Kelly/Strazer Associates INC
Geotechnical Consultants

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Mr. Phil Smith, P.E.
Murray, Smith & Associates, Inc.
1800 S.W. First, Suite 510
Portland, Oregon 97201

GEOTECHNICAL REPORT: RECONNAISSANCE & FIELD INVESTIGATION
BOLTON/RIVER STREET FORCE MAIN &
WEST LINN PIPELINE PROJECTS
WEST LINN, OREGON

Gentlemen:

We are pleased to present the results of our field and laboratory investigation for the proposed West Linn pipelines. The primary objectives of this work were to: 1) explore subsurface conditions, 2) estimate the quantity of rock excavation, and 3) make a general evaluation of slope stability. Mr. Walt Gamble, W.R. Gamble Engineering, assisted in the study.

On March 3, 1984 our office submitted preliminary field logs of materials encountered. Presented herein are the final results of the investigation, including a description of the field and laboratory test results, an estimate of rock excavation volumes, and a discussion of potential stability and drainage problems.

BACKGROUND INFORMATION

Proposed Project. We understand the sewer project consists of 3500 feet of 16-inch diameter force main along the Bolton/River Street segment and 11,000 feet of 18-inch diameter force main and gravity sewer in the West Linn or Willamette Falls Drive segment. The force main lines will generally have a burial depth of 5 or 6 feet to flow line with occasional areas up to 12 feet below grade; the gravity portion will have a maximum depth of flow line to 11.5 feet.

Site Locations. As shown in Figure 1 (Vicinity Map) the Bolton Park/River Street Force Main alignment is located approximately 1 mile north of West Linn city hall along the west bank of the Willamette River. Extending to the southwest of City Hall, primarily along Willamette Falls Drive, is the West Linn Force Main alignment. Detailed descriptions of the pipe alignments are presented in the following paragraphs.

Bolton/River Street Force Main. Along the proposed alignment, the ground surface elevation ranges from +8 to +78 feet. Within the easement, ground surface slopes in the vicinity range from a 5% to 90%. Between Stations 3+00 and 10+00 the ground slopes to the east approximately 5%. Past the angle point at 11+15, slopes increase to 40% and flatten at 14+10 to 10-25%. South of this point, the force main route generally follows the original ground contour parallel to an existing sewer. Steeper slopes are to the left (downslope) and below the force main route; slopes range from 40% to 90% with the steeper areas between 25+50 and 29+00 some 50 to 80 feet left of the proposed alignment. Slopes above (to the right of) and adjacent to the alignment range from 16% to 45% with maximum slopes in the vicinity of Station 16+00.

Vegetation consists of low grasses on the alignment; outside the easement, south of Station 6+00 (approximate), occasional mature deciduous and conifer trees exist.

Existing improvements along the Bolton/River Street route consist of an sewer line with manholes along the alignment south of Station 14+82 (refer to Figures 2 and 3 for plan view of proposed force main). Note that the existing pipe is exposed where it crosses the creek drainage near Station 25+00.

West Linn Force Main (Willamette Falls Drive/Willamette Area). Ground surface elevations range from +63 feet (Station 4+00) to 203.5 feet (Station 38+00). Between Stations 0+00 and 21+00 elevations range from +63 to +93 feet. North of Station 21+00 the ground surface is steep (48 to 70 degrees from horizontal) as the route climbs a rock ledge to Willamette Falls Drive where the ground surface elevation ranges between +160 and +203.5 feet. At 91+77 the ground surface elevation drops about 35 feet. North of 93+00 the surface gradually drops from +123 to approximately +95 feet (at the north end of proposed force main at Station 100+82).

Surface slopes in the vicinity of the alignment range from 1% near the existing treatment plant in Willamette to over 100% near the rock outcrop near Station 25+00. From Station 0+00,

nearby slopes increase from 1% to 31% with steepest slopes near Stations 9+50 and 21+00. As described above, the slopes range from 48 to 70 degress at the rock ledge between 21+00 and 25+50. Approximately between Station 25+50 and 29+92 (angle point) there is a 12 to 15 feet high fill slope (inclined 50% to 80%) 30 to 50 right of the alignment and a 2 to 4 foot high fill slope 10 to 20 feet left. Between the two angle points where the force main crosses Willamette Falls Drive, the ground is relatively flat.

From Station 31+07 to Station 87+19 (where the alignment is on the west side of Willamette Falls Drive) slopes to the west (or left) above the alignment range from 35% to over 80% with localized slopes as low as 15% (near Station 67+00). Maximum slopes are at the road cuts through rock between Station 41+69 (angle point) and 55+00, and near Stations 57+00, 60+00, and from 81+00 to 87+00. Slopes are relatively flat from Station 87+19 to 91+77 where the alignment crosses Willamette Falls Drive.

The alignment drops in elevation from 91+77 and 92+93 where the ground slopes initially from over 100% and gradually flattens with proximity to Pickens Street grade. A fill slope with a 100% grade is located some 10 feet right of the alignment between 92+93 and 94+50, yet to the left Pickens Street the ground slopes 5 to 10 % to the east and north. Slopes up to 70% can be found some 60 to 80 feet left of Station 97+50.

Much of the proposed alignment is located along shoulders of existing roadways (Fourth Street in the south, Willamette Falls Drive for most of the alignment, and Pickens Street in the north). Throughout nearly the total length of the alignment, underground utility lines (gas, water, and sewer) are in the vicinity; much of the underground lines parallel the proposed alignment and are generally located on Figures 4 through 9. Along Willamette Falls Drive between 41+69 and 87+19 the underground utilities are located on the opposite (or east) side of Willamette Falls Drive, except for occasional feeder lines that cross the alignment.

FIELD INVESTIGATION - RECONNAISSANCE

Geologic Reconnaissance. Walking reconnaissances of both proposed alignments were made by an engineering geologist on our staff on February 17, 1984. Rock outcrops, areas of possible man-made fill, evidence of slope movement, areas of seepage and changes of estimated subsurface conditions were noted. The geologic reconnaissance, supplemented by geologic maps published

in a State of Oregon publication (Bulletin 99, Geology and Geologic Hazards of N.W. Clackamas County), was utilized to plan exploratory excavations, i.e. test pits. A summary of the reconnaissance work is presented by stationing in the following paragraphs.

Bolton/River Street Force Main. Man-made fill and near-surface seepage noted along much of the proposed alignment. Localized areas of rock exposure and slope movement were also observed.

3+00 (Start) - 14+82 No exposed rock; possible slope movement between 13+00 and 14+00. No evidence of man-made fill.

14+82 - 31+07 (end) No exposed rock except fresh basalt in the bottom of the stream drainage at 25+00, some 8 to 12 feet below the upper ground surface near elevation +50 feet. Possible man-made fill proximal to existing sewer main trench and areas along alignment (estimated maximum depth = 8 feet). Possible slope movement between 26+00 and 28+10; movement is likely over 100 years ago and appears to be inactive. Minor surface slumping or soil creep in the cut slopes apparently made for existing sewer pipe installation. Soft and wet near-surface conditions noted near Stations 17+00 and 26+00.

West Linn Force Main/Gravity Sewer (Willamette Falls Drive Area). Rock exposures, man-made fill, and areas of seepage were observed along much of the route. No evidence of slope movement was observed on the pipe alignment; tension cracks were noted in bus parking fill slope above Station 26+75±.

0+00 - 21+00 No exposed rock or areas of seepage; possible man-made fill in vicinity of existing underground utility trenches.

21+00 - 23+50 Rock expected 3 to 7 feet below ground surface; no fill or seepage.

23+50 - 25+50 Rock exposed at the ground surface.

25+50 - 30+00 Man-made fill (estimated maximum thickness = 10 feet).

30+00 - 31+07 Possible man-made fill (estimated less than 3 feet thick).

31+07 - 40+00 Possible man-made fill from 32+70 to 40+00; nearby existing sewer line. Possible seepage from slope above alignment to the left.

40+00 - 87+19 Exposed rock outcrops near the pipe centerline were noted from 41+69 to 55+00, at 57+00, at 60+00, and 81+00 to 87+00; estimated maximum depth to rock in these areas is 2 feet. Elsewhere between Stations 40+00 and 87+19, the rock is estimated at 3 to 7 feet below surface. Possible man-made fill at 40+50 line crosses Willamette Falls Drive. Surface seepage and overflow of drainage ditches observed.

87+19 - 100+82 Probable man-made fill from 91+75 to 92+75 (estimate maximum depth = 10 feet). No rock exposures or seepage observed.

FIELD INVESTIGATION - EXPLORATIONS

Bolton/River Street Force Main. Our scope of work included a series of eight (8) hand auger borings which were advanced to practical refusal at depths ranging from 2.0 to 8.0 feet; the borings are located as shown on Figures 2 and 3. Samples were obtained at approximately 1 foot intervals and placed in air-tight glass jars. All borings were logged by an experienced soils engineer on our staff who collected the samples and recorded their depth, field classified the soils, and developed a preliminary log of the soil units encountered.

Final logs of the hand borings are presented on Figure 10 & 11. These reflect the descriptions of soil units encountered along with information relative to groundwater. Also presented are groundwater levels estimated from relative moisture descriptions of the samples.

In general, three subsurface materials were encountered: 1) Loose to medium dense silty to slightly silty fine SANDS, 2) soft to medium stiff SILT, and 3) fully weathered basalt consisting of very stiff to hard clayey SILT to

silty fine SAND. Presented below is a summary of the units encountered; refer to Hand Auger Logs (Figures 10 and 11) for details.

> Silty Fine SAND. Found only in Hand Auger Boring HA-1 and HA-2, the material consist of loose to medium dense silty to slightly silty fine SAND. Occasional fine to medium gravels are expected in this unit since gravels are exposed at the surface in drainage channels; both borings encountered refusal on apparent gravels at depths of 3.5 and 8.0 feet. The borings are expected to represent the general conditions Stations 3+00 and 11+50. Groundwater is expected very near the surface and most likely fluctuates with the Willamette River level.
>
> Both of the units below represent the conditions expected on the remaining portion of the alignment south of Station 11+50.
>
> SILT. Encountered at the surface in the remaining hand auger borings (except HA-6) is a soft to medium stiff brown SILT to slightly clayey SILT. This is an older alluvium unit which varies in thickness along the proposed alignment from over 7 feet to less than 1 foot thick and thins from north to south, yet thickens near Station 30+00.
>
> Clayey SILT to silty fine SAND. Underlying the SILT unit, the material consists of very stiff to hard clayey SILT with a relict appearance of weathered basalt. Similiar material is exposed in the stream channel at Station 25+00 and overlies fresh basalt at depth.

West Linn (Willamette Falls Drive) Force Main. Our scope of work included a series of eleven (11) test pits, designated TP-1 through TP-11 on Figures 4 through 9. The test pits were excavated with a tractor-mounted 450C backhoe (gross weight 13,000 pounds) under subcontract to Dan Obrist Excavating. The test pits were excavated to depths of 0.5 to 7.0 feet using a 30-inch wide bucket with 3-inch teeth.

Representative samples of the various soil units were taken and placed in air-tight jars. Relative strength measurements were made at frequent intervals where soil was present in the test pits with a Pocket Penetrometer and/or Torvane Shear. These manually operated devices are used to approximately determine the in-situ relative strength of cohesive soils. An experienced

soils engineer from our firm classified the soil units, logged the test pits, obtained the required samples and generally directed the field operations.

All field data is compiled on the Logs of Test Pits, Figures 12 through 22. These include descriptions of the various soil strata encountered, sample type and location, Pocket Penetrometer/Torvane data and natural moisture contents (as determined in our laboratory) of the various samples.

Upon completion of each test pit, the excavation was backfilled with the excavated soils without systematic compaction to the original density. In our opinion, the test pit backfill will slough if exposed in future excavations.

The conditions encountered in our field investigation can be generalized into four(4) subsurface units: MAN-MADE FILL/TOPSOIL, stiff to very stiff SILT, very dense silty sandy GRAVEL/COBBLE weathered basalt, and FRACTURED BASALT. Presented below is a summary of the units encountered; refer to Logs of Test Pits for details.

MAN-MADE FILL/TOPSOIL. Fill material over 1 foot thick was encountered in Test Pits TP-3, TP-4, and TP-8. The material has a variable classification ranging from medium stiff to stiff gravelly organic SILT (in part of TP-3 & TP-4) to very dense silty sandy GRAVEL/COBBLE/BOULDER with basalt fragments ranging in size from 1" to 24" diameter, but typically 4" to 8" diameter. Thickness of the fill in these test pits is over 7 feet (likely about 12 feet) and thins to the west. Thin (0.5 to 1.0 feet) surficial FILL material was also found in other test pits and consists of 0.5 to 1.0 feet of silty crushed rock or SILT. A TOPSOIL zone was encountered in TP-2,4,6, and 11, variably consisting of medium stiff to very stiff dark brown organic SILT to gravelly ORGANIC SILT. Thickness of this zone ranges from 0.3 (in TP-6) to 1.8 feet (in TP-2).

Stiff/very stiff SILT. Found in TP-1 and TP-2 to 5 feet below ground surface, the unit consists of medium stiff to very stiff brown & gray mottled slightly clayey SILT to fine sandy SILT. Natural water contents range from 17 to 34 % and average about 26%.

Silty sandy GRAVEL/COBBLE. Considered as a zone of weathered basalt and a transition zone between the surface units and

fresh bedrock, this material typically consists of very dense silty sandy angular GRAVEL/COBBLE sized basalt fragments with occasional boulders to 24-inches diameter. Found in TP-7 and TP-9, the unit is 1 foot thick and underlies the FILL unit described above. Two-feet of SILT with angular gravel/cobble sized fragments was penetrated in TP-4 and found underlying 5 feet of FILL.

Very dense FRACTURED BASALT. Encountered in TP-5, 6, 7, 9, 10, and 11, this unit was difficult to excavate with the backhoe equipment and resulted in refusal to the equipment at depths of 0.5 to 3.5 feet, i.e. penetration into the very dense, stained, fractured BASALT of 0.0 to 2.0 (average of 0.8 feet). Fragments of basalt in-place vary from 1" to 24" diameter.

LABORATORY TESTING

All jar samples were visually classified to refine, when necessary, the field soil classification. In addition, natural moisture contents were taken on all samples in accordance with ASTM D 2216. The moisture contents are expressed as a percent of free water lost by evaporation compared to the dry weight of soil. These are presented numerically on the Logs of Test Pits.

COMMENTS AND RECOMMENDATIONS

Slope Stability. Evidence of slope movement on or adjacent to the West Linn pipeline alignment was noted only in the bus parking lot fill near Station 26+00. Excavation near the toe of this slope could trigger additional movements or slope failure. In our opinion, construction restrictions (limited lengths of open trench or trench shoring shoring) should be considered.

We believe that the massive slope failure that occurred during the construction of I-205 is located above the proposed pipe line. Based on the level of work accomplished for this study, there is no indication that the pipeline will be affected by that slide.

Possible slope movement areas were noted along the Bolton line at Station 13+00 and from 25+50 to 30+00. Both areas of movement appear to be relatively shallow (3 to 6 feet) and inactive at the present time. It is suggested that both areas be examined closely during construction to determine whether additional excavation may be required. The stability of these areas could be increased with subsurface drainage (see discussion below).

Footings. It is understood that spread footings designed for a maximum contact pressure of 1000 psf will support the pipe and trestle structure proposed to span a stream channel from Station 32+14 to Station 31+79 on the Bolton/River Street Force Main line. It is recommended that these footings be placed on undisturbed natural ground with a minimum embedment depth of 2 feet, as measured from the footing base to the surface of the restored slope. Settlements of 1/4 to 1/2-inch are estimated based on prior experience with similiar soil types (if accurate estimates of footing settlements are required consolidation testing would be necessary). To limit disturbance of the footing subgrade (and reduce the risk of excessive settlements), a 4-inch layer of clean, well-graded 3/4-inch minus crushed rock should be placed over the exposed surface immediately after completing the excavation.

Subsurface Drainage. In addition to the possible slide areas discussed above, subsurface drainage or cut-off collars should be considered in the steeply sloping section of the West Linn line between Stations 21+00 and 26+00 to limit the potential for the trench backfill conveying water downhill and causing springs or slope movements. If desired, subsurface drainage could be incorporated into the trench backfill by placing ADS "Drainguard" pipe or similiar in a 12-inch diameter envelope of clean (i.e. not more than 2% passing the No. 200 sieve based on the wet sieve analysis) fine to medium sand. Alternatively, a subdrain could be designed into a bedding layer with the use of filter fabric material. We can provide design recommendations for subsurface drainage within the pipe trenches, if desired.

Volume of Rock Excavation. Based on our field investigations and the proposed invert depths noted in this report, it is doubtful that rock excavation

will be required on the Bolton/River Street Force Main. However, significant rock excavation (i.e. removal of rock by systematic and continuous drilling and blasting) will, in our opinion, be required for the West Linn Force Main project. We estimate that the thicknesses of rock excavation will vary from 3.5 to 8.5 feet and that trench excavations made to an average of 6 inches below the inverts shown on your January 6, 1984 drawing will involve approximately 900 cubic yards of rock excavation per foot of trench width.

GENERAL NOTES

This report was prepared solely for the Owner, Architect and Engineer for the design of the project. We encourage its review by bidders and/or the Contractor as it relates to factual data only (logs of borings, test pits and laboratory data). The opinions and recommendations contained within the report are not intended to be nor should they be construed to represent a warranty of subsurface conditions but are forwarded to assist in the planning and design process.

If, during construction, unexpected subsurface conditions are encountered within excavations, we should be notified at once so that we may review such conditions and revise our recommendations, if necessary. We request that we be retained to review the applicable portions of the plans and specifications for the project prior to bidding for conformance to our recommendations.

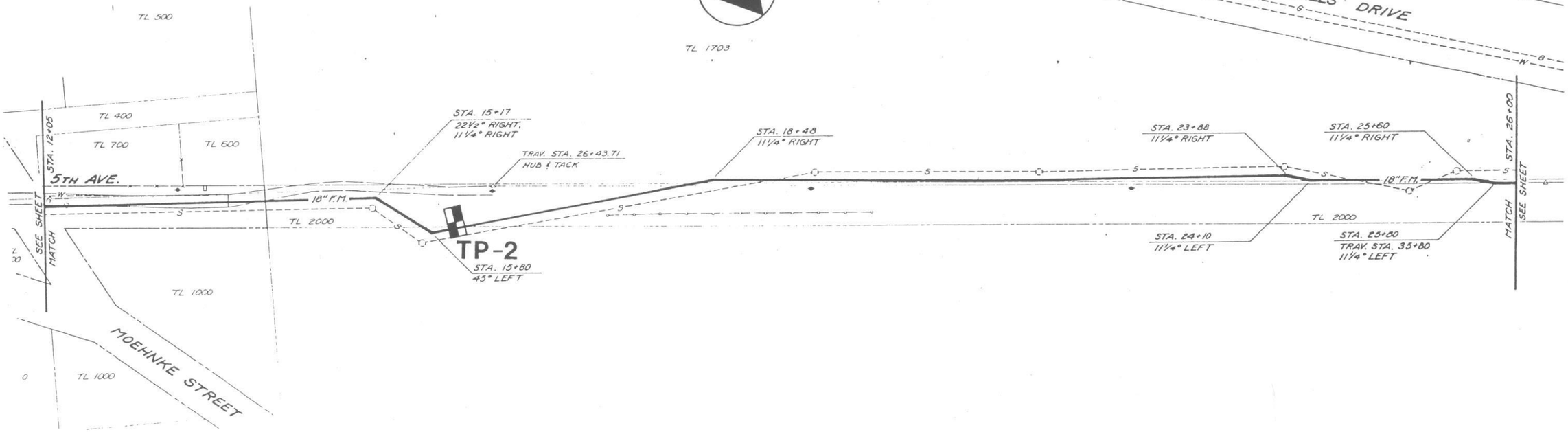
We would be pleased to provide additional input, as necessary, during the design process and to provide on-site observations during construction. Please feel free to contact us for this work as well as for any questions you might have regarding this report.

Very truly yours,
KELLY/STRAZER ASSOCIATES, INC.

Patrick B. Kelly, P.E.

David K. Rankin

STATION 12+05 to 26+00



LEGEND

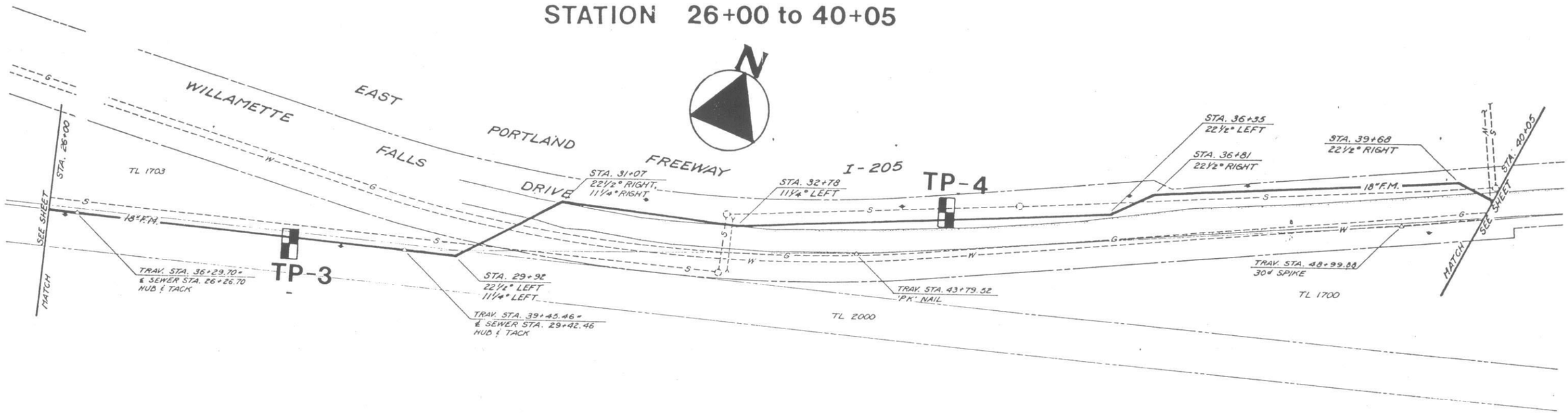
TP-6 EXPLORATORY TEST PIT made by Kelly/Strazer Assoc. on 3/24/84 & 3/27/84.

SCALE: 1"=100'

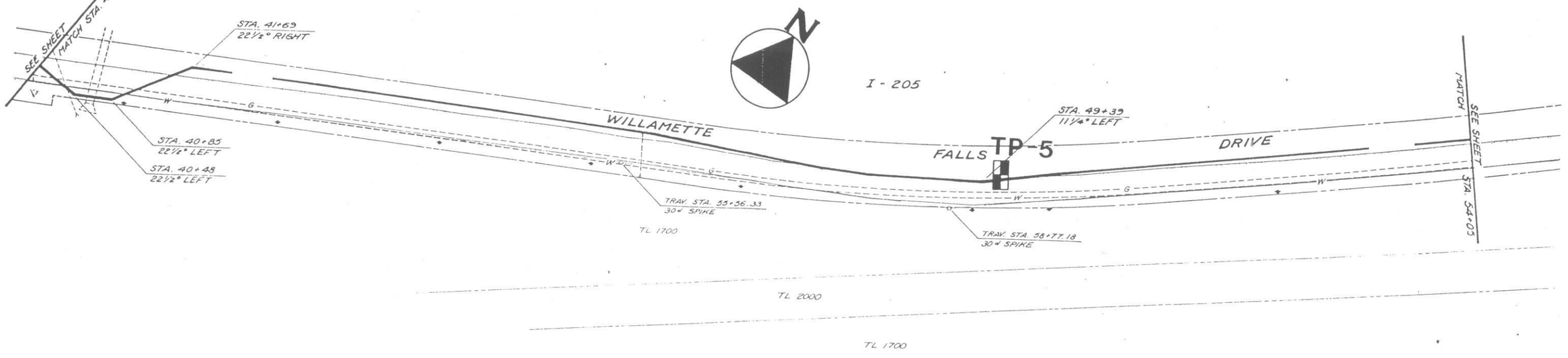
100 0 100 200ft.

Kelly/Strazer Associates Geotechnical Consultants	WEST LINN FORCE MAIN West Linn, Oregon	TEST PIT LOCATION PLAN sta 12+05 to 26+00 March, 1984 O-460.01	FIGURE 5

STATION 26+00 to 40+05



STATION 40+05 to 54+05



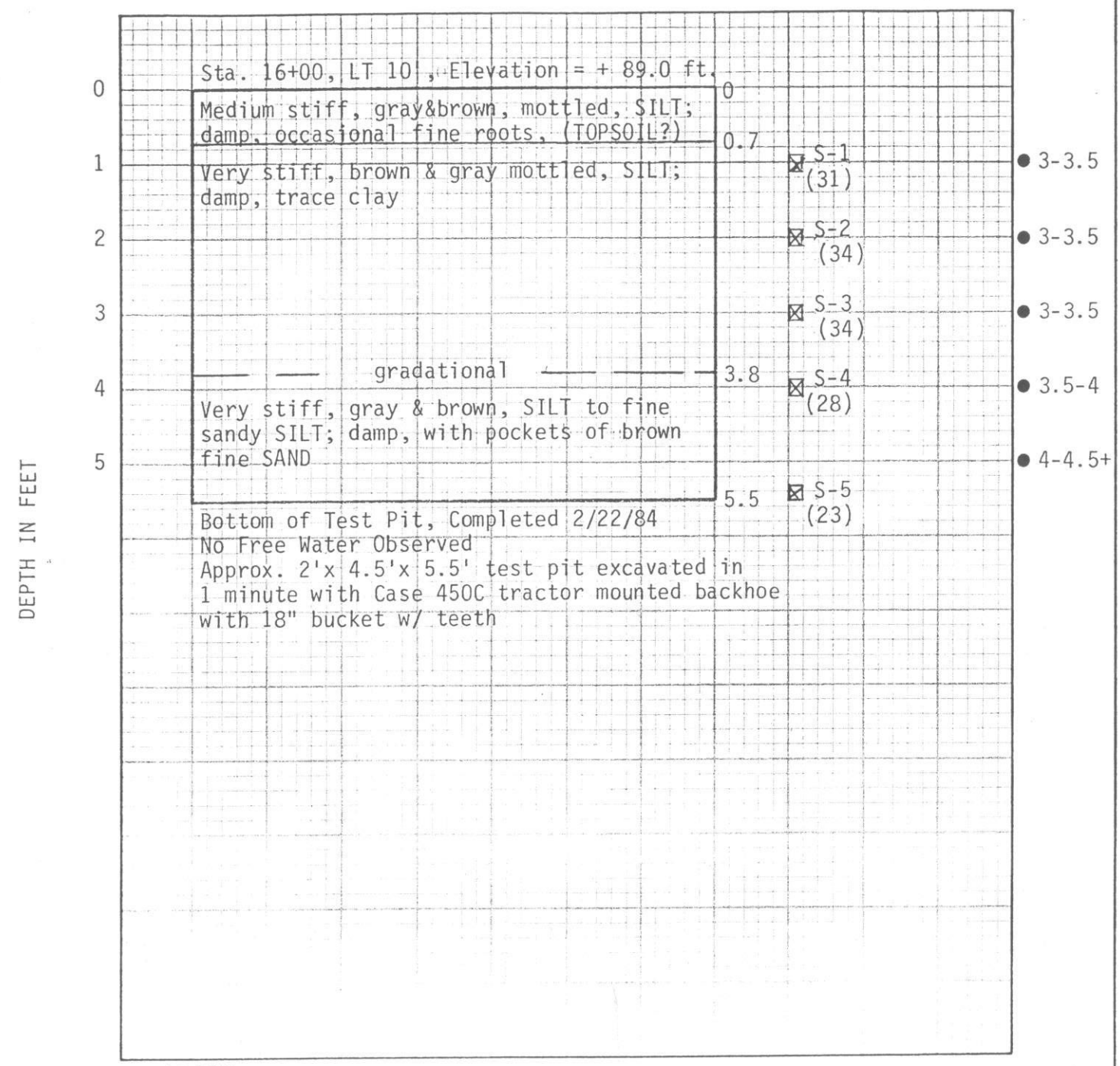
100 0 100 200 ft

SCALE 1"=100'

LEGEND

TP-6 EXPLORATORY TEST PIT made by Kelly/Strazer Assoc., Inc. on February 22, 1984.

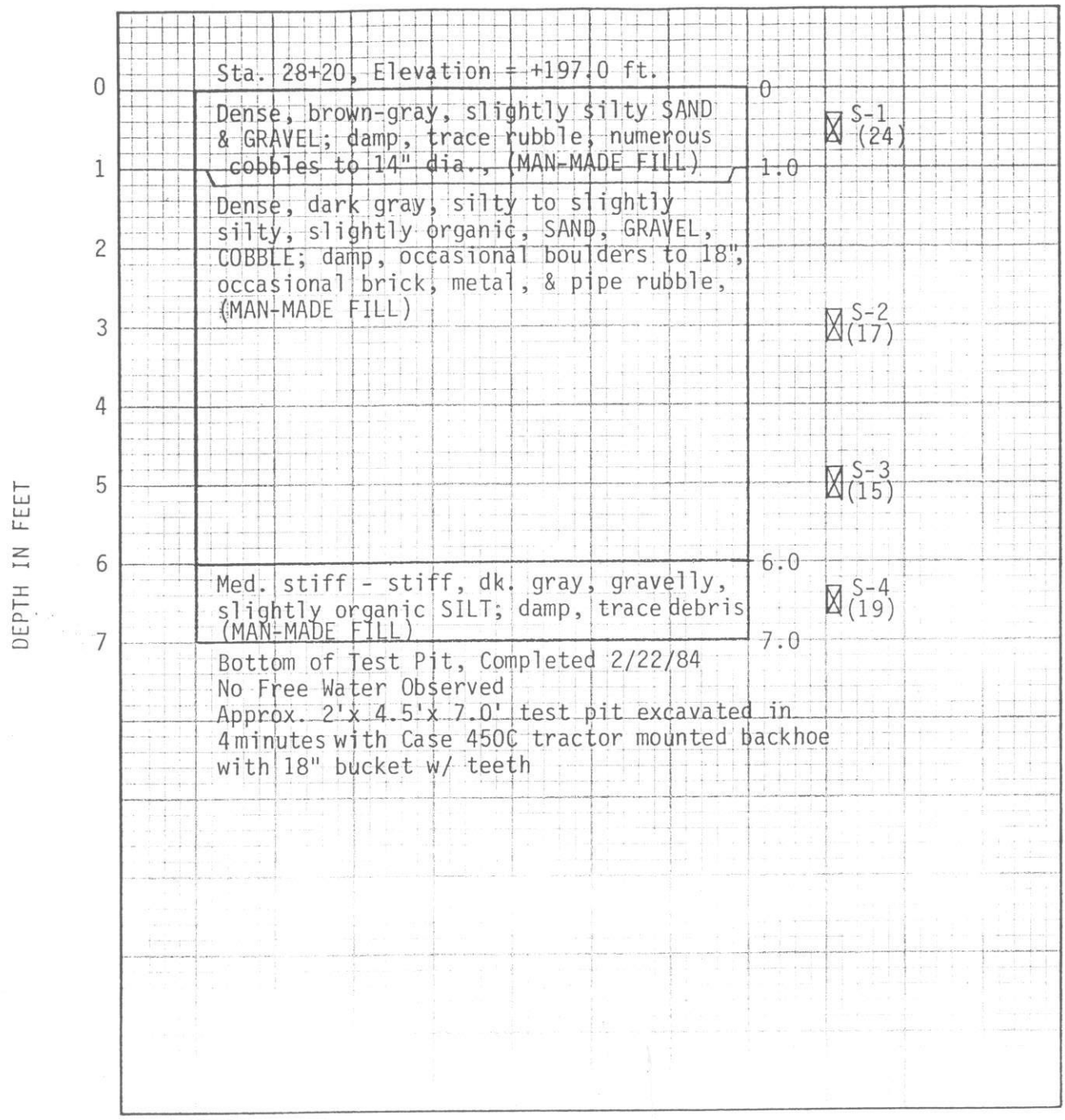
Kelly/Strazer Associates Geotechnical Consultants	WEST LINN FORCE MAIN West Linn, Oregon	TEST PIT LOCATION PLAN sta 26+00 to 54+05 March, 1984 0-460.01	FIGURE 6



LEGEND

- ⊠ S- GRAB SAMPLE LOCATION AND NUMBER
- ▯ S- SHELBY TUBE SAMPLE LOCATION AND NUMBER
- ( ) WATER CONTENT IN PERCENT
- ● POCKET PENETROMETER READING IN TSF
- ▽ FIELD DENSITY TEST IN PCF
- X POCKET TORVANE SHEAR READING IN KG/SQ.CM.

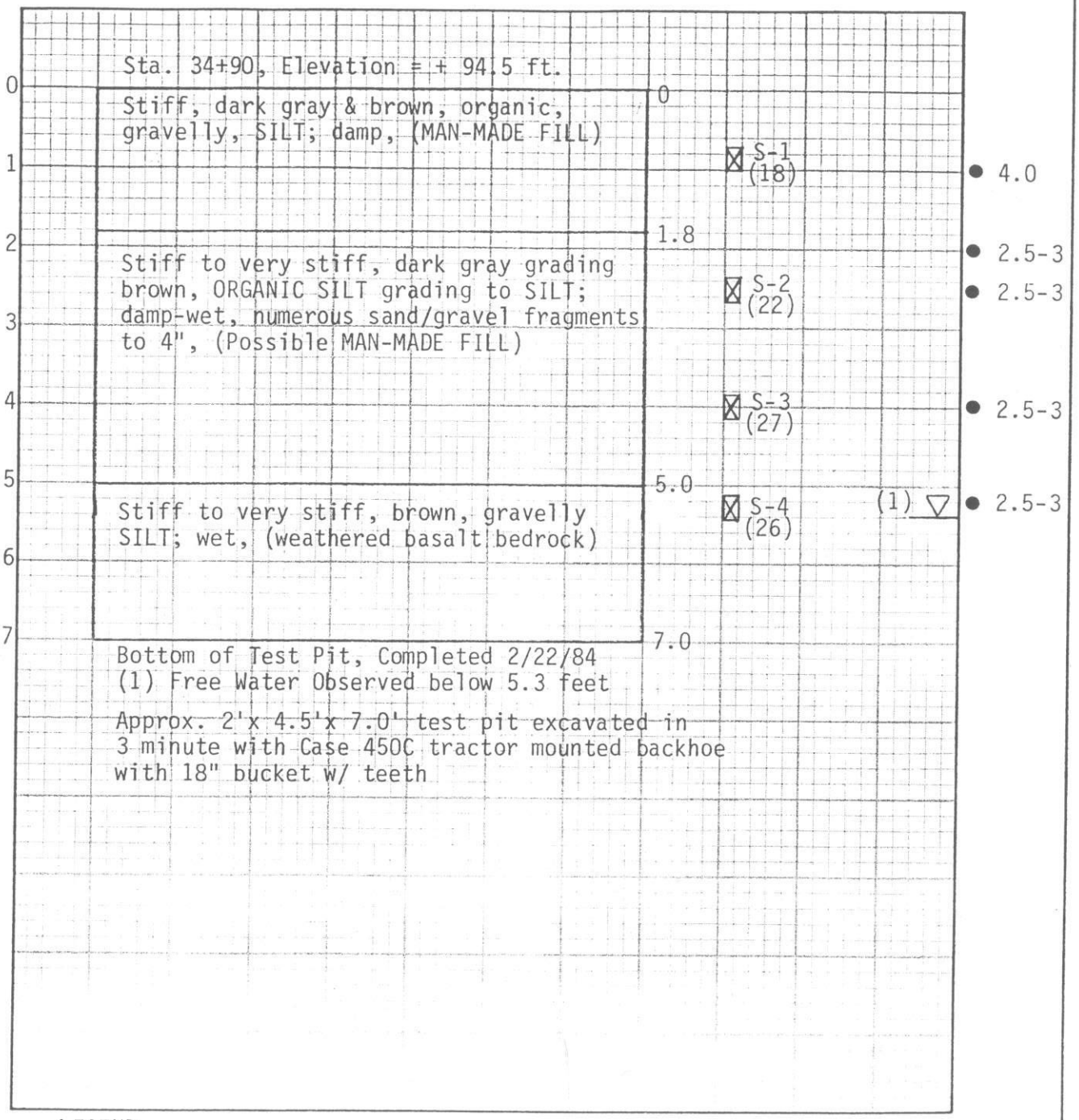
Kelly/Strazer Associates, Geotechnical Consultants	WEST LINN FORCE MAIN West Linn Area Sewers West Linn, Oregon	LOG OF TEST PIT **TP-2** March, 1984 0-460.01	FIGURE **13**



LEGEND

- ⊠ S- GRAB SAMPLE LOCATION AND NUMBER
- ⊟ S- SHELBY TUBE SAMPLE LOCATION AND NUMBER
- ( ) WATER CONTENT IN PERCENT
- ● POCKET PENETROMETER READING IN TSF
- ▽ FIELD DENSITY TEST IN PCF
- X POCKET TORVANE SHEAR READING IN KG/SQ.CM.

Kelly/Strazer Associates Geotechnical Consultants	WEST LINN FORCE MAIN West Linn Area Sewers West Linn, Oregon	LOG OF TEST PIT **TP-3** March, 1984 0-460.01	FIGURE **14**



LEGEND

- ⊠ S- GRAB SAMPLE LOCATION AND NUMBER
- ⊓ S- SHELBY TUBE SAMPLE LOCATION AND NUMBER
- ( ) WATER CONTENT IN PERCENT
- ● POCKET PENETROMETER READING IN TSF
- ▽ FIELD DENSITY TEST IN PCF
- X POCKET TORVANE SHEAR READING IN KG/SQ.CM.

Kelly/Strazer Associates Geotechnical Consultants	WEST LINN FORCE MAIN West Linn Area Sewers West Linn, Oregon	LOG OF TEST PIT **TP-4** March, 1984 0-460.01	FIGURE **15**