Brookfield Properties Monitoring Plan Essential Infrastructure Monitoring:

Fairview Drury Development

Prepared By:

EXP Services Inc.
405 Maple Grove Road, Unit 6
Cambridge, ON N3E 1B6

Date Submitted
June 23, 2022

Letter of Introduction

June 23, 2022

Tom Maxwell,
Assistant Project Manager
Multiplex Construction Canada Ltd.

Re: **Monitoring Plan for Essential Infrastructure Monitoring During Land Development**

Dear Tom Maxwell,

EXP Services Inc. (EXP) has grown into one of North America's largest engineering and consulting firms. With a mission to understand, innovate, partner and deliver, EXP provides professional, technical and strategic advisory services to the world's built and natural environments in six key practice areas: Buildings, Earth & Environment, Energy, Industrial, Infrastructure, and Sustainability. Our heritage dates back to 1906 when the earliest of EXP's predecessor companies started its engineering infrastructure practice in northern Ontario. Today, close to 3,000 creative EXP professionals across North America and around the globe provide the expertise and experience needed to deliver successful projects for clients. We're an integrated, motivated team of experts working together with all types of clients on projects big and small, locally, regionally, nationally and globally. We provide the experience and expertise needed to deliver successful project outcomes, locally and globally. With local knowledge and registrations in strategic locations around the world, we've got it covered.

With 110 offices across North America and over 20 offices and laboratories in Ontario, we are able to offer our services across the country and globally through our regional offices. This project will be completed through our Cambridge office Led by Project Manager, Andrew Holford, P. Eng., with support from our other offices and labs.

We have put together a team of professionals who have experience providing services on similar sized projects, and who are local and responsive. Based on our expertise and experience with similar projects, we confirm that we can comply with the scope of work, design stages and other requirements as outlined. Based on our experienced and specialized project team, our past project experience, and our dedication to a high level of quality and project management, EXP can provide Multiplex with exceptional quality service tailored to meet your specific project needs. EXP has a particularly strong background in the areas of Structural Monitoring and Building Science and was one of the first firms in Canada to develop expertise in this field; EXP has been involved in the rehabilitation of building structures since 1967, including Structural Monitoring. EXP's monitoring group has developed extensive experience including:

- Long-Term Structural Monitoring Campaigns;
- Rail & Bridge Structural Monitoring;
- Static and Dynamic Load Testing;
- Pre-Condition and Post-Condition Surveys;
- Sensitive Infrastructure Monitoring.

Thank you for this opportunity and please do not hesitate to contact us with any questions or comments.

Yours truly,



Zach Suderman
Lead Technologist
EXP Services Inc.



Andrew Holford, P.Eng.
Discipline Manager
EXP Services Inc.

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A. Monitoring Plan

Site Specifics

It is our understanding that Multiplex Construction Canada Ltd. ("Client") requires consulting services for Structural Monitoring and Sensor Layout to provide monitoring in compliance with GO Transit/Metrolinx's technical advisor during the development of the property located at 2243 Fairview Street, Burlington, Ontario. We are proposing two variations of monitoring for this project that will meet, and even exceed, the requirements set out by GO Transit/Metrolinx and their technical advisor of choice. This monitoring plan will work to provide monitoring solutions that answer all concerns that are typical of these project profiles. The proposed monitoring system will utilize long-based fibre optic strain gauges, tiltmeters, and inclinometers in combination with traditional survey displacement monitoring. The automated system will record continuously in real-time, live over the internet with automated multi-level alarm notifications. This monitoring plan will outline the strategic sensor layout in the rail corridor that will provide complete coverage.

The proposed excavation will extend approximately 11m below the current grade. The adjacent properties, including the GO Transit/Metrolinx rails and pedestrian bridge, are to be supported by a shoring system during the construction and redevelopment process. The design of the shoring is such that it will not encroach on any of the surrounding properties.

This monitoring plan is for the monitoring of the north shoring wall that supports the GO Transit/Metrolinx rail corridor including the pedestrian bridge and railway tracks adjacent. The pedestrian bridge is in proximity to the site while the nearest tracks are approximately 4.5m north of the excavation.

Work Plan

The work plan is being developed as per Part 6 of the Guidelines for shoring wall design and monitoring as dated November 15, 2018. The monitoring requirements of this project are summarized, below.

- The monitoring will provide coverage of two tracks as per meetings and the adjusted 1/1.5 slope for the furthest track.
- The monitoring instrumentation will be read daily either automated and/or traditional from the first day of excavation for shoring wall installation until the excavated area is backfilled (i.e. the construction reaches the ground level) (Section 12.6)
- Daily visual monitoring of the ground behind the shoring wall shall be performed by on-site staff (Section 12.9)
- Reflective monitoring targets shall be placed on a minimum of 1/3 of the piles (Section 12.11)
- The targets are to be placed at the top of the selected piles, at the level of all tiebacks and at the mid-point between two (2) consecutive levels of tiebacks (Section 12.12)
- The tracks are to be monitored as well as the shoring wall piles (Section 12.14)
- For filler caisson monitoring, the total number of inclinometers at filler piles shall be equal to 25% of the total number of king piles (Section 12.16)
- All inclinometers shall be installed such that initial readings can be obtained a minimum of 1 week prior to first drilling for the installation of the shoring wall (Section 12.17)
- The inclinometers will be read at the same schedule as that of the shoring targets (daily) (Section 12.18)
- The threshold of the lateral displacement is 0.1% of the excavated height (Section 12.22)
- In-ground monitoring points will be extended to cover 12m on either side of the proposed works, equally spaced and extended to 1.2 m below the ground surface (Section 13.4). Additional IMP survey points will be included at the requested spacing for two (2) tracks. As per the new 1/1.5 slope ratio, tracks 3 and 2 nearest the construction will be monitored.

The system layout for monitoring the north shoring wall the ground between the shoring wall and the nearest two tracks will include the following;

One-hundred and ninety-five (195) Conventional survey targets will be installed along with fifteen (15) inclinometers to monitor the north shoring wall adjacent to Metrolinx property;

Fibre optic sensors and autonomous monitoring stations with alarming capabilities will provide live monitoring utilizing in-ground points of the adjacent Metrolinx property in close proximity to the two (2) closest tracks;

In-ground traditional surveyed monitoring points adjacent Metrolinx property in close proximity to the two (2) closest tracks;

Surface mounted targets will be provided on the two (2) closest tracks;

Surface mounted targets on retaining walls & signal bungalow/transformer will be installed and monitored daily until the shoring wall is fully installed;

Bi-axial tiltmeters will be installed on the signal bungalow/transformer to provide inclination readings and alarming capabilities live after the shoring installation is complete.

As discussed, this plan will provide a sensor layout that will be provided to Metrolinx and their technical advisor to satisfy and meet their monitoring requirements and allow the development of the site to continue with all required safeguards in place.

The work plan specifics are as follows:

- **Provide multiple standalone monitoring systems to be installed in multiple stages (depending on access), that satisfies all stakeholder needs and concerns.**
- **Complete installation of the five (5) monitoring stations, cellular access points, and fifty-two (52) long based optical sensors providing in-ground monitoring points in close proximity to the nearest two tracks along the length of the excavation between the shoring wall and existing GO Transit/Metrolinx rail corridor;**
- **Complete installation of the two (2) bi-axial tiltmeters to monitor the exterior foundation of the GO Transit/Metrolinx transformer/signal bungalow closest to the work occurring;**
- **Complete installation of one-hundred and forty (140) in-ground monitoring points extending 1.2m below ballast grade, to be monitored daily once excavation starts until the shoring wall is completed. After that they will only be read if the continuous monitoring review threshold is exceeded;**
- **Complete installation of two-hundred and eighty (280) surface-mounted rail monitoring points to be monitored daily once excavation starts until the shoring wall is completed. After that they will only be read if the continuous monitoring review threshold is exceeded;**
- **Complete installation of one-hundred and ninety-five (195) surface-mounted targets on the south face of the north shoring wall. Installation of fifteen (15) inclinometers installed behind the north shoring wall;**
- **After installation has concluded baseline readings will be taken for at least one (1) week prior to construction to determine the normal operating mode of all monitored elements;**
- **Monitoring will be continuous for the automated rail and bi-axial tilt monitoring and daily for the inclinometer and survey displacement targets on the shoring wall. The automated rail monitoring will record static readings once every ten (10) minutes, 24 hours a day, throughout the duration of construction;**
- **Reporting will be completed daily and will be submitted every business day until construction reaches ground level;**
- **Live access to the system will be provided to the Client as well as any concerned party that has been given access;**
- **Review and alarm thresholds will be programmed into the automated system with limits provided in the below chart, each system can be tailored to automatically send review and alarm emails to all concerned parties when either a review limit or alarm limit is reached. This alert system will run 24/7 365 days a year.**

At the completion of the need for monitoring, all monitoring system components will be removed from the site. The inclinometers will be properly decommissioned at the conclusion of monitoring.

Installation and Removal

There will be two (2) independent monitoring systems to facilitate meeting the full monitoring requirements at this site, five (5) automated monitoring stations, conventional surveying and inclinometers for the shoring wall and integrated tilt monitoring for the signal bungalow. Each of the five (5) automated systems will have signage on the monitoring station that reads as follow:

Project Number: Metrolinx 3rd Party File Number XX
Contractor 24hr Contact Number:
AECOM Contact: XX
Monitoring System No.

The Contractor Contact and number will be added when selected. Each of the five (5) automated systems will be identified on the signage as well.

System 1: Location – Within Rail Corridor

The systems within the rail corridor will have a combined fifty-two (52) ground sensors separated into five (5) separate monitoring stations, ten (10) sensors in four and twelve (12) in the last station. Sensors will be installed parallel to the rails with twenty-six (26) in-ground sensors being installed between the rails in Track 3, the southern track, and then twenty-six (26) in-ground sensors will be installed approximately 0.5m south of the southern rail of Track 2, centre track. The strain sensors will be installed on plates with a 1.2m ground rod at the underside. The 1.2m deep points will be driven via handheld electric hammer into the ballast until flush with the finished grade. The stands will be installed on the in-ground points to mounting plates and then protected with a cover. The covers can be painted to highlight the sensor locations. The system will also include the installation of one-hundred and forty (140) in-ground monitoring points extending 1.2m below ballast grade and two-hundred and eighty (280) surface mounted rail to be monitored daily once excavation starts until the shoring wall is completed. After that, they will only be read if the continuous monitoring review threshold is exceeded. The signal bungalow on the east of the excavation will be monitored utilizing two (2) integrated bi-axial tiltmeters that will provide autonomous live monitoring of tilt and provide inclination values with alert thresholds. The sensors will be installed during the rail installation. The sensors will be mounted on the exterior east and west foundation. They will be fastened via tapcon for a permanent and stable fixture to the structure.

The monitoring cabinet and temperature sensor will be mounted on the existing chain link fence on the outside of the rail corridor. The fibre optic communication for each sensor will be bundled and highlighted to prevent tripping hazards. The installation of this system is anticipated to take up to thirty (30) days depending on the frequency of interruption from trains, ballast conditions and work times. Installation is anticipated to be completed during the day, after hours installation can be completed to minimize installation disruption but may impact installation cost and timing. Removal of this system will include removal of all ground rods and is anticipated to be performed in fifteen (15) days. The removal work can be performed after hours if necessary but may impact cost and timing.

System No. 2: Location – North Shoring Wall

The traditional survey system monitoring the shoring wall will include one-hundred and ninety-five (195) surface mounted targets and fifteen (15) in-ground inclinometers. All fifty (50) of the king piles of the north shoring wall will be monitored with a single surface mounted target both above and below the top waler for a total of two (2) targets per pile totalling one hundred (100) targets. There are 3 tieback levels for the piles along the north wall, so beyond the target at the top and bottom of the highest support of the piles, there will be five (5) additional targets to be installed at the upper, middle and bottom level tiebacks and between the tieback pairs. These targets will be applied to approximately 17 piles (Pile N2, N5… N50 on every 3rd king pile) for an additional total of eighty-five (85) targets. Additionally, ten (10) control points (reflective monitoring targets) will also be installed off-site to provide a stable

comparison for lateral and vertical pile movements. Fifteen (15) inclinometers will be drilled and installed on the north side of the north shoring wall. The installation will proceed prior to the installation piles, inclinometers will be installed in drilled holes to approximately 1.0 m into the sound rock (12 m depth from the surface on average). The location of the piles will need to be laid out prior to the installation of the inclinometers so that the pile installations will not damage the inclinometer installation locations.

Once installed the systems and sensors do not need any further maintenance or calibration. Any physical damage or displacement of sensors will be attended to as required. All monitoring systems will be maintained in place and monitored until the shoring wall is deemed to be laterally braced at the ground floor level.

Monitoring

EXP's continuous monitoring campaign will provide ongoing monitoring of the condition of the rail infrastructure and signal bungalow 24 hours a day, 7 days a week. This will be achieved by accessing the live data from all instrumented elements prior to and during the excavation, shoring and development to take place. With this system reading static measurements every 10 minutes continuously along with automatic review and alarm notification, no movements will go undetected for any length of time.

In addition to the autonomous monitoring, the shoring wall will be monitored daily through the surveying of all surface targets and the reading of inclinometers. The staff on-site will complete daily visual inspection of the shoring wall and the rail corridor. During the monitoring, if any sensors are observed to be damaged during operations, EXP will attend the site to replace the sensor as soon as possible upon notification of the damage.

The monitoring stations will be accessible over the internet and will be configured with review and alarm thresholds set to comparable levels that meet the intent requested by Metrolinx. Sensor layout and continuous live monitoring will provide an unmatched warning system for the rail infrastructure and pedestrian bridge to allow for effective response to any unwanted or deleterious quantifiable movement related to the excavation and development.

Reporting

Monitoring reporting will be completed as per Metrolinx Guidelines with daily readings and reports being completed throughout the entire open excavation phase of development, this will continue until the shoring wall becomes structurally braced at ground level, at which time monitoring will continue as follows:

-Once per day for 14 days

-Twice weekly for four (4) weeks (1 month)

-Monthly for three additional months.

Monday through Friday (Reports will be issued the next business day). For each sensor, a graphical representation of measurement vs time will be provided. These measurements will be reported to the micron **(0.001mm)** for strain and **0.001˚** for inclination. The cumulative movement will be presented from initial readings on an ongoing basis. For displacement and inclinometer readings, results will be reported to the nearest millimeter **(1mm)**

Reports will be distributed based on the list to be provided by all stakeholders.

Review and Alarm Automated Notifications

EXP's monitoring system will have an automated preprogrammed distribution list for both review and alarm thresholds. This list can be updated or modified at any time as required. The list can include up to five (5) contacts for each alert type (i.e. review and alarm). For surveying and inclinometers if any thresholds are exceeded EXP will immediately notify all parties of threshold exceedance.

Threshold Exceedance Protocol

A baseline of existing static movement ranges will be measured prior to any work. This baseline data can be used to identify and quantify any changes in behaviour or response pattern. This baseline can be used to change and update the initial thresholds below:

Table 1: Automated Movement Levels & Corresponding Actions

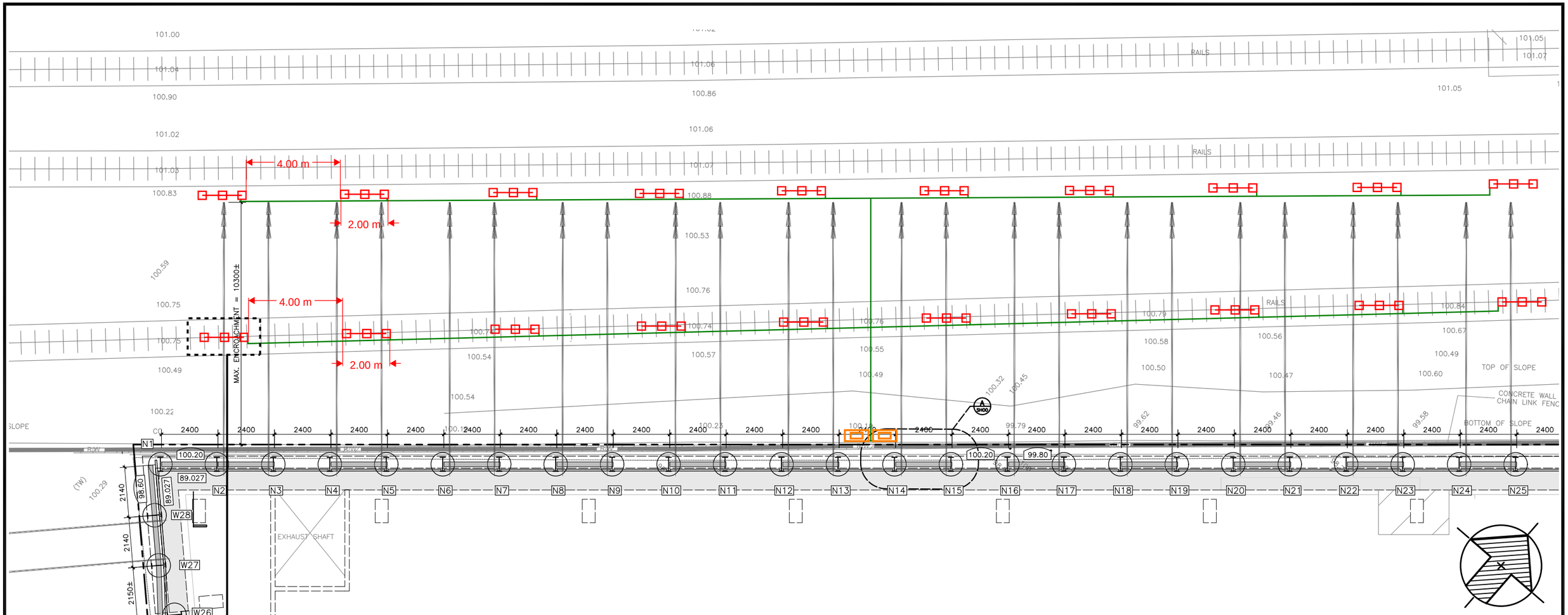
Action Status	Ground Strain	Signal Bungalow Tilt	Action
Level 0 (Allowable Limits)	**<5.000mm**	**<0.50˚**	**None**
Level 1 (Review Limits)	**>5.000mm**	**>0.50˚**	• **Automated notification of review level threshold exceedance** • **Review status of the monitoring station** • **Additional visual review of the site** • **A set of production readings of all survey points in the rail will be completed.**
Level 2 (Alarm Limit)	**>7.000mm**	**>1.00˚**	• **Automated notification of alarm level threshold exceedance** • **Review status of the monitoring station** • **Suspension of all construction activities** • **Review by shoring Engineer to assess the cause of identified movement** • **Development of a corrective/preventative plan** • **Implementation of necessary corrective/preventative measures** • **A set of production readings of all survey points in the rail will be completed.**

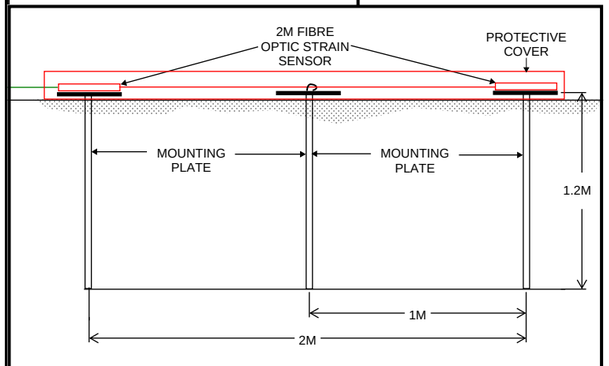
Table 2: Conventional Movement Levels & Corresponding Actions

Action Status	Movement (mm)	Action
Level 0 (Allowable Limits)	**< 4 Lateral** **<4 Settlement**	**None. Monitoring continues as per schedule. EXP will review the available data and provide comments on any potential ground movement concerns and implications to railway operations. The ground movement monitoring reports shall be forwarded to GO Transit / Metrolinx / their representative within 24 hours of readings.**
Level 1 (Review Limits)	**4 to 9 Lateral** **4 to 12 Settlement**	**EXP will immediately notify all parties involved. Monitoring frequency shall be increased to determine if any additional ground movement is occurring. Monitoring frequency shall remain increased until there is stabilization of the ground movement. The contractor shall plan for remedial track works within seven (7) days. The work may continue.**
Level 2 (Alarm Limit)	**9+ Lateral** **12 + Settlement**	**EXP will immediately notify all parties involved. The work will immediately cease until an assessment of the observed ground movement is conducted and inspected by a qualified and competent Geotechnical Engineer. The contractor shall arrange for immediate repairs to the track. The findings with a proposed action plan will be reviewed by GO Transit / Metrolinx / their representative. No construction shall take place until instructed by a qualified and competent Geotechnical Engineer and GO Transit / Metrolinx / Representative of GO Transit / Metrolinx subsequent to the following conditions being satisfied:** **1) The cause of the settlement has been identified;** **2) A corrective / preventative plan is established and adopted;** **3) Any corrective and / or preventative measures deemed necessary are implemented.**

If Alarm Level Threshold is exceeded all work will cease until an assessment of the observed ground movement is conducted and inspected by the Client's Geotechnical Engineer. The findings will be reviewed by GO Transit / Metrolinx and their technical advisors. Work may resume at the discretion of GO Transit / Metrolinx and their technical advisors after the implementation of satisfactory mitigation and preventative measures.

DRAWINGS





FIBRE OPTIC STRAIN GAUGE
TYPICAL INSTALL DETAIL
N.T.S

NOTES

ONE HUNDERED AND NINETY-FIVE (195) SURFACE SURVEY TARGETS WILL BE INSTALLLED ON THE SOUTH FACE OF THE NORTH SHORING WALL TO MONITOR DISPLACEMENT READINGS DAILY;
FIFTEEN (15) INCLINOMETERS WLL BE INSTALLED NORTH OF THE SHORING WALL AND WILL BE READ DAILY;
AECOM / GO TRANSIT / METROLINX SHALL BE NOTIFIED IMMEADIATELY IF REVIEW LEVEL IS REACHED;
AECOM / GO TRANSIT / METROLINX AND THE RAILWAY FLAGMAN SHALL BE NOTIFIED IMMEADIATELY IF THE ALERT LEVEL IS REACHED OR ANY ERRATIC GROUND MOVEMENT IS OBSERVED;
AECOM / GO TRANSIT / METROLINX SHALL HAVE THE RIGHT TO REQUEST ADDITIONAL MONIOTRING AT ANY TIME, PARTICULARLY IN REGARD TO THE FREQUENCY OR ACCURACY OF THE MONITORING.

LEGEND

- OPTICAL STRAIN SENSOR
- COMMUNICATION CABLE
- BI-AXIAL TILTMETER
- MONITORING STATION

REVISIONS:

No.	DATE	DESCRIPTION	INIT.

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DRAWING TITLE: MONITORING PLAN SENSOR LAYOUT- WEST SECTION

LOCATION: 2243 FAIRVIEW STREET, BURLINGTON, ON.

JOB #:

DWN.: ZS

SCALE: NTS

CHKD.: AH

DATE: NOVEMBER 26, 2021

DWG. No.: 1

PEDESTRIAN BRIDGE

4.00 m

4.00 m

4.00 m

4.00 m

GROUND CONNECTIONS

PROP. STM AD 14

TRACKSIDE BUNGALOW (TW)

CONCRETE WALL

CHAIN LINK FENCE ON

OF SLOPE

MAX. ENCROACHMENT = 10300±

3 SH6

4 SH7

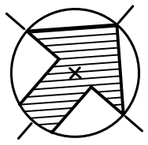
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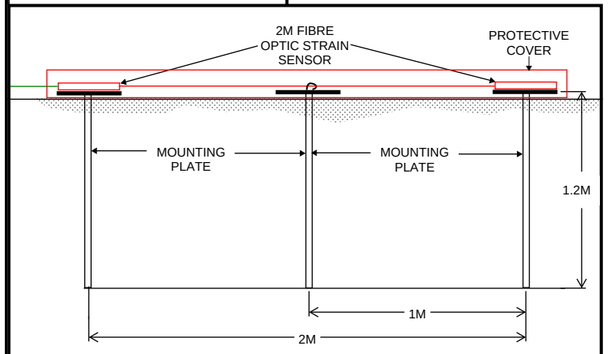
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99.60

99.10

N25 N26 N27 N28 N29 N30 N31 N32 N33 N34 N35 N36 N37 N38 N39 N40 N41 N42 N43 N44 N45 N46 N47 N48 N49 N50





FIBRE OPTIC STRAIN GAUGE
TYPICAL INSTALL DETAIL
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DRAWING TITLE: MONITORING PLAN SENSOR LAYOUT- EAST SECTION

LOCATION: 2243 FAIRVIEW STREET, BURLINGTON, ON.

JOB #:

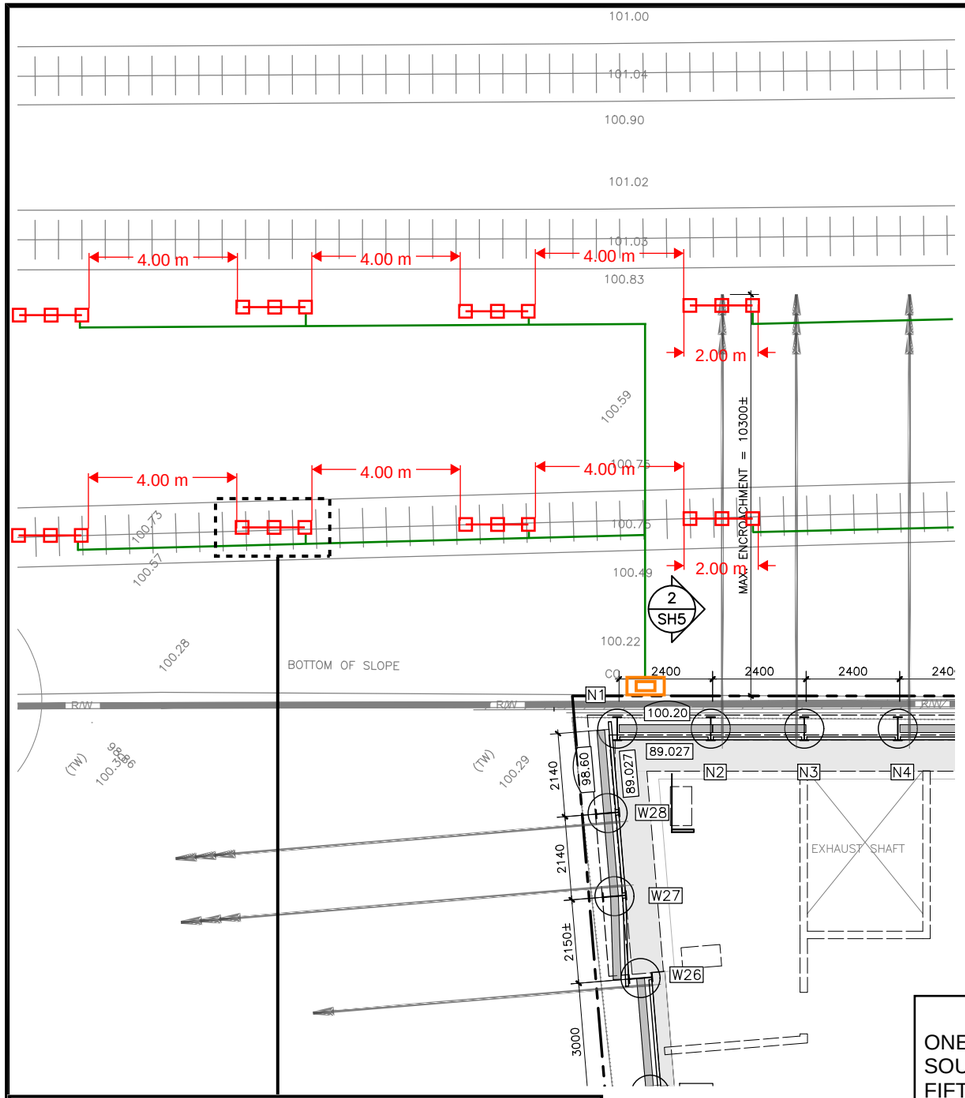
SCALE: NTS

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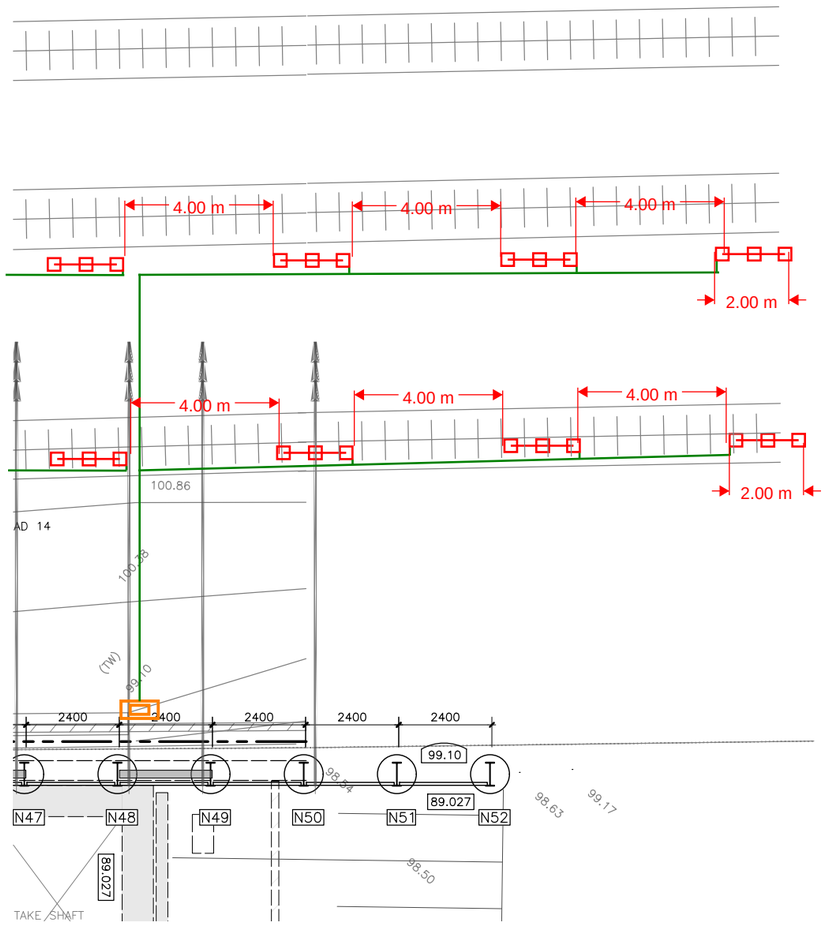
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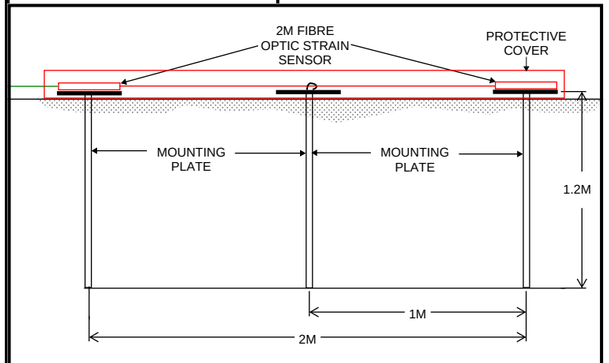
DWG. No.: 2



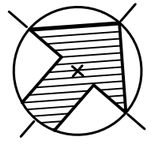
WEST 12M EXTENT

EAST 12M EXTENT





FIBRE OPTIC STRAIN GAUGE
TYPICAL INSTALL DETAIL
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DRAWING TITLE: MONITORING PLAN SENSOR LAYOUT- 12M EXTENTS

LOCATION: 2243 FAIRVIEW STREET, BURLINGTON, ON.

JOB #:

DWN.: ZS

SCALE: NTS

CHKD.: AH

DATE: NOVEMBER 26, 2021

DWG. No.: 3



exponential possibilities.