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HARTCROWSER

Earth and Environmental Technologies

Geotechnical Engineering Design Study
Paine Field Parcel
Everett, Washington

Prepared for
James S. Griffin Company

January 11, 1989
J-2306

- Slopes need to analyzed to see if ESA
- This study was done prior to 37 adoption & does not address pts. in ~~the~~ title 37 pertaining to ESA slopes

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GEOTECHNICAL ENGINEERING DESIGN STUDY
PAINE FIELD PARCEL
EVERETT, WASHINGTON

This report presents the results of our geotechnical engineering design study for the proposed development of a 40-acre parcel located within one mile north of Paine Field, in Everett, Washington. It includes the following:

- Purpose of Our Work
- Scope of Our Work
- Limitations of Our Work
- Our Understanding of the Project
- Geotechnical Engineering Design Recommendations
- Recommendations for Continuing Services
- Appendices of Field and Laboratory Procedures and Results

PROJECT PURPOSE

The purpose of this study was to assess subsurface conditions at the site and provide design and construction recommendations. We make specific recommendations regarding:

- Foundation Type, Depth, and Bearing Pressure;
- Site Preparation Activities for Foundation and Pavement Construction; and
- Pavement Design.

PROJECT SCOPE

Our scope of work for this project included:

- Completing test pit excavations;
- Completing laboratory tests on field samples;
- Reviewing field and laboratory data;
- Estimating ability of the soils to support structure loads; and
- Producing geotechnical engineering design report.

LIMITATIONS OF OUR WORK

We prepared this report for the exclusive use of the James S. Griffin Company for specific application to this project and proposed site location. This work has been accomplished

within the scope of work outlined in our confirming letter dated December 15, 1988, and our FAX transmittal of December 9, 1988. We completed the work in accordance with generally accepted geotechnical engineering practices in the same or similar localities, related to the nature of the work accomplished at the time the services were performed. We make no other warranty, express or implied.

Thick vegetation limited our access for test pit explorations in the southwest, central, and northeast portions of the site (see Figure 1). Therefore, the subsurface conditions in these areas have been interpolated and/or extrapolated from the available test pit information and may be different than assumed. The risk in performing the engineering and analyses without this information should be understood. However, given the consistency of the available test pit data and the topography, we believe it is likely that the general subsurface conditions in the unexplored areas will be as observed in the test pits. The recommendations made within this report are based on this assumption.

OUR UNDERSTANDING OF THE PROJECT

Site Conditions

The project site is located approximately 3/4 mile due east of Mukilteo, Washington. The property is square in shape with dimensions of 1,320 by 1,320 feet. The southeast corner of the site lies at the center of Section 3, T28N, R4E, based on information provided by James S. Griffin Company. Existing site grades slope downward to the northwest and range from about 460 to 350 feet. The property is in an area of no previous development and is heavily vegetated with brush and small to large trees.

Development Plans

The property is being considered for an office park development. We understand that the building footings will support moderate loads. For our analyses, we have assumed that individual column loads will be on the order of 75 to 125 Kips each. Access roads and parking areas are also planned for the development. We based our recommendations on our current understanding of the project. If the proposed

development changes, we should be notified so we can modify or verify our recommendations.

Subsurface Conditions

We oversaw excavation of 21 test pits at the locations shown on Figure 1. Test pit logs are presented in Appendix A. We based our interpretation of subsurface conditions on information from our test pit explorations. The nature and extent of variations between explorations and in areas without explorations may not become evident until construction. If variations then appear evident, it will be necessary to reevaluate the recommendations of this report.

Subsurface explorations encountered four general soil types as listed below in descending order from the ground surface:

- Recently deposited organics;
- Loose, silty sand;
- Very stiff, very sandy silt; and
- Hard, very sandy silt (Till).

Recently Deposited Organics. The surface material consisted primarily of dark brown to black organic matter including thick root growth. It was generally loose or soft, moist, and is considered highly compressible. This layer ranged in thickness from about 1/2 to 1-1/2 feet (see Figure 2).

Loose, Silty Sand. This material was generally encountered as a thin layer between the surficial organic soils and the underlying very stiff, sandy silt. It actually varied between silty sand and sandy silt and often included roots. We do not recommend that footings bear on this material.

Very Stiff, Very Sandy Silt. This material consisted primarily of a gray mottled brown, very stiff, slightly gravelly, very sandy silt with occasional cobbles. Samples within this unit were occasionally classified as dense, very silty sand (weathered till). We consider the compressibility to be low and the strength to be moderate to high. The top of this layer was encountered generally about 2 or 3 feet below the ground surface but was as deep as 6 feet (see Figure 3).

Hard, Very Sandy Silt (Till). This material was generally classified as gray, hard, slightly gravelly, very sandy silt with occasional cobbles. As above, soils were sometimes classified as a very dense, very silty sand. It is generally the same soil type as the material directly above it only in a less weathered condition. It exhibits high strength and low compressibility. The top of this layer was generally encountered at about 4 feet and as much as 8 feet below the ground surface (see Figure 4).

We encountered occasional junk and debris across the site. No buried refuse or discolored soils were encountered within test pits. No noxious or harmful odors were noticed during test pit excavation.

Soil conditions in this area are not typically corrosive to buried utilities and footings.

Groundwater was observed in 15 of the 21 test pits. It ranged from slight seepage to rapid seepage occurring at different elevations throughout the site, usually along the contacts between soil types. It appeared to be a perched water level above the relatively impermeable very sandy silt. Fluctuations in groundwater levels and conditions may occur due to variations in rainfall, temperature, and other factors.

We observed surface water near test pit TP-2. We estimated a flow of about 5 gallons per minute (gpm) along the western man-made dirt road. It appeared to be fed from seepage out of the surficial organic layer between TP-10 and TP-11. This area appears to be a small drainage basin.

GEOTECHNICAL ENGINEERING DESIGN RECOMMENDATIONS

The site soils are generally suitable for development of retail and office park facilities. Proper site preparation and particularly, consideration of the surficial organic soils will be necessary for successful development.

Site Preparation and Grading

We recommend that initial preparation of the site for construction and pavement support include the following:

- Strip all surface vegetation and organics beneath proposed pavement, slabs-on-grade, and footings. We expect that initial site stripping will primarily include the "Recently Deposited Organics" described above. We have estimated the required stripping depth at the test pit locations on Figure 2;

- After site stripping, proofroll the exposed subgrade with a vibratory roller to compact the in-place soils to a firm, non-yielding condition. Soft or yielding areas disclosed by the proofrolling may require local over-excavation and backfilling and compacting. If necessary, low areas that may result from site stripping can be backfilled with structural fill;

- Proceed with foundation work immediately after stripping and proofrolling. This will reduce the time during which rain could disturb or muddy the exposed soils. Due to their silty nature, the natural soils are easily disturbed by construction and foot traffic when they become wet. We expect the foundation bearing soils to consist of the very stiff or hard, very sandy silt described above;

- Overexcavation beneath individual footings may be necessary. The minimum lateral limits of the overexcavation and structural fill placement beneath footings should be defined by a line extending downward and out from the outer edge of the footing to the top of the bearing soils at an angle of 1H:1V;

- In the pavement areas, after stripping the organic soils, proofroll the subgrade.

  The purpose of proofrolling is to delineate excessively loose or soft areas which require improvement prior to fill placement.

Improvements that may be necessary include:

- Overexcavation of excessively soft, wet, or organic soils and replacement with compacted fill.
- Aeration of wet soils followed by compaction.
- Compaction of loose soils.

General Foundation Considerations

We anticipate that building loads will be supported on shallow spread and continuous wall footings. Footings can be designed to bear on the natural stiff, very sandy silt. Alternatively, if an increased allowable bearing pressure is desired, footings may be designed to bear in the natural hard, very sandy silt (unweathered till). This material however is beneath the weathered zone and for footings to bear on the unweathered till would generally require deeper footing excavations. If final grades require, footings could also be designed to bear on compacted structural fill placed directly above these natural bearing soils. Design and construction criteria for shallow footings are addressed below.

Design of Shallow Foundations

We make the following recommendations for design and construction of shallow footings:

- o Found shallow footings in very stiff to hard natural soils or in compacted structural fill placed directly above these natural soils;
- o Design footings so that:
  - Isolated footings have a minimum dimension of 24 inches;
  - Continuous wall footings have a minimum width of 18 inches;
  - All footings have a minimum embedment depth of 18 inches below lowest adjacent grade.
- o Use an allowable soil bearing pressure as indicated in Table 1. The estimated depths to the top of the bearing soils, which would

correspond to footing bearing elevations, are shown on Figures 3 and 4;

- If foundation subgrades become loosened or disturbed during construction, remove the material and replace with structural fill; and

- Allow a qualified geotechnical engineer or geologist to observe exposed subgrades prior to footing construction to verify suitable bearing surfaces.

The allowable bearing pressure presented in Table 1 can be increased by one-third for loads of short duration, such as wind or seismic loads. Assuming proper subgrade preparation (as described herein) we expect total settlement of the footings to be less than 1 inch and differential settlement to be less than half the total settlement. This settlement is expected to occur essentially as the loads are applied.

Table 1 - Maximum Allowable Bearing Pressures

	Material	
	Hard Till	Very Stiff Natural Soil or Structural Fill
Continuous Footing	6,000 psf	4,000 psf
Square Footing	8,000 psf	5,000 psf

Note: See Figures 3 and 4 for estimated depths to bearing soils.

Construction Sequence

We anticipate a general design and construction sequence as follows:

1) Determine final planned grades for buildings and pavements;

2) Compare final grades with test pit data from Figures 2, 3, and 4 to identify those areas requiring special site preparation such as overexcavation and replacement of near-surface soils, raising site grades, etc.;

3) Strip vegetation and organics;

4) Complete major overexcavation, backfill, and general site filling as required; and

5) During building construction complete any additional required overexcavation at specific footing locations.

Floor Slabs

The interior floors of the building could be constructed as slabs-on-grade supported by non-yielding native soil or on a suitable thickness of compacted structural fill, placed directly above medium dense to stiff natural soils. We recommend the following:

- Provide a minimum of 4 inches of compacted, clean (less than 5 percent fines) well-graded sand or sand and gravel below the slab as a cushioning layer and as a capillary break and drainage layer;

- Compact the subgrade and drainage layer to the criteria of structural fill presented herein;

- Require the contractor to submit a sample of the capillary break fill to the engineer for acceptance before placement;

- Include a vapor barrier below any floor slabs. Place the vapor barrier above the drainage layer; and

- All slabs should be underlain by at least 2 feet of compacted structural fill and/or stiff to hard natural soil.

Drainage

Based on observed groundwater conditions, we anticipate that permanent underslab drainage will be necessary. We recommend the following:

- Provide perimeter drains and occasional cross drains beneath building slabs. The need for

and spacing of drains will depend on final site grades and floor slab elevations;

- Final grade the site in such a way that surface water will not pond near the structures; and

- Slope roof drains to a suitable outlet away from the proposed buildings. Do not connect the roof drains to the foundation drainage system.

Surface water and groundwater may be encountered in excavations during construction. We anticipate that it could be handled by the contractor using conventional methods such as diversion ditches and sumps.

Pavement Design

After the site is prepared, we recommend a minimum pavement section of 2 inches of asphalt over 4 inches of crushed rock for light traffic or parking areas. Use a thicker section of 3 inches of asphalt over 6 inches of crushed rock in heavy truck traffic areas. Compact crushed rock to the degree recommended herein for structural fill.

Backfill and Compaction

Soil placed beneath footings or below paved areas should be considered structural fill. We make the following recommendations:

- Place structural fill in lifts (maximum 8-inch loose thickness) and compact it to a minimum of 95 and 92 percent of the modified Proctor maximum dry density (as determined by ASTM D 1557 test procedure) beneath footings and in pavement areas, respectively; and

- Prior to placement of structural fill, compact the exposed subgrade to a dense, non-yielding condition.

Based on samples obtained from the test pits, the surficial soils are not suitable for use as structural fill because of their silty nature and organic/root content. Also, the lower sandy silt would probably not be suitable for use as structural fill because of its relatively high silt content. As the silt content of soil increases, it becomes increasingly difficult to

compact properly, particularly in wet weather conditions. We make the following recommendations:

- Imported fill should be required for use as structural fill. During wet weather months, we recommend a clean, well-graded sand or sand and gravel with less than five (5) percent by weight passing the No. 200 mesh sieve be used;

- During periods of wet weather, limit equipment traffic on subgrades to reduce potential for disturbance; and

- Allow a qualified geotechnical engineer or geologist to observe subgrades prior to placement of structural fill and/or pavement sections.

RECOMMENDATION FOR CONTINUING SERVICES

- Hart Crowser should review final development plans to determine the necessity for further subsurface explorations;

- Hart Crowser should review final design plans and specifications to verify that recommendations presented herein have been properly interpreted and incorporated into the final design. At this time, our recommendation to provide underslab drains could be conformed or modified as appropriate; and

- Qualified personnel should observe conditions during construction to review the site preparation activities and subgrade conditions.

After the site has been cleared and becomes more accessible, it may be advantageous and cost-effective to have Hart Crowser assess subsurface conditions in the previously unexplored areas.

The purpose of the review and observations are to verify compliance with the design concepts, specifications, and recommendations, and to allow timely design changes in the event that subsurface conditions differ from those anticipated prior to construction.

We trust this report meets your current needs and look forward to working with you in the future. If you have any questions, please call.

Sincerely,

HART CROWSER, INC.

John R Verduin III

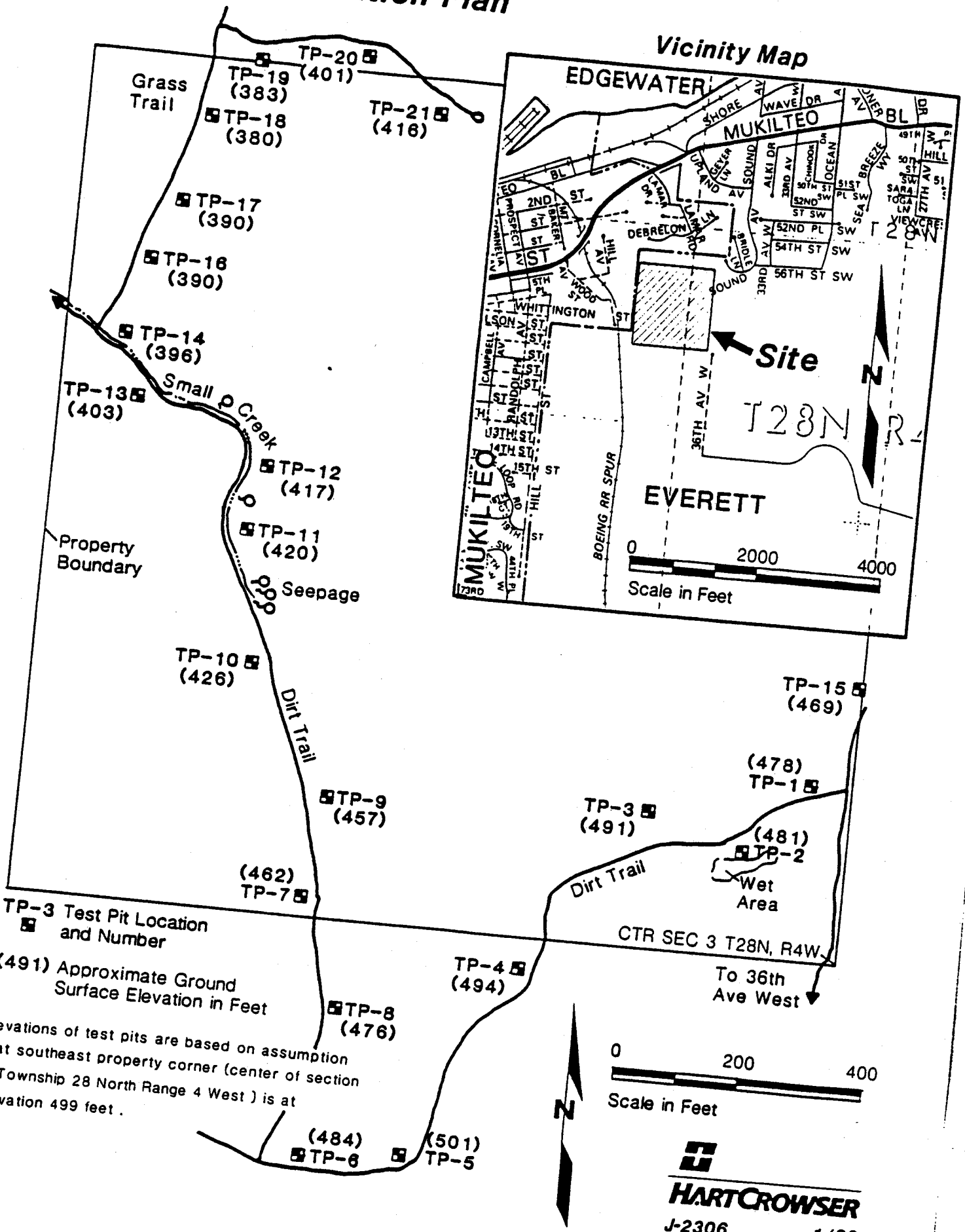
JOHN R. VERDUIN, III
Staff Engineer

J. Jeffrey Wagner

J. JEFFREY WAGNER, P.E.
Project Engineer

JRV:JJW:tab
FR2306/JOBS

Site and Exploration Plan



Elevations of test pits are based on assumption that southeast property corner (center of section 3, Township 28 North Range 4 West) is at elevation 499 feet .

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Figure 1

Estimated Thickness of Organic Material

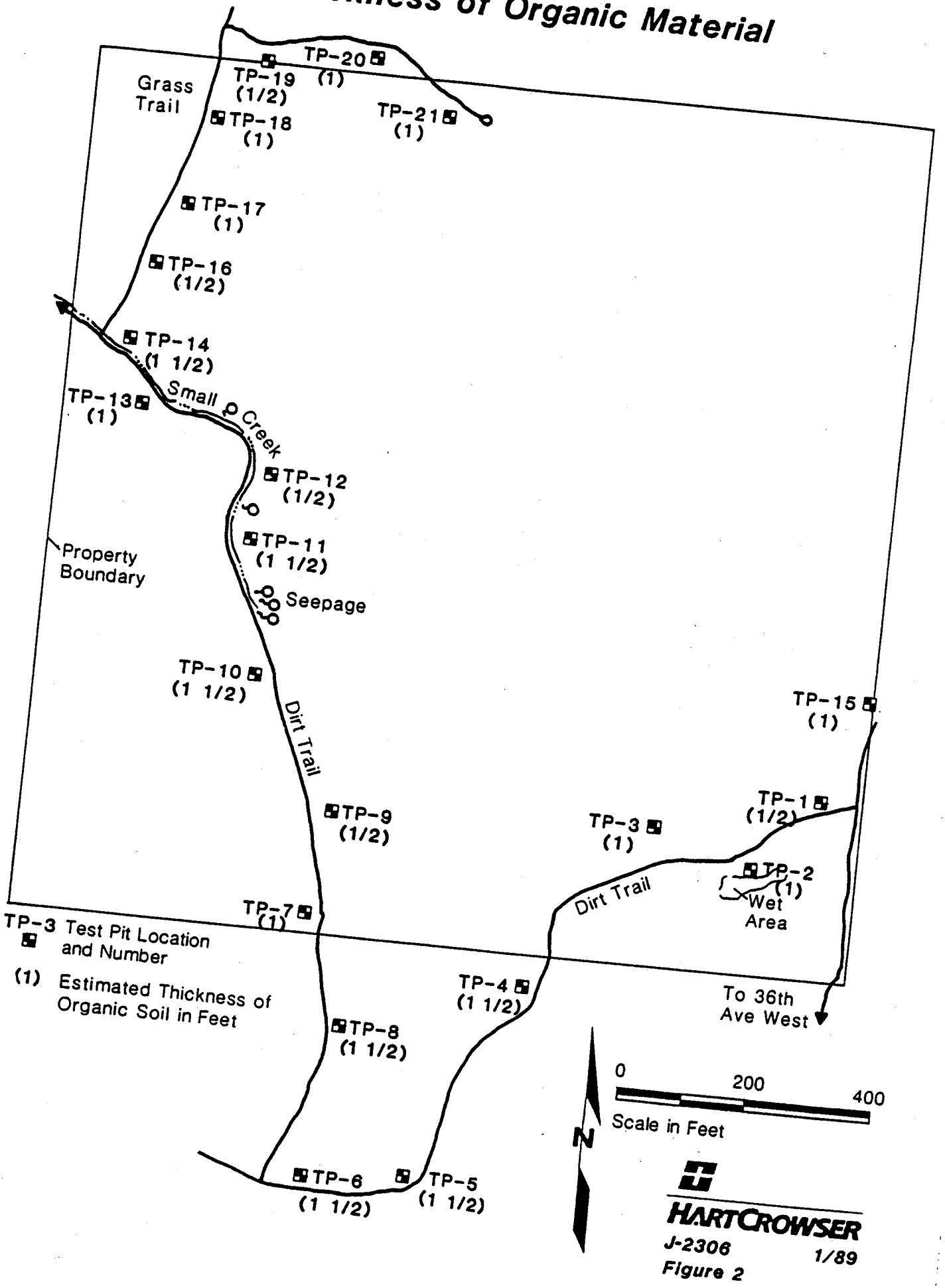

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Figure 2

Estimated Depth to Very Stiff Bearing Layer (Weathered Till)

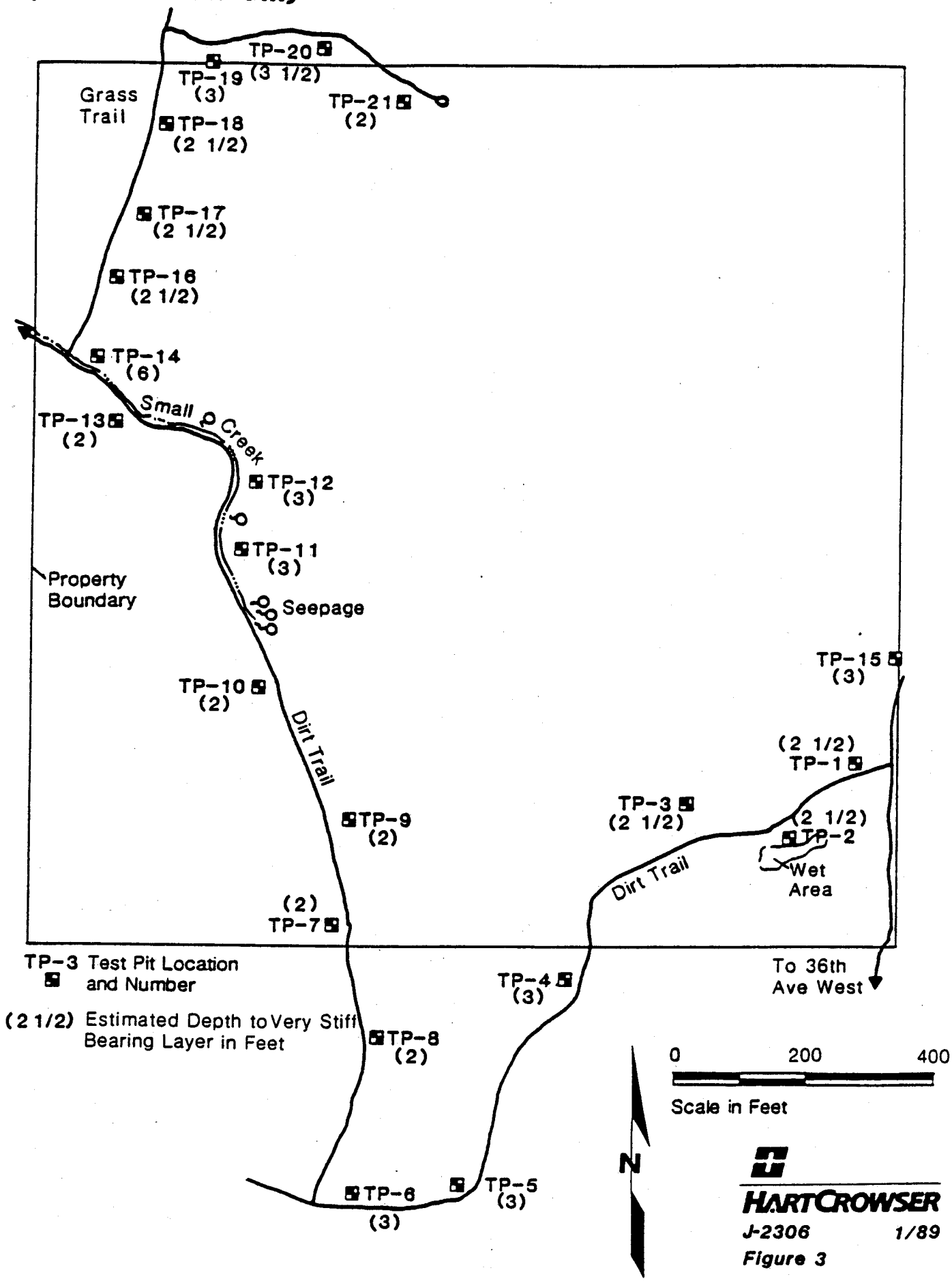

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Figure 3

Estimated Depth to Hard Bearing Layer (Till)

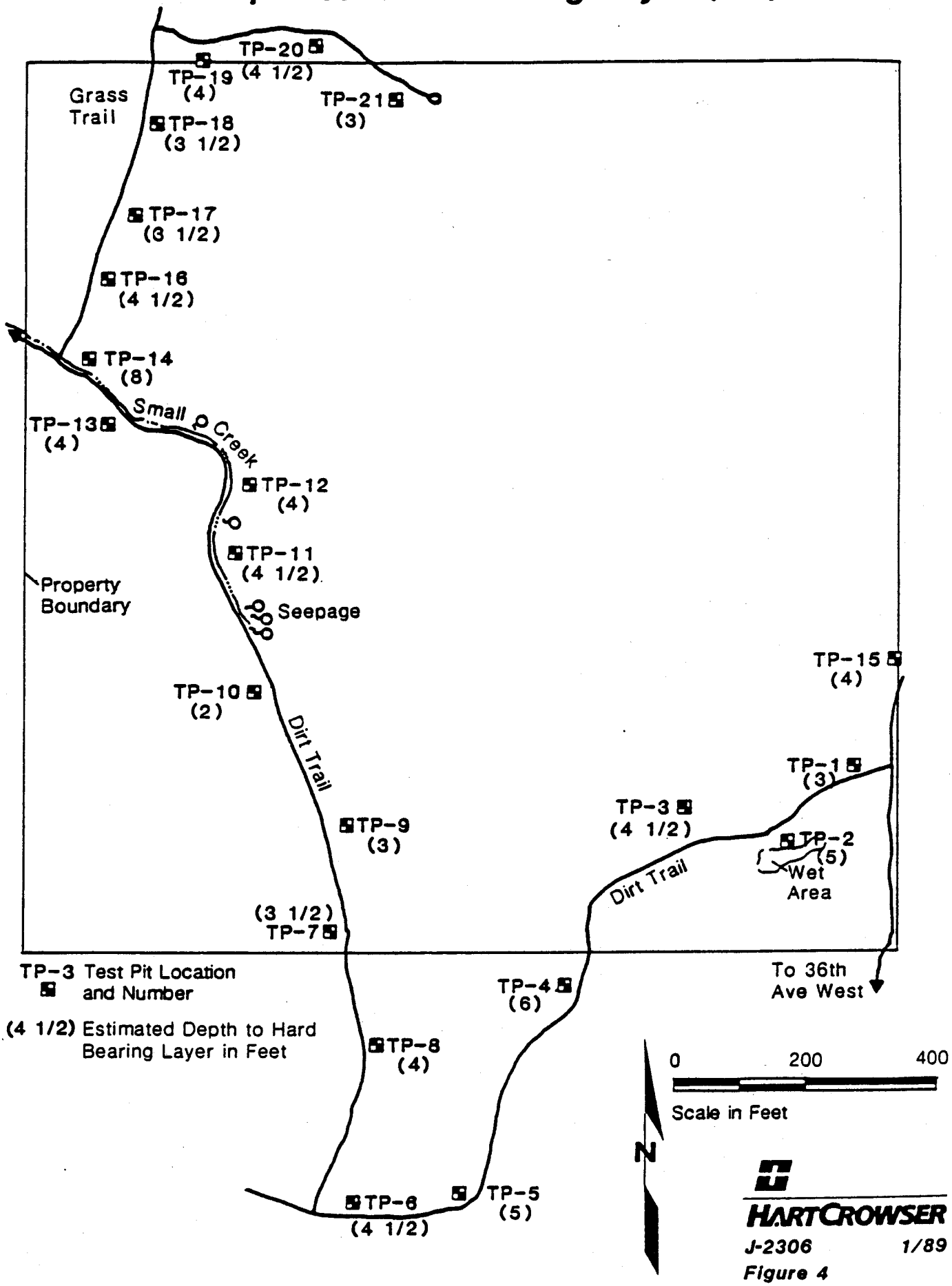

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Figure 4

APPENDIX A
FIELD EXPLORATIONS

The program of subsurface explorations for this project included completion of 21 test pits. The results of our exploration program are presented on the exploration logs within this appendix. The exploration logs represent our interpretation of the excavation, sampling, and testing information. The depth where the soils or characteristics of the soils changed is noted. The change may be gradual. Soil samples recovered in the explorations were visually classified in the field in general accordance with the method presented on Figure A-1. A legend for the field exploration logs defining symbols and abbreviations used is also presented on Figure A-1.

The exploration locations are presented on Figure 1. The actual locations and relative ground surface elevations of the explorations, as given in this report, were established during a site survey by Jon Mattoon of James S. Griffin Company. The relative ground surface elevations are presented on the exploration logs. The elevations are based on an assumed elevation of 499 feet at the center of Section 3, T28N, R4W.

Test Pits

A series of 21 test pits, designated TP-1 through TP-21, were excavated across the site utilizing a tractor-mounted backhoe. Test pits allow direct visual observation of the subgrade soils on the sides of an excavated trench. Jon Mattoon of James S. Griffin Company directed where test pits were to be excavated. An engineering geologist from our firm observed the excavations. Descriptive logs were developed in the field by observation of the soil disclosed in the test pits. Representative samples of soil types encountered were placed in plastic jars and taken to our laboratory for further observation and testing. Groundwater levels or seepage encountered during excavation were also noted. The density/consistency of the soil is based on visual observation and is not measured with a quantitative test during the excavation of the pits. The density/consistency is presented in parentheses on the test pit logs to indicate the value is estimated. The test pit logs are presented on Figures A-2 through A-9.

Key to Exploration Logs

Sample Descriptions

Classification of soils in this report is based on visual field and laboratory observations which include density/consistency, moisture condition, grain size, and plasticity estimates and should not be construed to imply field nor laboratory testing unless presented herein. Visual-manual classification methods of ASTM D 2488 were used as an identification guide.

Soil descriptions consist of the following:
Density/consistency, moisture, color, minor constituents, MAJOR CONSTITUENT, additional remarks.

Density/Consistency

Soil density/consistency in borings is related primarily to the Standard Penetration Resistance. Soil density/consistency in test pits is estimated based on visual observation and is presented parenthetically on the test pit logs.

SAND or GRAVEL Density	Standard Penetration Resistance in Blows/Foot	SILT or CLAY Consistency	Standard Penetration Resistance in Blows/Foot	Approximate Shear Strength in TSF
Very loose	0 - 4	Very soft	0 - 2	<0.125
Loose	4 - 10	Soft	2 - 4	0.125 - 0.25
Medium dense	10 - 30	Medium stiff	4 - 8	0.25 - 0.5
Dense	30 - 50	Stiff	8 - 15	0.5 - 1.0
Very dense	>50	Very stiff	15 - 30	1.0 - 2.0
		Hard	>30	>2.0

Moisture

Dry	Little perceptible moisture
Damp	Some perceptible moisture, probably below optimum
Moist	Probably near optimum moisture content
Wet	Much perceptible moisture, probably above optimum

Minor Constituents

	Estimated Percentage
Not identified in description	0 - 5
Slightly (clayey, silty, etc.)	5 - 12
Clayey, silty, sandy, gravelly	12 - 30
Very (clayey, silty, etc.)	30 - 50

Legends

Sampling

BORING SAMPLES

- Split Spoon
- Shelby Tube
- Cuttings
- Core Run
- * No Sample Recovery
- P Tube Pushed, Not Driven

TEST PIT SAMPLES

- Grab (Jar)
- Bag
- Shelby Tube

Ground Water Observations

- Surface Seal
- Ground Water Level on Date (ATD) At Time of Drilling
- Observation Well Tip or Slotted Section
- Ground Water Seepage (Test Pits)

Test Symbols

GS	Grain Size Classification
CN	Consolidation
TUU	Triaxial Unconsolidated Undrained
TCU	Triaxial Consolidated Undrained
TCD	Triaxial Consolidated Drained
QU	Unconfined Compression
DS	Direct Shear
K	Permeability
PP	Pocket Penetrometer Approximate Compressive Strength in TSF
TV	Torvane Approximate Shear Strength in TSF
CBR	California Bearing Ratio
MD	Moisture Density Relationship
AL	Atterberg Limits

Water Content in Percent
- Liquid Limit
- Natural
- Plastic Limit

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Figure A-1

Test Pit Log TP-1

Sample	Water Content Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
				Ground Surface Elevation in Feet 478
S-1	34		0–1	(Loose), moist, dark brown, very silty, fine SAND with numerous roots in upper 1/2 foot.
S-2	19		1–3	(Loose to medium dense), moist, gray-brown, very silty SAND to very sandy SILT with occasional cobbles, scattered roots, and organics.
S-3	11		3	(Very stiff), moist, gray, very sandy SILT.
S-4	9		3–5	(very dense), damp, gray, very silty SAND.
			6	Bottom of Test Pit at 5-1/2 Feet. Completed 12/14/88.
				Note: Light groundwater seepage observed at 2-1/2-foot-depth.

Test Pit Log TP-2

Sample	Water Content Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
				Ground Surface Elevation in Feet 481
S-1	88		0–1	(Very soft), wet, dark brown, sandy SILT with numerous roots and organic matter.
S-2	56		1–2	(Medium stiff), wet, brown, slightly gravelly, fine sandy SILT.
S-3	26		2–3	(Very stiff), wet, brown, very sandy SILT. (TILL)
S-4	26	PP3.25	3–5	Interlayered (very stiff), wet, gray-brown, clayey SILT and (dense), wet, gray-brown, silty SAND.
S-5	11		5–6	(Very dense), damp, gray, silty to very silty, fine to medium SAND with occasional gravel. (TILL)
			6	Bottom of Test Pit at 6 Feet. Completed 12/14/88.
				Note: Moderate to heavy groundwater seepage observed at 1-foot-depth. Light seepage observed at 2-1/2-foot-depth.

Test Pit Log TP-3

Sample	Water Content Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
				Ground Surface Elevation in Feet 491
			0–1	(Soft), wet, dark brown, organic SILT with numerous roots and organic matter.
S-1	31		1–2	(Medium dense), moist, red-brown, very silty SAND with roots to 1-foot-depth.
S-2	13		2–5	(Very stiff), moist, gray-brown, very sandy SILT.
S-3	9		5	(Hard), moist, dark gray, very sandy SILT. (TILL)
			6	Bottom of Test Pit at 5-1/2 Feet. Completed 12/14/88.
				Note: Light groundwater seepage observed at 2-1/2-foot-depth.

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Ground water conditions, if indicated, are at time of excavation. Conditions may vary with time.

J-2306 December 1988

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Figure A-2

Test Pit Log TP-4

Sample	Water Content Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS Ground Surface Elevation in Feet 494
			0–1	(Medium dense), moist, light brown, very silty SAND with large roots in upper 1/2 foot and numerous small roots to 1-1/2-foot-depth.
S-1	21		1–2	(Stiff), moist, gray-brown, gravelly, very sandy SILT, with numerous cobbles.
S-2	15	GS	2–3	
			3–6	(Dense), moist, gray-brown, gravelly, very silty, fine to medium SAND with large cobbles intermixed with (stiff), gray-brown, gravelly, sandy SILT.
S-3	26		6–7	(Dense), moist, dark gray, very silty SAND. (TILL) Becomes (very dense).
S-4	13		7–8	Bottom of Test Pit at 7-1/2 Feet. Completed 12/14/88.
			8–9	Note: Light seepage observed at 6-foot-depth.

Test Pit Log TP-5

Sample	Water Content Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS Ground Surface Elevation in Feet 501
			0–1	(Loose to soft), red-brown, very silty SAND to very sandy SILT with large roots.
S-1	27		1–2	(Medium dense to medium stiff), moist, brown, very silty SAND to very sandy SILT.
S-2	15		2–4	(Dense), moist, brown mottled gray, gravelly, very silty SAND with zones of sandy SILT and occasional cobble.
S-3	13		4–6	(Hard), moist, gray-brown, very sandy SILT. (TILL)
			6–9	Bottom of Test Pit at 6 Feet. Completed 12/14/88.

Test Pit Log TP-6

Sample	Water Content Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS Ground Surface Elevation in Feet 484
			0–1	(Loose to soft), moist, brown, silty SAND to sandy SILT with numerous roots.
S-1	19		1–2	(Medium dense), moist, brown, slightly gravelly, very silty SAND.
S-2	15		2–4	(Very stiff), moist, gray-brown, slightly gravelly, very sandy SILT.
S-3	9		4–5	(Very dense), moist, dark gray, very silty SAND. (TILL)
			5–9	Bottom of Test Pit at 5-1/2 Feet. Completed 12/14/88.

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Ground water conditions, if indicated, are at time of excavation. Conditions may vary with time.

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Figure A-3

Test Pit Log TP-7

Sample	Water Content Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
				Ground Surface Elevation in Feet 462
			0–1	(Loose), moist, black, very silty, fine SAND with numerous large roots and organic matter.
S-1	27		1–2	(Medium dense), moist, brown, slightly gravelly, very silty SAND with occasional cobbles and small roots. 2 inch ash layer at 1 to 1-1/2-foot-depth.
S-2	15		2–3	(Medium dense to dense), moist, gray-brown, very silty SAND with zones of sandy SILT.
S-3	9	GS	3–4	(Hard), moist, dark gray, very sandy SILT. (TILL)
			4–9	Bottom of Test Pit at 4-1/2 Feet. Completed 12/14/88.
				Note: Light seepage observed at 2-foot-depth.

Test Pit Log TP-8

Sample	Water Content Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
				Ground Surface Elevation in Feet 476
			0–1	(Loose), moist, black, very silty SAND with numerous roots.
S-1	29		1–2	(Medium dense), moist to wet, brown, very silty SAND with occasional cobbles.
S-2	15		2–3	(Dense), moist, gray-brown, very silty SAND with sandy SILT zones.
S-3	11		3–4	(Hard), moist, dark gray, very sandy SILT. (TILL)
			4–9	Bottom of Test Pit at 4-1/2 Feet. Completed 12/14/88.
				Note: Light groundwater seepage observed at 2-foot-depth.

Test Pit Log TP-9

Sample	Water Content Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
				Ground Surface Elevation in Feet 457
			0–1	(Loose), moist, dark brown, very silty SAND with organic matter.
S-1	19		1–2	(Medium dense), moist, brown, sitly SAND with occasional gravel, cobbles, and small roots.
S-2	16		2–3	(Medium dense to dense), moist to wet, gray-brown, very silty SAND to very sandy SILT with occasional cobbles.
S-3	8		3–4	(Hard), moist, gray, very sandy SILT with occasional cobbles.
			4–9	Bottom of Test Pit at 3-1/2 Feet. Completed 12/14/88.
				Note: Light groundwater seepage observed at 1-1/2-foot-depth.

1. Refer to Figure A-1 for explanation of descriptions and symbols.
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3. Ground water conditions, if indicated, are at time of excavation. Conditions may vary with time.

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Figure A-4

Test Pit Log TP-10

Sample	Water Content Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
				Ground Surface Elevation in Feet 426
			0–1	(Loose), moist, brown, slightly gravelly, very silty SAND with numerous roots.
S-1	25		1–2	(Medium dense), moist, gray-brown, silty SAND with occasional cobbles.
S-2	15		2–3	(Hard), moist, dark gray, very sandy SILT with occasional cobbles. (TILL)
S-3	8		3	Bottom of Test Pit at 3 Feet. Completed 12/15/88.
			4–9	

Test Pit Log TP-11

Sample	Water Content Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
				Ground Surface Elevation in Feet 420
			0–1	(Soft), moist, black ORGANIC MATTER with numerous roots.
			2	(Loose), moist, brown, silty SAND.
S-1	19		3–4	(Medium dense to dense), moist, gray mottled brown, very silty SAND.
S-2	10		5	(Hard), moist, gray-brown, very sandy SILT. (TILL)
			6	Bottom of Test Pit at 5-1/2 Feet. Completed 12/15/88.
			7–9	

Test Pit Log TP-12

Sample	Water Content Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
				Ground Surface Elevation in Feet 417
			0–1	(Very loose), moist, black ORGANIC MATTER including numerous roots.
S-1	26		1–2	(Medium dense), moist, brown, very silty SAND with scattered roots.
S-2	16		2–3	(Medium dense), moist, brown, very silty SAND to very sandy SILT.
			3–4	(Very stiff), moist, gray, very sandy SILT.
S-3	8		4–5	(Hard), moist, gray-brown, very sandy SILT. (TILL)
			5	Bottom of Test Pit at 5 Feet. Completed 12/15/88.
			6–9	Note: Moderate groundwater seepage observed at 1 to 2-foot-depth.

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Ground water conditions, if indicated, are at time of excavation. Conditions may vary with time.

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Figure A-5

Test Pit Log TP-13

Sample	Water Content Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
				Ground Surface Elevation in Feet 403
			0	(Soft), moist, black ORGANIC MATER including numerous roots.
			1	(Medium dense), moist, brown, very silty SAND with occasional cobbles.
			2	(Medium dense to dense), moist, gray mottled brown, very silty SAND with occasional cobbles.
S-1	14		3	
S-2	12		4	(Very stiff to hard), moist, gray-brown, slightly gravelly, very sandy SILT. (TILL)
			5	Bottom of Test Pit at 4-1/2 Feet. Completed 12/15/88.
			6	
			7	Note: Moderate groundwater seepage observed at 1 and 2-foot-depths.
			8	
			9	
			10	
			11	
			12	
			13	
			14	
			15	

Test Pit Log TP-14

Sample	Water Content Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
				Ground Surface Elevation in Feet 396
			0	(Loose), moist, black ORGANIC MATTER including numerous roots.
			1	
			2	(Medium dense), moist, brown, slightly gravelly, silty SAND with occasional cobbles and 2 inch ash layer at approximately 1-1/2-foot-depth.
S-1	21			
			3	(Medium dense), wet, brown, slightly gravelly, silty SAND with occasional cobbles.
S-2	26		4	Interbedded (medium dense), moist, gray, slightly gravelly, very silty SAND and (medium stiff), gray, very fine sandy SILT.
S-2	21		5	
			6	(Very stiff), moist, gray, slightly gravelly, very sandy SILT with occasional cobbles. (TILL)
			7	
			8	Becomes (hard) at approximately 8-foot-depth.
			9	
S-3	11		10	Bottom of Test Pit at 9-1/2 Feet. Completed 12/15/88.
			11	
			12	Note: Moderate groundwater seepage observed at 1-1/2-foot-depth.
			13	
			14	
			15	

1. Refer to Figure A-1 for explanation of descriptions and symbols.
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Figure A-6

Test Pit Log TP-15

Sample	Water Content Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
				Ground Surface Elevation in Feet 469
			0	(Soft), moist, black ORGANIC MATTER with numerous roots.
			1	(Medium dense), moist, brown, very silty SAND with occasional cobbles.
			2	
S-1	10		3	(Medium dense to dense), moist, gray mottled brown, silty SAND with occasional cobbles.
			4	
S-2	10		5	(Hard), moist, dark gray, very sandy SILT with occasional gravel.
			6	Bottom of Test Pit at 5 Feet. Completed 12/15/88.
			7	
			8	
			9	

Test Pit Log TP-16

Sample	Water Content Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
				Ground Surface Elevation in Feet 390
			0	(Loose to soft), wet, black ORGANICS with thick root growth.
S-1	28		1	(Medium stiff), moist, brown, gravelly, very sandy to sandy SILT with occasional cobbles.
			2	
S-2	18		3	(Stiff to very stiff), moist to wet, mottled brown gray, gravelly, very sandy SILT with occasional cobble.
			4	
S-3	9		5	(Very stiff to hard), moist, gray, gravelly, very sandy SILT with occasional cobbles. (TILL)
			6	Bottom of Test Pit at 5-1/2 Feet. Completed 12/21/88.
			7	Note: Seepage occuring continuously from 2-1/2 feet to 4-1/2 feet at about 3-4 gpm.
			8	
			9	

Test Pit Log TP-17

Sample	Water Content Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
				Ground Surface Elevation in Feet 390
			0	(Loose to soft), moist, black ORGANICS with thick root growth.
			1	(Medium stiff), moist, brown, slightly gravelly, very sandy SILT.
			2	
S-1	17		3	(Stiff to very stiff), moist, mottled gray-brown, slightly gravelly, very sandy SILT.
S-2	9		4	(Very stiff to hard), moist, gray, slightly gravelly, very sandy SILT. (TILL)
			5	Bottom of Test Pit at 4 Feet. Completed 12/21/88.
			6	
			7	
			8	
			9	

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Test Pit Log TP-18

Sample	Water Content Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
				Ground Surface Elevation in Feet 380
			0	(Loose to soft), moist, black ORGANICS with thick root growth.
			1	(Medium stiff), moist, brown, slightly gravelly, sandy SILT.
			2	(Stiff to very stiff), moist, mottled gray-brown, silty, very gravelly SAND.
S-1	11		3	
S-2	10		4	(Very stiff to hard), moist, gray, very gravelly, sandy SILT. (TILL)
			5	Bottom of Test Pit at 4-1/2 Feet. Completed 12/21/88.
			6	Note: Seepage at 2 feet is about 2-3 gpm.
			7	
			8	
			9	

Test Pit Log TP-19

Sample	Water Content Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
				Ground Surface Elevation in Feet 383
			0	(Loose to soft), moist, black ORGANICS with thick root growth.
			1	(Medium stiff), moist, brown, very sandy SILT.
			2	
			3	(Stiff to very stiff), wet, mottled gray-brown, slightly gravelly, very sandy SILT with occasional cobble.
S-1	21		4	
S-2	12		5	(Very stiff to hard), moist, gray, slightly gravelly, very sandy SILT with occasional cobble. (TILL)
			6	Bottom of Test Pit at 4-1/2 Feet. Completed 12/21/88.
			7	Note: Light seepage at 3-foot-depth.
			8	
			9	

Test Pit Log TP-20

Sample	Water Content Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
				Ground Surface Elevation in Feet 401
			0	(Loose to soft), moist, black ORGANICS with thick root growth.
			1	(Medium stiff), moist, brown, sandy SILT.
			2	(Stiff), moist, mottled gray-brown, gravelly, very sandy SILT.
S-1	23		3	
S-2	13		4	(Stiff to very stiff), moist, gray, gravelly, very sandy SILT. (TILL) Becomes very stiff to hard.
			5	Bottom of Test Pit at 5 Feet. Completed 12/21/88.
			6	Note: Seepage at 3 feet is about 1-2 gpm.
			7	
			8	
			9	

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Figure A-8

Test Pit Log TP-21

Sample	Water Content Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
				Ground Surface Elevation in Feet 416
			0	(Loose to soft), moist, black ORGANICS with thick root growth.
			1	(Medium stiff), moist, brown, gravelly, sandy SILT with occasional cobbles and boulders.
S-1	17		2	(Very stiff to moist), gray, gravelly, very sandy SILT with occasional cobble.
S-2	13		3	(Very stiff), moist, gray, gravelly, very sandy SILT with occasional cobble. (TILL)
			4	Becomes hard.
			5	Bottom of Test Pit at 5 Feet. Completed 12/21/88.
			6	
			7	Note: Seepage at 2 feet is about 3-4 gpm.
			8	
			9	

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Ground water conditions, if indicated, are at time of excavation. Conditions may vary with time.

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Figure A-9

APPENDIX B
LABORATORY TESTING PROGRAM

A laboratory testing program was performed for this study to evaluate the basic index and geotechnical engineering properties of the site soils. Laboratory tests were performed on both disturbed and relatively undisturbed samples. The laboratory tests performed and the procedures followed are outlined below.

Soil Classification

Soil samples recovered in the explorations were visually classified in the field and then taken to our laboratory where the classifications were verified in a relatively controlled laboratory environment. Visual-manual field and laboratory observations include density/consistency, moisture condition, grain size and plasticity estimates.

The classifications of selected samples were checked by performing laboratory tests such as grain size analyses. Classifications were made in general accordance with the Unified Soil Classification (USC) System, ASTM D 2487, as presented on Figure B-1.

Water Content Determinations

Water contents were determined for most samples recovered in the explorations in general accordance with ASTM D 2216 as soon as possible following their arrival in our laboratory. Water contents were not determined for very small samples nor samples where large gravel contents would result in values considered unrepresentative. The results of these tests are indicated at the respective sample depth on the exploration logs. In addition, the water contents of samples subjected to other testing have been determined and are presented on the exploration logs as well as with the various test results which follow in this appendix.

Grain Size Analysis (GS)

Grain size analyses were performed on two representative samples in general accordance with ASTM D 422. The wet sieve analysis method was used for most samples and determines the size distribution greater than the U.S. No. 200

mesh sieve. The size distribution for particles smaller than the No. 200 mesh sieve was determined by the hydrometer method for a selected number of samples. The results of the tests are presented as curves on Figure B-2 plotting percent finer by weight versus grain size.

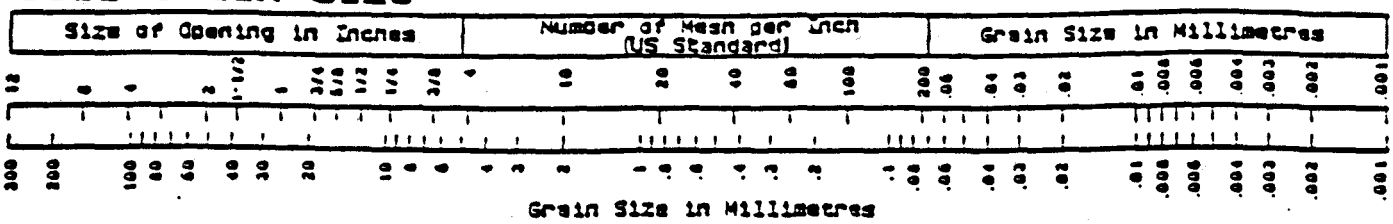
Pocket Penetrometer (PP)

The pocket penetrometer procedure provides quick approximate tests of the consistency (undrained shear strength) of a cohesive soil sample. The pocket penetrometer device consists of a calibrated spring mechanism which measures penetration resistance of a 1/4-inch-diameter steel tip over a given distance. The penetration resistance is correlated to the unconfined compressive strength of the soil, which is typically twice the undrained shear strength of a saturated, cohesive soil.

Pocket penetrometer values are presented on the exploration logs at their respective depths.

Unified Soil Classification (USC) System

Soil Grain Size



COBBLES	GRAVEL	SAND	SILT and CLAY
Coarse-Grained Soils			Fine-Grained Soils

Coarse-Grained Soils

G W	G P	G M	G C	S W	S P	S M	S C
Clean GRAVEL <5% fines	*	GRAVEL with >12% fines		Clean SAND <5% fines	*	SAND with >12% fines	
GRAVEL >50% coarse fraction larger than No. 4				SAND >50% coarse fraction smaller than No. 4			
Coarse-Grained Soils >50% larger than No. 200 sieve							

G W and S W $\left(\frac{D_{60}}{D_{10}}\right) > 4$ for G W, > 6 for S W & $1 \leq \left(\frac{(D_{30})^2}{D_{10} \times D_{60}}\right) \leq 3$

G P and S P Clean GRAVEL or SAND not meeting requirements for G W and S W

G M and S M Atterberg limits below A Line with PI <4

G C and S C Atterberg limits above A Line with PI >7

* Coarse-grained soils with percentage of fines between 5 and 12 are considered borderline cases requiring use of dual symbols.

D_{10}, D_{30}, and D_{60} are the particle diameter of which 10, 30, and 60 percent, respectively, of the soil weight are finer.

Fine-Grained Soils

M L	C L	O L	M H	C H	O H	Pt
SILT	CLAY	Organic	SILT	CLAY	Organic	Highly Organic Soils
Soils with Liquid Limit <50%			Soils with Liquid Limit >50%			
Fine-Grained Soils >50% smaller than No. 200 sieve						

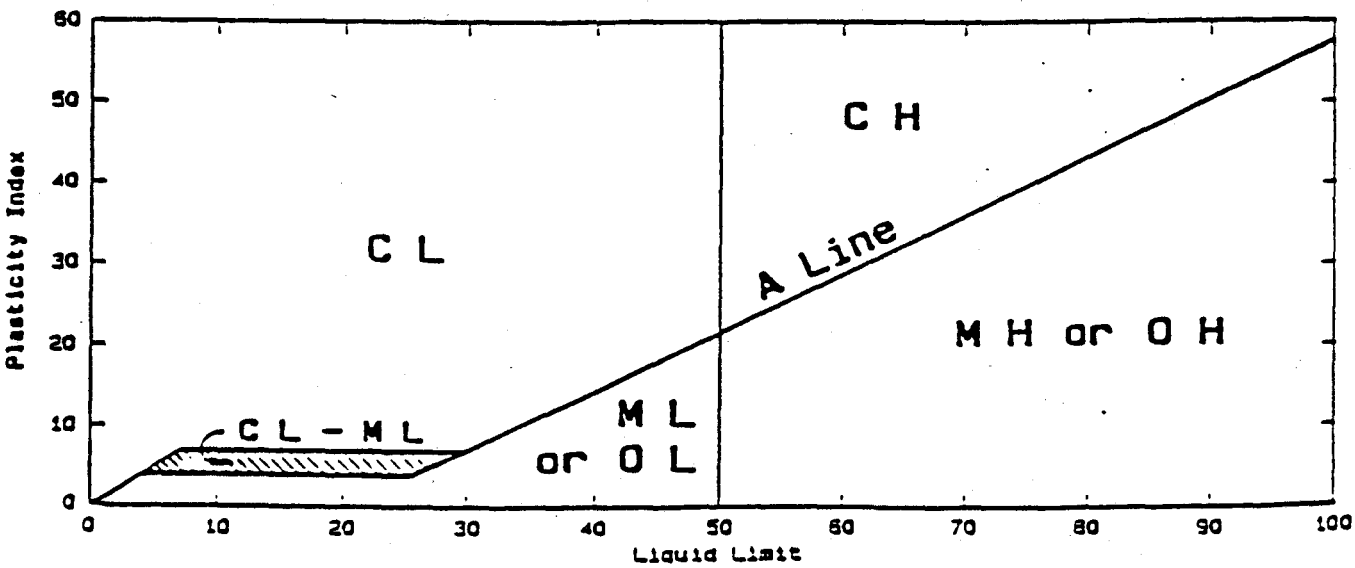


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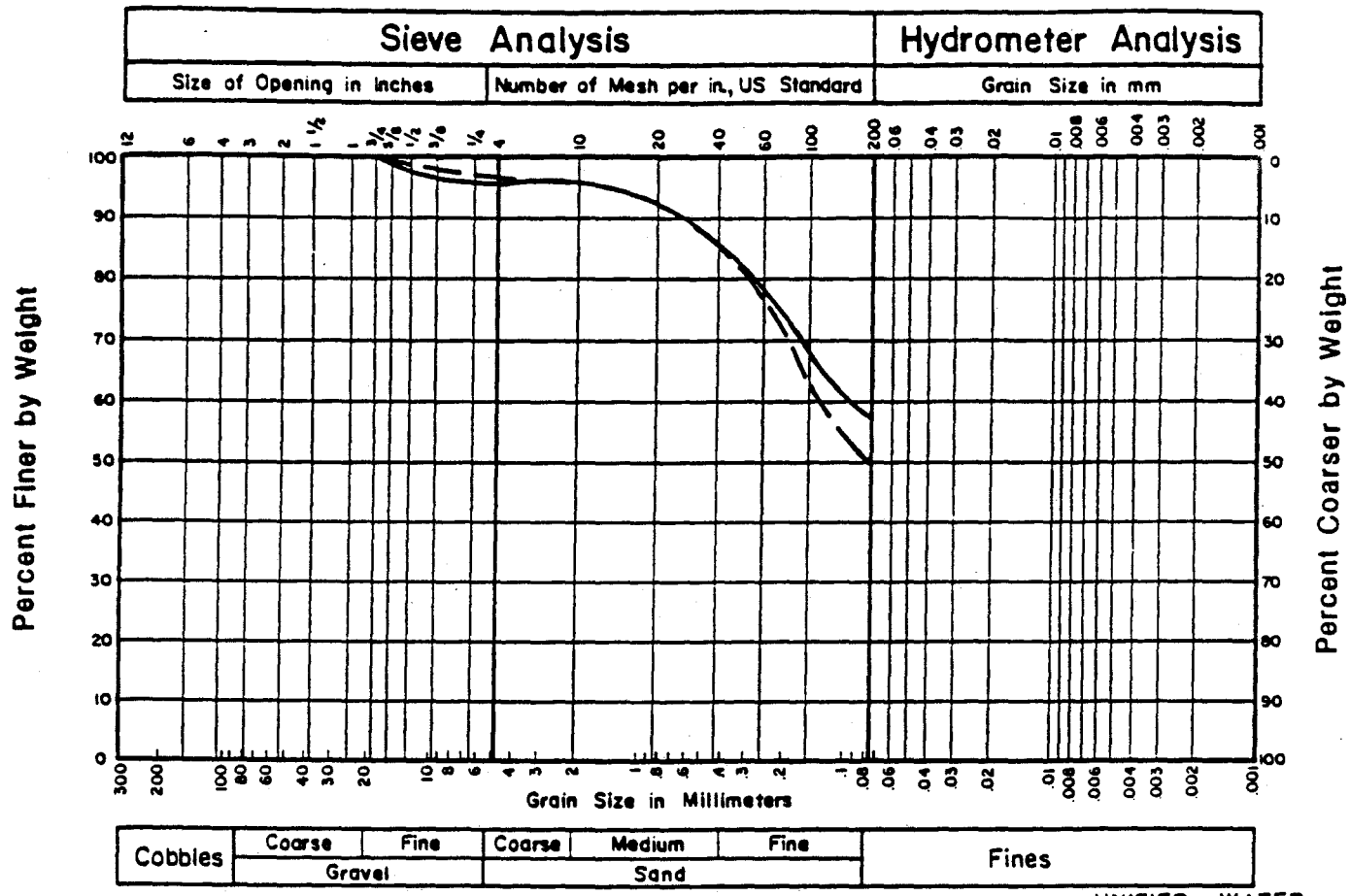
Figure B-1

Grain Size Classification



LINE SYMBOL	BORING NUMBER	SAMPLE NUMBER	DEPTH IN FEET	CLASSIFICATION	UNIFIED SOIL CLASS.	WATER CONTENT PERCENT
———	TP-4	S-2	2.5-3.0	Very sandy SILT.	ML	15
— —	TP-7	S-3	4.0-4.5	Very sandy SILT.	ML	9

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Figure B-2