



Specialists in Explosives, Blasting and Vibration
Consulting Engineers

**Vibration Monitoring Plan
1040 Somerset Street West Development Project
Ottawa, Ontario**

Submitted to:

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Submitted by

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**Pre-Blast Inspection Report (150m)
Vibration Monitoring Location Overview
Blastvibrations.com Information Sheet**

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Corporate Profile

Since 1978, **Explotech Engineering** has provided vibration and blast consulting services to the mining and construction industries. Originally created in response to the need for specialized blast consulting services, we have continued to advance strategic partnerships and alliances in the blasting, engineering and technology sectors in an effort to provide turn-key services to our clients in both the public and private sectors. Explotech's offices in Ottawa and Sudbury provide industries across Canada and offshore with the expertise they need for consistently successful and cost effective blasting operations, no matter how difficult the situation may be.

Our experienced, qualified, hands on team has the specialized knowledge and training to effectively address every blasting issue which may arise. Utilizing our network of professional personnel and state of the art technology, we are able to provide solutions for the full range of blasting and construction requirements. We aim to provide elite class specialty engineering solutions to meet the needs of our clients.

Explotech Engineering provides the personal, hands on attention which is too often lacking in today's consulting industry. Under the capable direction of Rob Cyr, P. Eng, a designated specialist with over 30 years of international experience in the explosives and blasting field, our staff of engineers and associated professionals has the capability to address the complete range of blasting and related needs.



In the **construction** industry, Explotech expertise and services include:

- Blast design, control and monitoring of blasts
- Vibration, noise, and overpressure monitoring
- Damage criteria determination for vibration, overpressure and flyrock
- Preblast and postblast inspections
- Blast damage claim investigation
- Expert testimony in blast related lawsuits

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Services provided to the **mining** industry include:

- Blast design to address fragmentation, dilution and environmental impact.
- Vibration and overpressure monitoring locally and remotely via modems.
- VOD monitoring
- Vibration signature analysis and diagnostics
- Blast performance evaluation and optimization
- Blast Environmental impact analysis
- Damage criteria assessments for vibration, overpressure and flyrock



Explotech provides blast services to the **pipeline** industry in areas such as:

- Blast design, control and monitoring of blasts
- Vibration and overpressure monitoring
- Preblast and postblast inspections
- Damage criteria determination for vibration, flyrock and overpressure
- Blast safety and general blast information for pipeline inspectors
- Blast damage claim investigation
- Testimony in blast related lawsuits

Explotech technical and hands on experience has been called on to provide investigation services and expert testimony in cases where legal action was required. Personnel have been consistently recognized as experts in the field both in Canada and abroad.

Explotech has been involved in the design and implementation of Federal, Provincial and Municipal regulations across Canada. Additionally, training programs have been developed and provided to professional and academic institutions including the training of hands-on blasting contractors, education of professionals and management personnel, and the presentation of courses at the College and University levels.





Evidence of relevant experience/references

ExploTech engineers and associates represent amongst the most experienced, capable experts operating within the industry today. As demonstrated in the attached Curriculum Vitae, expertise provided incorporates years of invaluable practical experience coupled with extensive academic preparation. Such wide ranging qualifications permit the opportunity for analysis and commentary on most blast and construction related issue from both the technical and experience view-point.

ExploTech personnel are leaders in the Canadian explosive industry with over 100 years of combined experience in explosives and blasting. The organization has been instrumental in the development of Provincial and Federal legislation implemented to regulate blasting across the country. Over the past 40 years, ExploTech has successfully instituted vibration control programs on thousands of construction projects across Canada.



In accordance with your request, Explotech Engineering Ltd. (Explotech) has completed a site visit to the 1040 Somerset Street West Development Project site. Upon review of the current site conditions, as well as the contract documents and accompanying reports, we offer the following recommendations for implementation as a vibration control plan in accordance with applicable City of Ottawa specifications for the 1040 Somerset Street West Development Project.

1.0 Site Conditions for 1040 Somerset Street West

The construction site property is immediately bound by the Somerset Street West retaining wall and bridge abutment to the North, the O-Train railway tracks to the East, 55 Breezehill Avenue North to the South and Breezehill Avenue North to the West. Construction on site is expected to employ equipment typical of commercial development projects including rotary drill rigs, piling rigs, mechanical demolition equipment, excavators, hoe-rams, bulldozers and tri-axle trucks as well as the use of explosive blasting. Given that, the construction and blasting operations on site have the potential to generate vibrations outside of the property limits.

This vibration control plan has been prepared in order to comply with applicable City of Ottawa Specifications, specifically F-1201 "Use of Explosives", and other recommendations or requirements provided by project stakeholders and City of Ottawa personnel.

1.1 - Pre-Blast Inspection Surveys

In accordance with City of Ottawa F-1201 specification requirements, the 1040 Somerset Street West Development Project anticipates bedrock excavation from approximately 48.5masl to 42.6masl which should result in a total depth of rock excavation between 5m to 10 m. Given this, Explotech will complete a pre-blast inspection survey of the properties located within 150m of the defined construction limits in compliance with the outlined specification requirements. An overview of this inspection radius is attached to this report.

2.0 Vibration Monitoring Plan

In accordance with your request, Explotech Engineering Ltd. (Explotech) completed a review of the site conditions, upcoming construction activities including explosive blasting, as well as the contract documents and offer the following recommendations for implementation as a vibration control plan. The intent of this Vibration Monitoring Plan and ensuing monitoring program is to



delineate the intensity of vibrations generated by the construction operations and blasting operations imparted on adjacent structures.

As per the City of Ottawa F-1201 specification, “during each blast, ground vibration PPV and the peak sound pressure level shall be monitored at the closest structure, or 100 m, from the blast or at the closest portion of any residence, utility, structure, or facility within this radius” and “Multiple units may be required to establish base readings”. Considering this, the Vibration Monitoring Plan proposed includes provisions for monitoring four (4) categories of structures in order to guard against possible adverse impacts from vibrations generated from the construction and blasting operations, namely:

1. the Somerset Street West retaining wall and bridge abutment structures
2. the O-Train railway
3. adjacent surface structures
4. 1372mm watermain along Breezehill Avenue North

This plan shall be adopted for all earthworks operations including all excavation, piling, shoring, and blasting in the area to ensure that the applicable vibration limits are adhered to and that the possibility of damage to neighbouring structures is managed and mitigated.

3.0 Instrumentation, Daily Notification System & Distribution of Data

The Vibration Monitoring Plan proposed incorporates the application of the Blastvibrations.com online data dissemination service. The service automates the collection of blast and vibration information from seismographs in the field and provides global access to client data anytime, anywhere. The remote seismograph installed will be programmed to automatically upload vibration information to the internet for viewing by authorized individuals all the while ensuring the security and integrity of the data. The process is simplified even more by having the event automatically forwarded directly to personal e-mail accounts or text messaged to a cell phone if so desired.

The monitoring instruments installed will consist of Instantel tri-directional digital seismographs capable of measuring vibration intensities up to 254mm/s at a frequency response of 2 – 250Hz as a minimum. The units will be programmed to measure all vibration levels and corresponding frequencies continuously at a sampling rate of 1024 samples per second or higher depending on the installation location and the particular construction operation monitored. Following each five-minute interval, the units will review the 307,200 measured vibrations and frequencies and permanently record the peak particle velocity and the associated frequency for that time



interval while deleting all subordinate vibration intensities. This process is repeated for all subsequent five minute time intervals thereby providing maximum vibration intensities experienced at the structures throughout the day. Such a configuration permits continuous monitoring of vibration levels and provides complete coverage of all vibrations, construction induced or otherwise, experienced at the monitored structure.

As an additional analytical tool, the seismographs will be configured to record a more detailed waveform in the event that vibration intensities exceed a pre-set trigger level which will be individually programmed based on the limits applicable to each monitoring location. This feature will permit advanced analysis in the event that higher readings are recorded.

As a minimum, vibration data will be uploaded to the online servers on a daily basis to confirm equipment is functioning properly and to permit viewing of the trailing day vibration results by authorized stakeholders. In the event that elevated vibrations are generated, reporting procedures will adopt a soft real time protocol as outlined under Item 6.0 below.

4.0 Proposed Location of Installations

Prior to commencement of excavation, piling, shoring or blasting operations, eleven (11) seismographs will be installed adjacent to the development project. These proposed locations are visually demonstrated in the vibration monitoring location overview attached to this report and their naming convention will be as follows:

1. Somerset Retaining Wall Location 1
2. Somerset Retaining Wall Location 2
3. Somerset Bridge Abutment
4. O-Train Railway North
5. O-Train Railway South
6. 47 Hintonburg Place
7. 55 Breezehill Avenue North
8. 1372mm Watermain Location 1
9. 1372mm Watermain Location 2
10. 1372mm Watermain Location 3
11. 1372mm Watermain Location 4



4.1 Proposed Method of Installation for the Retaining Wall and Bridge Abutment

Two (2) vibration monitors will be installed along the approximate 20m span of Somerset Street West retaining wall which directly abuts the Northern edge of the project site. Furthermore, a third (3rd) monitor will be installed at the closest point of the bridge abutment structure to the immediate North of the site. Given the proximity of these sensors, geophones will likely be bolted directly to the concrete using 3/8" drop-in concrete anchors for both retaining wall and bridge abutment structures.

4.2 Proposed Method of Installation for the O-Train Railway

Two (2) vibration monitors will be installed on the closest (Western) edge of the O-Train track on the East side of the project site. The monitoring locations will represent the Northern and Southern portions of the adjacent railway respectively. Each geophone will be installed in or near the rail ballast either buried in the ground or coupled with spikes and a weighted sandbag as per industry best practices.

4.3 Proposed Method of Installation for the Adjacent Surface Structures

Two (2) vibration monitors will be installed at adjacent structures, namely 47 Hintonburg Place and 55 Breezehill Avenue North. These seismographs will likely be installed on the exterior point of each structure in order to measure the vibration readings at the closest point of the receptor. Geophone sensors may be bolted to an exterior foundation wall if approved by the individual homeowners, buried in the ground or coupled to the adjacent surface with spikes and a weighted sandbag as per industry best practices. Note that exact installation locations for these buildings would be determined after coordinating access and approvals with the required property owners and/or representatives.

4.4 Proposed Method of Installation for the 1372mm Watermain

Four (4) vibration monitors will be installed between the watermain structure and the subject excavation. These sensors will be installed on 9m to 10m spacing along Breezehill Avenue North to ensure the utility is sufficiently represented along the 45m long section of the 1372mm watermain directly adjacent to the Western side of the site.

The particulars of the sensor placement will be dependent on applicable approvals, equipment security, roadway and sidewalk access, logistics for drill access and ensuring a safe distance for the borehole from any tiebacks or existing utilities and services. Given the watermain is situated in overburden, Explotech recommends a subsurface sensor installation above, or in the near vicinity of the 1372mm-C01 watermain (refer to Figure 1 below). In order to permit

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subsurface sensor installation, the General Contractor would safely excavate down to the watermain using hydrovac equipment, casing the hole using a 300mm (12") diameter pipe installed vertically to maintain the opening and backfill around the vertical pipe for stability. Once the 300m PVC is secured in place, a cap will be installed on the top of the vertical pipe to prevent debris and water infiltration. The added benefit of this particular hydrovac operation is a safe methodology to visually identify the exact location of the watermain so that it's setback distance offset from the shoring system is confirmed for future reference from both a ground vibration and ground disturbance perspective.

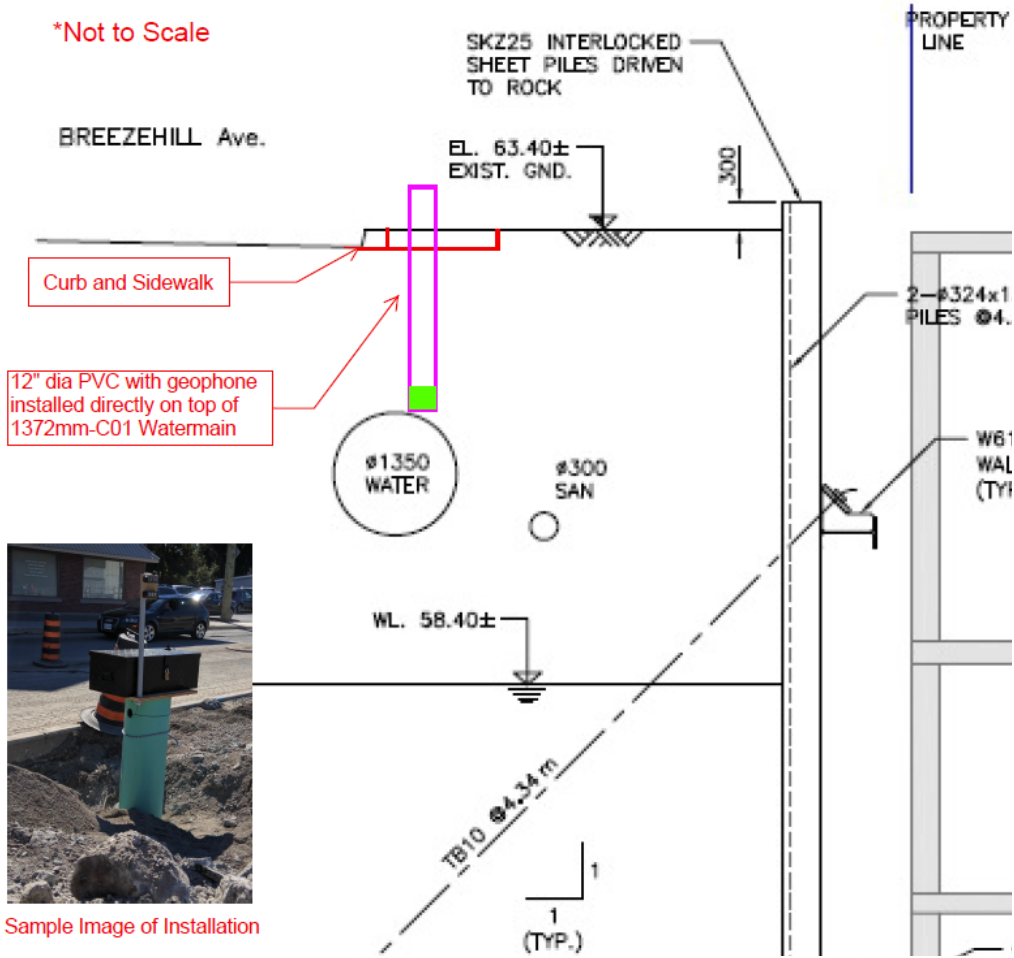


Figure 4 – Cross Section View of Geophone Sensor Installation Relative to the 1372mm-C01 Watermain structure



Explotech will subsequently install the geophone sensors in the bottom of the pipe directly above the watermain. This pipe method permits continual access throughout the project and allows for the removal of sensors at the end of the project so that no equipment requires abandonment. With that said the pipes are expected to be installed above the sidewalk which will require the necessary permissions from the City. Each of the four (4) monitoring locations will require approximately 0.6m x 0.6m of sidewalk space around the areas denoted in Figure 3 above.

5.0 Vibration Limits

Particle velocity is the descriptor of choice when dealing with construction vibrations because of its superior correlation with the appearance of cosmetic cracking. While particle velocities provide one measurement statistic, structural response to varied frequency necessitates the inclusion of frequency analysis in all vibration measurement. The United States Bureau of Mines (USBM) developed the RI8507 criteria utilizing a graded scale incorporating reduced permissible particle velocities at reduced dominant frequencies (refer to Figure 2 below). This is not to say that damage automatically occurs once these levels are breached and, in fact, threshold damage would not occur in the average structure until ground vibrations reached significantly higher intensities than those listed. These standard criteria have been set at very conservative levels in an effort to restrict adverse public response as opposed to strictly alleviating possibility for structural and cosmetic damage. Threshold damage would not normally occur until ground vibrations reached significantly higher intensities than those listed.

While the USBM graded scale from RI8507 represents the most accurate application of the findings of the study, as a simplification, the City of Ottawa Special Provision F-1201 implements particle velocity limits of 50mm/s at high dominant frequencies (in excess of 40 Hz) and 20mm/s for low frequency vibrations (less than 40Hz) (Refer to Figure 2 below).

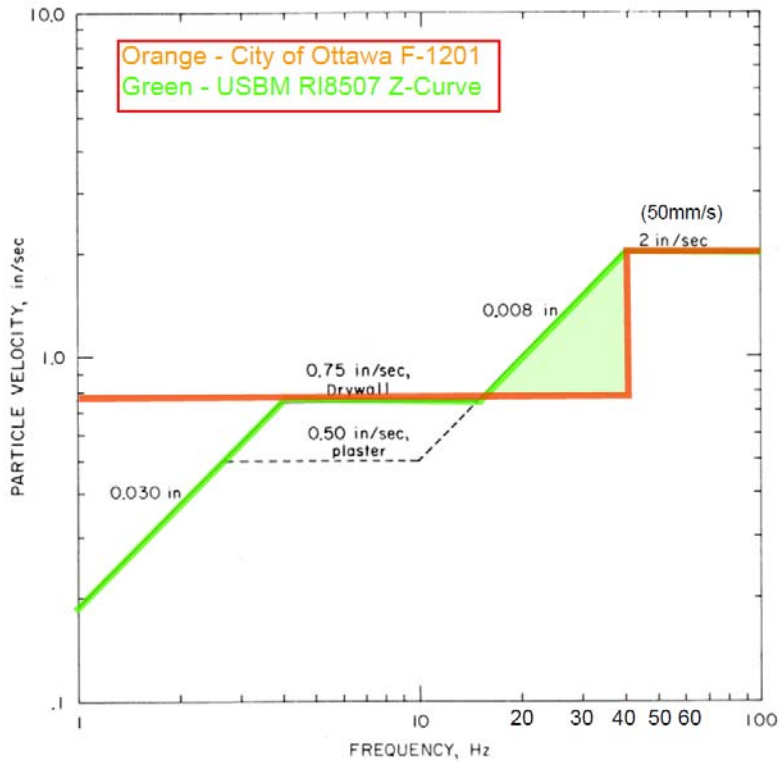


Figure 2 – USBM Z-Curve and City of Ottawa F-1201 Limits

With specific regards to the 1040 Somerset Street West Development Project, the following vibration limit will be enforced for each respective monitoring category:

1. the Somerset Street West retaining wall and bridge abutment
 - **F-1201 Limits as per City of Ottawa specification**
2. the O-Train railway
 - **50mm/s (regardless of associated frequency) as per rail specifications**
3. adjacent surface structures
 - **F-1201 Limits as per City of Ottawa specification**
4. 1372mm watermain along Breezehill Avenue North
 - **USBM Z-Curve as per Paterson Group’s Recommendations**

6.0 Notification System

For all monitoring scenarios outlined above, each time the seismographs installed register a vibration above a specified trigger level, the seismographs will automatically call up the Blastvibrations.com server and upload the vibration data to the website for notification to stakeholders. This will happen every time the unit is triggered. All of the old vibration data will remain accessible on the website so that it can be easily reviewed if required. If vibration levels remain below the trigger level, data will be collected and posted to the website on a daily basis.

Email notifications will be sent to an email notification list of approved stakeholders and personnel approved by Claridge. Explotech will review all email notifications to determine if the event recorded complies with contract limitations and that the event recorded is a valid construction and/or blasting induced vibration event. If Explotech personnel confirm a valid exceedance has occurred, Explotech will notify Claridge and designated onsite personnel who will review their construction and blasting operations and alter procedures as necessary.

Table 1: Vibration Limit Notifications for all Monitoring Locations		
PPV (mm/sec)	Action	Description of Event
PPV < 20	No action required	
$20 \leq \text{PPV} < 50$	Warning Level - Review construction / blasting operations and alter procedures as necessary. Proceed with caution with activities.	<u>Warning Notification Sent</u> Explotech will review vibration event and associated frequency for compliance
PPV ≥ 50	Exceedance Level - Cease construction / blasting operations until Explotech confirms event legitimacy. Review construction operations and alter procedures as necessary.	<u>Exceedance Notification Sent</u> Explotech will review vibration event and associated frequency for compliance

7.0 Equipment Malfunction

In the event that a component of the vibration monitoring system is no longer properly functioning, Explotech will notify Claridge personnel stating that a location is experiencing difficulties and ask that any vibration intensive work directly adjacent to the monitoring location is temporarily ceased. Explotech will then inspect the malfunctioning location to assess the repair actions that will be required. Upon completion of the inspection Explotech will notify all personnel via an email to the Email Notification List with an update on the status of the malfunctioning equipment and an estimation of the time required to complete the repairs. Once the repairs are complete and the vibration monitoring location is fully functional, Explotech will notify the required personnel.

8.0 Conclusion

The vibration monitoring plan detailed above represents a substantial and comprehensive monitoring program to assist in on-site vibration control, facilitate resolution of any concerns or complaints which may arise over the course of the project, and to ensure compliance with applicable guidelines, specifications, and industry standards. Should you require any additional information or clarification with regards to the above plan, please do not hesitate to contact our office at your leisure.

Kindest Regards,



Mitch Malcomson, P.Eng.
Explotech Engineering Ltd.





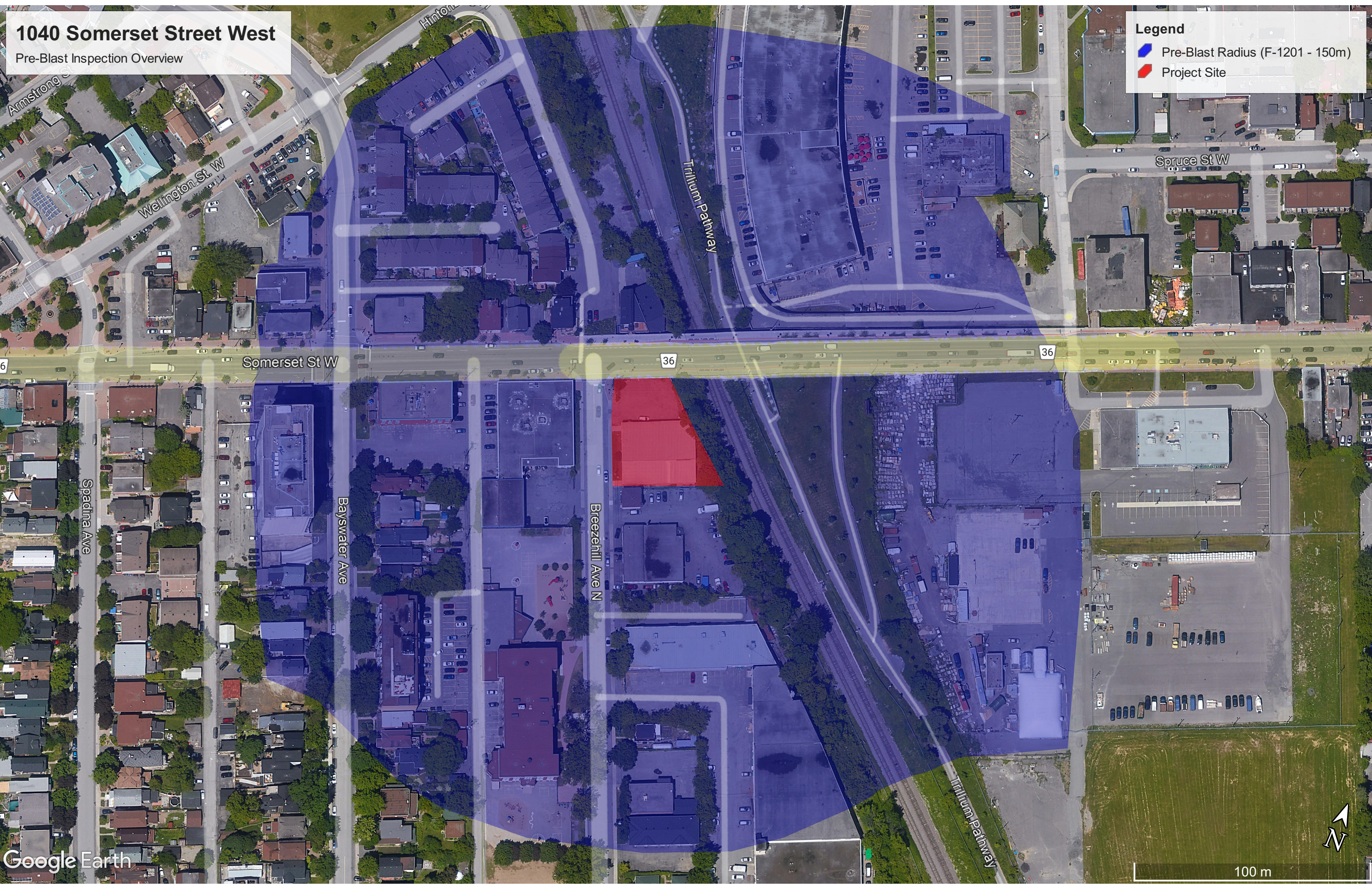
Encl.

1040 Somerset Street West

Pre-Blast Inspection Overview

Legend






-  Pre-Blast Radius (F-1201 - 150m)
-  Project Site



1040 Somerset Street West

Vibration Monitoring Overview

Legend

-  O-Train Railway Vibration Monitors
-  Working Area
-  Retaining Wall and Bridge Abutment Vibration Monitors
-  Surface Structure Vibration Monitors
-  Watermain Vibration Monitors

47 Hintonburg Place

Bridge Abutment

Retaining Wall 2

Retaining Wall 1

O-Train North

Somerset St W

Watermain 1

O-Train South

Watermain 2

Sen. Trillium

Watermain 3

Watermain 4

55 Breezehill Avenue North

Breezehill



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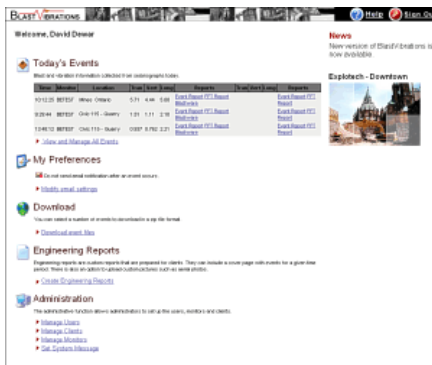
Simply the most effective, cost efficient way to monitor today

In order to remain compliant with increasingly stringent government regulations, project specifications and corporate protocol, there has developed a need within the industry for a timely, efficient, automated method for the reporting and dissemination of vibration data. The BlastVibrations system provides the efficient, effective, affordable means to achieve third party independent vibration monitoring in a simple and organized format.



The BlastVibrations monitoring system represents the latest advancement in the evolution of the vibration monitoring and control industry. Developed in response to an increased demand for immediate and automated access to vibration data, the *BlastVibrations* system leverages the power of the Internet to simplify the monitoring and reporting process and permit secure and reliable access to data from anywhere, at anytime.

The *BlastVibrations* system is configured to operate with the InstanTel Blastmate III and Minimate Plus line of vibration monitors to provide a direct remote link between operator and seismograph. When a monitor records a vibration event, it automatically uploads the recorded data to the Internet where it can be easily viewed on the password-protected BlastVibrations website. Authorized personnel can review data within minutes of an event, and the security and integrity of the data is ensured.



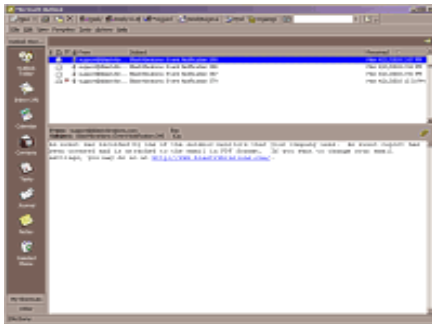
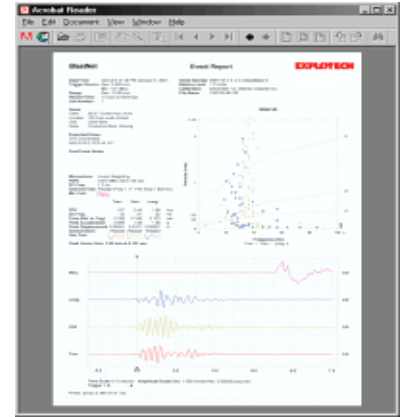
Access to your data is always available. This new web service collects event report information as it happens. This information is automatically updated and archived on an Internet server for later viewing by simply logging onto the *BlastVibrations* system with your user name and password. With the access to the data being password protected, this allows clients to choose who can view the data and prevents unauthorized individuals from viewing your information.

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Simply the most effective, cost efficient way to monitor today

Convenient filters are provided to narrow the set of events and to view events coming from a particular location. These filters make it possible to view and sort events based on date, time, location and particle velocity. Furthermore, on board filters now permit analysis of events on site to limit the recording of non-blast related nuisance events such as spikes due to power surges and direct movement of the seismograph.

The BlastVibrations web application provides one click access to seismographic event reports. To simplify the process further, users and field offices can subscribe to receive event data via email immediately after each blast.



Recent advancements in technology now permit wireless installations, allowing remote setup at any location providing cellular telephone service.

Take advantage of today's state-of-the-art technology to ensure that your monitoring operations provide the security and insurance they are intended to.

System Highlights:

- Automatic downloading of data immediately after event or at specified times.
- Automatic notification and Event Report directly to your e-mail account.
- Controlled access to data through a conventional internet connection from anywhere, anytime.
- Permits complete remote access to the seismograph from your PC.
- No complicated hardware/software requirements.

System requirements:

- Instantel Series III Seismograph S/N 6000 and higher
- Instantel Series IV or Micromate Seismograph
- External Modem with seismograph connection cables
- Cellular Service