



FINAL REPORT

**Wick Drain Installation and Monitoring Program on Hwy 17 from Station
15+775 to Station 16+100, Rossport, Thunder Bay Area, ON**
(Latitude: 48.8763; Longitude: -87.5379)

**Agreement No. 6017-E-0066
Assignment No. 5
WO No. 2018-11011
GWP No. 6120-15-00
MTO GEOCRES No. 42D-57**

Prepared for:
Ontario Ministry of Transportation
Regional Director's Office -NW Region
615 James Street South
Thunder Bay, ON P7E 6P6
Attn: Matthew Leavitt

Ontario Ministry of Transportation
Pavements and Foundations Section
Foundations Group
Building 'C', Room 223, 2/F,
145 Sir William Hearst Avenue,
Downsview, ON M3M 0B6
Attn: K. Ahmad

exp Services Inc.
September 9, 2019

Ontario Ministry of Transportation

Northwestern Region Geotechnical Section

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Type of Document:
FINAL

Project Name:
Wick Drain Installation and Monitoring Program on Hwy 17 from Station 15+775 to Station 16+100, Rossport, Thunder Bay Area, ON

Project Number:
ADM-00248798-E0

Prepared by:
Silvana Micic, Ph.D., P.Eng.

Reviewed by:
TaeChul Kim, M.E.Sc., P.Eng.
Stan E. Gonsalves, M.Eng., P.Eng.

exp Services Inc.
56 Queen St, East, Suite 301
Brampton, ON L6V 4M8
Canada



Silvana Micic, Ph.D., P.Eng.
Senior Geotechnical Engineer



Stan Gonsalves, M.Eng., P.Eng.
Designated MTO Contact

Date Submitted:
September 9, 2019



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Wick Drain Installation, Instrumentation and Monitoring Program

1. General

This report presents wick drain installation and monitoring program prepared by Exp Services Inc. (exp) for new eastbound and westbound truck climbing lanes on Hwy 17 from Pays Plat River easterly for 7.2 km (from Station 15+775 to Station 16+100 of the proposed new alignment), Rossport, Thunder Bay Area, Ontario. The work was undertaken under Agreement No. 6017-E0066, Assignment No. 5. The terms of reference (TOR) were as presented in Ministry of Transportation Ontario (MTO) email dated May 8, 2019.

This program has been prepared specifically and solely for the project described herein. Exp should be given the opportunity to confirm recommendation in the event of material change in scope of the project (concept, layout, levels) or delays exceeding 2 years from acceptance of report.

1.1 Scope

This program applies to Section 1 – High Fill Embankment on Very Soft to Soft Foundation Soil covered in the FIDR “Widening of Highway 17 East from Pays Plat River Easterly 7.2 km, Thunder Bay Area, Ontario” prepared by Exp Services Inc. dated June 13, 2019 (Geocres No. 42D-56). Drawings outlined this area can be found in Appendix A.

In particular this program addresses the following:

1.1.1 Excavation of Organics and Compressible Soils

This program details the procedures to be used for excavation organic (i.e. muskeg/peat) and/or soft compressible deposits below the footprint of the new embankment. The non-standard special provision outlines these procedures can be found in Appendix B.

1.1.2 Wick Drain Installation

A portion of this program details wick drain installation requirements for specific embankment area from Station 15+775 to Station 16+100 of Section 1 of the Highway 17. Installation details for the drainage blanket are contained in Appendix C and details regarding wick drain supply and installation is contained in Appendices D and E.

1.1.3 Installation Monitoring and Reporting

This program also applies to the instrumentation and monitoring required for the following items:

- Settlement Plates (SP)
- Settlement Pins (S)
- Slope Inclinator (SI)
- Vibrating Wire Piezometers/Reference Vibrating Wire Piezometers (VWP/RVWP)
- Survey Bench Marks (BM)

The installation details for the above noted items are contained in Appendix F.

The purpose of these instruments (Settlement Plates, Settlement Pins, Slope Indicators and Vibrating Wire Piezometer) is to monitor settlements, lateral displacement and dissipation of excess pore-water pressures in the foundation soils during construction of the embankments along Section 1 of Highway 17 from Station 15+775 to Station 61+100.

Monitoring services include the following:

- Requirements for data collection/reporting; and,
- Assessment of embankment performance based on data collected during instrumentation monitoring.

These requirements, as well as critical measurement readings are outlined in Appendix G.

1.2 Or Equal

Throughout this document, the term "*or equal*" is used frequently. The term, "*or equal*", indicates that the equal product is the same or better than the specified product in function, performance, reliability, quality and general configuration.

2. Purpose

The rate and staging of fill placement and the timing for the removal of surcharge shall be controlled by the instrumentation readings. This is outlined in further detail in Appendix G. Pavement construction shall not take place until sufficient consolidation has been achieved as determined by the Contract Administrator.

It should be noted that monitoring of the instruments will be carried out by others after the installation of instrumentation by the Contractor.

The instrumentation shall not be decommissioned unless instructed by the Contract Administrator.

3. Personnel, Responsibilities and Submission

3.1 Personnel

The Contractor shall issue plans and specifications prepared by the **exp** Services Inc. to the Contractor or undertaking the work.

The Contractor shall retain a Foundation Engineering consultant as their Subcontractor registered in MTO's Consultant Registry, Appraisal and Qualifications System (RAQS) for "Geotechnical Specialty – High Complexity", for this assignment.

The Foundation Engineer shall have a minimum of five (5) years' experience in the supply, installation and monitoring of the items listed in Section 1.1.3, or alternatively demonstrated expertise through providing satisfactory monitoring services for the instrumentation specified for a minimum of two (2) projects in which the work was of similar scope to that in the Contract.

"The Subcontractor" shall be understood to refer to the Contractor and their *Foundation Engineering Consultant*.

3.2 Responsibilities

The *Foundation Engineering Consultant* shall:

- Review the Monitoring Program. If recommendations for modifications are required, these recommendations should be submitted in writing to the Contract Administrator;
- Review the reading frequency and ensure that data loggers have sufficient storage capacity to store data for the entire duration of the monitoring program;
- Meet with the Contractor to receive the VW Data Recorder, Portable Laptop Computer and associated software and to receive installation of instrument reports, as specified in Appendix A of this document. Contractors reports shall include all calibration certificates;

- With the exception of the Portable Laptop Computer, VW Data Recorder and all instruments installed by the Contractor, supply all materials and equipment required for the Monitoring Program;
- Calibrate and maintain instrumentation equipment;
- Take instrument readings, reduce data, prepare reports;
- Interpret readings as needed for the purposes of ongoing construction;
- Transmit instrumentation readings and reports to the Contract Administrator;
- Notify the MTO Contract Administrator if modifications to the construction procedures are required. Interpretation shall include making correlations between instrumentation data and specific construction activities;
- If critical measurement readings, as specified herein, for any instrumentation are reached, notify the Contract Administrator within 24 hours;
- Within 48 hours, discuss with the Contract Administrator response action(s), and submit a plan of action to prevent the critical instrument readings from being exceeded.

A progress report shall be provided to the Contract Administrator on a monthly basis. The report shall discuss the Contractor's operations with respect to the installation of instrumentation and/or a summary of the monitoring that was completed for the month.

The MTO Contract Administrator shall:

- Maintain a Foundations Monitoring diary. The diary shall include the following:
 - Document the original conditions;
 - Document work in progress (including extent/height of fill placement);
 - Record unusual situations or problems that arise;
 - Record actions taken by the Contractor to rectify these situation (if applicable); and,
 - Document the restored conditions (if applicable).
- Provide photographs of these conditions.

3.3 Submission Requirements

The *Foundation Engineering Consultant* shall discuss the applicable experience and qualifications of specialist staff, the role that each will play in administration of the contract, the authority to be assumed, and the reporting relationships with the construction administration staff.

The Consultant shall complete the Foundation Monitoring Plan table in the format provided below in Table 1.

Table 1. Foundation monitoring plan form

Foundation Monitoring Plan		
Major Monitoring Tasks	Level of Monitoring	Deliverable Record(s)
List major monitoring tasks associated with foundation monitoring.	State frequency/level of monitoring.	List associated Deliverable Records for each task.

4. Drawings

Reference shall be made to the following drawings that are contained in Appendix A:

- Typical Monitoring Sections;
- Monitoring Section Location Plans; and,
- Monitoring Instrument Details.

5. Subsurface Conditions

As noted in previous sections, this program relates specifically to the area from Station 15+775 to Station 16+100. The subsurface conditions at that site are described in the reports:

1. *Geocres No. 42D-56: "Foundation Investigation and Design Report, Widening of Highway 17 East from Pays Plat River Easterly 7.2 km, Thunder Bay Area, Ontario" prepared by Exp Services Inc., June 13, 2019.*
2. *Geocres No. 42D-45: "Preliminary Foundation Investigation and Design Report, Proposed Embankment Station 15+800 to 16+275 Township of Lahontan Highway 17" prepared by TBT Engineering Ltd., December 19, 2016*
3. *Drainage and Hydrology Report GWP 612-15-00 "Highway 17 Eastbound and Westbound Truck Climbing Lane, Curve Realignment and Hazard Rock Improvements Pays Plat First Nation Easterly" prepared by Associated Engineering, July 28, 2017*
4. *Preliminary Design Report GWP 6120-15-00 "Highway 17 Pays Plat River Easterly, Truck Climbing Lanes, Curve Realignment, Hazard Rock and Resurfacing Pays Plat First Nation Easterly" prepared by TBT Engineering Ltd., October 9, 2018*

6. Equipment Operation

Monitoring shall be conducted year round. All monitoring equipment and associated materials shall be capable of withstanding the range of temperatures possible for their location within the ground or on the surface. The instruments shall be capable of operating within the manufacturer's stated accuracy throughout the temperature range.

Any malfunctioning equipment shall be investigated and the malfunction should be remedied or replaced within two (2) business days. The Contract Administrator should be notified of any malfunctioning equipment.

September 9, 2019

7. Closure

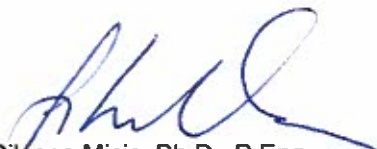
The recommendations made in this report are in accordance with our present understanding of the project and are provided solely for the team responsible for the design of the works described herein.

Details of the limitations of this report are presented and as attached as "Limitations and Use of Report".

This program has been prepared by Silvana Micic, Ph.D., P.Eng. and it was reviewed by TaeChul Kim, M.E.Sc., P.Eng. and Stan E. Gonsalves, M.Eng., P.Eng., Designated MTO Foundation Contact.

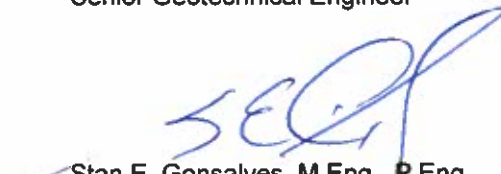
Yours truly,

exp Services Inc.


Silvana Micic, Ph.D., P.Eng.
Senior Geotechnical Engineer



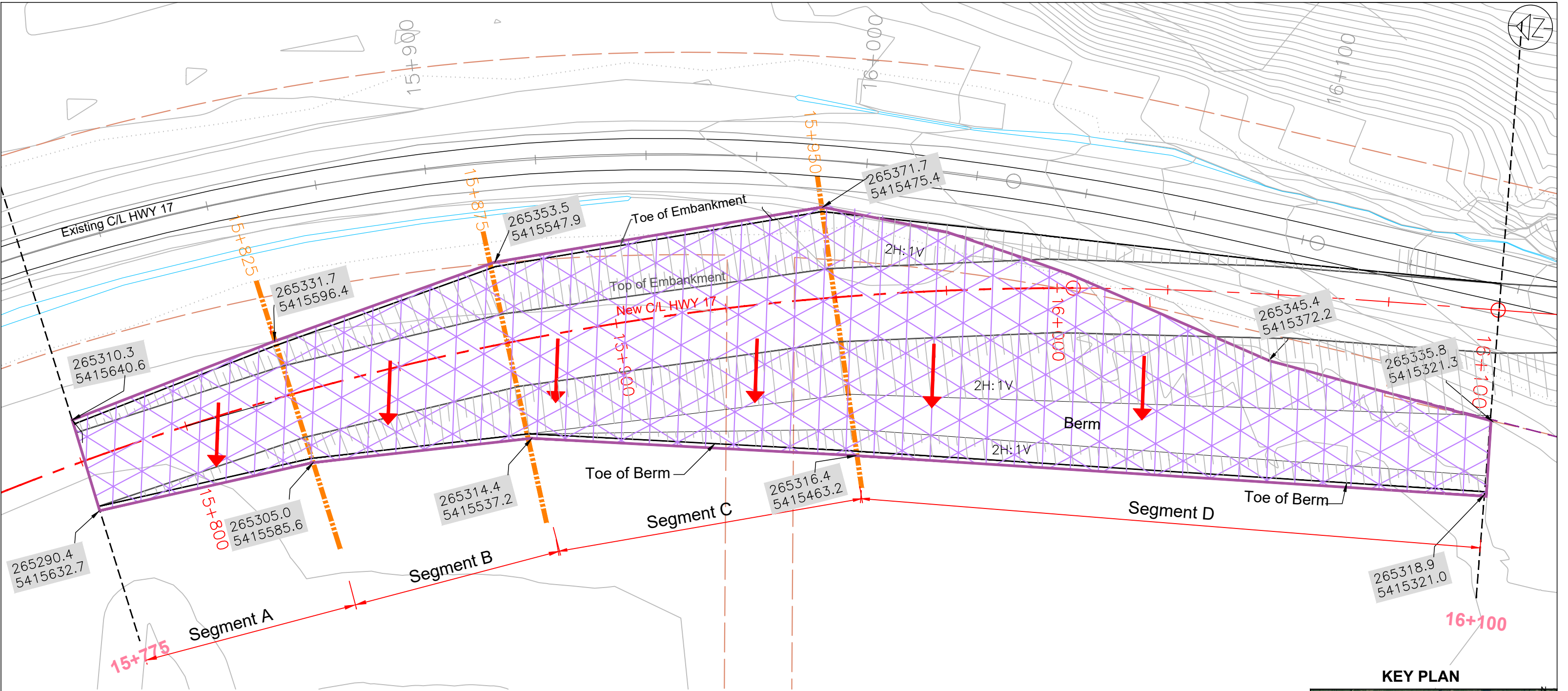

TaeChul Kim, M.E.Sc., P.Eng.
Senior Geotechnical Engineer


Stan E. Gonsalves, M.Eng., P.Eng.
Executive Vice-President
Designated MTO Foundation Contact

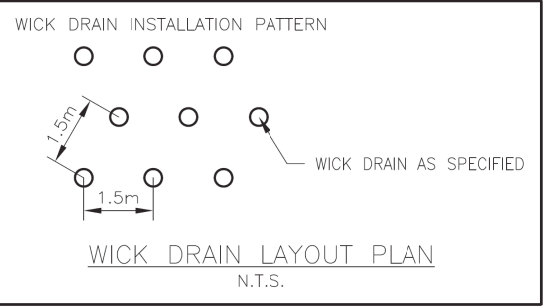


Encl.

Appendix A – Drawings





PLAN



KEY PLAN



LEGEND

-  Plan extent of wick drain installation
-  Plan extent of granular blanket installation

265316.4
5415463.2

Estimated locations of lateral extents of wick drain/granular blanket based on provided drawings (Easting and Northing)
Granular blanket drainage direction (minimum 2% cross fall required)



SCALE

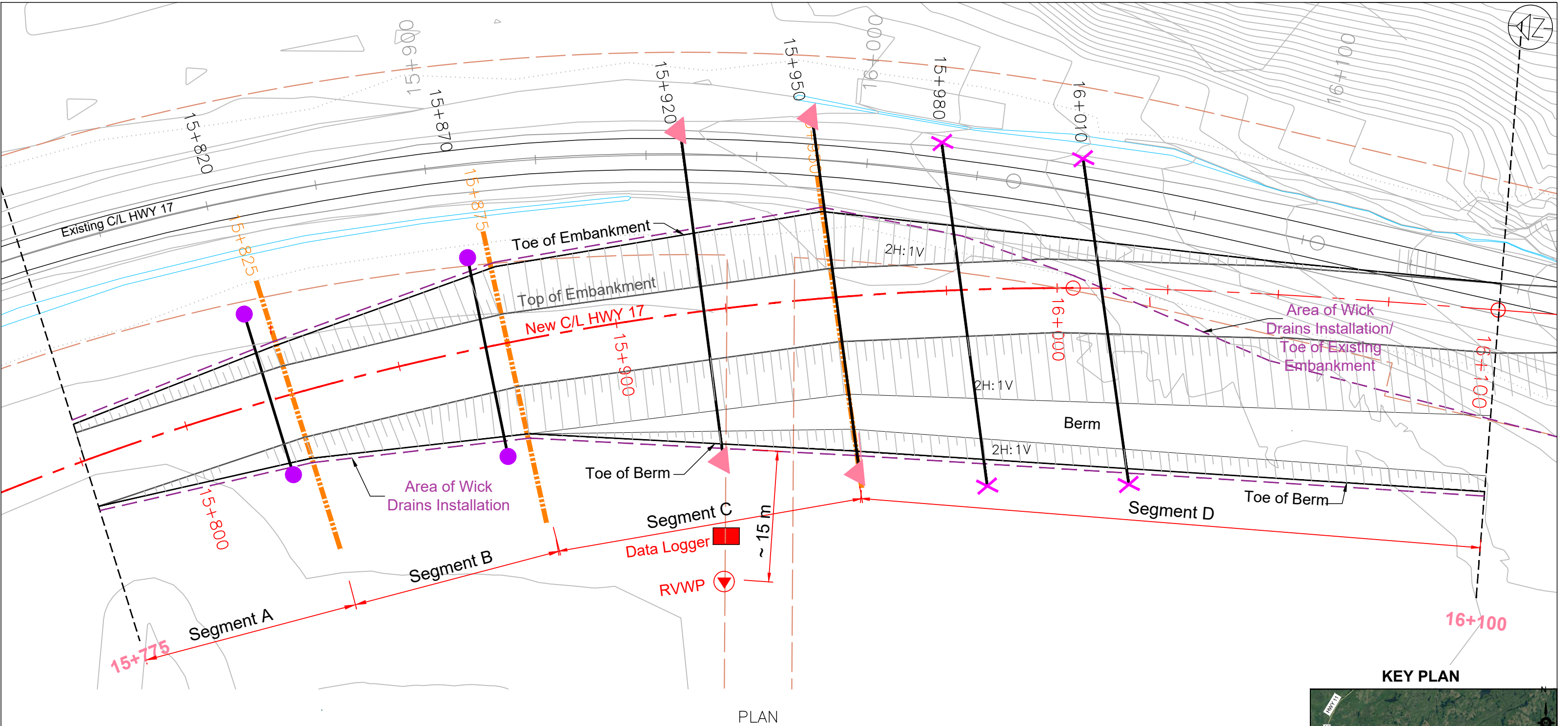


HIGHWAY 17 FROM STATION 15+775 TO 16+100 (SECTION 1)
WICK DRAIN INSTALLATION DETAILS



EXP Services Inc.

DRAWN	SH	DATE	Jul. 12, 19
CHECKED	SM	DWG.	1



KEY PLAN



LEGEND

- Monitoring Section- Type A
- Monitoring Section- Type B
- Monitoring Section- Type C

- Data Logger
- RVWP - Reference Vibrating Wire Piezometer

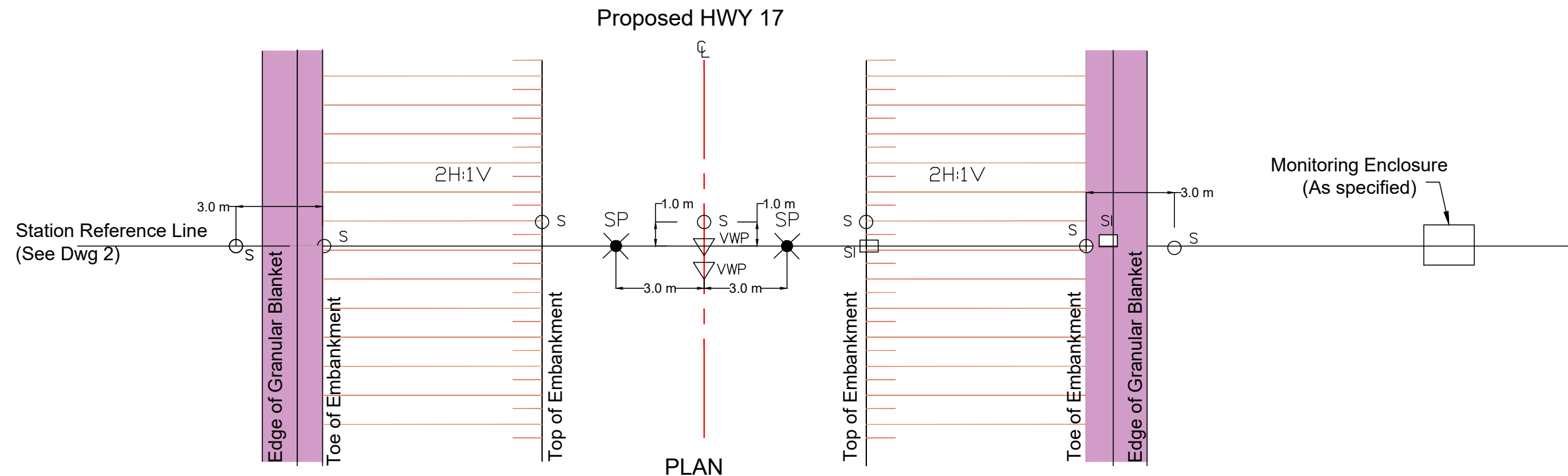
SCALE

0 5 25 m

HIGHWAY 17 FROM STATION 15+775 TO 16+100 (SECTION 1)
WICK DRAIN INSTALLATION DETAILS

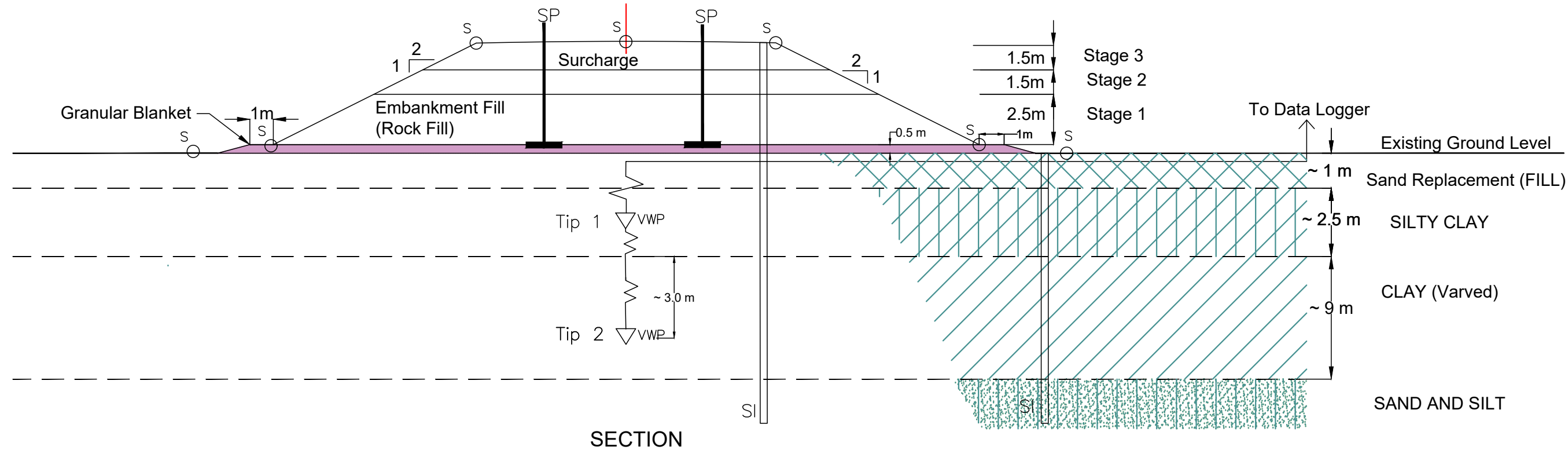
EXP Services Inc.

DRAWN	SH	DATE	Jul. 12, 19
CHECKED	SM	DWG.	2



EAST

WEST



LEGEND



Settlement Plate (plan)



Settlement Plate (section)



Vibrating Wire Piezometer



Slope Inclinator



Settlement Pin

SCALE

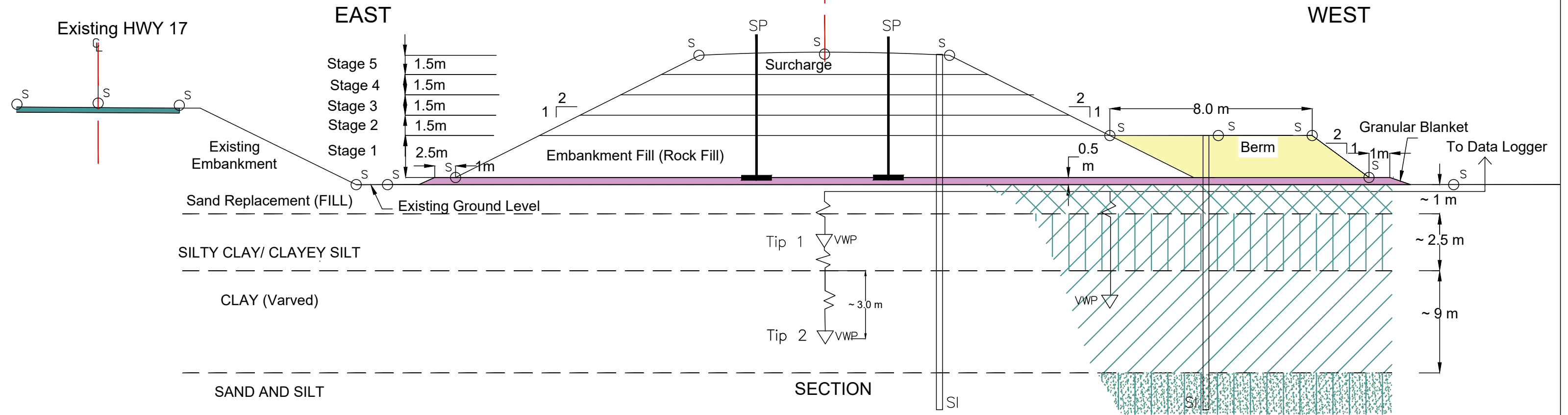
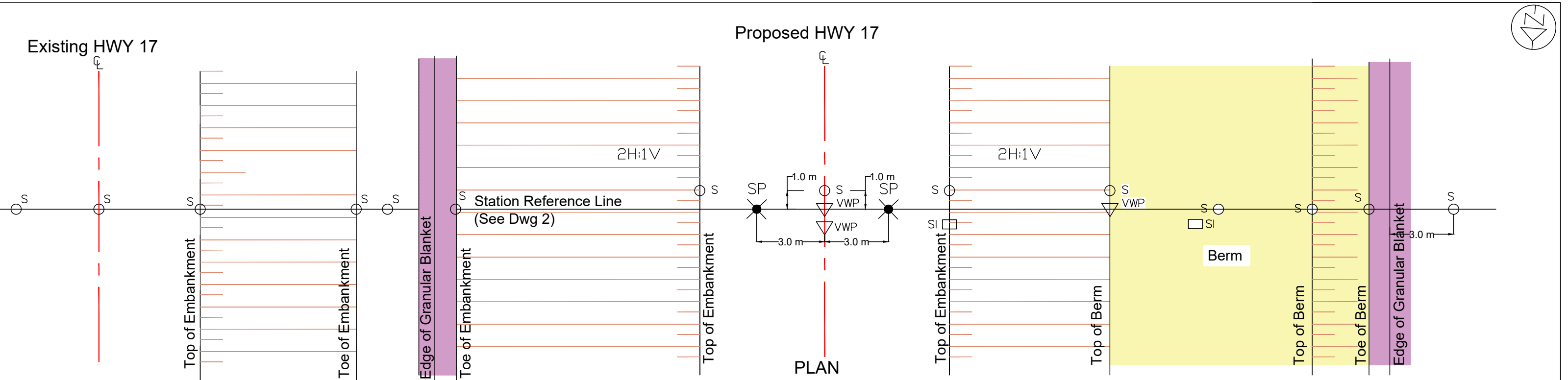
NTS

HIGHWAY 17 FROM STATION 15+775 TO 16+100 (SECTION 1)
MONITORING SECTION- TYPE A



EXP Services Inc.

DRAWN	SH	DATE	Jul. 16, 19
CHECKED	SM	DWG.	3



LEGEND

- SP Settlement Plate
- VWP Vibrating Wire Piezometer
- S Settlement Pin
- SI Slope Inclinometer

SCALE

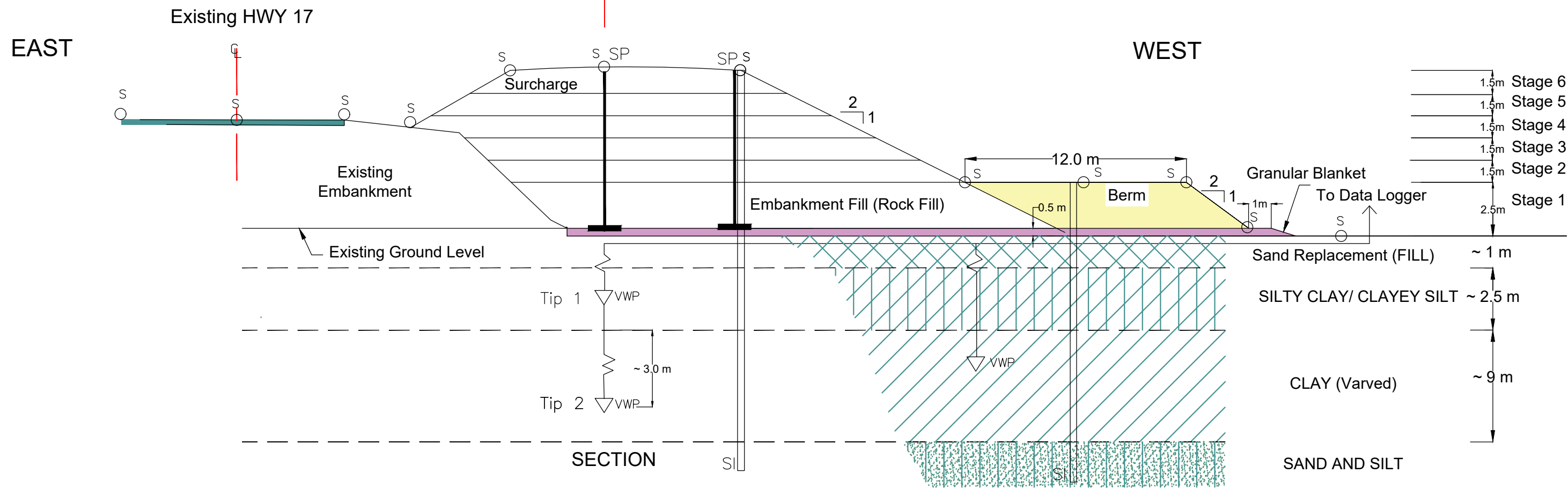
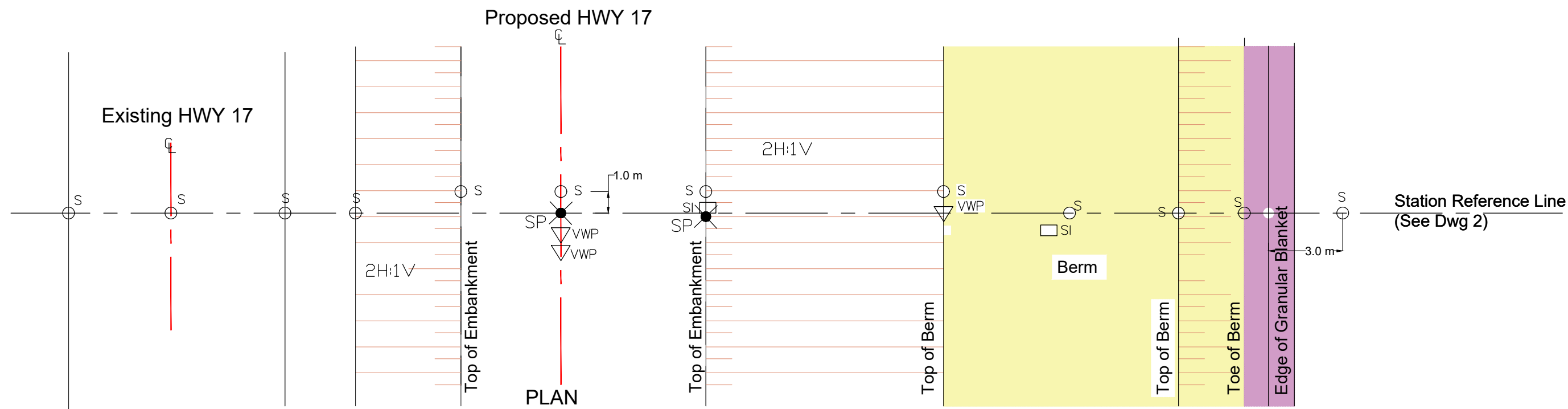
NTS

HIGHWAY 17 FROM STATION 15+775 TO 16+100 (SECTION 1)
MONITORING SECTION- TYPE B







EXP Services Inc.

DRAWN	SH	DATE	Jul. 16, 19
CHECKED	SM	DWG.	4



LEGEND

	SP	Settlement Plate		SI	Slope Inclinator
	VWP	Vibrating Wire Piezometer			
	S	Settlement Pin			

SCALE

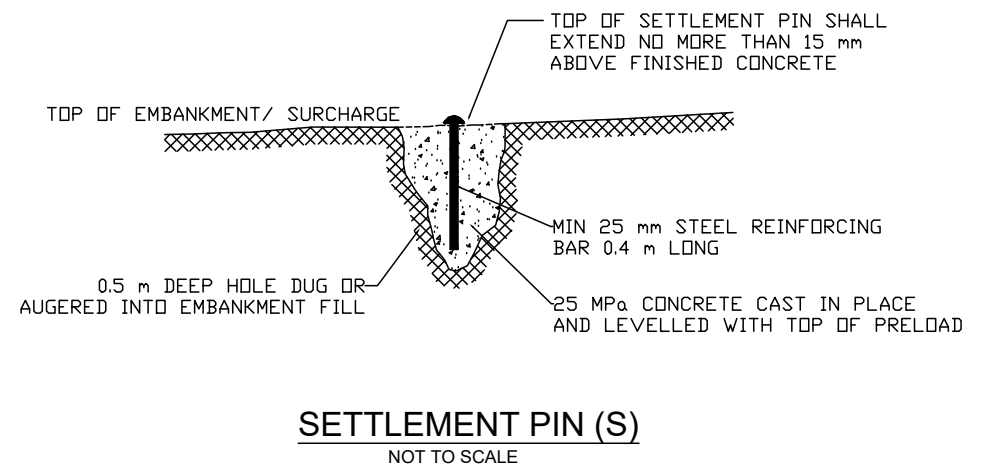
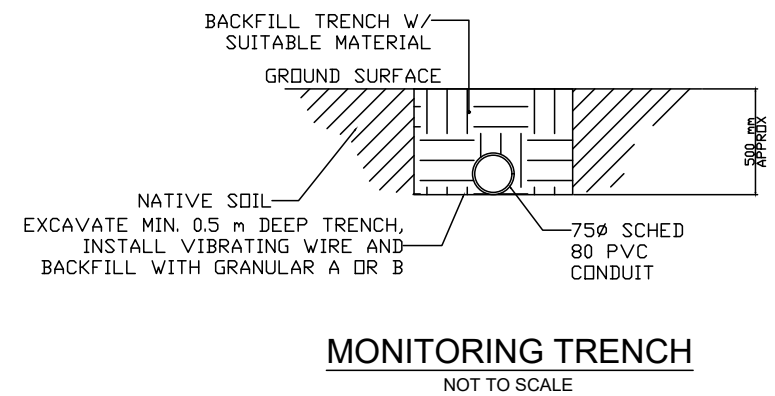
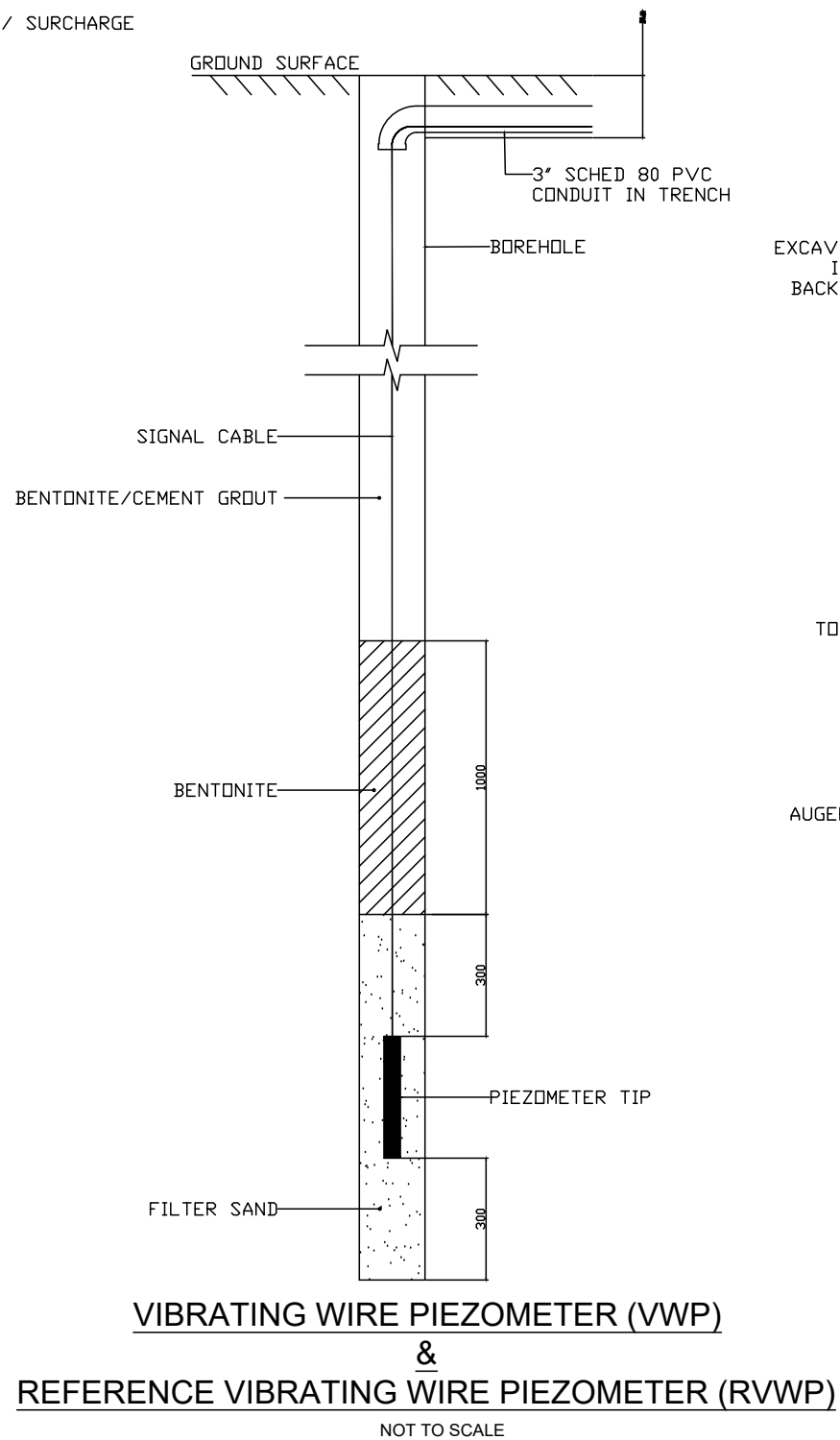
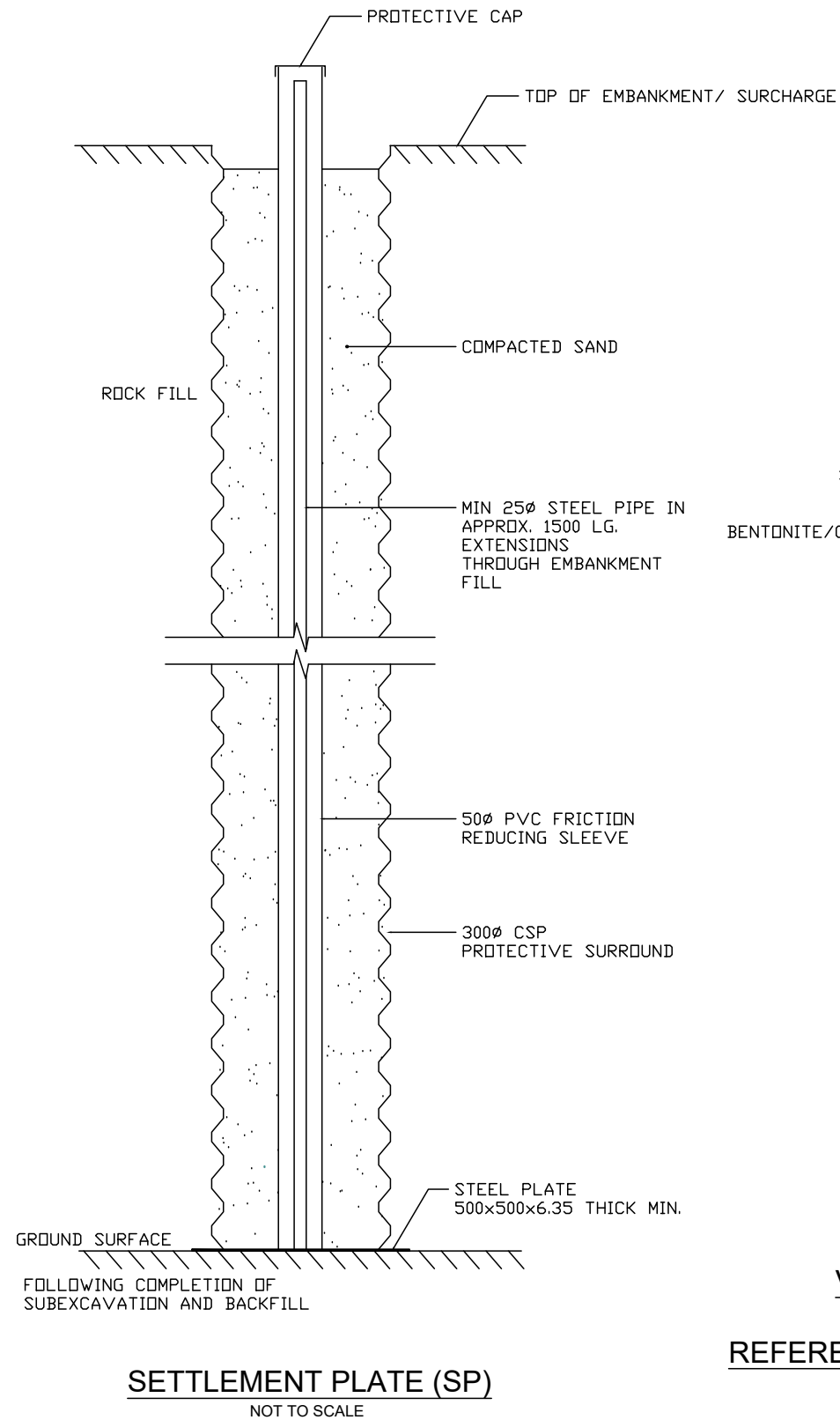
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HIGHWAY 17 FROM STATION 15+775 TO 16+100 (SECTION 1)
MONITORING SECTION- TYPE C



EXP Services Inc.

DRAWN	SH	DATE	Sep. 5, 19
CHECKED	SM	DWG.	5

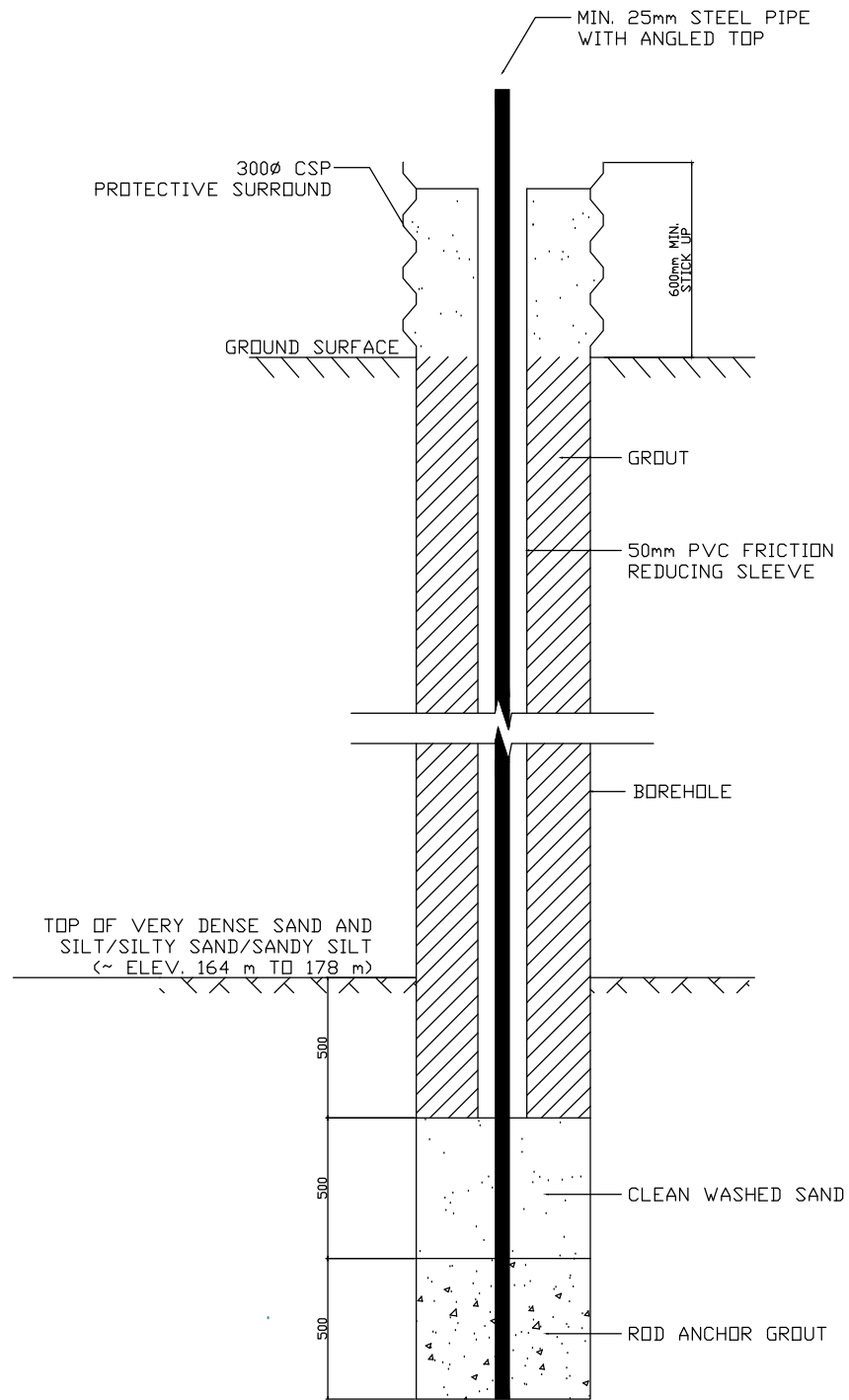


NOTES
*This drawing is schematic only. Please refer elsewhere in the contract documents for Instrument Depth of Installation.

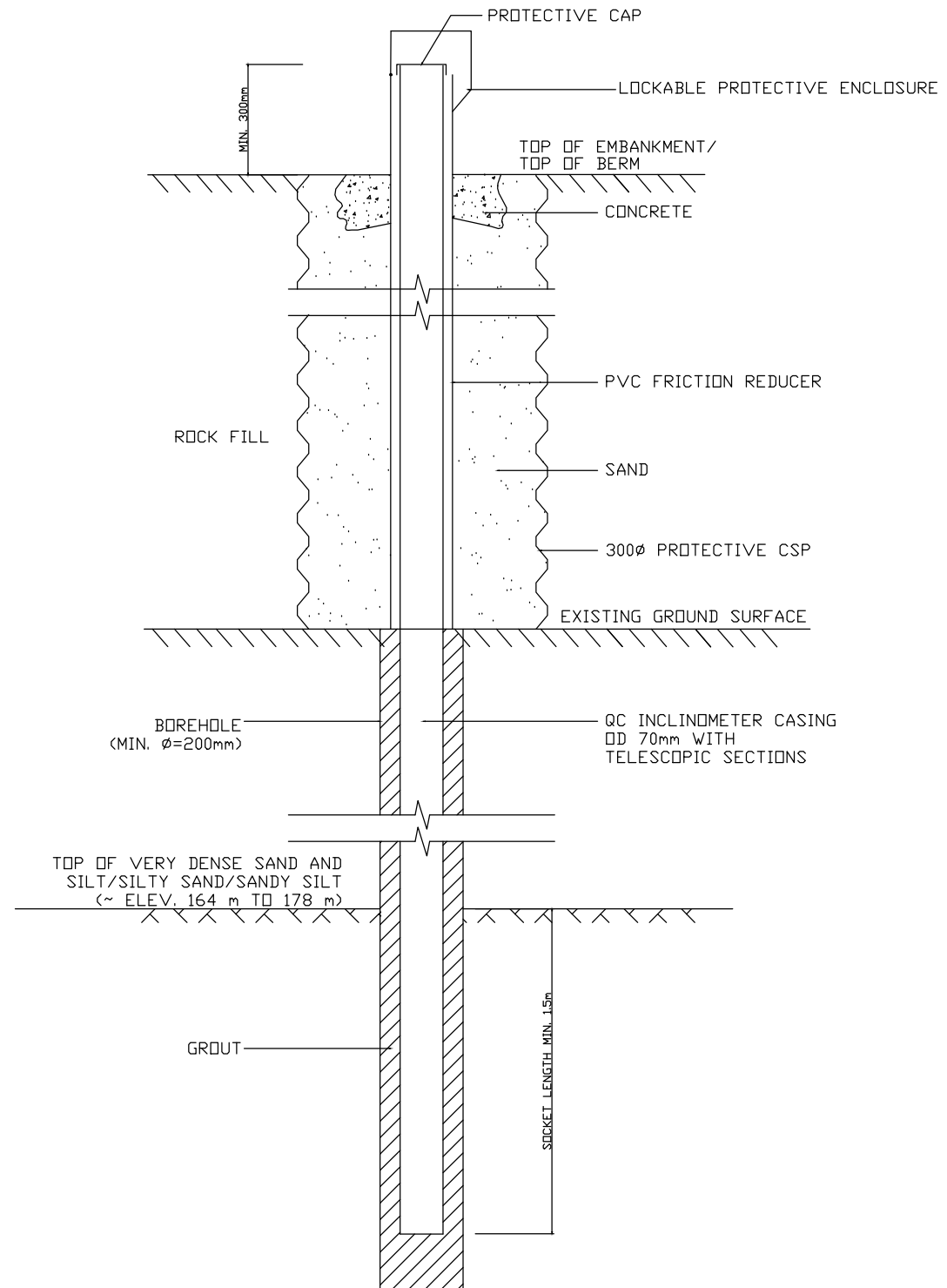
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HIGHWAY 17 FROM STATION 15+775 TO 16+100 (SECTION 1)
MONITORING INSTALLATION DETAILS
SHEET 1 OF 2

exp.		EXP Services Inc.		
DRAWN	SH	DATE	Jul. 12, 19	
CHECKED	SM	DWG.	6	



BENCHMARK (BM)
NOT TO SCALE



INCLINOMETER (SI)
NOT TO SCALE

NOTES

*This drawing is schematic only. Please refer elsewhere in the contract documents for Instrument Depth of Installation.

SCALE

NTS

HIGHWAY 17 FROM STATION 15+775 TO 16+100 (SECTION 1)
MONITORING INSTALLATION DETAILS
SHEET 2 OF 2



EXP Services Inc.

DRAWN	SH	DATE	Sep. 5, 19
CHECKED	SM	DWG.	7

**Appendix B –
NSSP for Excavation of Organics and Compressible
Soils**

NSSP FOR EXCAVATION OF ORGANICS AND COMPRESSIBLE SOILS

B.1 SCOPE

This non-standard specific provision outlines the procedures to be used for excavation of organics (i.e. muskeg/peat) and/or compressible deposits below the footprint of new embankment from Station 15+775 to Station 16+100 of Highway 17 where wick drain system will be installed.

Where there is restriction in space due to the proximity to an existing highway embankment, staged excavation in strips of limited width (max. 3 m) shall be carried out to maintain stability and to protect the existing embankment during sub-excavation and replacement operations. The staged operation procedures to be followed are:

- Work may be carried out simultaneously starting from both ends and progressing towards the center along the embankment footprint;
- The crest of the excavation shall be minimum 2 m from the edge of existing pavement;
- The excavation shall be carried out such that the base of the excavation is maintained outside a zone defined by a line downward at 1H:1V from the crest of existing highway embankment to the base of the excavation;
- Removal of the organic and, where applicable, soft compressible deposits within the embankment footprint and backfilling of the excavation shall be carried out simultaneously in accordance with OPSS 209;
- Temporary excavation side slopes or back slopes through the organic and soft compressible deposits shall be no steeper than 1.5H:1V adjacent to the existing highway. Temporary excavation through the existing highway fill (i.e. rockfill) shall be no steeper than 1H:1V;
- Provisions for traffic control measurements shall be available on site to maintain the safe operation of Highway 17 during excavation and backfilling operations in the event that distress to the existing highway occurs during the staged excavation

B.2 BASIS OF PAYMENT

Payment at the contract price for the above item shall be full compensation for all labour, equipment and material required to do the work.

Appendix C – NSSP for Granular Drainage Blanket

NSSP FOR GRANULAR DRAINAGE BLANKET

C.1 SCOPE

This non-standard special provision specifies the requirements for the surface preparation, supply, placement and compaction of the Granular Drainage Blanket in connection with the installation of the wick drains.

C.2 MATERIALS

The Granular Drainage Blanket shall be Granular 'A', Granular 'B' Type II or Granular 'B' Type I material and shall satisfy the physical and gradation requirements as specified in OPSS 1010 except that:

- 100% shall pass the 37.5 mm sieve;
- No more than 5% shall pass the 0.075 mm sieve.

C.3 CONSTRUCTION

- a. The Granular Drainage Blanket shall be placed to 1 m beyond the horizontal wick drain extent and grades shown on the Contract Drawings and as directed by Contract Administrator.
- b. The Granular Drainage Blanket shall be placed subsequent to the required sub-excavation of organic deposits, to an elevation meeting the following requirements:
 - at least 0.5 m above the groundwater level during the installation of the wick drains,
 - a minimum thickness of 0.5 m; and
 - at least 0.3 m above the original grade
- c. The wick drains shall not be installed in the frozen ground.
- d. The Granular Drainage Blanket shall be end-dumped for placement below water
- e. Placement method shall be selected in order to result in a uniform Granular Drainage Blanket with standard proctor density values of 90% ± 2%

C.4 PAYMENT

C.4.1 Measurement of Payment

Measurement of payment shall be by the tonne. The method of determining the mass of materials for payment shall conform to OPSS 102.

C.4.2 Basis of Payment

Payment at the contract price for the above item shall be full compensation for all labour, equipment and material required to do the work.

Appendix D – Supply and Installation of Wick Drains

SUPPLY AND INSTALLATION OF WICK DRAINS

Supply and installation of wick drains should be in accordance with OPSS.PROV 220 and the details shown on plans and profiles/cross-sections drawings with the requirements of these specifications. The following specifications are amended OPSS.PROV 220.

D.1 GENERAL

D.1.1 Scope

These specifications cover the requirements for the supply and installation of wick drains. The granular blanket is covered in Appendix C.

D.1.2. Definitions

The Quality Verification Engineer (QVE) is an engineer who is qualified to provide the services specified in the Contract Documents and to issue Certificate(s) of Conformance. Certificate of Conformance is a document confirming that the specified components of the Work are in accordance with the requirements of the Contract Documents. The QVE shall be retained by the Contractor.

D.1.3 Wick Drain Spacing and Pattern

Wick drains shall be installed in a triangular pattern with 1.5 m centre-to-centre spacing.

D.1.4 Wick Drain Tip Elevations

The wick drains shall be installed to the elevations as summarized in Table D.1. The anticipated wick drain tip elevations are interpreted from the available borehole data assuming that the wick drains will terminate approximately 1.5 m above the sand and silt layer. The wick drain tip elevations between and beyond the borehole locations were estimated by interpolation and extrapolation of the data, respectively. Therefore the actual tip elevations may vary on site during wick drain installation. The lateral extent of wick drain installation shall be 1 m beyond the proposed toes of embankment or stabilization berm.

D.2 SUBMISSION AND DESIGN REQUIREMENTS

D.2.1 Qualifications

The work shall be undertaken by a recognized specialist Contractor that has proven satisfactory experience in work of this type and magnitude and has completed a minimum of five wick drain installation projects in the last five years, each project with the following characteristics:

- a. Maximum installation depth: not less than 11.5 m
- b. Total length of wick drains: not less than 90,000 m

Prior to the commencement of the Work, the qualifications of the recognized specialist subcontractor shall be submitted to the Contract Administrator.

At least one month prior to commencing the installation of wick drains, the qualifications of the QVE undertaking the certification of the work shall be submitted to the Contract Administrator.

D.2.2 Material

At least 3 weeks prior to the installation of wick drains, the Contractor shall submit to the Contract Administrator the following:

- a) A minimum one metre sample of the wick drain.
- b) The manufacturer's technical specifications indicating that the materials meet the requirements shown in Table 1 of OPSS.PROV 220.

- c) A certificate for each production lot supplied indicating that the wick drain supplied was produced and tested according to the requirements shown in Table 1 of OPSS.PROV 220.

The Contractor shall have test results available for the aggregates to be used in the work. At the request of the Contract Administrator, the Contractor shall make available or submit quality control test results.

When more than one aggregate source is used for supplying material, test data from each source shall be submitted separately

D.2.3 Installation Procedures

At least 3 weeks prior to the installation of wick drains, the Contractor shall submit to the Contract Administrator the details of the sequence and method of installation outlining the following:

- a) Size, type, weight, maximum pushing force, and configuration of the installation rig.
- b) Dimensions of the mandrel to be used.
- c) Details of wick drain anchorage.
- d) Detailed description of proposed installation procedures.
- e) Alternative methods for overcoming obstructions.
- f) Methods for splicing wick drains.

D.2.4 Certificate(s) of Conformance

The following certificates of conformance shall be signed and sealed by the QVE and shall be submitted to the Contract Administrator:

- a) At least 3 weeks prior to the installation of wick drains, a certificate of conformance stating that the equipment, materials, and procedures are capable of achieving successful wick drain installation according to the requirements of the Contract Documents.
- b) Upon completion of the wick drain installation and prior to the placement of any overlying material, a final certificate of conformance stating that the work has been carried out according to the submitted installation procedures and the requirements of the Contract Documents.

D.3 SITE AND SUBSURFACE CONDITIONS

The Contractor shall refer to the following Foundation Investigation Report in the Contract Documents for a description of subsurface conditions at these sites:

"Foundation Investigation Report, Widening of Highway 17 East from Pays Plat River Easterly 7.2 km, Thunder Bay Area, Ontario" prepared by Exp Services Inc., June 13, 2019 (Geocres No. 42D-56)

The Record of Borehole sheets are not represented as a complete description of the subsurface conditions, but only present what was found in borings at the indicated locations on the date boreholes were drilled. The subsurface conditions may be variable between and beyond the borehole locations. The Contractor should verify existing subsurface and surface conditions.

The contract drawings include elevation contour plots for wick drain tip at 1.5 m above the anticipated base of clay. Contours provided between and beyond the borehole locations are interpolated and extrapolated, respectively, and should be used for estimation purposes only.

D.4 MATERIALS

D.4.1 Wick Drain

The prefabricated drain shall consist of a continuous plastic drainage core wrapped in a non-woven geotextile material. The core configuration should be "Grooved" or "Studded". The geotextile, core, and composite wick drain shall meet the minimum requirements specified in Table 1 of OPSS.PROV 220.

All drains supplied shall be free of defects, rips, holes or flaws. During on-site storage the storage area shall be such that the drain is protected from sunlight, dirt, dust, mud, debris and any other detrimental substances.

D.4.2 Sample Wick Drain

The Contractor shall submit a 1 meter sample of the vertical drain material to the Contract Administrator for information at least three (3) weeks prior to commencement of work under this item. The sample shall be stamped or labeled by the manufacturer as being representative of the drain material having the specified trade name. Documentation indicating the source of the drain and the physical and mechanical properties of the drain shall be provided.

D.4.3 Manufacturer Certification

Manufacturer certification shall be provided for all drain material delivered to the project. Quality test certificates for each production lot supplied, showing compliance with all requirements of this special provision shall be obtained by the Contractor and submitted to the Contract Administrator prior to installation.

D.5 EQUIPMENT

Vertical drains shall be installed with equipment, which will minimize disturbance to the drainage blanket or the native subsoil during the installation operation. Static or vibratory methods are considered acceptable. Falling weight impact hammers will not be allowed.

D.6 CONSTRUCTION

D.6.1 Operational Constraints

If the site is designated as an environmentally sensitive area, the control of any water effluent needs to be carefully planned and organized. Jetting techniques shall not be used unless approved by the Contract Administrator.

Vertical drains shall be installed subsequent to the construction of the granular drainage blanket and prior to installation of monitoring instruments and placement of the embankment material. The vertical drains shall not be installed in frozen ground and shall be protected by a minimum of 2 m of earth fill or 4 m of rock fill before ground freezing. In Segment A area the earth fill can be placed for protection, and then removed before construction of embankment.

Installation of the wick drains shall be coordinated with the placement of geotechnical instrumentation as specified in the Contract Documents. Wick drains shall be installed in a manner that does not disturb geotechnical instrumentation already in place. Geotechnical instrumentation damaged as a result of Contractor's activities shall be replaced by the Contractor.

D.6.2 Trial Wick Drains

Prior to the installation of prefabricated drains within the areas designated on the plans, the Contractor shall demonstrate that the proposed materials, equipment and installation method produce a satisfactory drain installation in accordance with these specifications. The Contractor will be required to install ten (10) trial drains within the work area as designated by the Contract Administrator.

Should the trial drains be installed to the satisfaction of the Contract Administrator, the trial drains can be incorporated as part of the permanent installation. The Contractor will be compensated for each trial wick drain if the installation satisfies the requirements of this specification, at the same unit price as the production drains. The Contractor shall not be compensated for unsatisfactory trial wick drains.

Full time monitoring of the Contractor's method of installation will be required by the Contractor's Quality Verification Engineer. If, at any time, the Quality Verification Engineer considers that the method of installation does not produce a drain that satisfies the project requirements, the Contractor shall alter the method and/or equipment as necessary to comply with these specifications.

D.7 INSTALLATION

D.7.1 General

Wick drains shall be installed to the depths specified in the Contract Documents.

Each prefabricated wick drain shall be installed using a mandrel or sleeve that shall be advanced through the underlying soil and the drainage blanket. The mandrel shall protect the prefabricated drain material from tears, cuts and abrasions during installation and shall be withdrawn after the installation on the drain. The mandrel shall be provided with an "anchor" rod or plate at the bottom to prevent the soil from entering the bottom of the mandrel during installation of the drain and to anchor the bottom of the drain at the required depth at the time of mandrel removal. The projected cross-sectional area of the mandrel and anchor combination shall not exceed 7,700 mm².

The Contractor shall be permitted to use augering equipment to pre-drill or loosen the native soils and the drainage blanket, if required, to facilitate the installation of the wick drains. The use of augering or vibrating equipment shall not extend more than 1 m into the soil to be consolidated.

D.7.2 Layout

Prefabricated drains shall be located and staked out by the Contractor. The location of the drains shall not vary by more than 150 mm from the locations indicated on the drawings.

D.7.3 Plumbness

Drains shall be installed vertically, within a tolerance of not more than 10 mm per 500 mm. The equipment shall be carefully checked for plumbness, and the Contractor shall provide the Contract Administrator with a suitable means of verifying the plumbness of the mandrel and of determining the depth of the drain at any time.

D.7.4 Splices

Splices or connections in the vertical drain material shall be done in a professional manner so as to ensure continuity and to avoid any reduction of the flow characteristics of the wick material. Splices shall be a minimum of 150 mm in length.

D.7.5 Cut-off

The prefabricated drain shall be cut at the surface such that at least a 150 mm length protrudes above the top of the granular blanket at each drain location.

D.7.6 Obstructions

Where obstructions are encountered below the working surface and at less than 90% of the anticipated depth that cannot be penetrated by the wick drain installation equipment, the Contractor shall complete the drain from the elevation of the obstruction to the working surface and notify the Contract Administrator. At the direction of the Contract Administrator, the Contractor shall attempt to install a new drain within a 500 mm radius of the obstructed drain.

A maximum of two (2) attempts shall be made as directed by the Contract Administrator. The Contractor will be compensated for each obstructed drain unless the drain is improperly completed, in which case no compensation will be allowed.

Obstructions encountered within 10% of the anticipated wick drain tip depth shall complete the drain from the elevation of the obstruction to the working surface and notify the Contract Administrator. No additional attempts shall be made to re-install the wick drain unless otherwise directed by the Contract Administrator. The Contractor will be compensated for each obstructed drain unless the drain is improperly completed, in which case no compensation will be allowed.

D.7.7 Management of Excess Material

Management of excess material shall be in accordance with the Contract Documents.

D.7.7 Pre-augering and Vibratory Equipment

Pre-augering and/or suitable vibratory equipment for installation through the native soils and the drainage blanket to facilitate the installation of pre-fabricated wick drains may be required. The depth of augering shall be the minimum depth required to facilitate the wick drain installation. Any additional cost for pre-augering or vibratory equipment shall be incorporated into the unit price.

D.8 QUALITY ASSURANCE

D.8.1 Certificate

Certificates for each production lot indicating that the wick drain supplied was produced and tested according to the requirements of this specification shall be provided by the manufacturer for all wick drains delivered to the Contract.

D.8.2 Rejected Drains

Prefabricated drains that are installed beyond the plan location by more than 150 mm, or that are damaged or are not installed in accordance with the specifications described above shall be rejected. Rejected drains may be removed at the Contractor's own expense and time. The Contractor shall not be compensated for the materials and work associated with rejected drains.

Replacement drains shall be installed within a 500 mm radius from the location of the rejected drain as directed by the Contract Administrator.

D.9 PAYMENT

D.9.1 Measurement of Payment

Measurement of the item shall be by the linear metre for all accepted drains installed including the protruding portion up to 150 mm per installation. Properly completed obstructed wick drains and properly installed replacement wick drains and trial drains will be measured for payment.

When measurement is by Plan Quantity, such measurement shall be based on the units shown in the clauses under Actual Measurement.

D.9.2 Basis for Payment

Payment at the contract unit price per linear metre for the above item shall be full compensation for all labour, materials and equipment to complete the work in accordance with the contract drawings and specifications.

Geotechnical instrumentation damaged as a result of the Contractor's activities shall be replaced at no additional cost to the Owner.

No payment shall be made for unacceptable drains or delays or expenses incurred by the Contractor as a result of improper or unacceptable material or installation.

Table D.1. Tip elevations for wick drain installation

Segment	Chainage	Anticipated Tip Elevations (m)				
		WBL – East Toe	WBL – Centreline	Median Centreline	EBL – Centreline	EBL – West Toe
Segment A	15+775	175.0	174.45	174.8	174.20	173.8
	15+785	175.0	174.45	174.8	174.20	173.8
	15+795	175.0	174.45	174.8	174.20	173.8
	15+805	175.0	174.45	174.8	174.20	173.8
	15+815	175.0	174.45	174.8	174.20	173.8
	15+825	175.0	174.45	174.8	174.20	173.8
Segment B	15+835	175.0	174.44	174.37	174.26	173.8
	15+845	175.0	174.44	174.37	174.26	173.8
	15+855	175.0	174.44	174.37	174.26	173.8
	15+865	175.0	174.44	174.37	174.26	173.8
	15+875	175.0	174.44	174.37	174.26	173.8
Segment C	15+885	175.4	174.35	174.27	174.12	173.17
	15+895	175.4	174.35	174.27	174.12	173.17
	15+905	175.4	174.35	174.27	174.12	173.17
	15+915	175.4	174.35	174.27	174.12	173.17
	15+925	175.4	174.35	174.27	174.12	173.17
	15+935	175.4	174.35	174.27	174.12	173.17
	15+945	175.4	174.35	174.27	174.12	173.17
Segment D	15+955	-	-	181.8	177.2	175.57
	15+965	-	-	181.8	177.2	175.57
	15+975	-	-	181.8	177.2	175.57
	15+985	-	-	181.8	177.2	175.57
	15+995	-	-	181.8	177.2	175.57
	16+005	-	-	181.8	177.2	175.57
	16+015	-	-	181.8	177.2	175.57

	16+025	-	-	181.8	177.2	175.57
	16+035	-	-	181.8	177.2	175.57
	16+045	-	-	181.8	177.2	175.57
	16+055	-	-	181.8	177.2	175.57
	16+065	-	-	181.8	177.2	175.57
	16+075	-	-	181.8	177.2	175.57
	16+085	-	-	181.8	177.2	175.57
	16+095	-	-	181.8	177.2	175.57
	16+100	-	-	181.8	177.2	175.57

Note: The tip elevation for each section was determined by utilizing the BH and CPT data that best represented each section after which the obtained value was replicated for the individual cross sections within the section. For Section D, no data for the WBL centerline nor east toe were provided because of the presence of the existing Hwy 17.

**Appendix E –
NSSP for Embankment Construction Constraints**

NSSP FOR EMBANKMENT CONSTRUCTION CONSTRAINS

E.1 GENERAL

The Contractor is advised that the timing for placement of various stages of embankment fill and surcharge material is critical to the overall schedule. The Contractor shall schedule their operations such that preload or surcharge material is in place for the entire period of time (as specified in Table E.1 and E.2) such that subsequent stages of construction are not delayed as a result of the requirement for the waiting periods outlined below.

E.2 DRAINAGE

The subgrade below the drainage blanket should be sloped towards the outside slope of the embankment so that the excess water can be suitably drained during the consolidation process.

E.3 CONSTRUCTION EQUIPMENT

Construction equipment or traffic shall not be permitted to travel in areas of exposed wicks and/or exposed geogrid (if applicable).

E.4 TEMPORARY HAUL ROAD CONSTRUCTION

The design and construction of temporary haul roads is the responsibility of the Contractor. The temporary haul roads must be designed not to cause rutting, softening or disturbance of the subgrade foundation soils. The haul roads and hauling of excess excavated soils and rock or granular material must not cause instability of the newly constructed embankments and berms or existing embankments and slopes. The temporary haul roads must not damage any installed wicks, geosynthetic reinforcement and any geotechnical instrumentation. No material stockpiling or parking of construction equipment shall be allowed on temporary haul roads. The design of temporary haul roads shall take into account the construction sequences listed in the following sections.

For soft wet subgrade areas with high water table, a minimum of 1 m thickness of initial lift of rock fill shall be placed on the subgrade or on the drainage blanket in the wick drain areas prior to using the haul road for heavy construction equipment or trucks hauling rock or granular material. If the subgrade is excessively soft or swampy, a thicker initial lift of rock fill will be required.

If the Contractor chooses to use the new embankments for hauling rock or granular material, the trucks shall travel on the top of the newly constructed embankment and not on top of the stabilizing berms

E.5 PRIOR TO EMBANKMENT CONSTRUCTION

The construction of the embankments including associated topsoil/peat/muskeg removal and, if applicable: surcharge construction, wick drains installation, placement geosynthetic reinforcement (if applicable) and installation of monitoring instruments shall be in accordance with the contract documents and drawings. The embankment construction shall start only after the following construction sequence:

- Completion of topsoil/peat/muskeg removal;
- Completion of placement of granular drainage blanket and installation of wick drains;
- Completion of installation of monitoring instruments and if it has been determined by the Contract Administrator that the Vibrating Wire Piezometers (VWP) and

Slope Inclinator (SI) "zero readings" have stabilized. The stabilization time is estimated to be in the order of fifteen (15) days after the completion of installation of the VWPs and SIs;

- Completion of placement of geosynthetic reinforcement (if applicable)

E.6 FILL PLACEMENT

Fill should be placed as soon as possible with minimum preloading durations indicated in Sections E.7 and E.8 below. Placement of embankment fill should be as per OPSS.PROV 206.

E.7 SINGLE STAGE EMBANKMENT CONSTRUCTION

The embankments in the following table are anticipated to be constructed in one stage. The anticipated waiting period for settlement and dissipation of excess pore pressures prior to surcharge removal (if applicable) and paving are as follows:

Table E.1 Single stage embankment

Segment	Station	Stage Fill Height (m)	Anticipated Waiting Period(*) After Completion of Fill Placement with Wick Drains (months)
Segment A	15+775 to 15+825	From 0 to 2.5 m	No waiting period only construction time

Note : () Actual time for waiting period will be governed by results from the instrumentation monitoring program and may differ from the estimates provided .*

The construction sequence shall be as follows:

- In one stage, construct embankment with overbuild as per the contract documents and drawings and limited to the rate of fill placement specified in the documents..
- After receiving written instruction from the Contract Administrator, design road base elevation as per the contract documents and drawings
- Construct pavement structure

E.8 MULTISTAGE EMBANKMENT CONSTRUCTION

The embankments that are anticipated to be constructed in more than one stage with a waiting period for settlement and dissipation of excess pore pressures between stages and prior to surcharge removal and/or paving are as follows:

Table E.2. Multistage embankments

Segment	Stage	Stage Fill Height (m)	Stabilization Berm	Anticipated Waiting Period (*) After Completion of Fill Placement (months) with Wick Drains and Surcharge of 1.5 m
Segment B (15+825 to 15+875)	1	2.5	No	1
	2	1.5		1.3
	3	1.5 (Surcharge)		4
Segment C (15+825 to 15+875)	1	2.5	Yes, on the west side (8 m wide and 2.5 m high)	0
	2	1.5		1.3
	3	1.5		1
	4	1.5		0.5
	5	1.5 (Surcharge)		5
Segment D (15+950 to 16+100)	1	2.5	Yes, on the west side (12 m wide and 2.5 m high)	0
	2	1.5		1.3
	3	1.5		1
	4	1.5		0.5
	5	1.5		0.5
	6	1.5 (Surcharge)		6

Note: (*) Actual time for waiting period will be governed by results from the instrumentation monitoring program and may differ from the estimates provided.

The construction sequence shall be as follows:

- Concurrently construct stabilization berms and embankment to Stage 1 level as per the contract documents and drawings and limited to the rate of fill placement specified in the documents. The mainline embankment shall only be built after the stabilizing berms are in place;
- The stabilization of settlements and the waiting time for dissipation of excess pore pressure (EPP) following Stage 1 fill placement shall be determined by the Contract Administrator.
- The anticipated waiting times are shown in the table above. Written approval to proceed shall be provided by the Contract Administrator prior to further construction activities;
- Construct embankment to Stage 2 as per the contract documents and drawings and limited to the rate of fill placement specified in the documents;

- The stabilization of settlements and the waiting time for dissipation of excess pore pressure (EPP) following Stage 2 fill placement shall be determined by the Contract Administrator.
- The anticipated waiting times are shown in the table above. Written approval to proceed shall be provided by the Contract Administrator prior to further construction activities;
- Construct embankment to Stage 3 as per the contract documents and drawings and limited to the rate of fill placement specified in the documents;
- The stabilization of settlements and the waiting time for dissipation of excess pore pressure (EPP) following Stage 3 fill placement (if applicable) shall be determined by the Contract Administrator. The anticipated waiting times are shown in the table above. Written approval to proceed shall be provided by the Contract Administrator prior to further construction activities;
- Construct embankment to Stage 4 (if applicable) as per the contract documents and drawings and limited to the rate of fill placement specified in the documents;
- The stabilization of settlements and the waiting time for dissipation of excess pore pressure (EPP) following Stage 4 fill placement (if applicable) shall be determined by the Contract Administrator. The anticipated waiting times are shown in the table above. Written approval to proceed shall be provided by the Contract Administrator prior to further construction activities;
- Construct embankment to Stage 5 (if applicable) as per the contract documents and drawings and limited to the rate of fill placement specified in the documents;
- The stabilization of settlements and the waiting time for dissipation of excess pore pressure (EPP) following Stage 5 fill placement (if applicable) shall be determined by the Contract Administrator. The anticipated waiting times are shown in the table above. Written approval to proceed shall be provided by the Contract Administrator prior to further construction activities;
- Construct embankment to Stage 6 (if applicable) as per the contract documents and drawings and limited to the rate of fill placement specified in the documents;
- The stabilization of settlements and the waiting time for dissipation of excess pore pressure (EPP) following Stage 6 fill placement (if applicable) shall be determined by the Contract Administrator. The anticipated waiting times are shown in the table above. Written approval to proceed shall be provided by the Contract Administrator prior to further construction activities;
- After receiving written instruction from the Contract Administrator, remove surcharge (if applicable) the design road base elevation as per contract documents and drawings
- Construct pavement structure

**Appendix F –
NSSP for Supply and Installation of Embankment
Monitoring Equipment**

NSSP FOR SUPPLY AND INSTALLATION OF EMBANKMENT MONITORING EQUIPMENT

F.1 GENERAL

F.1.1 Scope

This non-standard special provision contains the requirements for the supply and installation of the following geotechnical instruments:

- Settlement Plates (SP)
- Settlement Pins (S)
- Slope Inclinator (SI)
- Vibrating Wire Piezometers (VWP/RVWP)
- Survey Bench Marks (BM)

This special provision also contains the requirements for the supply and installation of temporary survey benchmarks (BM), if necessary. The Contractor shall provide a minimum of two survey Benchmarks, and shall

F.1.2 Purpose

The purpose of these instruments is to monitor settlements, lateral displacement and dissipation of excess pore-water pressures in the foundation soils during construction of the new embankment along Section 1 of the Highway 17 (Station 15+775 to Station 16+100), located in Rosspoint, Thunder Bay Area, Ontario. The purpose of the Survey Benchmarks is to provide a non-settling reference point.

The rate and staging of fill placement and the timing for the removal of surcharge shall be controlled by the instrumentation readings. Pavement construction shall not take place until sufficient consolidation has been achieved as determined by the Contract Administrator.

Given the proximity of the existing Highway 17 and the requirement (if any) for highway to remain in operation during the construction of new embankment, instrumentation for monitoring of settlement and lateral movements shall be included in the monitoring program.

It should be noted that monitoring of the instruments will be carried out by others after the installation of instrumentation by the Contractor.

The instrumentation shall not be decommissioned unless instructed by the Contract Administrator.

F.1.3 Specialist Qualifications

The Contractor shall retain a *Geotechnical Consultant* as their Subcontractor registered in MTO's Consultant Registry, Appraisal and Qualifications System (RAQS) for "Geotechnical Specialty – High Complexity", to undertake the supply and installation of geotechnical monitoring instrumentation.

The *Foundation Engineering Consultant* shall not be the same Geotechnical Consultant retained for the supply and installation of the embankment monitoring equipment.

"The Subcontractor" shall be understood to refer to the Contractor and their *Geotechnical Consultant*.

F.1.4 Or Equal

The term, "*or equal*", shall be understood to indicate that the equal product is the same or better than the specified product in function, performance, reliability, quality and general configuration.

F.1.5 Notification

The Contract Administrator shall be notified a minimum of thirty (30) days in advance of commencing the installation of instruments.

F.1.6 Submission Requirements

The Contractor shall submit details of proposed installation methods, including location and types of data-acquisition system, survey Benchmarks, and installation schedule to the Contract Administrator, a minimum of 30 days before the start of instrument installation.

F.1.7 Drawings

Reference shall be made to the following drawings that are contained elsewhere in the Contract Documents:

- Typical Monitoring Sections;
- Monitoring Section Location Plans; and,
- Monitoring Instrument Details.

F.1.8 Subsurface Conditions

The subsurface conditions at the sites are described in the report:

"Foundation Investigation Report, Widening of Highway 17 East from Pays Plat River Easterly 7.2 km, Thunder Bay Area, Ontario" prepared by Exp Services Inc., June 13, 2019 (Geocres No. 42D-56)

F.1.9 Equipment Operation

Monitoring shall be conducted year round. All monitoring equipment and associated materials shall be capable of withstanding the range of temperatures possible for their location within the ground or on the surface. The instruments shall be capable of operating within the manufacturer's stated accuracy throughout the temperature range.

Any malfunctioning equipment shall be investigated and the malfunction should be attempted to be remedied. The Contract Administrator should be notified of any malfunctioning equipment.

F.2 INSTALLATION

The quantities and location of instruments are presented in Table F.1 and are shown on the Contract Drawings.

Table F.1 Instrument quantities and locations

Monitoring Section				NO. of Instruments				
Segment	Station	Approximate Embankment Height ¹ (m)	Type	SP	S	VWP	SI	RVWP
A	15+820	2.5	A	2	7	2	-	-
B	15+870	5.0	A	2	7	2	2	-
C	15+920	7.0	B	2	14	3	2	-
C	15+950	8.0	B	2	14	3	2	1
D	15+980	9.0	C	2	12	3	2	-
D	16+010	10.5	C	2	12	3	2	-
TOTAL				12	66	16	10	1

Note: 1. At the centerline of embankment

F.2.1 Instrument Location

Prior to the installation of instruments, the Contractor shall accurately survey and stake the location of each instrument and obtain a ground elevation and coordinates at each instrument location.

F.2.2 Accuracy of Surveying for Elevations

Elevations shall be surveyed to an accuracy of ± 2 mm or better.

F.2.3 Survey Personnel

Surveying to establish the benchmarks and other elevations shall be carried out by a registered surveyor with appropriate equipment.

F.2.4 Underground Utilities

The Contractor shall be responsible for locating and protecting all underground utilities prior to any drilling/excavations required for installing instruments. Any damage to underground utilities caused by the Contractor's work shall be repaired by the Contractor at no cost to the Owner or Contract Administrator.

F.2.5 Materials and Equipment

The Contractor shall supply all materials and equipment required for the installation of instrumentation unless noted otherwise.

F.2.6 Marking and Labelling

The location of any above ground monitoring fixture shall be made clearly visible to nearby traffic before, during and after embankment and surcharge construction. Marking shall be of sufficient size to be visible from a reversing vehicle and after heavy snow falls.

Instruments or their data cables shall be clearly labelled in the field, each instrument having a unique identifier. The labelling shall remain legible for the entire duration of monitoring.

F.2.7 Protection of Instruments

The Contractor shall adequately protect all instruments such that they are not damaged during construction. Any instrument damaged by the Contractor's work shall be immediately replaced by the Contractor at no cost to the Owner or Contract Administrator.

Instruments should also be adequately protected by the Contractor from natural effects such as lightning strikes.

F.2.8 Boreholes

The Contractor shall make a basic stratigraphic log of boreholes as they are being drilled for the installation of monitoring instruments. In situ or laboratory geotechnical testing is not required.

Boreholes shall be advanced using conventional drilling methods and shall be as straight and vertical as practicable.

F.2.9 Installation Program

Instrument installation shall commence immediately after wick drain installation (if applicable) and before any embankment construction. No material stockpiling shall be allowed within the embankment construction area during instrument installation.

Table F.2 Installation program

Type	Location	Start Installation	Completion of Installation
SP	At new embankment	After wick drain installation	At completion of embankment construction
S	At new embankment	After placement of surcharge	At completion of embankment construction
	At existing embankment	After wick drain installation	Before embankment construction
VWP	At new embankment	After wick drain installation	Before embankment construction
SI	At new embankment	After wick drain installation	Before embankment construction
RVWP	At new embankment	After wick drain installation	Before embankment construction

F.3 SETTLEMENT PLATES (SP) - SUPPLY & INSTALLATION

F.3.1 General

F.3.1.1 Scope

This Section contains the requirements for the supply and installation of settlement plates (SP).

The purpose of the Settlement Plates is to monitor settlements of the embankment base. The settlement readings shall help establish the timing for fill placement of subsequent stages, establish the timing for completion of the preload period and/or the removal of any surcharges. Settlement is measured by survey of the top of the rod with reference to stable, non-settling benchmarks.

F.3.1.2 General Procedure

The settlement rods shall be attached to a plate at the existing ground surface. As embankment construction proceeds, the rods shall be extended above the new top of embankment.

Sleeves around the rods shall be installed to reduce friction and allow uninhibited movement of the rod with the plate.

A protective surround shall be extended with the rods as embankment construction proceeds.

As the Settlement Plates are located within the new highway structure, the rods shall be cut down to a minimum of 0.3 m below the subgrade level after the monitoring program is complete.

F.3.1.3 Location

The locations of the settlement rods are shown on the attached drawings and are given in Table F.3.

Table F.3 Settlement plate locations

Segment	Station ¹	Monitoring Section Type	Lane	Offset from Hwy Central Line	Approximate Elev. of Existing Ground ² (m)	Estimated Thickness of Embankment ³ (m)
A	15+820	A	WBL	3 m L of C/L	187.0	2.5
			EBL	3 m R of C/L		
B	15+870	A	WBL	3 m L of C/L	187.0	5.0
			EBL	3 m R of C/L		
C	15+920	B	WBL	3 m L of C/L	186.9	7.0
			EBL	3 m R of C/L		
C	15+950	B	WBL	3 m L of C/L	187.3	8.0
			EBL	3 m R of C/L		
D	15+980	C	WBL	3 m L of C/L	187.8	9.0
			EBL	3 m R of C/L		
D	16+010	C	WBL	3 m L of C/L	187.5	10.5
			EBL	3 m R of C/L		

Notes:

1. The stations for the settlement plates are approximate and are referenced from the centreline.
2. Ground elevation at the centreline
3. Embankment thickness includes surcharge of 1.5 m where applicable

F.3.2 Materials

F.3.2.1 General

The Contractor shall supply all materials and equipment required for the installation of the Settlement Plates.

F.3.2.2 Plate

The Contractor shall supply a steel plate with thickness of at least 6.35 mm. The plate shall be at least 0.5 m by 0.5 m.

F.3.2.3 Rod

The Contractor shall supply a steel pipe with an outside diameter not less than 25.4 mm (1"), supplied in lengths as required to complete the installation.

The top end of each length of rod shall be threaded to receive a cap. A rounded cap shall be installed at the top of the rod in such a way that a single survey point can be clearly identified and returned to.

F.3.2.4 Friction Reducing Sleeve

The Contractor shall supply a friction reducing sleeve consisting of Schedule 40 - 50.8mm (2") O.D. PVC pipe cut perpendicular to the axis of the pipe.

F.3.2.5 Protective Surround

The Contractor shall supply a protective surround for the portion of the rod within the embankment.

The surround shall consist of 300 mm diameter corrugated steel pipe (CSP) with the ends cut perpendicular to the axis of the pipe and free of burrs and sharp edges. The space between the CSP and the friction reducing sleeve shall be filled with medium to coarse sand.

F.3.3 Installation

F.3.3.1 General

The Contractor shall install settlement rods as per the contract drawings provided in addition to what is stated below.

F.3.3.2 Settlement Plate

The settlement plate shall be installed horizontally on the ground surface following completion of the sub-excavation and backfilling works. The elevation of the base of the plate shall be surveyed before fill placement commences for the embankment.

F.3.3.3 Rod

The rod shall be fixed to the centre of the plate and perpendicular to the plate.

The coupling of the rods shall be such that all sections have the same axis and no separation or contraction will occur at the couplings.

F.3.3.4 Friction Reducing Sleeve

The friction reducing sleeve shall be over the entire length of the rod that is below ground and within the embankment fill except that the cap on top of the settlement rod shall extend 25 mm above the top of the friction sleeve at all times.

F.3.3.5 Extension of Rod

The settlement rods shall be extended upwards as the embankment is constructed so that the top of the rod is always at least 0.3 m but no more than 2 m above the surrounding fill. The top of the rod shall be surveyed before and after each rod extension is added.

F.3.3.6 Protective Surround

The CSP, friction reducing sleeve and sand protective surround shall be extended with the rods.

The settlement plate rod shall be in the centre of the CSP and friction reducing sleeve.

The annulus between the CSP and the friction-reducing sleeve shall be filled with sand to a level not higher than the top of the sleeve.

F.3.3.7 Installation Details

The elevation, easting and northing of the centre of the base of the plate shall be surveyed.

The elevation, easting and northing of the top of the rod shall be surveyed before and after each rod extension is added.

The total distance from the base of the plate to the top of the rod shall be measured to an accuracy of ± 2 mm or better.

F.3.4 Coordination with Monitoring

F.3.4.1 Notification

The Contractor shall notify the Contract Administrator no later than three (3) working days after installing a Settlement Plates . At this time, the Contractor shall also supply the following information to the Contract Administrator:

- Elevations of plate and top of rod referenced to geodetic datum;
- Northing and easting of each Settlement Plate in MTM ON-10 coordinates;
- Dates of installation;
- Description of settlement rods, sleeve and plate;
- Installation photos.

Adjustments in the length of any settlement rod shall be coordinated with the Contract Administrator to allow surveying by others of the elevation of the top of rod immediately before and immediately after adjustment. This surveying is necessary to accurately track the settlement data.

F.3.4.2 Monitoring

Monitoring of the settlement rods shall be done by others. Monitoring shall be conducted prior to, during the embankment and surcharge construction. The Contractor shall provide installation information as specified above and provide access to the settlement rods for monitoring including, but not limited to a scaffolding platform and ladder if required and snow clearing in the winter. The Contractor shall provide electric power and general area lighting as needed for reading the instruments.

F.4 SETTLEMENT PINS (S) - SUPPLY & INSTALLATION

F.4.1 General

F.4.1.1 Scope

This section contains the requirements for the supply and installation of settlement pins (S).

The purpose of the settlement pin is to monitor settlement of the embankment fill . Settlement is measured by survey of the top of the pin with reference to stable non-settling benchmarks.

F.4.1.2 General Procedure

The Settlement Pins shall be cast into concrete at the top of the embankments, as shown on the Contract Drawings. The concrete will be cast in situ in a hole dug at the locations of the Settlement Pins.

F.4.1.3 Location

The Contractor shall install Settlement Pins on the shoulder of the Highway 17 embankment, at the locations shown on the Contract Drawings and given in Table F.4.

Table F.4 Settlement pin locations

Segment	Station ¹	Monitoring Section Type	Location ³	Left Settlement Pin Offset (WBL) ^{1,2}	Centre Settlement Pin Offset	Right Settlement Pin Offset (EBL) ^{1,2}
A	15+820	A	At new embankment crest	6	0	10
			At new embankment toe	10	-	14
			At ground surface	12	-	16
B	15+870	A	At new embankment crest	6	0	10
			At new embankment toe	15	-	19
			At ground surface	18	-	22

C	15+920	B	At new embankment crest	6	0	10
			At new embankment toe	20	-	-
			At berm crest	19	23	27
			At berm toe	-	-	32
			At ground surface	23	-	35
			At existing embankment crest	6	0	6
			At existing embankment toe	-	-	11
C	15+950	B	At new embankment crest	6	0	10
			At new embankment toe	22	-	-
			At berm crest	21	25	29
			At berm toe	-	-	34
			At ground surface	23	-	37
			At existing embankment crest	6	0	6
			At existing embankment toe	-	-	10

D	15+980	C	At new embankment crest	6	0	10
			At new embankment toe	18	-	-
			At berm crest	23	29	35
			At berm toe	-	-	40
			At ground surface	-	-	43
			At existing embankment crest	6	0	6
D	16+020	C	At new embankment crest	6	0	10
			At new embankment toe	14	-	-
			At berm crest	26	32	44
			At berm toe	-	-	49
			At ground surface			52
			At existing embankment crest	6	0	6

Note:

1. The stations for the settlement pins are approximate and are referenced from the centreline.
2. Left and Right Settlement Pins should be installed at the crest of the surcharge fill
3. For location see the typical drawings

F.4.2 Materials

F.4.2.1 General

The Contractor shall supply all materials and equipment required for the installation of the settlement pins.

F.4.2.2 Pin

The Contractor shall supply a 25.4 mm minimum diameter reinforcing steel bar (OPSS 905) cut 0.15 m long, or equal. The top reinforcing steel bar shall be angled or rounded in such a way that a single survey point can be clearly identified.

F.4.2.3 Concrete

The Contractor shall supply concrete (OPSS 1350) of minimum 25 MPa strength and set time sufficient to secure the pins within two (2) days of pouring.

F.4.3 Installation

F.4.3.1 General

The Contractor shall install settlement pins as per the drawings provided.

F.4.4 Coordination with Monitoring

F.4.4.1 Notification

The Contractor shall notify the Contract Administrator no later than three (3) days after installing a settlement pin. At this time, the Contractor shall also supply the following information to the Contract Administrator.

- Settlement pin location, easting and northing;
- Elevation of top of pin;
- Dates of installation and datum readings;
- Installation notes, sketches and photographs;

F.4.4.2 Monitoring

Monitoring of the settlement pins shall be done by others. Monitoring shall be conducted during the embankment construction. The Contractor shall provide installation information as specified above and provide access to the settlement pins for settlement monitoring.

F.5 INCLINOMETERS (SI) - SUPPLY & INSTALLATION

F.5.1 General

F.5.1.1 Scope

This section contains the requirements for the supply and installation of inclinometers (SI).

The purpose of the inclinometers is to monitor lateral displacement and its rate in the foundation soils as a result of the embankment construction.

F.5.1.2 General Procedure

The inclinometers shall be installed to the ground surface elevations after wick drain installation but prior to embankment construction. Monitoring, by others, shall be carried out prior to embankment construction to obtain baseline data. As the embankment height increases in lifts, the inclinometer casing shall be extended upward through the embankment fill. Immediately after the addition of extensions to the inclinometer and surrounding backfill is placed, a new inclinometer reading shall be taken.

The installation phase shall be complete when the surrounding embankment is at final design height and extension of the inclinometer casing is no longer required.

F.5.1.3 Location

The location and approximate installation depths of the inclinometers are given in Table F.5:

Table F.5 Slope inclinometer locations

Location					Estimated Elevation of Bottom of Inclinometer (m) ³	Estimated Inclinometer Length (m) to Ground Surface ⁴
Segment	Station ¹	Monitoring Section Type	Location	Approximate Offset from C/L ^{1,2} (m)		
B	15+870	A	At new embankment crest	10	162.5	29.5
			At new embankment toe	15	162.5	24.5
C	15+920	B	At new embankment crest	10	165.5	28.5
			At berm crest	24	165.5	24.0
C	15+950	B	At new embankment crest	10	165.5	29.5
			At berm crest	26	165.5	24.0
D	15+980	C	At new embankment crest	10	170	26.1
			At berm crest	28	170	19.6
D	16+010	C	At new embankment crest	10	176.5	20.5
			At berm crest	31	176.5	12.5

Notes:

1. The stations for SI are approximate and are referenced from the centreline of either the new highway or existing highway.
2. Actual locations of SI shall be determined on site based on the location of the embankment toe.
3. The actual elevation of the bottom of the inclinometer shall be determined by the Contractor during drilling of the borehole, based on socketing a minimum of 1.5 m into the very dense/hard deposit.
4. Top of surcharge or berm.

F.5.2 Materials

F.5.2.1 General

The Contractor shall supply inclinometer QC casing, manufactured by Slope Indicator Company, or equal. Fittings for the casing shall be consistent in manufacturer and system.

F.5.2.2 Casing

Casing shall be 70 mm OD, (Slope Indicator - model 57501100 or 51160311 - or equal) with telescoping sections (model 51160320 or equivalent) and anchors (model . 51104370 or equivalent).

F.5.2.3 Splices

If required, splice-kits shall be Slope Indicator model 51150250 (male) or 51150251 (female) - or equal.

F.5.2.4 Bottom Caps

Bottom caps shall be Slope Indicator model 51104370 - or equal.

F.5.2.5 Top Caps

Top caps shall be Slope Indicator model 51101500 - or equal.

F.5.2.6 Protective Surround During Embankment Construction

The Contractor shall supply a protective surround for the portion of the inclinometer casing in the embankment during construction. The protective surround shall consist of an inner plastic sleeve to reduce friction, and an outer 300 mm diameter corrugated steel pipe (CSP) filled with compacted sand. The CSP should be selected in accordance with OPSS 1801.

F.5.2.7 Protective Housing -Post Embankment Construction

The Contractor shall supply a protective housing consisting of galvanized steel pipe or box section with a minimum internal dimension of 100 mm and equipped with a locking cap to enclose the portion of the inclinometer casing that is above ground after construction of the embankment at the inclinometer locations.

F.5.2.8 Grout

The annular space between the inclinometer casing and the borehole shall be filled with grout that has similar strength as the surrounding soil, using the mix recommended by the casing manufacturer. The grout mix shall have a low drying shrinkage.

The Contractor shall submit a grout mix design to the Contract Administrator for information purposes, no later than fifteen (15) days prior to the start of installation of the Inclonometers.

F.5.3 Installation

F.5.3.1 General

Installation of the inclinometer casing shall be as per the manufacturer's recommendations in addition to what is stated or emphasized below.

Standard inclinometer casing lengths and bottom anchors shall be used. Telescopic inclinometer casing is recommended for this gradually raised embankment, since the casing might be subject to settlement more than 1 %. The casing anchor shall be installed in place of the bottom cap. Activated before the borehole is grouted, the anchor prevents the casing from floating upwards.

It should be noted that the inclinometers will be installed into the rockfill during the staged construction. The Contractor should be careful to prevent damaging the inclinometer pipe and casing during the placing the fill at each stage.

F.5.3.2 Boreholes

Boreholes for inclinometers shall be $\pm 2\%$ of vertical. The boreholes shall be of sufficient diameter to enable installation of the inclinometer casing and grouting of the annular space between the inclinometer casing and borehole.

F.5.3.3 Inclinometer Casing

The A inclinometer casing grooves shall be aligned perpendicular to the road centreline, with the A+ direction towards the outer side slope.

The B inclinometer casing grooves shall be aligned parallel to the road centreline, with the B+ direction 90 degree positive (anti-clockwise) from the A+ direction.

A+ and B+ direction grooves shall be permanently marked and identified on each casing. Care shall be taken not to apply torsion to the inclinometer casing during installation.

Inclinometer casing shall not be exposed to prolonged direct sunlight as it will cause deformation.

Prior to the embankment construction the casings which length is specified in Table F.5 shall be installed, by drilling a borehole using a 6" hollow stem auger drill, and then grouting the inclinometer casing in place

When installing and grouting around the inclinometer casing, the buoyancy force acting on the casing must be balanced. In addition to the bottom anchor clean water can be added inside the inclinometer casing, but additional force may be required and is ideally applied at the base of the inclinometer casing. The casing or pipe shall not be pushed down from the top to prevent buoyancy.

Above ground the inclinometer casing will be extended as the embankment is built. using the 300 mm CSP pipe, PVC pipe and the void should be filled with clean sand. The sand should be placed in stages and water shall be added to moisten the sand to increase the stiffness.

To extend the inclinometer casing the followings are instructions:

- When the end is a machined collar: the next piece will be glued, using ABS glue, in place paying attention to correctly aligned the pieces using the alignment key and notch in the matching pieces.
- When the end has been cut, the next piece will also be cut so the length of the new piece has a length of whole meters (i.e.: a piece can be 1.0m, 2.0m but not 1.xm or 2.x, where x is number different from zero),
- then using alignment tools and inclinometer coupling the pieces shall be glued together using ABS glue.
- The next section of CSP pipe shall be added using an appropriate coupling and then taped to prevent sand loss.
- At all times efforts shall be made to keep the inclinometer straight.

F.5.3.4 Grouting

Prior to grouting, the Contractor shall lower the dummy probe to confirm that all grooves are properly aligned and that the probe can reach the bottom of the inclinometer casing.

The annulus between the borehole and inclinometer casing shall be grouted up to the ground level. All drilling slurry shall be flushed out of the borehole. Grout shall displace any water from the borehole.

Once grouting is completed, the Contractor shall lower the dummy probe to the bottom of the inclinometer casing to confirm that it has been correctly installed.

Once the grout has set, the water level inside the casing shall be lowered to approximately 6 m below the ground to prevent freezing.

F.5.3.5 Protective Surround

A protective surround, consisting of a CSP and a friction reducing sleeve (PVC pipe) and sand backfill as specified in Drawing 7, shall be placed around the portion of inclinometer casing that is above the ground level. The length of the protective surround shall be such that the top of the inclinometer is approximately 300 mm above the top of the friction sleeve and the CSP.

The above ground portion of inclinometer casing shall be greater than 0.3 m in length.

F.5.3.6 Extension of inclinometer

As embankment construction proceeds, the inclinometer casing, PVC pipe sleeve and the protective surround shall be extended so that they are always above the current ground level.

Extension of the casing shall be coordinated with the placement of fill such that after the extension is added, the top of casing is not more than 2 m above the surrounding fill before placement and shall not be less than 0.3 m after fill placement.

F.5.3.7 Protective Housing

A protective housing shall be installed securely over the protective surround.

The protective housing shall allow easy access to the top of the inclinometer casing by hand and shall allow for the installation of the cable pulley/cable grip collar assembly used in monitoring by others.

F.5.4 Coordination with Monitoring

F.5.4.1 Notification

The Contractor shall notify the Contract Administrator no later than three (3) days after grouting of an inclinometer. At this time, the Contractor shall also supply the following information to the Contract Administrator.

- Northing and easting of each Inclinometer in MTM coordinates;
- Magnetic and grid bearings of A+ and B+ groove directions;
- Difference between A-axis bearing and line perpendicular to road centreline;
- Stratigraphic log of subsurface conditions at the inclinometer, including drilling method notes;
- Telescopic section and socket details;
- Elevations of top and bottom of casing and ground;
- Dates of installation; and,

- Installation notes and grouting notes.

F.5.4.2 Monitoring

Monitoring of the inclinometers shall be done by others. The Contractor shall provide installation information as specified above and provide access to the inclinometer for monitoring, including but not limited to providing a scaffolding platform and ladder as required and snow clearing in the winter. The Contractor shall provide electric power and general area lighting as needed for reading the instruments.

F.6 VIBRATING WIRE PIEZOMETER (VWP) & REFERENCE VWP (RVWP) - SUPPLY & INSTALLATION

F.6.1 General

F.6.1.1 Scope

This Section contains the requirements for the supply and installation of vibrating wire piezometers (VWP) and reference vibrating wire piezometers (RVWP).

The purpose of the piezometers is to monitor the piezometric head at depth within the foundation soil. The piezometer readings shall help establish the timing for fill placement for various stages and any surcharge removal.

F.6.1.2 General Procedure

The piezometers shall be installed in boreholes after wick drain installation but prior to any embankment construction.

The VW signal cables shall be extended out of the embankment footprint area through a metal or plastic conduit buried in trenches, as shown in the attached drawings.

Boreholes containing VWP sensors shall be located at least 3 m from other instrument boreholes.

F.6.1.3 Locations

The Contractor shall install VW sensors at the centre of the triangular wick drain grid at the locations and depths given in Tables F.6.1 and F.6.2.

Table F.6.1 Vibrating wire piezometers locations

Location				Approximate Elevation of Existing Ground Surface (m)	Estimated Tip Elevation of VWP ² (m)
Segment	Station ¹	Monitoring Section Type	Approximate Offset from C/L ^{1,2} (m)		
A	15+820	A	0	187.0	184.5 (Tip 1)
			0	187.0	179.5 (Tip 2)

B	15+870	A	0	187.0	184.0 (Tip 1)
			0	187.0	178.0 (Tip 2)
C	15+920	B	0	186.9	182.5 (Tip 1)
			0	186.9	178.0 (Tip 2)
			19	186.9	178.0
C	15+950	B	0	187.3	182.5 (Tip 1)
			0	187.3	178.0 (Tip 2)
			21	187.3	178.0
D	15+980	C	Close to C/L	187.8	185.0 (Tip 1)
			Close to C/L	187.8	181.0 (Tip 2)
			23	187.8	181.0
D	16+010	C	Close to C/L	187.5	185.0 (Tip 1)
			Close to C/L	187.5	181.0 (Tip 2)
			23	187.5	181.0

Notes:

1. The stations for VWP are approximate and are referenced from the centreline of the new highway.
2. Where multiple elevations are listed at the same location, install multiple VWP into one borehole.

Table F.6.2 Reference vibrating wire piezometers locations

Location			Approximate Elevation of Existing Ground Surface (m)	Estimated Tip Elevation of RVWP (m)
Segment	Station	Location		
C	15+920	Approximate location noted on Dwg 2	186.9	182.5 (Tip 1)
			186.9	178.0 (Tip 2)

Note: The provided elevations are estimated based on the closest available borehole. In some cases, this can be up to 50 m away. The RVWP tip should be placed within the soft clay deposit which should be confirmed on site through sampling.

F.6.2 Materials

F.6.2.1 VW Piezometers

The Contractor shall supply VW borehole piezometers (eg. Geokon model 4500S rated at -5 to 50 psi, or equal); compatible with a data logger (eg. Geokon model 8002-I, 8002-4, 8002-16 data logger, or equal). All VW piezometers and data loggers shall be of the same make/supplier.

All VWP shall be calibrated prior to installation and the calibration data for each VWP shall be provided to the Contract Administrator. Lightning protection for VWPs has to be considered. If the instrument is damaged by lightening the Contractor has to replace it within 2 days..

F.6.2.2 VW Data Recorder

The Contractor shall supply a Data Recorder (eg. Geokon model GK-404, or equal); compatible with the above VW piezometers. All VW equipment shall be of the same make.

F.6.2.3 Signal Cable

The Contractor shall supply signal cable compatible with the VW equipment. The VWPs shall withstand all of the temperature variations. The length of cable for each piezometer shall be carefully estimated from the construction drawings to ensure that there is enough signal cable for each piezometer to provide enough slack in the borehole and along the monitoring trenches to reach the location of each terminal. The cables and terminals shall be protected from construction equipment at all times.

F.6.2.4 Bentonite

The Contractor shall supply bentonite (OPSS 1205) in pellet form in sufficient quantity to form borehole plugs as required.

The Contractor shall supply bentonite in powder form in sufficient quantity for the bentonite-cement grout mix for general borehole backfilling.

F.6.2.5 Filter Sand

The Contractor shall supply clean washed sand with the following gradation:

Table F.6.3 MTO sieve designation

MTO Sieve Designation	Percentage Passing
4.5 mm - #4	100%
2 mm - #10	80% - 100%
850 µm - #20	20% - 100%
425 µm - #40	5% - 40%
150 µm - #100	0% - 5%

F.6.2.6 Grout

The annular space between the vibrating wire, cables and the borehole shall be filled with cement-bentonite grout prepared as follows: 17.7 kg of bentonite (OPSS 1205), 284 litres of water and 42.6 kg of cement (Type 10 - OPSS 1301).

F.6.2.7 Trench Burial and Conduit

The signal cable for each piezometer shall be buried in a shallow trench as shown in the attached drawings, and taken out of the embankment footprint area. The Contractor shall supply suitable conduits (e.g. Schedule 40- 75 m- 3" rigid PVC pipe) to protect the signal cables in the trenches and above ground surface. If appropriate, several signal cables may be housed in a single conduit and laid in a common trench. Before trenches are backfilled, the VW piezometers shall be tested.

F.6.2.8 Data Logger

The signal cables from the VWP and RVWP shall be connected to the nearest data logger, Slope Indicator Model 56701000 (CR1000), RST Model ELGL1200 – or equal. The data logger shall include, but not be limited to, interface modules, interface cables, data logger retrieval computer software, power supplies, solar panels, charge regulators and batteries that will allow for ten (10) years of regular monitoring. All data loggers shall be of the same make and shall be compatible with the VWP and RVWP instruments.

The Contractor shall submit a detailed proposal on the setup of the data-logger (i.e. numbers and locations of the data-logger units) to the Contract Administrator for review and approval, prior to ordering the data-loggers. An effort should be made to minimize the amount of data loggers at each site location to ease data retrieval. The Contractor shall program the data loggers according to the following:

- VWP and RVWP data shall be recorded two (2) times a day (i.e. one (1) reading every 12 hours)
- Test Software: once this program is transfer to the data logger, the system shall be able to be tested and record data manually on site.

The data shall be retrieved on site by direct wire (eg. RS232 or USB Cable) with a portable laptop computer.

F.6.2.9 Data Retrieval

The Contractor shall supply a laptop computer, Lenovo X140e or equal, equipped with a 128 gigabyte (gb) solid state drive, 4gb of RAM, two batteries, Microsoft Windows 7 Professional, Microsoft Office Home and Business 2013, Adobe Acrobat XI Standard and data logger software compatible with the data logger system selected. A vehicle adaptor for the computer charger is also required.

The portable laptop computer shall be handed to the Contract Administrator after the installation of instruments for the Monitoring Program.

The calibration factors for all vibrating wire piezometers shall be entered in the portable laptop computer by the Contractor for initialization of the instruments.

F.6.2.10 Wooden Posts

Wooden posts for the support of the data acquisition system enclosures shall be 100 mm by 100 mm in cross-section, minimum 3 m long pressure treated lumber, installed a minimum of 1.5 m into the ground.

F.6.3 Installation

F.6.3.1 General

Installation of the VW piezometers shall be as per the manufacturer's recommendations in addition to what is stated or emphasized below.

F.6.3.2 Borehole Installation

The borehole shall be advanced to 300 mm below the lowest tip elevation using suitable drilling techniques. The sides of the borehole shall be stable and the borehole shall be free of drilling mud and debris.

The exact borehole location shall be at the centre of the triangular wick drain grid and shall be determined in the field, after the wick drain installation.

F.6.3.3 Data Logger Boxes and Monitoring Shed

The data logger boxes shall be lockable and weatherproofed and securely attached inside the monitoring shed. The terminal boxes and data logger accessories shall be properly grounded.

The Contractor shall provide appropriate protection against natural hazards including but not limited to lightning strike. The Monitoring Shed shall be lockable. The Monitoring Shed shall be seated on a gravel pad and securely tied down to ground. The location of the Monitoring Shed shall not be susceptible to ground settlement. The Contractor shall submit a detailed proposal of the Monitoring Shed (i.e. materials and locations) to the Contract Administrator for review, prior to construction.

The Contractor shall ensure safe access to the Monitoring Shed at all times including, but not limited to, snow clearing in the winter.

F.6.3.4 Completion of Installation

It is known that the process of installing VW piezometers can temporarily alter the pore water pressure acting on the piezometer tip. The installation of a VW piezometer shall not be considered to be complete until the pore pressure acting on the piezometer has returned to and stabilized at the value prevailing in the surrounding, unaffected soil mass. The Contractor shall take daily reading of the pore pressures until the value has stabilized. Stabilization shall be deemed to have occurred:

- a. When no change in the measured value has occurred over a period of five (5) days and the measured value is within 10% of the anticipated hydrostatic value;
- b. When the daily rate of change is less than four (4) kPa per day for three (3) consecutive days and the measured value is within 5% of the anticipated hydrostatic value;
- c. Failing either of the two above conditions, as determined by the Contract Administrator

The Contractor should be prepared to wait for a period of 10 to 15 days after completion of installation of instruments for the baseline readings to stabilize.

F.6.4 Coordination with Monitoring

F.6.4.1 Notification

The Contractor shall notify the Contract Administrator no later than three (3) days after installing a VW piezometer. At this time, the Contractor shall also supply the following information to the Contract Administrator.

- VW piezometer location, easting, northing in MTM coordinates;
- Elevations of VWP sensors to geodetic datum;
- Stratigraphic log of subsurface conditions, including drilling method notes;
- Dates of installation;
- Installation notes, grounding method, sketches and photographs;
- Model, make and serial number of VW sensors, data logger and signal cable; and,
- Calibration details of VW sensors.

F.6.4.2 Monitoring

Monitoring of the VW piezometers, including establishment of baseline data, shall be done by others. Monitoring shall be conducted during the embankment and surcharge construction.

The Contractor shall provide installation information as specified above and provide access to the monitoring shed for data retrieval. The Contractor shall provide electric power and general area lighting as needed.

The Contractor shall transfer the Portable Laptop Computer and VW Data Recorder to the Contract Administrator, including all of the data logging software and hardware, operating instructions and calibration constants. The Contractor shall also transfer the keys for the locks of the Monitoring Shed(s). The Contractor shall be available for one site meeting with the Contract Administrator to transfer the items and answer any questions the Contract Administrator may have regarding the data-logging system.

F.7 BENCHMARKS (BM) - SUPPLY & INSTALLATION

F.7.1 General

F.7.1.1 Scope

This Section contains the requirements for the supply and installation of benchmarks (BM).

The purpose of the benchmarks is to provide non-settling references for the surveying of slope inclinometers (SI), settlement plates (SP) and settlement pins (S).

F.7.1.2 General Procedure

The benchmarks shall be installed prior to the embankment construction. The benchmark (BM) consists of a steel rod anchored to the bottom of a borehole.

F.7.1.3 Number and Location

The minimum number of benchmarks is specified on the contract drawings at each site. The number and locations of benchmarks shall be adjusted in the field such that the benchmarks are sufficient distance from the embankments to remain non-yielding, not affected by the embankment construction and direct sighting is possible from all inclinometers (SI), settlement plates (SP) and settlement pins (S) to at least one benchmark within each site.

The minimum number and approximate locations of the Benchmarks should be shown on the Contract Drawings.

F.7.2 Materials

F.7.2.1 General

The Contractor shall supply all materials and equipment required for the installation of the benchmarks (BM).

F.7.2.2 Rod

The Contractor shall supply a steel pipe Schedule 40 with an outside diameter not less than 25.4mm (1"), supplied in lengths as required to complete the installation as described in Section F.7.3.

The top end of each length of rod shall be threaded to receive a cap. A rounded cap shall be installed at the top of the rod in such a way that a single survey point can be clearly identified and returned to.

F.7.2.3 Sand

The Contractor shall supply clean washed sand with the following gradation:

Table F.7 MTO sieve designation

MTO Sieve Designation	Percentage Passing
4.5 mm - #4	100%
2 mm - #10	80% - 100%
850 µm - #20	20% - 100%
425 µm - #40	5% - 40%
150 µm - #100	0% - 5%

F.7.2.4 Grout

The Contractor shall supply cement-bentonite grout. A suitable grout mix design shall consist of 23 kg of bentonite (OPSS 1205), 143 litres of water and 40 kg of cement (Type GU – OPSS 1301).

F.7.2.5 Rod Anchor Grout

The Contractor shall supply cement-bentonite grout. A suitable grout mix design consists of 14 kg of bentonite (OPSS 1205), 49 litres of water and 40 kg of cement (Type 10 - OPSS 1301).

F.7.3 Installation

F.7.3.1 General

The Contractor shall install benchmarks (BM) as per the drawings provided in addition to the information below.

F.7.3.2 Borehole Installation

The borehole shall be advanced using suitable drilling techniques. The diameter of the borehole shall be sufficient to fit the rod, friction-reducing sleeve and rod anchor. The sides of the borehole shall be stable and the borehole shall be free of drilling mud and debris.

F.7.3.3 Rod Couplings

The coupling of the rods shall be such that all sections have the same axis and no separation or contraction will occur at the couplings.

F.7.3.4 Rod Anchor

The rod shall be installed vertically in the borehole with its bottom end resting at the bottom of the borehole. The rod shall be grouted in place.

F.7.4 Coordination with Monitoring

F.7.4.1 Notification

The Contractor shall notify the Contract Administrator no later than three (3) days after installing a benchmark. At this time the Contractor shall also supply the following information to the Contract Administrator:

- Elevations of the rod anchor and the top of rod to geodetic datum;
- Dates of installation;
- Stratigraphic log of subsurface conditions at the benchmark, including drilling method notes;
- Installation notes, sketches and photographs;
- Description of benchmarks.

F.7.4.2 Personnel/Access

Data collection, interpretation and reporting shall be conducted by the Contract Administrator or his representative.

The Contractor shall provide access and assistance to the Contract Administrator's representative reading all geotechnical instruments. This may include, but not necessarily be limited to, the following:

- Safe access to each instrument location; and,
- A stable platform to support the technician and equipment to access instruments at times when the casing is more than 1.2 m above ground level.

F.7.4.3 Monitoring

Monitoring of settlements with reference to the benchmarks shall be done by others. Monitoring shall be conducted before, during and after the embankment construction. The Contractor shall provide installation information as specified above and provide access to the benchmarks for monitoring including, but not limited to snow clearing in the winter. The Contractor shall provide electric power and general area lighting as needed.

F.8 DECOMMISSIONING OF INSTRUMENTS

F.8.1 General

The Contractor shall decommission all the Settlement Plates (SP) and Settlement Pins (S) at the end of the monitoring program following construction unless advised otherwise by the Contract Administrator. The Benchmarks (BM), Slope Inclinerometers (SI) and VW Piezometers (VWP/RVWP) shall not be decommissioned unless advised otherwise by the Contract Administrator.

Decommissioning of instrumentation shall be carried out according to the Ontario Water Resources Act, R.R.O. 1990, Regulation 903.

F.8.2 Payment

F.8.2.1 Basis of Pavement

Payment at the Lump Sum price for this tender item shall be full compensation for all labour, monitoring equipment and materials to do the work.

Appendix G – NSSP for Monitoring Program

NSSP FOR MONITORING PROGRAM

G.1 GENERAL

This non-standard special provision contains the monitoring program (i.e. schedule and frequency) for readings of following geotechnical instruments installed along Section 1 of new Hwy 17 embankment from Station 15+775 to Station 61+100:

- Settlement Plates (SP)
- Settlement Pins (S)
- Slope Inclinator (SI)
- Vibrating Wire Piezometers (VWP/RVWP)
- Survey Bench Marks (BM)

The installation details for the above noted items are contained in Appendix F of this report.

Beside this instrumentation monitoring the scope of work includes:

- Excavation of organics and compressible soils (Appendix B)
- Wick drains installation (Appendix D and E)

G.1.1 Purpose

The purpose of these instruments is to monitor settlements, lateral displacement and dissipation of excess pore-water pressures in the foundation soils during construction of the embankment along Section 1 of Highway 17 from Station 15+775 to Station 61+100, Rosspoint, Thunder Bay Area, Ontario. The embankment is required for new eastbound and westbound truck climbing lanes from Pays Plat River easterly for 7.2 km.

Monitoring services include the following:

- Requirements for data collection/reporting; and,
- Assessment of embankment performance based on data collected during instrumentation monitoring.

These requirements, as well as critical measurement readings are outlined in this appendix.

The rate and staging of fill placement and the timing for the removal of surcharge shall be controlled by these instrumentation readings. Pavement construction shall not take place until sufficient consolidation has been achieved as determined by the Contract Administrator.

It should be noted that monitoring of the instruments will be carried out by others after the installation of instrumentation by the Contractor.

The instrumentation shall not be decommissioned unless instructed by the Contract Administrator.

G.1.2 Personnel, Responsibilities and Submission

The Contractor shall issue plans and specifications prepared by the **exp** Services Inc. to the Contractor or undertaking the work.

The Contractor shall retain a Foundation Engineering consultant as their Subcontractor registered in MTO's Consultant Registry, Appraisal and Qualifications System (RAQS) for "Geotechnical Specialty – High Complexity", for this assignment.

The Foundation Engineer shall have a minimum of five (5) years' experience in the supply, installation and monitoring of the items listed in Section 1.1.3, or alternatively demonstrated expertise through providing satisfactory monitoring services for the instrumentation specified for a minimum of two (2) projects in which the work was of similar scope to that in the Contract.

"The Subcontractor" shall be understood to refer to the Contractor and their *Foundation Engineering Consultant*.

The *Foundation Engineering Consultant* shall:

- Review the Monitoring Program. If recommendations for modifications are required, these recommendations should be submitted in writing to the Contract Administrator;
- Review the reading frequency and ensure that data loggers have sufficient storage capacity to store data for the entire duration of the monitoring program;
- Meet with the Contractor to receive the VW Data Recorder, Portable Laptop Computer and associated software and to receive installation of instrument reports, as specified in Appendix A of this document. Contractors reports shall include all calibration certificates;
- With the exception of the Portable Laptop Computer, VW Data Recorder and all instruments installed by the Contractor, supply all materials and equipment required for the Monitoring Program;
- Calibrate and maintain instrumentation equipment;
- Take instrument readings, reduce data, prepare reports;
- Interpret readings as needed for the purposes of ongoing construction;
- Transmit instrumentation readings and reports to the Contract Administrator;
- Notify the MTO Contract Administrator if modifications to the construction procedures are required. Interpretation shall include making correlations between instrumentation data and specific construction activities;
- If critical measurement readings, as specified herein, for any instrumentation are reached, notify the Contract Administrator within 24 hours;
- Within 48 hours, discuss with the Contract Administrator response action(s), and submit a plan of action to prevent the critical instrument readings from being exceeded.

A progress report shall be provided to the Contract Administrator on a monthly basis. The report shall discuss the Contractor's operations with respect to the installation of instrumentation and/or a summary of the monitoring that was completed for the month.

The MTO Contract Administrator shall:

- Maintain a Foundations Monitoring diary. The diary shall include the following:
 - Document the original conditions;
 - Document work in progress (including extent/height of fill placement);
 - Record unusual situations or problems that arise;
 - Record actions taken by the Contractor to rectify these situation (if applicable); and,
 - Document the restored conditions (if applicable).
- Provide photographs of these conditions.

The *Foundation Engineering Consultant* shall discuss the applicable experience and qualifications of specialist staff, the role that each will play in administration of the contract, the authority to be assumed, and the reporting relationships with the construction administration staff.

The *Foundation Engineering Consultant* shall complete the Foundation Monitoring Plan table in the format provided below in Table G.1.

Table G.1. Foundation monitoring plan form

Foundation Monitoring Plan		
Major Monitoring Tasks	Level of Monitoring	Deliverable Record(s)
List major monitoring tasks associated with foundation monitoring.	State frequency/level of monitoring.	List associated Deliverable Records for each task.

Reference shall be made to the following drawings that are contained in Appendix A:

- Typical Monitoring Sections;
- Monitoring Section Location Plans; and,
- Monitoring Instrument Details.

G.1.3 Equipment Operation

Monitoring shall be conducted year round. All monitoring equipment and associated materials shall be capable of withstanding the range of temperatures possible for their location within the ground or on the surface. The instruments shall be capable of operating within the manufacturer's stated accuracy throughout the temperature range.

Any malfunctioning equipment shall be investigated and the malfunction should be remedied or replaced within two (2) business days. The Contract Administrator should be notified of any malfunctioning equipment.

G1.4 Reference Documents

The followings are reference documents for this monitoring program:

1. Geocres No. 42D-56: "Foundation Investigation and Design Report, Widening of Highway 17 East from Pays Plat River Easterly 7.2 km, Thunder Bay Area, Ontario" prepared by Exp Services Inc., June 13, 2019.
2. Geocres No. 42D-45: "Preliminary Foundation Investigation and Design Report, Proposed Embankment Station 15+800 to 16+275 Township of Lahontan Highway 17" prepared by TBT Engineering Ltd., December 19, 2016
3. Drainage and Hydrology Report GWP 612-15-00 "Highway 17 Eastbound and Westbound Truck Climbing Lane, Curve Realignment and Hazard Rock Improvements Pays Plat First Nation Easterly" prepared by Associated Engineering, July 28, 2017
4. Preliminary Design Report GWP 6120-15-00 "Highway 17 Pays Plat River Easterly, Truck Climbing Lanes, Curve Realignment, Hazard Rock and Resurfacing Pays Plat First Nation Easterly" prepared by TBT Engineering Ltd., October 9, 2018

G.2 READING SCHEDULE AND FREQUENCY

The *Foundation Engineering Consultant* shall save and archive raw data in electronic and hard copy format.

The monitoring shall commence immediately after the installation of an instrument. Monitoring is to continue during a period from the start of embankment construction to at least six (6) months following surcharge removal. The actual length of the monitoring period depends on the construction schedule and the results of monitoring amongst other factors.

Settlement Plates and Settlement Pins at the top of the new embankment should be removed prior surcharge removal and pavement construction, therefore, their monitoring will be terminated before the other instruments. The new Settlement Pins shall be installed after paving to continue settlement monitoring of the new embankment.

The minimum monitoring frequencies along with the anticipated number of readings for the Hwy 17 embankment are given in Tables G.2.1 to G.2.4. The Contract Administrator may increase/decrease monitoring frequencies, if required.

It should be noted that the number of readings given in Tables G.2.1 to G.2.4 are approximate and may vary due to the uncertainty associated with the construction schedule.

Table G.2.1 Minimum monitoring frequency for the construction of Hwy 17 in Segment A (Station 15+820; No staged construction)

STAGE	FREQUENCY	ANTICIPATED NUMBER OF COLLECTIONS PER SECTION ²
Baseline reading ¹	3 readings on 3 consecutive days. Must not be sooner than 7 days following installation of monitoring equipment	3
Immediately prior to start of embankment construction	Once	1
During embankment construction (Maximum 2.5 m)	Once after 1.5 m lift and following placement of final lift (within 20 m of the monitoring section)	2
During waiting period (Estimated 6 months)	Weekly for first month Fortnightly for second month Monthly for remainder of waiting period	10

Table G.2.2 Minimum monitoring frequency for the staged construction of Hwy 17 in Segment B (Station 15+870)

STAGE	FREQUENCY	ANTICIPATED NUMBER OF COLLECTIONS PER SECTION ²
Baseline reading ¹	3 readings on 3 consecutive days. Must not be sooner than 7 days following installation of monitoring equipment	3
Immediately prior to start of embankment construction	Once	1
During Stage 1 embankment construction (2.5 m)	Once after 1.5 m lift and following placement of final lift	2
During Stage 1 waiting period (estimated 1 month)	Weekly	4
During Stage 2 embankment construction (1.5 m)	Once following placement of the lift	1
During Stage 2 waiting period (estimated 1 month)	Weekly	4
During Stage 3 embankment construction (1.5 m)	Once following placement of final lift	1
During Stage 3 waiting period (estimated 4 months)	Weekly for first month Fortnightly for second month Monthly for remainder of waiting period	8
After surcharge removal to completion of consultant assignment (estimated 6 months)	Weekly for first month Monthly for second month to 6 months following surcharge removal	7

Notes:

1. *Baseline readings: Values of readings taken prior to construction to provide a baseline against which all subsequent readings are compared to assess movements of the ground and changes in piezometers due to construction activities.*
2. *These values represent the anticipated number of visits and do not represent the total number of visits required to carry out the monitoring program described herein. In addition, depending on construction scheduling, the number of site visits may be greater than shown above.*

Table G.2.3 Minimum monitoring frequency for the staged construction of Hwy 17 in Segment C (Station 15+920)

STAGE	FREQUENCY	ANTICIPATED NUMBER OF COLLECTIONS PER SECTION ²
Baseline reading ¹	3 readings on 3 consecutive days. Must not be sooner than 7 days following installation of monitoring equipment	3
Immediately prior to start of embankment construction	Once	1
During Stage 1 embankment construction (2.5 m)	Once after 1.5 m lift and following placement of final lift	2
During Stage 2 embankment construction (1.5 m)	Once following placement of the lift	1
During Stage 2 waiting period (estimated 1.3 month)	Weekly	5
During Stage 3 embankment construction (1.5 m)	Once following placement of final lift	1
During Stage 3 waiting period (estimated 1 month)	Weekly	4
During Stage 4 embankment construction (1.5 m)	Once following placement of final lift	1
During Stage 4 waiting period (estimated 0.5 month)	Weekly	2
During Stage 5 embankment construction (1.5 m)	Once following placement of final lift	1
During Stage 5 waiting period (estimated 5 months)	Weekly for first month Fortnightly for second month Monthly for remainder of waiting period	9

After surcharge removal to completion of consultant assignment (estimated 6 months)	Weekly for first month Monthly for second month to 6 months following surcharge removal	7
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Notes:

1. *Baseline readings: Values of readings taken prior to construction to provide a baseline against which all subsequent readings are compared to assess movements of the ground and changes in piezometers due to construction activities.*
2. *These values represent the anticipated number of visits and do not represent the total number of visits required to carry out the monitoring program described herein. In addition, depending on construction scheduling, the number of site visits may be greater than shown above.*

Table G.2.4 Minimum monitoring frequency for the staged construction of Hwy 17 in Segment D (Station 15+970 and 16+020)

STAGE	FREQUENCY	ANTICIPATED NUMBER OF COLLECTIONS PER SECTION ²
Baseline reading ¹	3 readings on 3 consecutive days. Must not be sooner than 7 days following installation of monitoring equipment	3
Immediately prior to start of embankment construction	Once	1
During Stage 1 embankment construction (2.5 m)	Once after 1.5 m lift and following placement of final lift	2
During Stage 2 embankment construction (1.5 m)	Once following placement of the lift	1
During Stage 2 waiting period (estimated 1.3 month)	Weekly	5
During Stage 3 embankment construction (1.5 m)	Once following placement of final lift	1
During Stage 3 waiting period (estimated 1 month)	Weekly	4
During Stage 4 embankment construction (1.5 m)	Once following placement of final lift	1
During Stage 4 waiting period (estimated 0.5 month)	Weekly	2
During Stage 5 embankment construction (1.5 m)	Once following placement of final lift	1
During Stage 5 waiting period (estimated 0.5 month)	Weekly	2

During Stage 6 embankment construction (1.5 m)	Once following placement of final lift	1
During Stage 6 waiting period (estimated 6 months)	Weekly for first month Fortnightly for second month Monthly for remainder of waiting period	10
After surcharge removal to completion of consultant assignment (estimated 6 months)	Weekly for first month Monthly for second month to 6 months following surcharge removal	7

Notes:

1. *Baseline readings: Values of readings taken prior to construction to provide a baseline against which all subsequent readings are compared to assess movements of the ground and changes in piezometers due to construction activities.*
2. *These values represent the anticipated number of visits and do not represent the total number of visits required to carry out the monitoring program described herein. In addition, depending on construction scheduling, the number of site visits may be greater than shown above.*

G.2 INSTRUMENTATION SPECIFIC REQUIREMENTS

G.2.1 Monitoring of Foundation Settlement

G.2.1.1 Surveying

The surveyor shall be a registered surveyor with appropriate equipment and experience.

The elevations of the survey target of the settlement plates (SP) and settlement pins (S) shall be surveyed to an accuracy of (+/-) 2 mm or better. Results should be reported to the nearest millimeter.

During the embankment construction, the Contractor will extend all settlement rods, friction protection sleeves and CSP protective surrounds simultaneously prior to the next fill lift placement. Elevations of the top of rod should be taken immediately before and immediately after the extension of rod and must be coordinated with the Contract Administrator and Contractor. The Contractor will notify the Contract Administrator no less than three (3) days prior to extending any settlement rod.

When taking survey readings of the SP and S, the elevations of top of embankment and top of berm (if applicable) in the vicinity of the SR and NP shall be surveyed concurrently to an accuracy of (+/-) 10 mm or better. Results should be reported to the nearest millimeter.

G.2.1.2 Reporting

If critical measurement readings are reached, the Contract Administrator shall be notified within 24 hours. A brief interpretation of the updated monitoring data shall be reported to the Contract Administrator within five (5) working days after each set of readings is obtained. A full set of up-to-date and processed monitoring data shall be presented in tabular and graphical form in the monthly progress report.

The following shall be submitted to the Contract Administrator in the monthly progress report (as a minimum):

- A plot of settlement of the base of the embankment (SPs) versus time;
- A plot of settlement of the top of the surcharge (S) versus time;
- Fill height/top of fill elevation within 20m of the instruments versus time;
- Plan view, cross section and profile sketches showing the top of fill location of the embankment and berm (if applicable) while the instrument data is collected.

G.2.1.3 Review and Alert Levels

If acceleration of settlements after placement of a lift of fill is observed or the maximum settlement measured exceeds the review levels in Tables G.2.1.1 and G.2.1.2, the following actions shall be taken:

1. The *Foundation Engineering Consultant* shall immediately inform the Contract Administrator;
2. The Contractor will submit a plan of action(s) to prevent alert levels being reached;
3. The *Foundation Engineering Consultant* will review the Contractor's plan with the Contract Administrator and provide appropriate recommendations to the Contract Administrator; and,
4. All construction work shall be continued such that instrument alert levels are not reached.

If the maximum displacement measured exceeds the alert levels in Tables G.2.1.1 and G.2.1.2, the Contract Administrator shall be immediately informed so they can instruct the Contractor to stop all

construction activities. Further construction activity shall not take place on the affected embankment until all the following conditions are satisfied:

- The cause of the accelerated settlement has been identified and analyzed by *the Foundation Engineer Consultant*;
- Ask Contractor to submit a plan of corrective action(s);
- Review Contractors plan of corrective action and provide recommendations to the Contract Administrator accordingly;
- Any corrective action(s) deemed necessary by the Contract Administrator and *the Foundation Engineer Consultant* has been implemented;
- The Contract Administrator deems it is safe to proceed.

Table G.2.1.1 Review and alert levels for settlement monitoring at settlement plates (SP)

Segment	Monitoring Section Type	Station	Lane	Offset from C/L of Specified Lane	Settlement Response Levels (mm)	
					Review	Alert
A	A	15+820	WBL	3 m	400	500
			EBL	3 m	400	500
B	A	15+870	WBL	3 m	760	900
			EBL	3 m	760	900
C	B	15+920	WBL	3 m	1200	1400
			EBL	3 m	1200	1400
C	B	15+950	WBL	3 m	1200	1400
			EBL	3 m	1200	1400
D	C	15+980	WBL	0*	1100	1300
			EBL	10 m	1100	1300
D	C	16+010	WBL	0*	1100	1300
			EBL	10 m	1100	1300

Note: () Since the new embankment is adjacent to the existing embankment, the location of this settlement plate will depend on the actual geometry on the site. However it can be located as close as possible to the centreline.*

Table G.2.1.2 Review and alert levels for settlement monitoring at settlement pins (S)

Segment	Monitoring Section Type	Station	Location	Offset from C/L of Specified Lane ¹	Settlement Response Levels (mm)	
					Review	Alert
A	A	15+820	New embankment/WBL	6 m	420	500
			New embankment/CL	0 m	420	500
			New embankment/EBL	10 m	420	500
B	A	15+870	New embankment/WBL	6 m	760	900
			New embankment/CL	0 m	760	900
			New embankment/EBL	10 m	760	900
C	B	15+920	New embankment/WBL	6 m	1200	1400
			New embankment/CL	0 m	1200	1400
			New embankment/EBL	10 m	1200	1400
			Existing embankment/WBL	6 m	85	100
			Existing embankment/CL	0 m	85	100
			Existing embankment/EBL	6 m	85	100
C	B	15+950	New embankment/WBL	6 m	1200	1400
			New embankment/CL	0 m	1200	1400
			New embankment/EBL	10 m	1200	1400
			Existing embankment/WBL	6 m	85	100
			Existing embankment/CL	0 m	85	100
			Existing embankment/EBL	6 m	85	100
D	C	15+980	New embankment/WBL	6 m	1100	1300
			New embankment/CL	0 m	1100	1300
			New embankment/EBL	10 m	1100	1300

			Existing embankment/WBL	6 m	85	100
			Existing embankment/CL	0 m	85	100
			Existing embankment/EBL	6 m	85	100
D	C	16+010	New embankment/WBL	6 m	1100	1300
			New embankment/CL	0 m	1100	1300
			New embankment/EBL	10 m	1100	1300
			Existing embankment/WBL	6 m	85	100
			Existing embankment/CL	0 m	85	100
			Existing embankment/EBL	6 m	85	100

Note: 1. The stations for the settlement pins are approximate and are referenced from the centreline of the new and existing embankments.

G.2.2 Monitoring of Lateral Foundation Displacements

G.2.2.1 Equipment

The *Foundation Engineering Consultant* shall supply the following:

- a control cable (of adequate length) to read all slope inclinometers;
- an inclinometer probe; and,
- a readout unit (with required accessories) for the slope inclinometer monitoring.

The slope inclinometer system shall consist of a DigiTilt AT Inclinometer System, or equal.

Readings from the slope inclinometer shall be taken consistently in either metric or imperial units.

The probe, cable and readout unit shall be calibrated prior to taking baseline readings and following the manufacturers recommended maintenance schedule. Calibration records shall be available upon request by the Contract Administrator.

The slope inclinometer shall be read by an experienced geotechnical technologist or geotechnical engineer. One slope inclinometer probe, one control cable and one readout unit should be used exclusively throughout the entirety of the monitoring program. Should this not be the case and new equipment is used, two sets of readings should be taken in succession. These results should then be compared and, if required, corrections should be made. The readings obtained with the replacement equipment shall become the initial (baseline) readings for subsequent readings.

G.2.2.2 Data Collection

Data collection shall be done in accordance with the slope inclinometer probe's manufacturer's recommendations and instructions.

The readings shall be taken from the bottom of the casing upward. Care shall be taken not to take readings with the probe wheels in a casing joint. During fill placement, the slope inclinometer casing

shall be extended to accommodate the change in reference point (top of casing) such that the readings are taken at the same elevations for each data set.

One complete data set shall consist of two runs:

- with the uppermost wheel in the A+ groove (expected direction of movement)
- rotate probe 180°, with uppermost wheel in the A- groove (opposite expected direction of movement).

The convention for the direction and sign of lateral movements shall be:

1. "A" direction shall be in the direction perpendicular to the embankment centerline
- "B" direction shall be in the direction parallel to the embankment centerline
2. A+ shall be towards the toe of the embankment (away from embankment centerline)
3. A- shall be towards the centerline of the embankment

G.2.2.3 Reporting

The Contract Administrator shall be notified within 24 hours if critical measurement readings are reached. Should this occur, the following information shall be submitted to the Contract Administrator:

1. Fill height vs time;
2. Plan view, cross section and profile sketches showing the top of fill location while the inclinometer readings were being taken;
3. Top elevation of the slope inclinometer casing. These readings must be within +/- 2 mm;
4. Cumulative and incremental lateral displacement versus depth/elevation plots for both A and B directions;
5. Cumulative and incremental lateral displacement versus time plots at the elevation(s) of maximum lateral displacement, for both A and B directions; and,
6. A brief interpretation of recorded displacements.

This information must be submitted to the Contract Administrator within five (5) working days after each set of readings is obtained:

G.2.2.4 Review and Alert Levels

If displacement after placement of a lift of fill is observed or the maximum displacement measured exceeds the review levels in Table G.2.2.1, the following actions shall be taken:

1. The *Foundation Engineering Consultant* shall immediately inform the Contract Administrator;
2. The Contractor will submit a plan of action(s) to prevent alert levels being reached;
3. The *Foundation Engineering Consultant* will review the Contractors plan with the Contract Administrator and provide appropriate recommendations to the Contract Administrator; and,
4. All construction work shall be continued such that instrument alert levels are not reached.

If the maximum displacement measured exceeds the alert levels in Table G.2.2.1, the Contract Administrator shall be immediately informed so they can instruct the Contractor to stop all construction activities. Further construction activity shall not take place on the affected embankment until all the following conditions are satisfied:

- The cause of the displacement has been identified and analyzed by the *Foundation Engineering Consultant*;

- The Contract Administrator to ask Contractor to submit a plan of corrective action(s)
- *The Foundation Engineering Consultant* to review Contractors plan of action and provide recommendations for corrective actions to Contract Administrator
- Any corrective action deemed necessary by Contract Administrator and the *Foundation Engineering Consultant* has been implemented; or,
- The Contract Administrator deems it is safe to proceed.

Table G.2.2.1 Review and alert levels for horizontal displacement monitoring at slope inclinometer (SI)

Segment	Monitoring Section Type	Station	Location	Offset from C/L (m)	Horizontal Displacement Response Levels (mm)	
					Review	Alert
B	A	15+870	At new embankment	10	75	100
			At new embankment toe	15	75	100
C	B	15+920	At new embankment	10	75	100
			At berm crest	24	75	100
C	B	15+950	At new embankment	10	75	100
			At berm crest	26	75	100
D	C	15+980	At new embankment	10	75	100
			At berm crest	28	75	100
D	C	16+010	At new embankment	10	75	100
			At berm crest	31	75	100

G.2.3 Vibrating Wire Piezometers (VWP) and Reference Vibrating Wire Piezometers (RVWP)

G.2.3.1 Data Logger/Readout Unit

The VWPs and RVWPs shall be read using the VW Data Loggers and Data Recorder supplied by the Contractor.

These readout and data logger units shall be tested prior to taking any baseline readings to ensure functionality.

The hydrostatic groundwater level elevation should be taken at the time the VWPs were read so that VWP data reduction (calculation of excess pore pressure) can be carried out. Excess pore pressure

should be calculated based on the hydrostatic groundwater level measured by the RVWP at the specific site.

G.2.3.2 Reporting

If critical measurement readings are reached, the Contract Administrator shall be notified within 24 hours. A brief interpretation of the updated monitoring data shall be reported to the Contract Administrator within five (5) working days after each set of readings is obtained. A full set of up-to-date and processed monitoring data shall be presented in tabular and graphical form in the monthly progress report.

The following shall be submitted to the Contract Administrator in the monthly progress report (as a minimum):

- Fill elevation in the vicinity of the VWP versus time;
- Plan view, cross section and profile sketches showing the top of fill location while the VWP and RVWP readings were being taken.
- Plot of hydrostatic groundwater elevation (RVWPs) versus time for each monitoring section (if installed);
- Plots of piezometric elevation versus time for VWPs located in the same monitoring section;
- Same as above for excess pore pressure (EPP);

G.2.3.3 Review and Alert Levels

The Review level is the value of instrumentation readings at which the Contract Administrator and the Contractor jointly assess the necessity of alternating the method, rate or sequence of construction and is generally taken as 80% of the Alert Level.

The Alert Level is the value of instrument readings at which the Contract Administrator can order the Contractor to cease construction operations, make the site and affected properties secure and take necessary and agreed upon measures to mitigate unacceptable movements and assure the safety of the work and public. In this case, the Alert Level of each VWP should be defined as the baseline pore water pressure plus 0.9 times the total vertical stress of new grading and surcharge fill placed above the finished wick drain drainage blanket surface elevation at the monitoring instrument location.

This non-standard special provision contains the monitoring schedule and frequency for readings of following geotechnical instruments:

If increases in pore pressure in excess of the increase in total stress after placement of a lift of fill is observed or the maximum settlement measured exceeds the review levels in Table G.2.1.1 and G.2.1.2, the following actions shall be taken:

1. The *Foundation Engineering Consultant* shall immediately inform the Contract Administrator;
2. The Contractor will submit a plan of action(s) to prevent alert levels being reached;
3. The *Foundation Engineering Consultant* will review the Contractors plan with the Contract Administrator and provide appropriate recommendations to the Contract Administrator; and,
4. All construction work shall be continued such that instrument alert levels are not reached.

If the maximum excess pore pressure measured exceeds the alert levels in Table G.2.3.1, the Contract Administrator shall be immediately informed so they can instruct the Contractor to stop all

construction activities. Further construction activity shall not take place on the affected embankment until all the following conditions are satisfied:

- The cause of the excess pore pressure has been identified and analyzed by *the Foundation Monitoring Engineer*;
- Ask Contractor to submit a plan of correction action;
- Review Contractors plan of correction action and provide recommendations to the Contract Administrator accordingly;
- Any corrective action deemed necessary by the Contract Administrator and *Foundation Monitoring Engineer* has been implemented;
- The Contract Administrator deems it is safe to proceed.

Table G.2.3.1 Review and alert levels for excess pore pressures

Segment	Monitoring Section Type	Station	Offset from C/L (m)	Tip Elevation (m)	Stage	Excess Pore Pressure (EPP) – Response Levels (kPa)		
						Review Level	Alert Level	Max EPP Before Following Stage ¹
A	A	15+820	0	184.5 (Tip 1) & 179.5 (Tip 2)	1	32	41	3
B	A	15+870	0	184.0 (Tip 1) & 178.0 (Tip 2)	1	32	41	23
					2	52	65	36
					3 (Surcharge)	73	92	5
C	B	15+920	0	182.5 (Tip 1) & 178.0 (Tip 2)	1	32	41	23
					2	52	65	36
					3	71	89	50
					4	91	113	63
					5 (Surcharge)	112	140	8
C	B	15+920	19	178.0	1	32	41	23
					2	52	65	36
					3	71	89	50
					4	91	113	63
					5 (Surcharge)	112	140	8
C	B	15+950	0		1	32	41	23

				182.5 (Tip 1) & 178.0 (Tip 2)	2	52	65	36
					3	71	89	50
					4	91	113	63
					5 (Surcharge)	112	140	8
C	B	15+950	21	178.0	1	32	41	23
					2	52	65	36
					3	71	89	50
					4	91	113	63
					5 (Surcharge)	112	140	8
D	C	15+980	0	185.0 (Tip 1) & 181.0 (Tip 2)	1	32	41	23
					2	52	65	36
					3	71	89	50
					4	91	113	63
					5	110	138	77
					6 (Surcharge)	132	165	9
D	C	15+980	23	181.0	1	32	41	23
					2	52	65	36
					3	71	89	50
					4	91	113	63
					5	110	138	77
					6 (Surcharge)	132	165	9
D	C	16+010	0	185.0 (Tip 1) & 181.0 (Tip 2)	1	32	41	23
					2	52	65	36
					3	71	89	50
					4	91	113	63
					5	110	138	77
					6 (Surcharge)	132	165	9

D	C	16+010	23	181.0	1	32	41	23
					2	52	65	36
					3	71	89	50
					4	91	113	63
					5	110	138	77
					6 (Surcharge)	132	165	9

Note : 1. Waiting period between construction stages shall be determined based on the specified Excess Pore Pressures (EPP). Fill placement following the waiting period (or removal of surcharge) shall not take place before the EPP drops below the specified values. Where multiple elevations are listed, install multiple VWP into one borehole.

G.3 CONTROL LEVELS – STABILIZATION OF SETTLEMENTS

The anticipated total settlement amount and the required time for settlements due to primary consolidation to stabilize shall be assessed for each of the SP and S using an appropriate analytical method.

Settlement data monitored at SP and S allow an approximate assessment of the total settlement due to primary consolidation and the approximate time required for settlements due to primary consolidation to stabilize.

G.4 FINAL REPORT

A final monitoring report shall be issued to the Contract Administrator at the completion of the monitoring program.

The results shall be presented in tabular and graphical form as described in previous sections. Interpretation of the monitoring readings shall be included in the report.