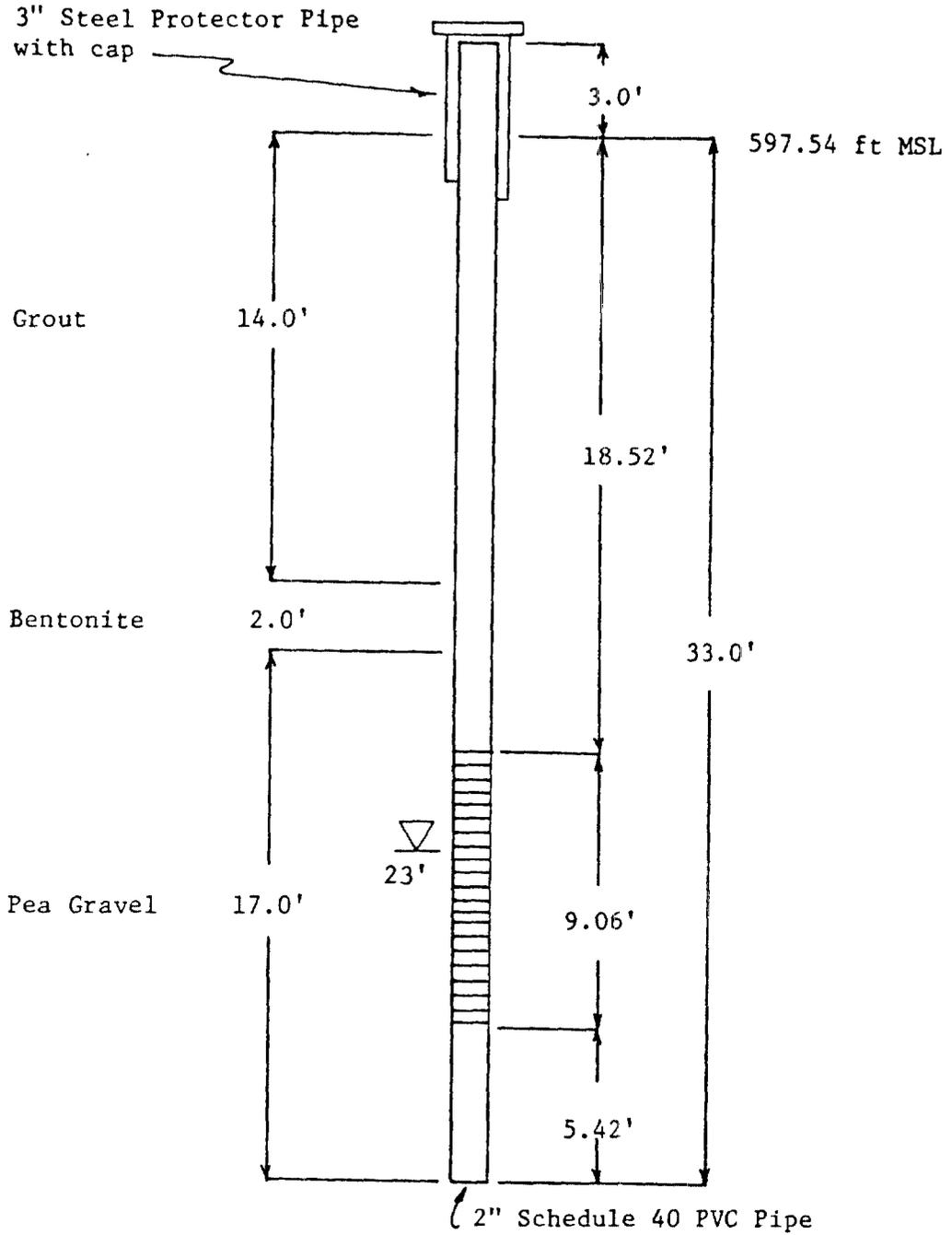
APPENDIX C: WELL COMPLETION DIAGRAMS



▽ Water depth at time of drilling

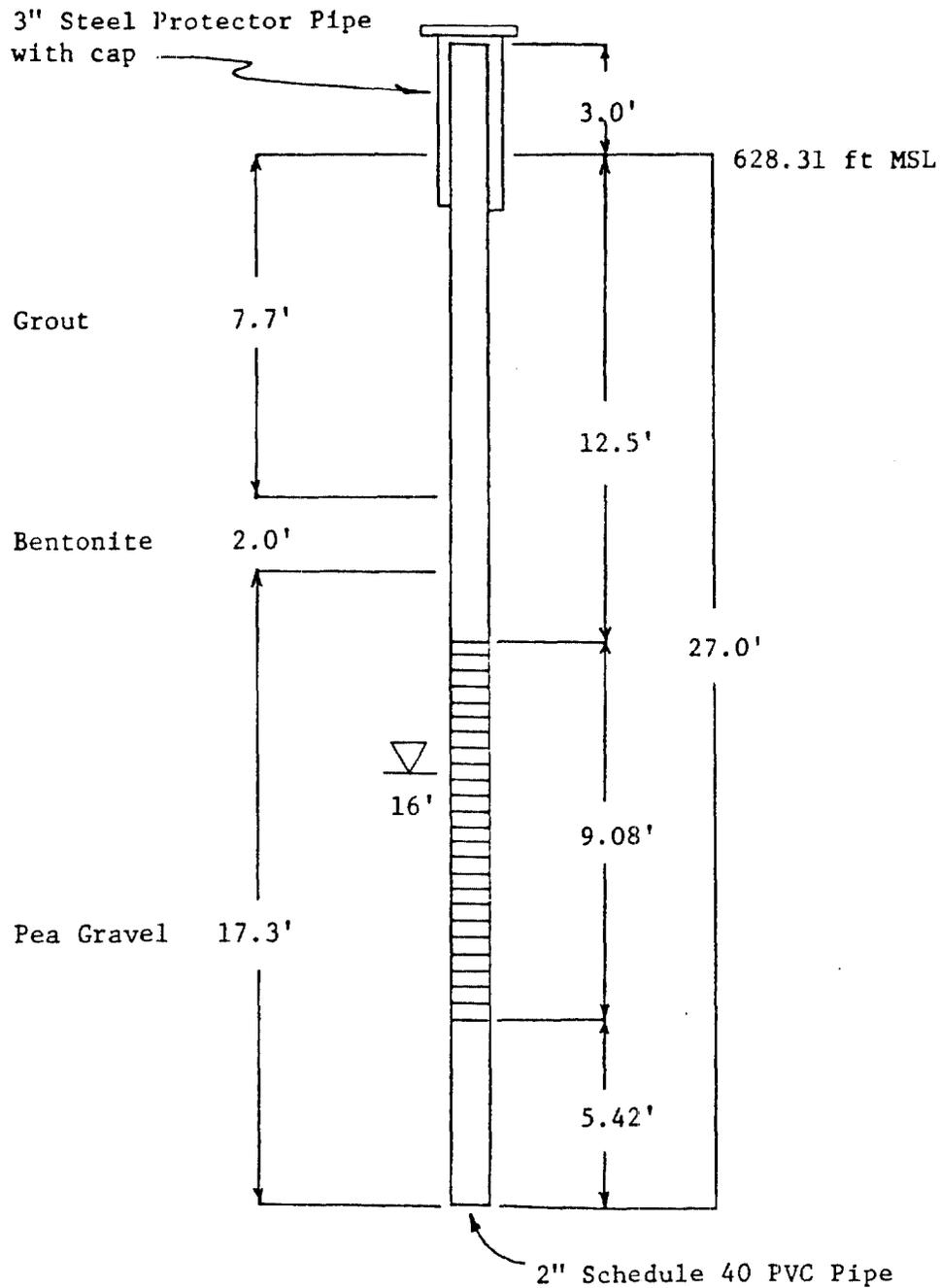
≡ Well Screen

NWSC, Crane, Indiana
 Ammunition Burning Grounds
 Well Completion
 Boring Number: WES-3-26-83



-  Water depth at time of drilling
-  Well Screen

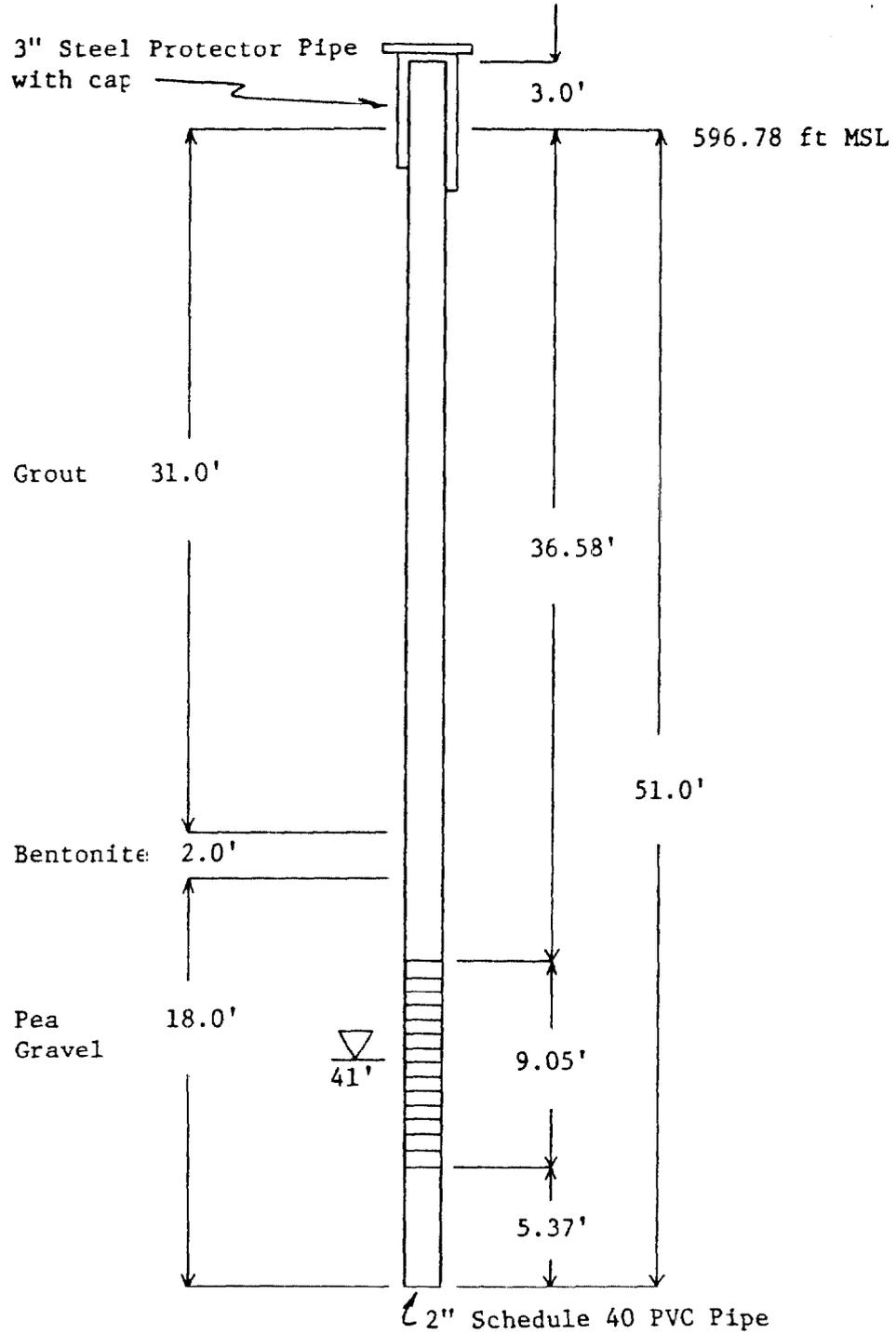
NWSC, Crane, Indiana
 Ammunition Burning Grounds
 Well Completion
 Boring Number: WES-3-27-83



▽ Water depth at time of drilling

▬ Well Screen

NWSC, Crane, Indiana
 Ammunition Burning Grounds
 Well Completion
 Boring Number: WES-3-28-83



▽ Water depth at time of drilling

≡ Well Screen

NWSC, Crane, Indiana
 Ammunition Burning Grounds
 Well Completion
 Boring Number: WES-3-29-83

APPENDIX D: GROUND-WATER ELEVATIONS

Ground-Water Elevations
Ammunition Burning Grounds

Boring Number: WES-3-26-83

Top of Pipe Elevation: 596.39 ft MSL

Screen Interval Elevation: from 560.51 to 551.38 ft MSL

Grid Coordinates:

<u>Date</u>	<u>Time</u>	<u>Depth to Water, ft</u>	<u>Water Elevation, ft MSL</u>	<u>Remarks</u>
4 Oct 83	11:34	36.90	559.49	
5 Oct 83	9:53	36.93	559.46	
7 Oct 83	1:05	37.22	559.17	
8 Oct 83	9:31	37.33	559.06	
10 Oct 83	7:54	37.38	559.01	
13 Oct 83	9:49	37.04	559.35	
17 Oct 83	9:32	37.34	559.05	

Ground-Water Elevations
Ammunition Burning Grounds

Boring Number: WES-3-27-83

Top of Pipe Elevation: 600.54 ft MSL

Screen Interval Elevation: from 579.02 to 569.96 ft MSL

Grid Coordinates:

<u>Date</u>	<u>Time</u>	<u>Depth to Water, ft</u>	<u>Water Elevation, ft MSL</u>	<u>Remarks</u>
7 Oct 83	1:10	29.76	570.78	
8 Oct 83				Purged well
10 Oct 83				Dry

Ground-Water Elevations
Ammunition Burning Grounds

Boring Number: WES-3-28-83

Top of Pipe Elevation: 631.31 ft MSL

Screen Interval Elevation: from 615.81 to 606.73 ft MSL

Grid Coordinates:

<u>Date</u>	<u>Time</u>	<u>Depth to Water, ft</u>	<u>Water Elevation, ft MSL</u>	<u>Remarks</u>
8 Oct 83	9:33	15.72	615.59	
10 Oct 83	7:51	15.94	615.37	
13 Oct 83	9:46	15.71	615.60	
17 Oct 83	9:35	15.57	615.74	

Ground-Water Elevations
Ammunition Burning Grounds

Boring Number: WES-3-29-83

Top of Pipe Elevation: 599.78 ft MSL

Screen Interval Elevation: from 560.20 to 551.15 ft MSL

Grid Coordinates:

<u>Date</u>	<u>Time</u>	<u>Depth to Water, ft</u>	<u>Water Elevation, ft MSL</u>	<u>Remarks</u>
10 Oct 83	7:56	34.17	565.61	
13 Oct 83	9:52	37.05	562.73	
17 Oct 83	9:30	37.38	562.40	

Ground-Water Elevations
Ammunition Burning Grounds

<u>Well Number</u>	<u>Top of Pipe Elevation</u>	<u>Date</u>	<u>Time</u>	<u>Depth to Water, ft</u>	<u>Water Elevation, ft MSL</u>
WES-3-1-83	605.45	17 Oct 83	9:45	45.07	560.38
WES-3-4-83	595.12	17 Oct 83	9:54	49.52	545.60
WES-3-5-83	596.25	17 Oct 83	9:48	48.42	547.83
WES-3-6-83	590.60	17 Oct 83	9:53	44.58	546.02
WES-3-8-83	587.76*	17 Oct 83	9:51	39.62	548.14
WES-3-9-83	625.25	17 Oct 83	9:41	66.89	558.36

* Change in top of pipe elevation - stickup of 3.5 ft