Final Demolition Work Plan
Unit 4 Cell Building
Nevada Environmental Response Trust Site
Henderson, Nevada

PREPARED FOR

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LIST OF ACRONYMS/ABBREVIATIONS

Acronyms/Abbreviations	Definition
ACM	Asbestos-Containing Material
AHA	Activity Hazard Analysis
APEX	Apex Regional Landfill
BCL	Basic Comparison Level
BMI	Black Mountain Industrial
CFR	Code of Federal Regulations
CMU	Concrete Masonry Unit
DAQEM	Department of Air Quality and Environmental Management
DCN	Document Control Number
DOT	Department of Transportation
EPA	United Stated Environmental Protection Agency
HASP	Health and Safety Plan
HAZWOPER	Hazardous Waste Operations and Emergency Response
HSM	Health and Safety Manual
In/sec	Inches per second
LBP	Lead-Based Paint
Mg/kg	Milligram per kilogram
Mg/l	Milligram per liter
NDEP	Nevada Division of Environmental Protection
NERT	Nevada Environmental Response Trust
NESHAP	National Emission Standards for Hazardous Air Pollutants
OSHA	Occupational Safety and Health Administration
PCB	Polychlorinated Biphenyl
PPV	Peak Particle Velocity
RACM	Regulated Asbestos-Containing Materials
RCRA	Resource Conservation and Recovery Act
SMP	Site Management Plan
SWP	Safe Work Practice
SVOC	Semivolatile Organic Compound
TC	Toxicity Characteristic
TCLP	Toxicity Characteristic Leaching Procedure
TETRA TECH	Tetra Tech, Inc.

CERTIFICATION

I hereby certify that I am responsible for the services described in this document and for the preparation of this document. The services described in this document have been prepared in a manner consistent with the current standards of the profession, and to the best of my knowledge, comply with all applicable federal, state, and local statutes, regulations, and ordinances. ***Description of Services Provided:*** Preparation of Final Demolition Work Plan, NERT Unit 4 Cell Building.

February 9, 2016

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Date

Nevada CEM Certificate Number: 2167
Nevada CEM Expiration Date: September 18, 2016

SUMMARY

This Final Demolition Work Plan presents the approach, means and methods for the demolition of certain components of the Unit 4 Cell Building at the Nevada Environmental Response Trust (NERT) site. The NERT site is located in Clark County, in Henderson, Nevada, (the "Site") within the larger Black Mountain Industrial ("BMI") complex. A portion of the NERT site, including the Unit 4 Cell Building, is leased to Tronox, a company that manufactures various chemicals used in batteries, airbags and other products. In addition to the Cell Building (which is vacant and partially demolished), Unit 4 includes the Chlorinator Building (which houses several large air compressors and related equipment operated by Tronox) and the Substation Building (which houses Tronox processing and electrical equipment). It also includes abandoned Wash Down Towers and several tanks and related facilities.

Environmental investigative activities are planned for the Unit 4 area that will require the demolition of the remaining portions of the Cell Building above the basement slab. In conjunction with the demolition an earthen/crushed concrete ramp will be constructed that will allow a drill rig and other related vehicles and equipment to access the basement slab to drill soil borings. All work associated with the demolition work will be performed in accordance with the Tetra Tech, Inc. (Tetra Tech) site-wide Health and Safety Plan (HASP) which incorporates NERT, Tronox and Tetra Tech health and safety requirements. All required permits and notifications will be secured prior to the start of work.

The major sections of this Final Demolition Work Plan presented below are:

1. Site Conditions
2. Site Health and Safety
3. Pre-Demolition Building Surveys
4. Permits and Notifications
5. Hazardous Materials Abatement
6. Building Demolition
7. Management of the Demolition Debris
8. Demobilization
9. References.

This Final Demolition Work Plan presents the findings of a pre-demolition building survey and several pre-demolition material surveys that were conducted during the summer and fall of 2015. It supersedes the Preliminary Demolition Work Plan that was included as an appendix to the Unit 4 and 5 Buildings Investigation Plan (Tetra Tech, 2015), which was approved by the Nevada Division of Environmental Protection (NDEP) on April 13, 2015.

1.0 SITE CONDITIONS

The NERT site comprises approximately 346 acres of the BMI Complex in an unincorporated portion of Clark County that is surrounded by the City of Henderson, Nevada. Figure 1 shows the location of the NERT site. The site has been used for industrial operations since 1942, when it was developed by the U.S. government as a magnesium plant in support of World War II operations. Following the war, various industrial activities, including the production of perchlorates, boron, and manganese compounds, continued at the BMI Complex.

The locations of the Unit 4 buildings are shown in Figure 2. The Unit 4 Cell Building is no longer used, and its above-ground structures were demolished in the mid-2000s. In 2012, the Unit 4 Substation Building was retrofitted by Tronox to house an advanced battery manufacturing process. The Unit 4 Chlorinator Building houses several large compressors that produce compressed air for Tronox operations at the NERT facility. That compressed air is transferred to other areas of the facility via pipeline that is attached to the southern exterior wall of the Chlorinator Building. The Unit 4 Chlorinator Building historically contained chlorinators (furnaces) that created molten magnesium chloride by reacting magnesium oxide/carbon pellets with chlorine gas at high temperatures. Magnesium metal was then produced in banks of electrolytic cells located in the Cell Building by electrochemical reduction of the molten magnesium chloride.

The following site background is based on information contained in the Site Environmental Conditions Assessment (Kleinfelder, 1993). The U.S. Government operated the BMI complex for the production of magnesium metal between August 31, 1941 and November 15, 1944. The magnesium process occurred in ten identical units at the BMI complex, including Unit 4. The magnesium metal production was discontinued at the end of World War II. From 1945 to 1989, several commercial companies manufactured sodium chlorate, potassium chlorate and potassium perchlorate in Unit 4. The sodium chlorate manufacturing process included the use of sodium dichromate (hexavalent chromium) as a necessary constituent of the electrolyte that was used as part of that process. The Unit 4 Cell Building basement reportedly collected process liquor, spillage, and wash water.

Based on the findings of concrete rubble, trench drain solids, piping contents and electrolytic cell content sampling conducted in or around the Unit 4 Cell Building as described in Section 3.2, it has been determined that explosives or propellant contaminants of concern, (including ammonium perchlorate and other perchlorate compound contamination), are not present within the Unit 4 Cell Building components at levels that will create either a fire or an explosion hazard during the demolition or follow-up investigative activities. While this is the current understanding of the conditions of the Unit 4 Cell Building construction materials, precautions will be taken to provide additional protection during the demolition activities. These precautions include the selection of demolition methods and the use of a Dust Boss misting system to keep the active demolition areas wetted while the demolition activities are ongoing. Additional soil sampling below the basement slab is planned after the removal of the elevated slab and remaining Unit 4 Cell Building structure.

Tetra Tech has interviewed facility personnel with historic knowledge of the facility, the methods implemented, and the potential hazards encountered during demolition of Unit 1, 2, and 3 Cell Buildings. Tetra Tech has approached Tronox personnel, and they have agreed to share relevant data with the Tetra Tech. NERT and Tetra Tech acknowledge that Tronox does not make representations or warranties regarding the conditions of the premises, including the condition of asbestos.

Best practices and approaches learned from previous unit building demolition activities at the site provided by Tronox staff familiar with this work are incorporated into the Demolition Work Plan. Those best practices include:

- Concrete pedestals will be removed to the floor grade instead of leaving stubs protruding from the floor. This practice is similar to how pedestals have been left at the Cell Buildings for Units 1, 2, and 3.
- A blanket of water mist will be placed using a Dust Boss over the entire Unit 4 Cell Building during demolition activities. This practice will eliminate dust and keep the area wet.

2.0 SITE HEALTH AND SAFETY

Tetra Tech has developed the Health and Safety Plan for Site-Wide Investigation and Remedial Activities at the NERT Site (HASP), which specifies the minimum required work practices and procedures for Tetra Tech and its subcontractor personnel engaged in the planned Site-wide activities at the NERT site. The HASP addresses items specified under Occupational Safety and Health Administration (OSHA) Title 29 of the Code of Federal Regulations (CFR), Part 1910.120(b), Hazardous Waste Operations and Emergency Response (HAZWOPER) and applicable Nevada Occupational Safety and Health requirements. The HASP is supported by the Tetra Tech Health and Safety Manual (HSM) and safe work practices (SWPs), which were developed to comply with the OSHA HAZWOPER standard and applicable sections of 29 CFR Part 1910 (General Industry Standards) and Part 1926 (Construction Standards). The HASP also incorporates elements of the Tetra Tech Nevada Workplace Safety Program, Document Control Number 2-13 (DCN 2-13) which complies with the Nevada Administrative Code Sections 618.540 and 618.542. The HASP will be revised to add additional health and safety measures as necessary to cover the planned demolition tasks.

The updated HASP will address risks and potential hazards associated with the proposed environmental demolition activities. The demolition team will develop an Activity Hazard Analysis (AHA) which lists the safety-critical job steps (mobilization to construction debris removal), health and safety hazards, and control measures to be implemented. The AHA will be reviewed by the Tetra Tech Program Health and Safety Manager and appended to the HASP.

Prior to the commencement of each day's activities, a tailgate Health and Safety meeting will be conducted. Onsite personnel will be required to be familiar with the HASP, attend the daily tailgate meeting, and sign the project HASP acknowledging familiarity with the contents of the document. Additionally, all site workers will be required to attend the Tronox Health and Safety training provided at the NERT site as the work area is located within the Tronox leasehold. Applicable components of Tronox's health and safety requirements have been incorporated into the Tetra Tech HASP.

3.0 PREDEMOLITION BUILDING SURVEYS

3.1 HAZARDOUS MATERIALS SURVEY

A pre-demolition hazardous materials inspection of the Unit 4 Cell Building first floor slab and basement was conducted by Tetra Tech on August 12, 2015. The findings of that inspection are presented in a report entitled "*Pre-Demolition Hazardous Materials Inspection, Unit 4 Cell Building*" (Tetra Tech, 2015), and summarized as follows:

Asbestos-Containing Material Findings. Tetra Tech collected and submitted 24 bulk samples to the lab for asbestos analysis. Based on the analyses, four materials were identified as Asbestos-Containing Material (ACM):

- Galbestos debris located throughout the basement (associated with siding from adjoining buildings) – estimated quantity of 80 square feet;
- Tar coating on various columns, beams and associated debris throughout the basement – estimated quantity of 900 square feet;
- Tar coating debris on some of the bolt insulators located throughout the basement – estimated quantity of 100 square feet; and
- Coal tar pipe wrap on 10-inch diameter pipe and associated debris located in the middle of the basement – estimated quantity of 20 square feet.

Tetra Tech's inspection of the Unit 4 Cell Building did not identify any in-place Regulated Asbestos-Containing Materials (RACM) which would be required to be removed prior to demolition in accordance with the National Emission Standards for Hazardous Air Pollutants (NESHAP) as enforced by the Clark County Department of Air Quality and Environmental Management (DAQEM). The Category I Non-Friable ACM that were identified are exempted from the removal requirement prior to demolition, because the demolition procedures will not include sanding, grinding, cutting, or abrading methods and these flexible tar-based materials do not generally release significant amounts of asbestos fibers, even when damaged. These materials will be managed as described in Section 5.1.

Lead-Based Paint Findings. Tetra Tech conducted a lead inspection of the Unit 4 Cell Building on August 12, 2015 utilizing X-ray Fluorescence testing. The inspection showed that lead-containing paint is present on interior and exterior components located throughout the Cell Building structure. Lead-based paint (LBP), defined by the United States Environmental Protection Agency (EPA) as containing lead at concentrations greater than 1 milligram per square centimeter, was identified on the following surfaces:

- Basement Level Black Paint – Located on metal vertical and horizontal H-beams, cross members and associated debris throughout the basement;
- Basement Level Silver Paint – Located on metal cross members and associated debris located throughout the basement;
- Yellow Paint on Handrail – Located on the metal handrail and associated debris located at the ground level around the Unit 4 Cell Building area; and
- Yellow Paint on the Metal Stairs – Located on the metal stairs that lead from the ground level to the basement level of the Unit 4 Cell Building.

These materials will be managed as described in Section 5.2.

Mercury-Containing Component Findings. Tetra Tech conducted a visual inspection of the Unit 4 Cell Building for potential mercury-containing equipment on August 12, 2015. That inspection identified the following mercury containing components:

- Fluorescent light bulbs – 11 bulbs were identified in the basement level; and
- Mercury vapor light bulbs – 3 bulbs were identified in the basement level.

These materials will be managed as described in Section 5.3.

Polychlorinated Biphenyl (PCB)-Containing Component Findings. Tetra Tech conducted a PCB inspection of the Unit 4 Cell Building on August 12, 2015. That inspection identified the following PCB-Containing Components:

- Ballasts located in fluorescent lighting fixtures in the basement – 10 ballasts were identified; and
- Ballasts located in mercury vapor lighting fixtures in the basement – 3 were identified.

These materials will be managed as described in Section 5.4.

Chlorofluorocarbons-Containing Component Findings. Tetra Tech conducted a visual inspection of the Unit 4 Cell Building for potential Chlorofluorocarbons-Containing Components. No such components were identified.

3.2 DEMOLITON MATERIALS SAMPLING

Sampling and analysis of the Unit 4 Cell Building first floor slab concrete, concrete pedestals for the columns supporting that slab, piping contents, trench drain contents, sump contents and electrolytic cell vessel contents were conducted to provide information to be used in planning the demolition activities. This section describes the findings of those investigations.

Concrete from First Floor Slab and Column Pedestals. To further understand the potential risk posed by residual chemicals in the building components that will be demolished, Tetra Tech collected bulk concrete samples from the column pedestals, cell decks, and floor of the Unit 4 Cell Building on July 17, 2015. Ammonium perchlorate had been historically manufactured elsewhere at the current NERT facility, and since it could not be ruled out that ammonium perchlorate may have been present in the Unit 4 Cell Building at some point in time, it was assumed that ammonium perchlorate could be present in the components of the Cell Building. Due to the concerns associated with the potential presence of ammonium perchlorate in the concrete, no chopping or cutting was used to collect the concrete samples. Rather, the samples that were collected consisted of spalling or loose material that could be removed by hand. Laboratory analyses were performed in two phases. The initial phase of testing consisted of preparing distilled water leachates of uncrushed concrete fragments, followed by analysis of the leachate for perchlorate (Method E314.0) and ammonia as nitrogen (Method SM4500).

The initial analyses found that perchlorate concentrations in the leachate ranged from 3.3 to 8,700 milligrams per liter (mg/L), while ammonia concentrations ranged from <2 to 6.3 mg/L. There was no correlation identified between the areas where perchlorate and ammonia were identified, indicating that the perchlorate salt present in the concrete was not ammonium perchlorate. These results are in agreement with historical process information in the Environmental Conditions Assessment report, which indicates that ammonium perchlorate was not manufactured in the Unit 4 Cell Building, but was manufactured at a separate area located in the middle of the NERT site.

With elimination of the concern that ammonium perchlorate was present in the collected samples, those samples were approved to be crushed and analyzed for perchlorate, ammonia, semivolatile organic compounds (SVOCs;

Method SW8270C), PCBs (Method SW8082), RCRA 8 Metals (Method SW6020A), and hexavalent chromium (Method SW7199). The results of the second phase of testing were as follows:

- Perchlorate was detected in all of the samples analyzed, at concentrations ranging from 53 to 2,400 mg/kg.
- Ammonia was detected in all samples analyzed at concentrations ranging from 2.4 to 4.5 mg/kg. The ammonia concentrations were relatively uniform between the method detection limit and practical quantitation limit, suggesting that it may be due to contamination of the samples in the laboratory.
- SVOCs were also detected in the samples. None of these SVOCs are regulated as hazardous wastes.
- PCBs were not detected in any of the samples.
- One or more of the RCRA 8 metals were detected in all of the samples. Arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver were all identified as being present in the samples. Therefore, additional testing of the demolition waste materials for the RCRA 8 Metals using the Toxicity Characteristic Leaching Procedure (TCLP) will be conducted as described in Section 7 to evaluate whether these materials are classified as hazardous waste.
- Hexavalent chromium was detected in all of the samples analyzed, at concentrations ranging from 15 to 420 mg/kg.

The ammonia and perchlorate concentrations identified by the laboratory analysis of the samples described above were evaluated to determine the potential fire and explosives safety risks associated with demolishing the Unit 4 Cell Building. Tetra Tech and its safety professionals did not identify any existing published industry safety benchmarks to evaluate the explosive risks for residual perchlorate compounds in concrete or other solid materials. Therefore, Tetra Tech's explosive safety professional conducted explosives modeling using conservative estimates of key risk factors and qualitative reviews of explosive material characteristics and data to develop a provisional safety benchmark for total perchlorate concentration of five percent (5%), or 50,000 mg/kg, on a dry weight basis. If perchlorate concentrations are below this benchmark, the material would not be considered a potential fire or explosion hazard.

Based on the provisional safety benchmarks described above, and the perchlorate and ammonia levels that have been observed to be present in the building material samples for the Unit 4 Cell Building, it is highly unlikely the planned demolition activities or handling of the demolition debris will encounter concentrations that exceed the provisional benchmark or pose a fire or explosion risk. As such it is anticipated that no significant modifications to the demolition methods and worker PPE beyond standard demolition safety practices are required. Supplemental precautionary measures for worker and environmental protection include staging of emergency decontamination equipment and spill kit in work zone, continuous water spraying for steel cutting and debris removal, and prohibition of both hot work (e.g., torch cutting) or unbolting of structural components.

Section 6.1.3 describes plans to utilize the concrete debris generated by the demolition of the Cell Building first floor slab to construct a temporary ramp down to the basement level of that building. The ramp will provide access for equipment to complete the demolition and for a drill rig and associated equipment that will be used as part of the environmental investigation of the soils below the basement slab.

Since use of the concrete debris for the construction of the ramp will result in potential worker contact with that material, the analytical results described above were compared to the Basic Comparison Levels (BCLs) that are provided in Table 1 of the Site Management Plan, Revision 2 (SMP) for the NERT site. The BCLs serve as soil screening levels for soil that is being considered for reuse at the NERT site. Review of the analytical results for the concrete samples described above reveals that the perchlorate concentrations in several of the concrete samples exceeded the BCL of 908 mg/kg. Additional sampling and analysis of the bulk concrete debris will be conducted after the demolition occurs, as described in Section 6.2.2 to determine if it meets the criteria to be classified as a hazardous waste. If it is a hazardous waste, it will not be used for the construction of the ramp, and will be managed as described in Section 7. If it is not hazardous waste, it will be used to construct the ramp, but since some of the concrete has been found to exceed the perchlorate BCL, use of the ramp will be limited to workers who have appropriate personal protective equipment (PPE), as described in the HASP. Once the demolition and environmental investigation activities that require use of the ramp are completed, the ramp will be removed and the concrete debris material will be disposed as described in Section 7.

Contents of Basement Trench Drains and Sump

The trench drains located in the basement level of the Cell Building contain a dry fine-grained solid material that was sampled during the July 2015 sampling event. Two samples were collected and submitted for analysis. Below is a summary of the laboratory results:

- Perchlorate was detected in both samples with the highest concentration being 250 mg/kg.
- Ammonia was detected in both samples with the highest concentration being 3.9 mg/kg.
- SVOCs were also detected in the samples. None of these SVOCs are regulated as hazardous wastes.
- PCBs (Aroclor 1254) were detected in one of the samples at a concentration of 2,400 micrograms per kilogram (µ/kg).
- Several of the RCRA 8 metals were detected in both of the samples. Arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver were all identified as being present in the samples. Therefore, additional testing of the demolition waste materials for the RCRA 8 Metals using the Toxicity Characteristic Leaching Procedure (TCLP) will be conducted as described in Section 7 to evaluate whether these materials are classified as hazardous waste.
- Hexavalent chromium was detected in all of the samples analyzed, at concentrations ranging from 620 to 690 mg/kg.

During December 2015 the sump in the Cell Building basement was sampled. The sump contained only clear liquid that appeared to be water. Analysis of the sample indicated a perchlorate concentration of 41,000 micrograms per liter (µg/L), and non-detectable levels of ammonia. The liquids from the sump will be transferred to the GW-11 Pond.

Piping Present in the Cell Building Basement

Abandoned process piping runs across sections of the bottom of the first floor slabs of the Unit 4 Cell Building. This piping will be demolished as part of the building demolition activities. In some cases, the ends of some of the piping are open and hardened solid residue has been observed. Some of this material was sampled as part of the July 2015 demolition material sampling event, and additional sampling was conducted during December 2015. For the sample collected in July, elevated levels of perchlorate (2,800 mg/kg) and hexavalent chromium (1,400 mg/kg) were identified. For the samples collected in December the perchlorates ranged from 122 to 20,000 mg/kg, with ammonia ranging from 5.7 to 190 mg/kg. Additional testing for chromium (both total and TCLP) in the solid material that is present in the pipes will be performed as described in Section 7 to evaluate whether this material will be classified and managed as hazardous waste.

Electrolytic Cell Vessels

Several of the electrolytic cell vessels remain along the eastern side of the Unit 4 Cell Building basement. There was solid material present in the cells, and two samples of that material were collected and analyzed. The results for those samples are described below:

- Perchlorate was detected in both samples with the highest concentration being 14,000 mg/kg.
- Ammonia was detected in both samples with the highest concentration being 3.1 mg/kg.
- SVOCs were also detected in the samples. None of these SVOCs are regulated as hazardous wastes.
- PCBs were not detected in any of the samples.
- Several of the RCRA 8 metals were detected in both of the samples. Arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver were all identified as being present in the samples. Therefore, additional

testing of the demolition waste materials for the RCRA 8 Metals using the Toxicity Characteristic Leaching Procedure (TCLP) will be conducted as described in Section 7 to evaluate whether these materials are classified as hazardous waste.

- Hexavalent chromium was detected in both of the samples analyzed, with the highest concentration being 66 mg/kg.

Additional sampling and analysis of the electrolytic cell shell walls will be conducted in conjunction with the Cell Building demolition activities, as described in Section 6.2.2.

3.3 STRUCTURAL ENGINEERING SURVEY AND VIBRATION STUDY

In accordance with OSHA requirements for demolition worker safety, Tetra Tech conducted a pre-demolition structural engineering survey of the Unit 4 buildings on May 19 and 20, 2015. The findings of the survey were summarized in a technical memorandum dated June 17, 2015 (copy included in Appendix A) which included recommended actions to reduce the risk of premature collapse of the structure during the demolition process. In addition to the structural engineering survey, Tetra Tech conducted a vibration study to evaluate the impact of the Unit 4 Cell Building. The findings of that evaluation are provided in the Demolition Vibration Impact Study letter report dated January 22, 2016 (copy included in Appendix B).

The structural engineering survey and the vibration study concluded that the demolition can be executed safely with the implementation of the recommendations described below.

Unit 4 Substation Building

Cracks are present in the basement wall that separates the Cell Building from the Substation Building. The basement wall will be reinforced to restore the strength of the wall. Epoxy and grout injection technology will be utilized to provide the necessary reinforcing.

A vibration monitoring system will be installed along the basement wall between the Cell and Substation Buildings to determine the magnitude of vibrations that occur during the demolition work. The Demolition Vibration Impact Study identified recommended peak particle velocity (PPV) threshold values that will be followed during the demolition work. The threshold values have been established to prevent further significant structural damage to the buildings. It is anticipated that minor loosening, raveling and falling of bricks from the façade of the Substation Building, spalling of concrete, and minor concrete cracking may occur due to the vibrations, but significant structural damage is not anticipated. The threshold PPV values that were selected are as follows:

- 0.25 inches per second (in/sec) for continuous vibrations (hydraulic hammer use, equipment traffic); and
- 0.6 in/sec for transient event (slab drop).

Figure 3 provides a logic flow diagram that describes how the vibration monitoring results will be used to guide the demolition activities and what actions will be taken if the threshold values are exceeded. Figure 3 references a Contingency Plan section. That reference is to the Contingency Plan section of the Demolition Vibration Impact Study. The Contingency Plan sections recommends the following actions if the vibrations are exceeding the acceptable PPV thresholds, or if better control and/or dampening of the vibrations is desired:

- A 5 feet wide (minimum) section of concrete basement slab be cut along the perimeter of the basement to separate the basement walls from the basement floor slab and thus reduce the vibrations transfer into the basement walls.
- If necessary, to further augment the control of the vibrations, a trench about 3 feet deep and 3 feet wide will be excavated in the soil beneath the cut-out section along the basement perimeter to intercept some of the vibration surface waves and confine the propagation of the vibrations.

The north side of the Substation Building includes a brick façade from which bricks have reportedly periodically fallen in the past. While the falling bricks do not hamper the structural integrity of the wall, they could cause injury to workers if they were to be struck by the falling bricks. To address that concern, the area below that wall will be cordoned off from all pedestrian access prior to and during the demolition activities. At the start of the demolition activities the visibly loose bricks on this wall will be carefully removed to minimize bricks that may fall. In the event that other façade bricks become loose, they will fall harmlessly to the ground within the cordoned off area.

Unit 4 Cell Floor Area

The demolition plan for the Unit 4 Cell Floor area will utilize a combination of breaking and processing (crushing/pulverizing) for concrete and shearing for steel. Equipment used will have rubber tires instead of steel tread, wherever possible, to minimize vibrations. Equipment and materials will be used and stored at least 8 feet away from the top edge of the basement walls to prevent increases in lateral earth pressure on the basement walls.

Unit 4 Chlorinator Building

The air compressor equipment located in the Unit 4 Chlorinator Building will be protected by a temporary shielding structure during the demolition. Temporary scaffolding will be used as the shielding structure as it is adaptable, easily installed and readily available. In addition, a scaffolding system will also be installed to protect the pipes on the south side of the building. This system will be installed between the concrete masonry unit (CMU) wall and the pipes and have appropriate decking material above the pipes to prevent any dislodged CMU from falling on them.

Structural Protection and Monitoring Specifications

Appendix C of this Demolition Work Plan includes the following specifications that have been developed to address the planned structural protection and monitoring measures described above:

- Specification 01 35 23 – Falling Debris Mitigation;
- Specification 01 71 33 – Existing Equipment Protection;
- Specification 02 22 13 – Vibration and Crack Monitoring;
- Specification 02 25 16 – Existing Concrete and CMU Crack Survey;
- Specification 03 62 13 – Grout Crack Repair; and
- Specification 03 64 23 – Epoxy Injected Crack Repair.

The activities described in the above-listed specifications will be implemented prior to and, in the case of Specification 02 22 13, during the course of the demolition work.

4.0 PERMITS AND NOTIFICATIONS

Prior to beginning the demolition fieldwork, Tetra Tech will provide copies of the final Demolition Work Plan for the Unit 4 Cell Building and the AHA that addresses the activities covered in the Demolition Work Plan to Tronox for review. Tetra Tech will prepare and submit Ground Breaking Permit applications to Tronox in accordance with Tronox requirements. Tetra Tech understands that Tronox expects that all permit applications be submitted for review at least two weeks prior to the date when work is to commence.

Tetra Tech will provide the following, as applicable:

- Demolition Permit application to the Clark County Department of Building and Fire Prevention;
- Demolition Notice to the Clark County DAQEM;
- Dust Control Permit application to the Clark County DAQEM; and
- Groundbreaking Permit application to Tronox.

5.0 HAZARDOUS MATERIALS ABATEMENT

5.1 ASBESTOS-CONTAINING MATERIALS

No RACM was identified in the areas that will be demolished, and the demolition procedures will not include sanding, grinding, cutting, or abrading methods. Thus the ACM identified in Section 3.1 do not require abatement prior to conducting the demolition work. However, based on the condition of the Galbestos siding debris that is present in portions of the planned demolition area and a concern that it could become friable if crushed by heavy equipment used in the demolition work or by falling debris, removal of the fallen Galbestos material will occur prior to the commencement of the demolition work. Workers with appropriate HAZWOPER and asbestos awareness training will manually remove the visible and accessible Galbestos debris on the work surfaces. The material that is picked up will be properly packaged, transported and disposed.

5.2 LEAD-BASED PAINT

Observed loose paint chip debris on floors and surfaces within the demolition area will be collected by workers with HAZWOPER training and placed in a bucket, drum or similar container. Once this task has been completed, a representative sample of the chips will be collected and submitted to a laboratory to be tested using the TCLP, for the RCRA metals analysis. The results of the TCLP testing will be used to determine if the paint chips are classified as hazardous or non-hazardous waste. Once that classification has been made, the paint chips will be disposed of appropriately. No additional LBP abatement activities are planned prior to the commencement of the demolition work, based on the NDEP guidance document *Disposal of Lead-based Paint Contaminated Demolition Debris*, which confirms that whole building demolition debris is considered a non-hazardous waste with regard to lead.

5.3 MERCURY-CONTAINING COMPONENTS

The mercury-containing components will be removed from the areas to be demolished prior to the commencement of demolition activities. Mercury-containing components will be managed in a way that prevents leakage, spillage, or damage in a closed container that is structurally sound and compatible with mercury and the contents of the device. Containers will be clearly labeled as "Universal Waste – Mercury Containing Equipment," and specify the type and amount of individual components. Wastes will be transported to an approved disposal facility in accordance with Universal Waste Transporter Regulations specified in 40 CFR Part 273, Subpart D.

5.4 PCB-CONTAINING COMPONENTS

The PCB-containing components will be removed from the facility prior to the commencement of demolition activities. PCB-containing components will be managed in a way that prevents leakage, spillage, or damage in a closed container that is structurally sound and compatible with PCBs and the contents of the device. Storage of the materials will comply with 40 CFR 761.65, and containers will be labeled, transported, and manifested for disposal in accordance with 40 CFR 761.62, and will comply with applicable DOT requirements.

5.5 MATERIALS CONTAINED IN PIPING IN THE DEMOLITION AREA

There are several pipes running across the underside of the Cell Building first floor slabs that have open ends and which have residue in them. The open ends of any such piping will be capped prior to the start of demolition to prevent the material contained in the pipes from being released and mixing with the other demolition debris. Demolition of the piping will be as described in Section 6.2.2. Disposal of the piping and contents will be as described in Section 7.

5.6 ELECTROLYTIC CELL VESSELS LOCATED IN THE CELL BUILDING BASEMENT

There are several electrolytic cells that remain in the Unit 4 Cell Building basement. The cells appear to be constructed of a cementitious material lined with a steel liner. While representative samples of the contents of the cells were sampled and analyzed as part of the Demolition Materials Investigation, perchlorate explosive safety concerns prevented the coring of the shell of the cells to characterize these materials. As described in Section 6.2.2, the electrolytic cells will be demolished separately from the concrete and steel portions of the Cell Building and characterized for disposal.

5.7 BASEMENT DRAINAGE TENCHES AND SUMP

Unit 4 Cell Building basement contains drainage trenches that lead to a sump. A dust-like material is present in the trenches, and the sump contains liquid and possible sediment. Prior to the commencement of the demolition work, the materials in the trenches and sump will be removed, stored, sampled and analyzed as described in Section 6.2.2.

6.0 BUILDING DEMOLITION

All work described in this Final Demolition Work Plan will be performed in accordance with the Section 3.0 of the SMP and the Tetra Tech HASP. Additionally, the work will be coordinated with Tronox to minimize disruptions of their operations.

6.1 MOBILIZATION AND SITE PREPARATION

6.1.1 Mobilization of Heavy Equipment

The following heavy equipment will be mobilized to conduct the demolition work:

- Hydraulic Excavator equipped with shear, concrete breaker and concrete processor attachments;
- Hydraulic Excavator equipped with a grapple and bucket;
- Wheel Loader equipped with a bucket and forks;
- Skid Steer equipped with a bucket and grapple bucket;
- Mini Hydraulic Excavator with bucket; and
- Dust Boss (dust control).

6.1.2 Setup of Site Facilities

Planned site facilities include a break/meeting trailer, worker sanitary/wash-up facilities, and an equipment decontamination area.

6.1.3 Temporary Access Ramp

As soon as the demolition progresses to the point that it can be constructed, a temporary equipment access ramp will be constructed on the west side of Unit 4 Cell Building. The ramp will facilitate the remaining demolition and waste removal operations as well as equipment access for the drilling of soil borings and the collection of environmental samples after completion of the demolition work. If the results of the analytical testing conducted on the concrete debris demonstrates that the debris is not classified as a hazardous waste (see Section 6.2.2), Tetra Tech will construct the ramp with that material. However, in the event that the debris is classified as hazardous waste, the ramp will be constructed from clean fill.

The ramp will be constructed at a maximum 5:1 (horizontal:vertical) slope resulting in an approximate length of 40 feet, and a width of approximately 20 feet. The ramp will be constructed within the existing footprint of the Unit 4 Cell Building basement, and the existing basement wall will remain in place. The tentative location for the proposed access ramp is shown on Figure 2. Tetra Tech will coordinate with Tronox to finalize the location for the access ramp. Design and construction of the access ramp will take into account the width and weight of the equipment necessary for the demolition and subsequent drilling.

The ramp is a temporary structure, and will remain in place following demolition to allow drilling equipment access to the basement during the planned second and third mobilizations of the buiding investigation. After the investigation is complete, the temporary ramp will be removed.

6.1.4 Work Zone Establishment

Prior to beginning demolition activities, Tetra Tech will establish a work zone area to limit access and maintain safe conditions within the work area. Demarcation of the work zone will consist of a combination of reflective plastic delineators or barricades, temporary fencing, caution tape, and signs designated the area as a Demolition Work Area. The proposed signage is shown in Figure 4.

Six foot high chain link fencing will be installed around the perimeter of the work site. A 20-foot wide access gate will be installed on the west side of the site to allow for ingress/egress of heavy equipment. Personnel gates will be installed on the east and west side of the site to allow for emergency egress from the Substation Building. This fencing will remain in place upon completion of the demolition activities.

Emergency exit stairs are located in the demolition work area on the west side of the basement to accomodate emergency access from the Substation Building. Those stairs fall within the demolition work zone and will be temporarily relocated to the east side of the basement during the work. The existing stairs on the east side of the site are unusable (see Figure 5).

Tetra Tech will saw cut an opening east side of the Cell Building to allow Tronox to install an additional set of emergency stairs for egress. Upon completion of the demolition on the west side of the basement, Tronox will reinstall stairs for emergency egress from either the east or west side of the Substation Building.

6.1.5 Lockout, Tag Out, Try Out

Currently there are no active utilities in the work zone with the exception of the lighting fixtures installed on the exterior wall of the substation. Prior to demolition, these lights will be removed by Tronox and reinstalled after demolition is complete. The existing piping will be handled as described in Section 5.5 of this Final Demolition Work Plan. All piping will be terminated flush with the existing basement wall. Caps or plates will be secured to the pipe stub to close the opening to the environment.

6.1.6 Protection of Existing Structures

Section 3.3 describes the findings of the structural inspection of the Unit 4 buildings. Based on those findings, the following structural protection and monitoring measures will be implemented and maintained during, the demolition of the Unit 4 Cell Building:

- A crack survey will be conducted along the basement wall between the Substation and Cell Buildings per Specification 02 25 16 – Existing Concrete and CMU Crack Survey.
- The basement wall between the Substation and Cell Buildings will be reinforced using grout and epoxy grout systems per Specification 02 25 16 – Existing Concrete and CMU Crack Survey, Specification 03 62 13 – Grout Crack Repair and Specification 03 64 23 – Epoxy Injection Crack Repair.
- A vibration monitoring system will be installed along the north wall of the Substation Building per Specification 02 22 13 – Vibration and Crack Monitoring.
- Caution tape and warning signs will be used to cordon off the area below the north (exterior) face of the Substation Building to keep workers and others away from this area due to the risk of falling bricks. In addition, prior to the start of the demolition work, loose bricks will be removed from that wall to prevent them from falling. A temporary ceiling will be constructed at the basement level of the Cell Building adjacent to the Substation Building wall using ½ inch thick sheets of plywood supported by scaffold jacks to provide protection from falling debris for the workers conducting the crack repair and monitoring.
- Demolition equipment equipped with rubber tires instead of steel tread will be used wherever possible to minimize vibrations. Equipment and materials will be used and stored at least 8 feet away from the top edge of the Cell Building basement walls to prevent increases in lateral earth pressure on the basement walls.
- The Tronox equipment located in the Unit 4 Chlorinator Building will be protected by temporary scaffolding per Specification 01 71 33 – Existing Equipment Protection.
- The piping that is supported by the south wall of the Chlorinator Building will be protected by temporary scaffolding per Specification 01 35 23 – Falling Debris Mitigation.

In addition to the measures listed above, two existing doors which provide access from the Substation Building onto the elevated slab that will be demolished will be permanently sealed by bolting plywood to the wall surrounding the openings. During demolition, the six windows on the north wall of the Substation Building on the basement level will be temporarily closed off by securing plywood over the opening. Upon completion of demolition, this material will be removed.

6.1.7 Dust Control

During demolition, a Dust Boss will be used to control any fugitive dust. A fine mist of water will be emitted from the Dust Boss machine to provide a constant blanket of water mist over the work area. Additional water for location-specific dust control will be supplied via a hose as required. Figure 6 shows a Dust Boss in use.

6.2 DEMOLITION ACTIVITIES

6.2.1 Saw Cutting-Structure Isolation

Prior to heavy equipment demolition, saw cutting of the ground level concrete slab will be performed from east to west along the length of the north wall of the Substation building to isolate the Substation building from the vibration caused by the demolition activities. The same process will be used on the ground level concrete slab at the base of the south wall of the Chlorinator building. Two cuts will be made at each location to provide for a minimum of a 12-inch gap between the buildings and the existing slab. Note that these cuts will be made to the concrete slabs at the first floor ground surface level of the the Cell Building. The optional cuts previously described in Section 3.3, which may be needed if the vibrations caused by the demoliiton activities are found by monitoring activities to exceed the criteria established for the work, would be made in basement level slab of the Cell Building.

6.2.2 Heavy Equipment Demolition

Prior to the start of the concrete and steel demolition the Cell Building basement trench drains and sump will be cleaned out. The materials removed will be managed as described in Section 7.

The existing empty tanks located on the northwest corner of the designated work area (see Figure 7) will be checked to determine if they contain any residual material. If material is present, it will be sampled and analyzed. The sample results will be used to determine how that material will be managed and disposed. Following removal of any residual material, the tanks will be demolished to grade using the excavator equipped with a hydraulic shear. The scrap steel will be managed as described in Section 7.

The first floor slab of the Unit 4 Cell Building will be broken apart using an excavator equipped with a hydraulic breaker or impact hammer attachment (see Figure 8), allowing the broken concrete to fall to the basement floor. Use of a concrete processor attachment may be required in lieu of a breaker in areas adjacent to the Substation and Chlorinator Buildings depending on the results of the vibration monitoring. Once on the basement floor, the concrete will be sized further, as necessary, using the excavator with a concrete processor attachment. The excavator or wheel loader will be used to lower a skid steer into the basement where it will be used to consolidate the concrete debris in piles. Bulk samples of that concrete debris will be collected and submitted for laboratory analysis for RCRA 8 metals (total and TCLP). The results of that analysis will be used to determine if the debris is classified as non-hazardous or hazardous waste.

If the concrete debris is determined to be non-hazardous, it will be used to construct the temporary ramp described in Section 6.1.3. Otherwise, clean fill material will be imported for ramp construction. Once the ramp has been constructed, the excavator will move to the lower level and finish breaking and processing the concrete. If the concrete debris is found to be classified as a hazardous waste, it will not be used to construct the ramp, and it will be disposed as described in Section 7.

The wheel loader will access the lower level using the ramp to consolidate any concrete that was not used to construct the ramp in one area for disposal per Section 7.

The excavator will complete the breaking and processing of each bay of concrete while working across the basement floor (approximately 40,000 square feet). Once the concrete has been processed, the processor jaws will be removed and the steel shear jaws will be installed. The steel shear jaws will then be used to remove the structural steel from each bay (see Figure 9). The cut steel sections will be collected with the skid steer, loaded into the wheel loader bucket and stockpiled for recycling at the Champion Recycling facility or disposal at the Apex Landfill, as described in Section 7.

As the concrete and steel is removed from around the piping described in Section 5.5, that piping will be cut into sections with the hydraulic shears and placed in an area away from the other debris materials. The contents of the piping will be sampled and analyzed for RCRA 8 TCLP metals. Disposal of the piping and its contents will be as described in Section 7.

As the concrete and steel is removed from over the electrolytic cells described in Section 5.6, those cells will be moved to an area away from the other debris. The sidewall of a representative cell will be cored or broken apart and the materials of construction will be visually observed. Samples will be collected of the materials that are found to be present and they will be analyzed to determine how they are to be disposed. The analyses will be selected once the materials can be observed, but it is anticipated that at a minimum the samples will be analyzed for the RCRA 8 metals, both total and TCLP. The results from that analysis will be used to determine if the material will be classified as non-hazardous or hazardous. The cells will be further demolished as necessary to allow the debris to be transported to a disposal facility. Disposal will be as described in Section 7.

When the concrete processing and shearing has been completed, the excavator will be demobilized. The wheel loader and the skid steer will be utilized to remove the remaining concrete or other debris generated during the demolition, allowing access to the ramp and basement by the drill rig.

Final clean-up of the basement floor will be accomplished as follows. The mini excavator will be used to remove accumulated materials from the trench drain channels that run from the south to the north. This material will be placed in the wheel loader bucket to be loaded for disposal to the Apex Landfill. Upon completion of the trench drain channel cleaning, the skid steer equipped with the broom attachment will be used to sweep the area. Dust suppression measures will be employed during the sweeping activity.

6.3 POST DEMOLITION STRUCTURE STABILIZATION

There are two tunnel openings in the Cell Building basement wall that allow piping to enter into the basement, one on the east side of basement and the other to the north at the Chlorinator Building (see Figure 10). Upon completion of the demolition work, the basement entrances to the two tunnels will be covered. Steel plates will be bolted to the basement wall surrounding the tunnel openings and clean stone fill will be added to the space behind the plate from openings at the ground surface to fill the void.

7.0 MANAGEMENT OF DEMOLITION DEBRIS

The following types of debris are anticipated to be generated by the Unit 4 Cell Building demolition activities:

- Steel debris from the demolition of the tank located to the northwest of the Unit 4 Cell Building;
- Processed concrete debris;
- Cut-up steel debris;
- Materials removed from the trench drains in the Unit 4 Cell Building basement;
- Demolished piping along with the contents of that piping;
- Material contained in the electrolytic cells; and
- The materials that were used to construct the electrolytic cells.

The debris from the demolition of the tanks will be loaded and hauled for disposal at the Apex Landfill located at 13550 North Highway 93 in Las Vegas, NV. Waste profile information will be sent to Republic Services, the owner and operator of Apex Landfill, prior to shipment of the wastes to that facility. Final disposal requirements will be determined based on the profile for the waste. Preliminary discussions with Mr. Rob Tidwell of Republic Services indicate that the waste will likely be classified as non-hazardous construction demolition waste.

A portion of the processed concrete debris will be utilized to construct the temporary ramp that leads to the Unit 4 Cell Building basement (see Section 6.1.3). If there is additional concrete debris remaining after the construction of the ramp, it will be loaded and hauled for disposal at the Apex Landfill. Waste profile information will be sent to Republic Services prior to shipment of the wastes to that facility. Final disposal requirements will be determined based on the profile for the waste. Preliminary discussions with Mr. Rob Tidwell of Republic Services indicate that the waste will likely be classified as non-hazardous construction demolition waste. After the completion of the demolition work and the follow-up environmental investigations in the Unit 4 area, the ramp will be removed and the debris generated by that removal will be disposed of at the Apex Landfill as described above.

The steel demolition debris will be loaded and hauled for recycling to the Champion Recycling facility located at 3000 Mead Avenue, Las Vegas Nevada. If it is determined that the steel cannot be sent to that recycling facility, it will be sent for disposal at the Apex Landfill. Waste profile information will be sent to Republic Services prior to shipment of the wastes to that facility. Final disposal requirements will be determined based on the profile for the waste. Preliminary discussions with Mr. Rob Tidwell of Republic Services indicate that based on the presence of non-friable coating on a portion of the steel, the waste will likely be classified as non-friable asbestos waste.

The contents of the material removed from the trench drains and the contents of the electrolytic cell vessels will be containerized and representative samples will be collected and submitted for laboratory analysis for waste profiling. The material contained in the cut-up piping will be sampled and analyzed as well. The samples will be analyzed for the RCRA 8 metals, both total and TCLP. The results from that analysis will be used to determine if the material will be classified as a non-hazardous or hazardous waste. If it is non-hazardous it will be transported to the Apex Landfill. If it is hazardous, arrangements will be made to transport it to a permitted hazardous waste landfill.

The materials that were used to construct the electrolytic cells will also be sampled and analyzed. The sidewall of a cell will be cored or broken apart and the materials of construction will be visually observed. Samples will be collected of the materials that are found to be present and they will be analyzed to determine how they are to be disposed. The analysis will be selected once the materials can be observed, but it is anticipated that at a minimum the samples will be analyzed for the RCRA 8 metals, both total and TCLP. The results from that analysis will be used to determine if the material will be classified as non-hazardous or hazardous. If it is non-hazardous it will be transported to the Apex Landfill. If it is hazardous, arrangements will be made to transport it to a permitted hazardous waste landfill.

8.0 DEMOBILIZATION

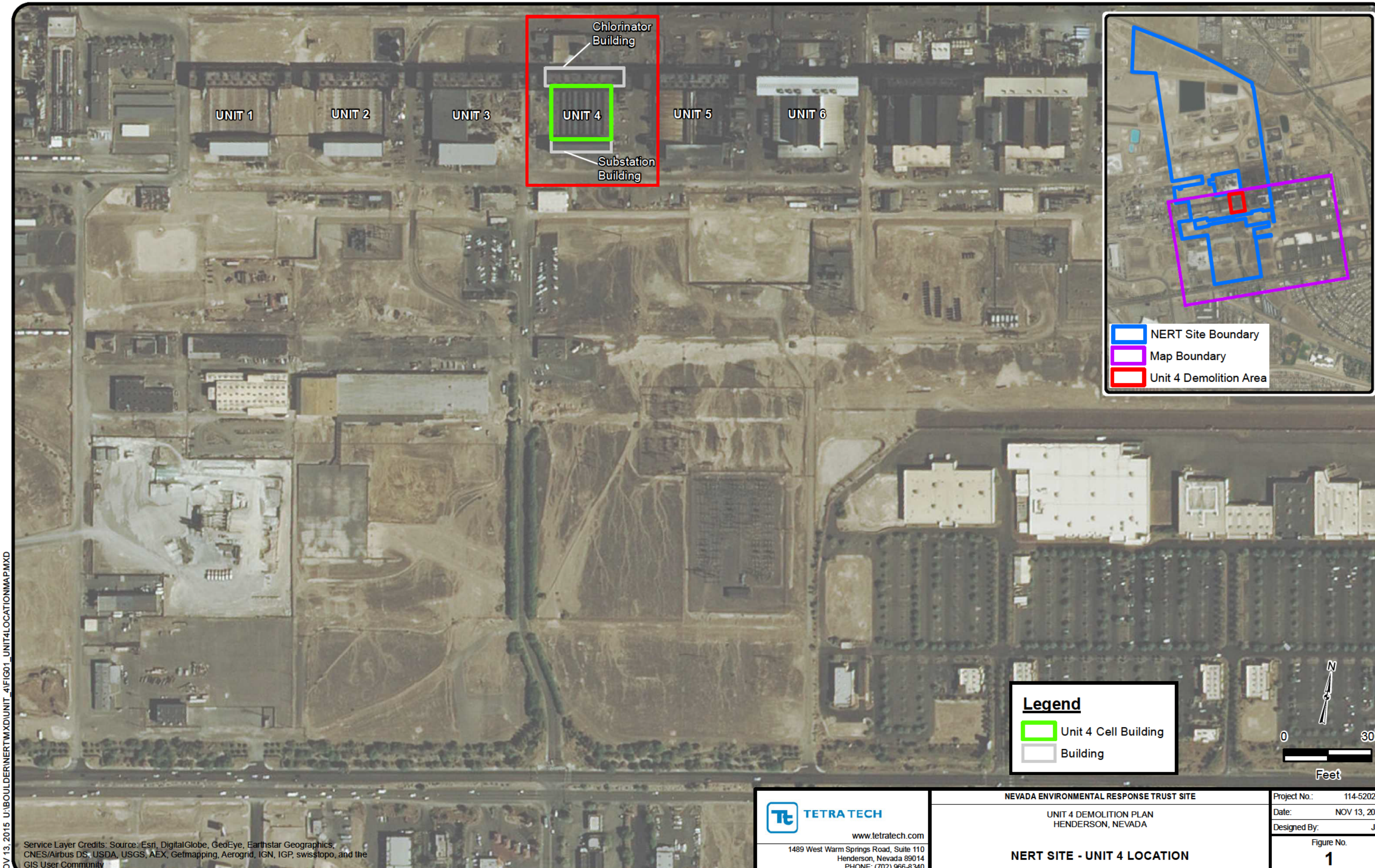
Upon completion of demolition activities, remaining equipment, materials, and personnel associated with demolition work will be demobilized from the site. The equipment that was used for the demolition work and to move the debris around will be decontaminated by pressure washing prior to removal from the site. Waste wash water generated by the decontamination will be discharged to the southwest corner of the GW-11 Pond.

9.0 REFERENCES

The following documents were referenced in this Demolition Work Plan:

- Unit 4 and 5 Buildings Investigation Work Plan, Tetra Tech, Inc., March 30, 2015
- Environmental Conditions Assessment, Kerr-McGee Chemical Corporation, Henderson Nevada, Kleinfelder, April 1993.
- Health and Safety Plan for Site-Wide Investigation and Remedial Activities, Nevada Environmental Trust, Henderson Nevada, Revision 4, Tetra Tech, Inc., December 4, 2015
- Site Management Plan, Revision 2 Nevada Environmental Response Trust Site, Ramboll Environ, July 17, 2015.
- Pre-Demolition Hazardous Materials Inspection, Unit 4 Cell Building, Tetra Tech, Inc. October, 2015.
- Unit 4 Buildings Condition Assessment Technical Memorandum, Tetra Tech, Inc., June 17, 2015.
- Demolition Vibration Impact Study, Tetra Tech, Inc., January 22, 2016

Figures



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NOV 13, 2015 U:\BOULDER\NERT\WXD\UNIT_4\FIG01_UNIT4LOCATIONMAP.MXD

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NEVADA ENVIRONMENTAL RESPONSE TRUST SITE

UNIT 4 DEMOLITION PLAN
HENDERSON, NEVADA

NERT SITE - UNIT 4 LOCATION

Project No.:	114-520225
Date:	NOV 13, 2015
Designed By:	JJA
Figure No.	1

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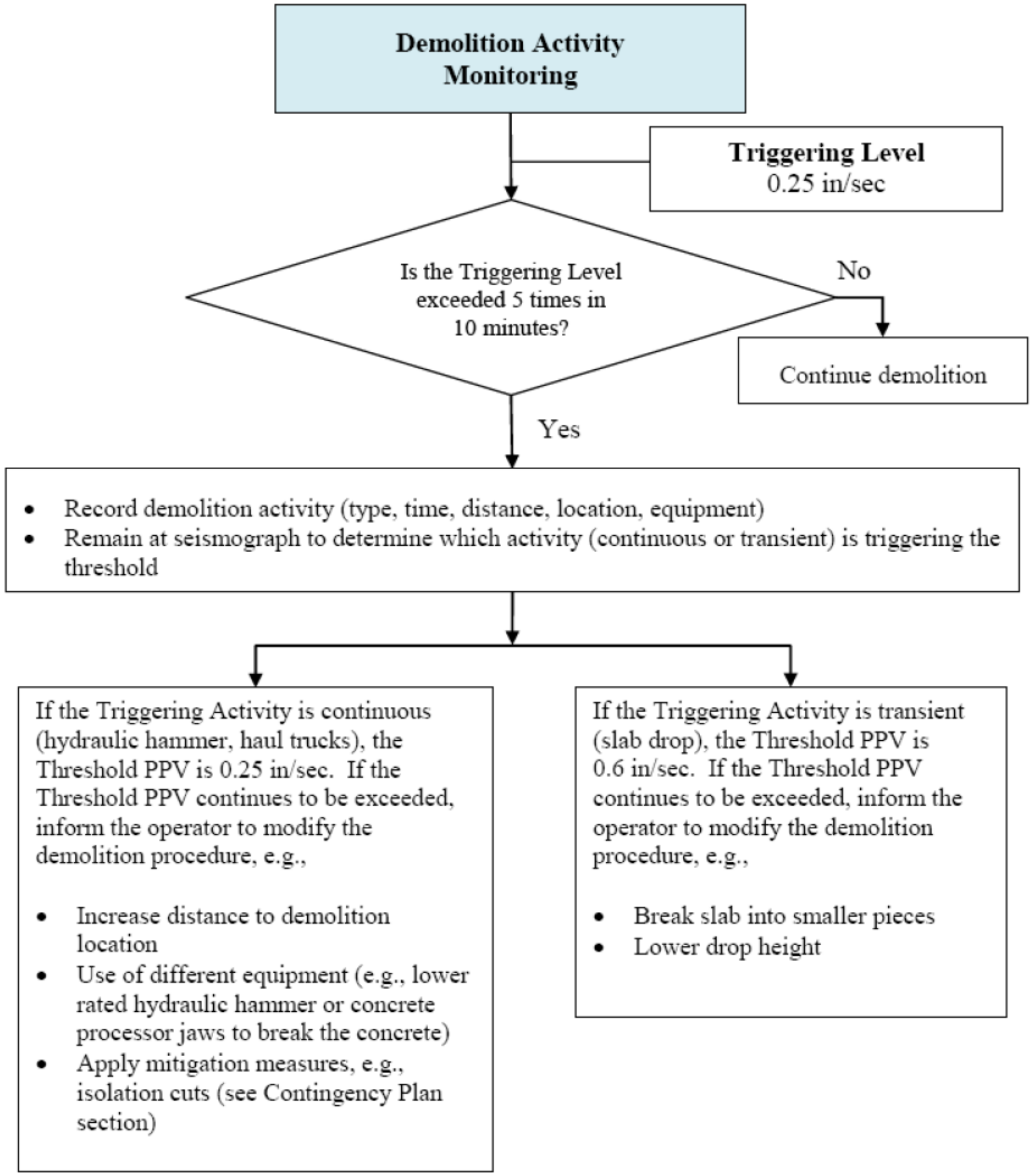
NEVADA ENVIRONMENTAL RESPONSE TRUST SITE

UNIT 4 DEMOLITION PLAN
HENDERSON, NEVADA

UNIT 4 BUILDING LOCATIONS

Project No.:	114-520225
Date:	NOV 12, 2015
Designed By:	JJA
Figure No.	2

NOV 12, 2015 U:\BOULDER\NERT\WXD\UNIT_4\FIG02_UNIT4CELLBUILDING.MXD



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NEVADA ENVIRONMENTAL RESPONSE TRUST SITE

UNIT 4 DEMOLITION PLAN
HENDERSON, NEVADA

DEMOLITION MONITORING

Project No.:	117-7502016
Date:	JAN 25, 2016
Designed By:	JJA
Figure No.	3

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NEVADA ENVIRONMENTAL RESPONSE TRUST SITE

UNIT 4 DEMOLITION PLAN
HENDERSON, NEVADA

PROPOSED WORK AREA SIGN

Project No.:	117-7502016
Date:	JAN 25, 2016
Designed By:	JJA
Figure No.	4

JAN 25, 2016 U:\BOULDER\NERT\MXD\UNIT_4\FIG03_WORKAREASIGN.MXD

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NEVADA ENVIRONMENTAL RESPONSE TRUST SITE

UNIT 4 DEMOLITION PLAN
HENDERSON, NEVADA

UNSTABLE STAIRS CURRENTLY LOCATED ON THE EAST SIDE OF DEMOLITION SITE

Project No.:	117-7502016
Date:	JAN 25, 2016
Designed By:	JJA
Figure No.	5

JAN 25, 2016 U:\BOULDER\NERT\MXD\UNIT_4\FIG04_UNSTABLESTAIRS.MXD

JAN 25, 2016 U:\BOULDER\NERT\MXD\UNIT_4\FIG05_DUSTBOSS.MXD

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NEVADA ENVIRONMENTAL RESPONSE TRUST SITE

UNIT 4 DEMOLITION PLAN
HENDERSON, NEVADA

DUST BOSS IN OPERATION

Project No.:	117-7502016
Date:	JAN 25, 2016
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Figure No.	6

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NEVADA ENVIRONMENTAL RESPONSE TRUST SITE

UNIT 4 DEMOLITION PLAN
HENDERSON, NEVADA

EXISTING TANK FOR DEMOLITION

Project No.:	117-7502016
Date:	JAN 25, 2016
Designed By:	JJA
Figure No.	7

JAN 25, 2016 U:\BOULDER\NERT\MXD\UNIT_4\FIG06_EXISTINGTANK.MXD

JAN 25, 2016 U:\BOULDER\NERT\MXD\UNIT_4\FIG07_EXCAVATORCONCRETE.MXD

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NEVADA ENVIRONMENTAL RESPONSE TRUST SITE

UNIT 4 DEMOLITION PLAN
HENDERSON, NEVADA

HYDRAULIC BREAKER

Project No.:	117-7502016
Date:	JAN 25, 2016
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Figure No.	8

JAN 25, 2016 U:\BOULDER\NERT\MXD\UNIT_4\FIG08_EXCAVATORSTEEL.MXD

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NEVADA ENVIRONMENTAL RESPONSE TRUST SITE

UNIT 4 DEMOLITION PLAN
HENDERSON, NEVADA

EXCAVATOR EQUIPPED WITH SHEAR FOR CUTTING STEEL

Project No.:	117-7502016
Date:	JAN 25, 2016
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Figure No.	9

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NEVADA ENVIRONMENTAL RESPONSE TRUST SITE

UNIT 4 DEMOLITION PLAN
HENDERSON, NEVADA

EXISTING TUNNEL ON THE EAST SIDE OF SITE

Project No.:	117-7502016
Date:	JAN 25, 2016
Designed By:	JJA
Figure No.	10

JAN 25, 2016 U:\BOULDER\NERT\MXD\UNIT_4\FIG09_EXISTINGTUNNEL.MXD

Appendix A

Technical Memorandum – Building Conditions Assessment

TECHNICAL MEMORANDUM

To:	Tetra Tech Nevada Environmental Response Trust Site Project Team
From:	Steve Babcock, P.E., Tetra Tech
CC:	Greg Farrell, Derek Amidon, Tetra Tech
Date:	June 17, 2015
Subject:	Building Conditions Assessment
Project Name:	NERT Unit 4 Cell Floor Demolition
Project No.	114-5200225-2015-M02

This technical memorandum summarizes the observed conditions of the Unit 4 buildings and provides recommended actions be taken prior to commencing with the demolition of the Unit 4 Cell Floor Area. The demolition work is planned to allow execution of the Soil Sampling program in the Unit 4 area.

A pre-demolition structural engineering survey has been completed for the Unit 4 Cell Floor, Substation Building and Chlorinator Building. This technical memorandum presents the results of the survey and recommends further actions that are designed to reduce the risk of premature collapse of the structure during the demolition process. Mr. Steve Babcock P.E. conducted the structural engineering survey on May 19 and 20, 2015.

1.0 Structural Description and Configuration

The Nevada Environmental Response Trust (NERT) site is located near Henderson, Nevada and includes ten unit buildings, each with three primary structural areas. The primary areas of each unit building are the Chlorinator Building, Cell Floor Area and Substation Building, from North to South. See Figure 1 for the overall site plan and Figure 2 for the Unit 4 plan view.

Figure 1: NERT Project Site Plan - Unit 4 location

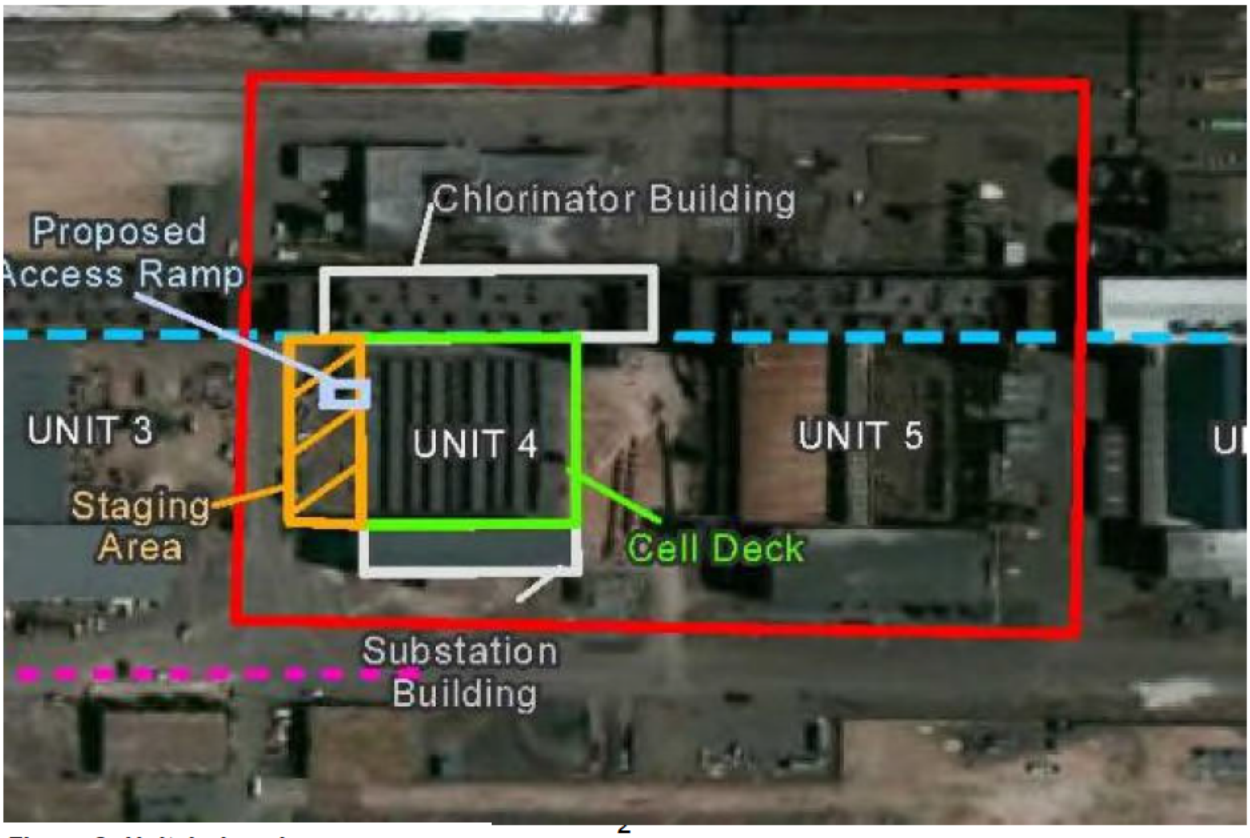

Figure 2: Unit 4 plan view

Unit 4 Substation Building

The Unit 4 Substation Building, (also referred to as the Rectifier Building), is constructed with large concrete portal frames with concrete masonry unit (CMU) block panel walls between. There are three levels to this building, one ground level and two basement levels. The ground level walls contain integrated bridge crane supports for an operational 5-ton crane. Also housed in this area is floor-supported process equipment for the tenant company, Tronox. The first basement level, constructed of cast-in-place concrete, houses various electrical panels. The second basement level was not observed due to time constraints, but design drawings indicate that it has a substantially smaller footprint area and does not directly border the basement of the Unit 4 Cell Area Building.

Figure 3: Unit 4 Substation Building brick wall, looking south

Unit 4 Cell Building

The Unit 4 Cell Building has been partially demolished. The remaining structure is a ground level concrete floor supported by steel beams and columns that extend to the basement level. The majority of the Cell Floor Area is physically isolated from the surrounding level (including the Substation and Chlorinator Buildings) as part of the original design. This isolation is achieved by a horizontal clear space of approximately twelve inches. This area is referred to as the Cell Island in this memo. The Cell Island and the adjacent slab that surrounds it, referred to as the curtain slab, are supported by steel columns that bear on pedestals in a common basement area. There are several places with loose grating and steel plates positioned for personnel and small vehicle access to the Cell Island, but they are not currently in use. The curtain slab is structurally integrated with the adjacent Substation Building and the Chlorinator Building floor slabs. The basement level consists of the aforementioned columns, and pedestals and trench drains in the basement floor. There are two access doors from this basement area into the adjacent Substation Building basement.

Unit 4 Chlorinator Building

The Unit 4 Chlorinator Building, which is shown in Figure 4, consists of three levels above ground. The structure is constructed with steel columns and beams encased in concrete, with concrete floor slabs at all levels. The second level wall contains a steel truss that appears to have been part of the original roof structure over the Unit 4 Cell Floor Area, which has been removed. The second level has a CMU curtain wall along the south side and panel siding on the other three sides. The third level has panel siding on all four sides. The first level houses an operational compressor system consisting of at least six pieces of equipment. The second and third levels are abandoned. They were not toured due to the poor conditions discussed in the following sections.

A number of elevated pipes are supported along the south side of the Unit 4 Chlorinator Building. These pipe appear to run from Unit 3 through Unit 4 and into Unit 5. It is suspected that these pipes extend through all ten units at the site, but that was not observed. These pipes contain active water and utility air pipeline and the recently decommissioned chlorine gas pipeline.

Figure 4: Unit 4 Chlorinator Building wall, looking northwest

A Wash Down Tower is located east of the Unit 4 Cell Floor Area and south of the Unit 4 Chlorinator Building, as shown in Figure 5. The Wash Down Tower is constructed of concrete and has brick lining. The Wash Down Tower is not currently in operation, and a few ground level openings have been infilled with brick.

Figure 5: Unit 4 Wash Down Tower, looking east

2.0 Design Modifications, Damage and Corrosion

Unit 4 Substation Building

The Unit 4 Substation Building has been affected by the removal of the roof structure over the Cell Floor Area, as shown in Figure 3. The north wall has a partial brick façade with visibly loose bricks along the upper portions, as shown in Figure 6. There are also visible horizontal ties to the CMU walls behind the brick; it is assumed that this construction method is typical and the brick is tied to the CMU wall throughout.

Figure 6: Loose façade bricks on the north wall of Unit 4 Substation Building

Inside the Unit 4 Substation Building there are two large cracks, approximately half way up in two of the ground level CMU wall panels located between column line 'G7-G9' and 'G9-G11'. The 'G7-G9' crack, shown in Figure 7, is representative of both cracks.

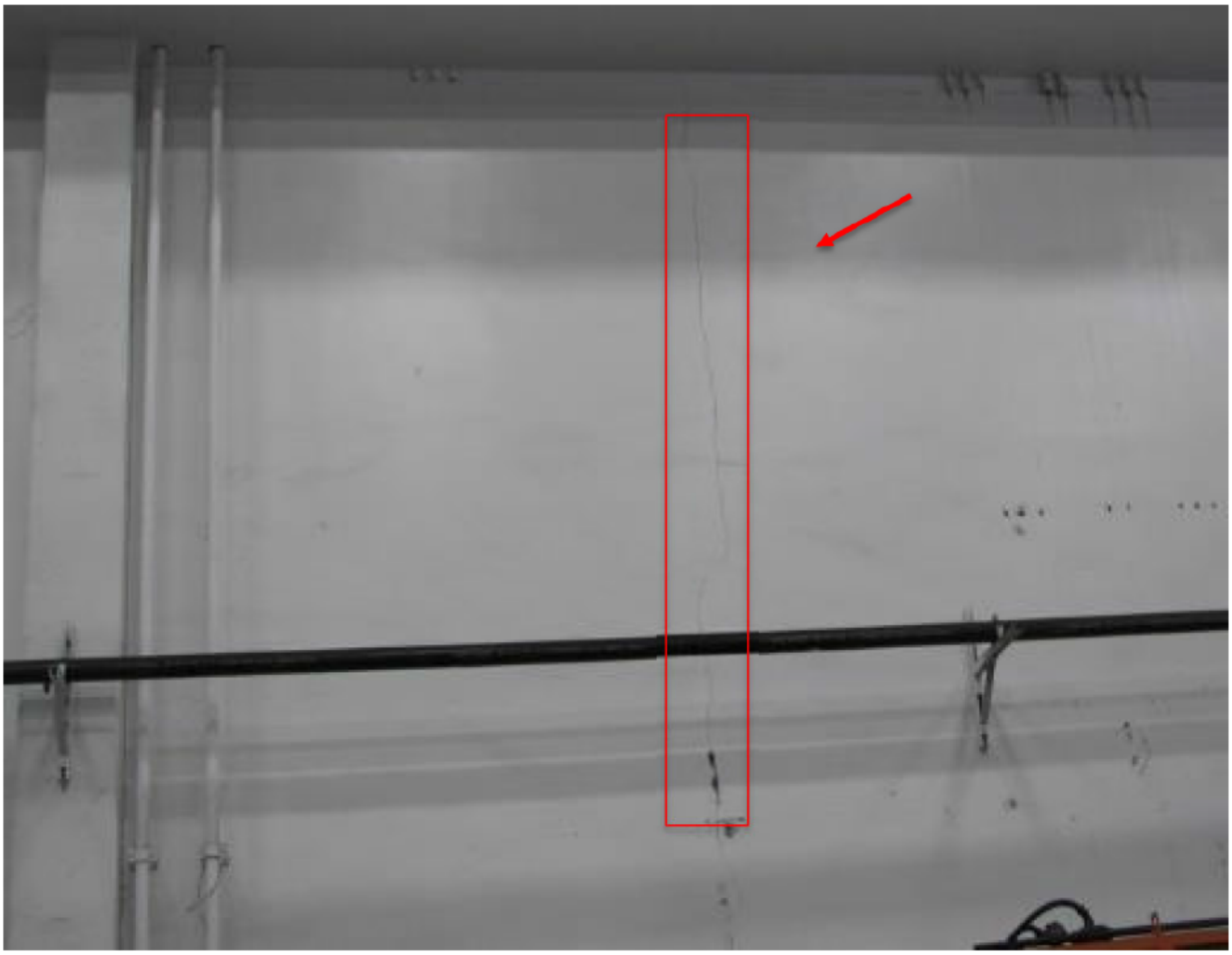

Figure 7: Crack in CMU wall in Unit 4 Substation Building

The ground level floor was substantially reinforced with steel beams and columns. Our Tronox escort indicated that this reinforcing was done to allow fork lift access on the ground level floor. See Figures 8, 9, 10 and 11 for illustration of this reinforcing.

Figure 8: Floor reinforcing bracket, Unit 4 Substation Building

Figure 9: Floor reinforcing beams, Unit 4 Substation Building

Figure 10: Floor reinforcing beams, Unit 4 Substation Building

Figure 11: Floor reinforcing columns, Unit 4 Substation Building

The north basement wall has significant horizontal cracking that appears to align with the bottom of the curtain slab in the Unit 4 Cell Floor Area. Figure 12 shows the cracks along a portion of that wall. The basement wall has also been modified with two gated doorways to provide personnel access to the adjacent Unit 4 Cell Area basement. There is one doorway on the west end and one on the east end of the Unit 4 Substation Building. Our escort indicated that these doorways were cut into the wall utilizing existing penetrations in the wall. It was also indicated that the horizontal cracking had already occurred at that time, and each doorway was reinforced with a steel channel header. A

Figure 12: Horizontal cracks in basement north wall

significant vertical crack was observed and can be seen in Figure 13 in the exterior wall at the outside middle third of the wall section. Both doorways are in similar condition.

Figure 13: Horizontal cracks in Unit 4 Substation Building basement wall near eastern door, and vertical crack in the wall section at the door opening

The basement wall was measured to be 16 inches thick with two layers of reinforcing, as shown in Figure 14. The wall has reinforcing at the center and the inside face, leaving an approximately 8 inch thick concrete cover adjacent to the Cell Floor Area, rather than reinforcing near both the inner and outer faces. It is suspected that this was done to provide a corrosion or thermal barrier.

Figure 14: Basement wall section at doorway to Cell Floor

Unit 4 Cell Floor Area

The curtain slab of the on the south side of the Unit 4 Cell Floor Area has structural support for the southern edge provided by the Unit 4 Substation Building foundation wall. The north side of this slab is supported by steel columns that bear on concrete pedestals in the basement area. The underside of the curtain slab shows severe concrete degradation and reinforcing bars are exposed and rusted. Figures 15, 16, and 17 illustrate the typical condition of the underside of the curtain slab.

Figure 15: Curtain slab of Unit 4 Cell Floor near Substation Building foundation wall

Figure 16: Curtain slab of Cell Floor near Unit 4 Substation Building foundation wall

Figure 17: Curtain slab of Unit 4 Cell Floor showing typical spalling

The support columns for the curtain slab and the Unit 4 Cell Island are supported by concrete pedestals in the basement area. All of these pedestals where observed to be severely corroded; many have catastrophic cracks and have partially crumbled. Figure 18, 19 and 20 illustrate the typical condition of the column pedestals observed in the Unit 4 Cell Floor basement area.

Figure 18: Unit 4 Cell Floor column pedestal, exposed rebar and severe rust and cracking

Figure 19: Unit 4 Cell Floor column pedestal, exposed rebar, severe spalling

Figure 20: A crumbling Unit 4 Cell Floor column pedestal

In the Unit 4 Cell Building basement area, many anchor bolts were observed, both in use and discarded. The bolts have a square washer that may contain asbestos, per our Tronox escort. One typical bolt is shown in Figure 21.

Figure 21: Anchor bolt with square washer suspected of containing asbestos

The Unit 4 Cell Floor Island consists of reinforced concrete slabs supported by steel beams and columns, as can be seen in the foreground of Figure 3 and in Figure 22. The concrete slab has spalling and exposed reinforcing bar similar to what was observed in the adjacent curtain slab. Portions of the Cell Island have been retrofitted with additional concrete encasement. Our Tronox escort indicated this was done by Tronox to allow for light vehicle use of the Unit 4 Cell Floor; however, this use has been discontinued. Typical encasing of the Unit 4 Cell Floor slab is shown in Figure 23. This encasement was not observed to be corroded or have areas of spalling concrete. The condition of the steel and original concrete slab are unknown, but are assumed to resemble the observed conditions of the unreinforced areas of the Cell Floor.

Figure 22: Cell Island slab

Figure 23: Typical cell floor concrete encasement

The southeast end of the Unit 4 Cell Island was not observed because the area was considered unsafe to access by our Tronox escort. As was the case with the south side of the Unit 4 Cell Floor Area, the north side also consists of a curtain slab. The north edge of that slab is supported by a partition wall. The south side of the curtain slab is supported by steel columns and pedestals, similar to the south side curtain slab described previously. A partition wall separates the Unit 4 Cell Floor Area from an air passageway. This passageway is inaccessible by design, its presence was indicated by our Tronox representative but not observable from the Unit 4 Cell Floor. The partition wall was observed to have extremely severe cracking along the top, between the wall and the curtain slab. It appears as though the curtain slab is no longer structurally connected to the partition wall, but simply bearing on top of it. This cracking is shown in Figure 24.

Figure 24: Cracking between the Unit 4 Cell Building north curtain slab and supporting partition wall

Furthermore, the partition wall was observed to have bowed inward to the south with significant horizontal cracking along the entire height and length of the wall. Typical cracking is shown in Figure 25.

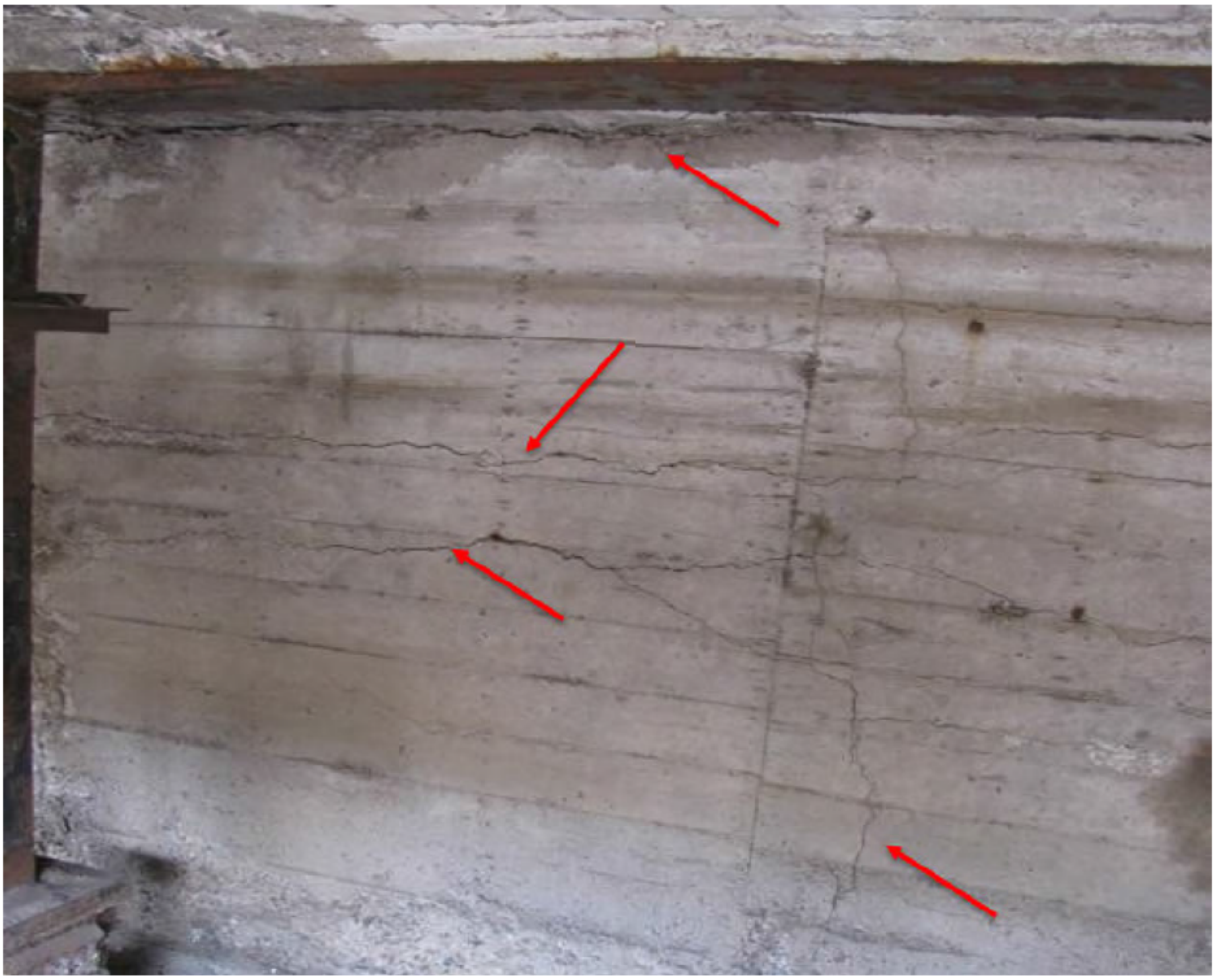

Figure 25: Horizontal cracking in the partition wall separating the Unit 4 Cell Floor Area from an air passageway

The curtain slab has a brick tile surface with significant cracking, as shown in Figure 26. The cracking appears to be located above the supporting partition wall. The condition of the concrete slab under the brick tile could not be observed.

Figure 26: Unit 4 Cell Building curtain slab brick tile cracking

Unit 4 Chlorinator Building

The Unit 4 Chlorinator Building was observed to have actively spalling concrete. Expanded metal grating was retrofit to the underside of the second level steel support beams along the south side of this building, as shown in Figure 27. The Tronox representative indicated that this was placed for catchment of spalling concrete. Areas of grating appear to also be failing, as shown in Figure 28.

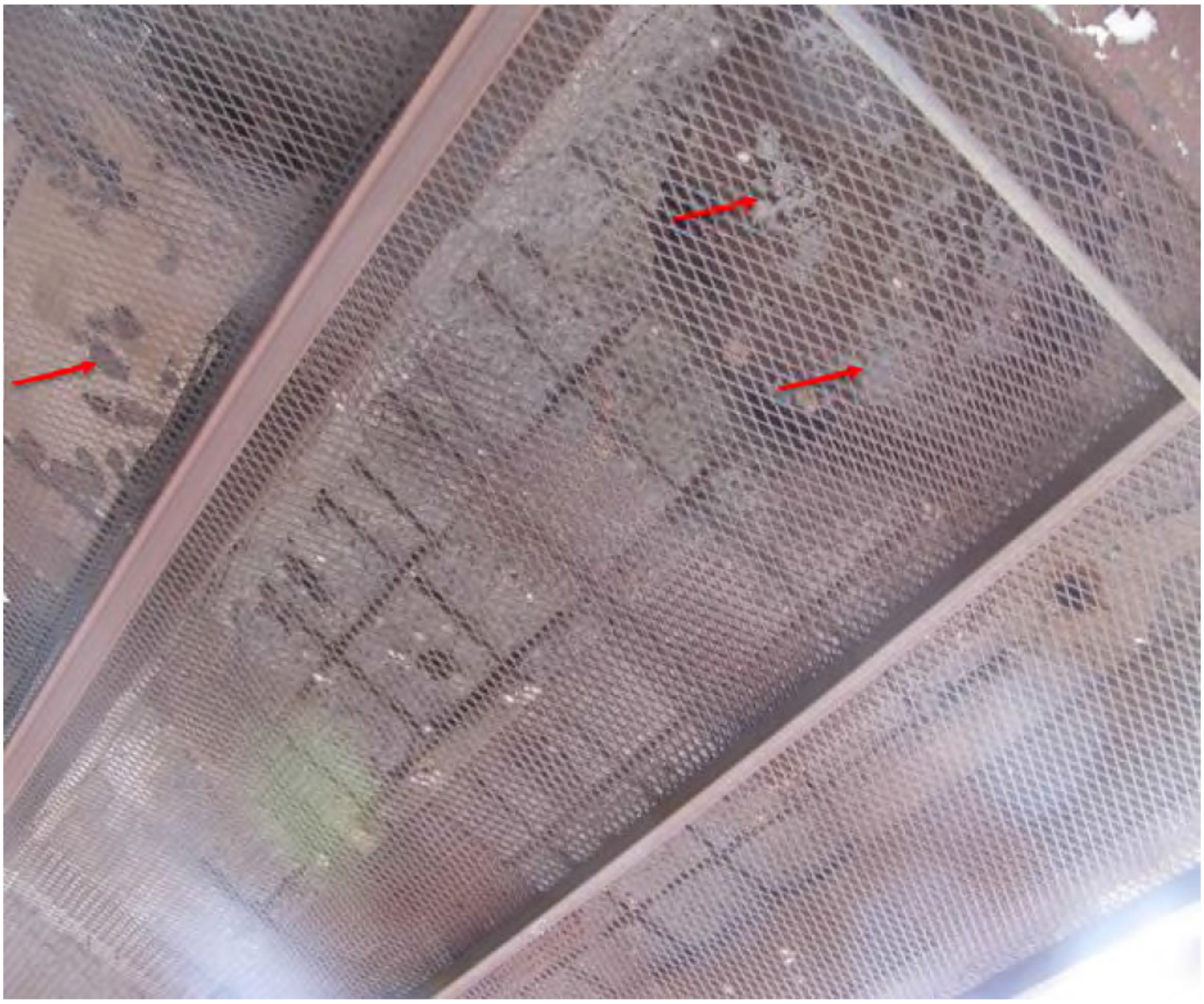

Figure 27: Unit 4 Chlorinator Building expanded metal grating retrofit under concrete actively spalling

Figure 28: Unit 4 Chlorinator Building spall protection failure

Inside the Unit 4 Chlorinator Building are operational compressors and air dryers. The second floor slab is actively spalling directly above the largest compressor, as shown in Figure 29 and Figure 30.

Figure 29: Unit 4 Chlorinator Building operational Compressor with active concrete spalling above

Figure 30: Unit 4 Chlorinator Building - spalling concrete above compressor

Active spalling was also observed above the air dryer, as shown in Figure 31 and Figure 32.

Figure 31: Unit 4 Chlorinator Building air dryer below spalling concrete

Figure 32: Spalling concrete above air dryer

The room east of the compressors does not have a second or third floor above. There are exposed steel beams, an abandoned elevator, and a stairway to the upper floors. The second floor was observed to have active and progressive concrete spalling and other deterioration, as shown in Figure 33 and Figure 34.

Figure 33: Unit 4 Chlorinator Building – second level

Figure 34: Unit 4 Chlorinator Building – second level

Significant spalled concrete, cracked floor slab, and rough and unmarked holes in the floor were observed on the second floor of the Unit 4 Chlorinator Building. A typical section of the floor slab is shown in Figure 35. One particular pile of spalled concrete was identified by our escort as being "new, from last night's rain." This material is shown in Figure 36.

Figure 35: Unit 4 Chlorinator Building – unmarked hole in second level slab

Figure 36: Unit 4 Chlorinator Building, second level “new” spalled concrete

Further observations of the second floor where not made due to safety concerns stemming from the structural condition of the floor and the absence of adequate railings and markings. The third level was also not observed due to these safety concerns. The south wall of the Unit 4 Chlorinator Building has an integrated steel truss that appears to have been part of the roof system formerly over the Cell Floor Area. This truss is infilled with a CMU wall. This CMU wall appeared to have superficial cracking. There is also an integrated pipe rack supported by cantilevers connected to this truss. One of the pipes is known to be compressed air from the compressor units within the Unit 4 Chlorinator Building; another is known to be a water supply pipe; and a third is the recently decommissioned chlorine gas pipe. The pipes are not readily marked but the Tronox representative could identify the service of each pipe. The integrated truss, CMU wall and piperack are shown in Figure 37.

Figure 37: Unit 4 Chlorinator Building - integrated roof truss along south side

Southeast of the Unit 4 Chlorinator Building is a Wash Down Tower. This tower is constructed of reinforced concrete that is actively spalling; reinforcing steel is also exposed and rusting. There is a heavy brick lining inside the tower but structural evaluation was not possible due to access restrictions. The Wash Down Tower is shown in Figure 5 and 38.

Figure 38: Unit 4 Wash Down Tower – spalling concrete near base

3.0 Areas of Consideration

Identified concerns for each of the Unit 4 structural areas are discussed in this section. Mitigation options are presented in the following section.

3.1 Unit 4 Substation Building

The cracking in the ground level north CMU wall, as shown in Figure 7, is considered more than superficial. However, the concrete portal frame design of the building is anticipated to provide adequate structural capacity for the operational bridge cranes and roof structure. There is concern that cracks in the CMU could become longer or wider as a result of demolition and soil sample drilling activities in the Unit 4 Cell Area.

The horizontal cracking in the north basement wall extends along the entire length of the building aligned with the curtain slab in the Unit 4 Cell Area, as shown in Figures 12 and 13. This slab is structurally connected to the Unit 4 Substation Building basement wall. The other side of the curtain slab is supported by periodic steel columns and concrete pedestals. Many of these pedestals are very corroded and crumbling, as shown in Figures 18, 19, and 20. It is likely that this corrosion has reduced the height of the pedestals, which then allowed excessive deflection of the Curtain Slab. This in turn caused an overstress in the connection of the curtain slab to the basement wall, resulting in the observed horizontal cracking. Having this type of cracking creates concerns of potential movement and vibration of the first floor and north wall, including the bridge crane support rails, when exposed to demolition and sample drilling activities. In addition, exposed concrete in the basement walls is in poor condition with some loss of cement paste resulting in areas of exposed aggregate at the wall face. Segregation of the aggregate was noted in some of the exposed areas and likely occurred during the original concrete placement. The current condition of the concrete will likely adversely influence tensile and compressive strengths both vertically and laterally along the existing wall.

The brick façade on the exterior face of the north wall covers much of the wall surface, as shown in Figure 3. The edges of this façade are visually separating from the CMU wall, as shown in Figure 6. It is probable that individual bricks will detach and fall to the ground during the demolition and soil sample drilling activities. However, due to the existence of intermediate brick ties, a complete collapse of the façade is not anticipated.

3.2 Unit 4 Cell Floor Area

The entire Unit 4 Cell Floor Area is in a state of disrepair and is in extremely poor condition. Caution should be used at all times when accessing this area. The primary focus of this work task is to demolish the Unit 4 Cell Floor Area to provide equipment access to the basement level to execute a drilling and soil sampling program. Therefore this area is not in need of any reinforcing, but the demolition process should be developed with careful considerations of the poor condition of this area. Due to the vibration sensitivity of the adjacent buildings, it is recommended that the demolition work be accomplished using shearing and cutting machinery instead of impact equipment.

Lateral earth pressures generated by the natural silty sand or sandy silt backfill are currently acting upon the existing east and west Unit 4 Cell Floor basement wall. These pressures will be redistributed after the demolition of the curtain slab and basement floor. This redistribution will occur because the curtain slab and basement floor provide lateral stiffness to the basement walls. Once removed or disrupted, the stiffness of this system will decrease and internal stress levels within the wall will increase. The increased stress in the wall may result in lateral deformation of the wall. Lateral earth pressures along the basement wall will vary from at-rest conditions at rigid intersections with perpendicular walls and concrete pilasters to active conditions between these points of rigidity. The resulting lateral deflection of the basement wall will also vary in magnitude correlating to the stiffness of the remaining basement wall system. The existing walls alone are anticipated to be capable of supporting the lateral earth pressure at their current level. Demolition debris or backfill for ramp construction should not be placed adjacent to the basement walls as this would apply a surcharge load and increase the lateral pressures acting on the basement walls. Increases in lateral pressure beyond the current levels could overstress the basement walls and result in excessive deformation or collapse. It is equally important that heavy equipment not be positioned closer than 6 feet to the basement walls to prevent additive lateral stresses above normal soil loading.

3.3 Unit 4 Chlorinator Building

The Chlorinator Building is in a state of disrepair and is in extremely poor condition. Concrete spalling is actively occurring due to seasonal weather events, and the upper levels are not well-maintained and should not be accessed as part of this project. There are operating compressor and air dryer units in the ground level of this building, as shown in Figures 29 and 31. This equipment was indicated as being crucial to the operations of Tronox. There is active concrete spalling occurring on the underside of the second level floor slab that is directly over this equipment, as shown in Figures 30 and 32.

There is a series of utility pipes supported along the south wall of the Chlorinator Building shown in Figure 37. These pipes are elevated above ground at approximately the second level of the building. Adjacent to these pipes is a CMU infill wall. This CMU wall appears to be in acceptable condition but may become loose if exposed to significant vibrations.

4.0 Recommendations

Overall, the Unit 4 site is in a state of active decay. Personnel and vehicle traffic should be minimized at all times. Personnel should not access the upper levels of the Unit 4 Chlorinator Building unless absolutely necessary. If such access to the upper levels of the Chlorinator Building is required, adequate fall protection measures are to be implemented.

It is believed that the demolition and soil sampling programs can be executed safely with the implementation of the recommendations described in the following sections of this Technical Memorandum.

4.1 Unit 4 Substation Building

The basement wall should be reinforced by suitable means. This reinforcing should target restoring or exceeding the original design strength of the wall. This wall appears to be a good candidate for the use of Epoxy Injections technology to provide the necessary reinforcing. In addition, a vibration monitoring system should be developed and installed along the north wall to mitigate the potential impacts of vibrations on the structural integrity of the building. As part of this system, allowable vibration criteria should be established utilizing industry standards for acceleration limits for the building construction types that are present in Unit 4.

Adequate monitoring technology should be chosen and utilized to provide the requisite evaluations in “real time” to act as a warning system during the demolition activities. This system should also include select crack monitoring to ensure significant cracks do not propagate as a result of the demolition and soil sampling activities.

An alternative to the basement wall reinforcing and monitoring system would be to relocate the process equipment out of the Unit 4 Area, either temporarily or permanently. If this relocation is temporary, the Substation Building would need to be reevaluated after the soil sampling program and necessary reinforcing would need to be implemented before re-occupying the space.

The north side of this building should be cordoned off from all pedestrian access prior to and during the demolition and soil sampling activities to mitigate the hazards of loose bricks falling on workers. At the start of the demolition activities the visibly loose bricks on this wall should be carefully removed to minimize bricks that may become loose and fall. In the even that other façade bricks become loose they will fall harmlessly to the ground within the cordoned off area.

4.2 Unit 4 Cell Floor Area

The demolition plan for the Unit 4 Cell Floor area should utilize shearing and cutting equipment. Impacting equipment should be avoided to minimize vibrations. All equipment used should have rubber wheels instead of steel tread, wherever possible, to minimize vibrations. Equipment and materials should be used and stored at least eight feet away from the top edge of the basement walls to prevent increases in lateral earth pressure on the basement walls.

4.3 Unit 4 Chlorinator Building

It is recommended that the critical equipment located in the Unit 4 Chlorinator Building be protected by a temporary shielding structure during the demolition and soil sampling program. Temporary scaffolding is recommended for use as the shielding structure as it is adaptable, easily installed without heavy equipment, and inexpensive. As a precautionary measure, a scaffolding system should also be installed to protect the pipes on the south side of the building. This system should be installed between the CMU wall and the pipes and have appropriate decking material above the pipes to preclude any dislodged CMU from falling on them.

Appendix B
Demolition Vibration Impact Study

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GEOSCIENCE

Project Number TET 16-83E
January 22, 2016

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Subject: **DEMOLITION VIBRATION IMPACT STUDY**
NERT Unit 4 Cell Building
Black Mountain Industrial Complex
Nevada Environmental Response Trust Site
Henderson, Nevada

Presented herein are the results of Tetra Tech BAS GeoScience vibration study evaluating the impact of the demolition of the concrete basement ceiling slab and steel supports at the Unit 4 Cell Building, at the Black Mountain Industrial (BMI) Complex in Henderson, Nevada (see Figure 1). The objective of the study was to determine how the vibrations generated by the demolition activities will affect buildings adjacent immediately to the north and to the south of the Unit 4 Cell Building, namely the Chlorinator Building and the Substation Building, respectively (see Figure 1) and provide vibrations mitigation and monitoring recommendations. This document is intended to provide a specific engineering evaluation and cannot be considered an independent document, as it does not provide adequate background information. Thus, this document is directed only to persons with detailed knowledge of the subject project.

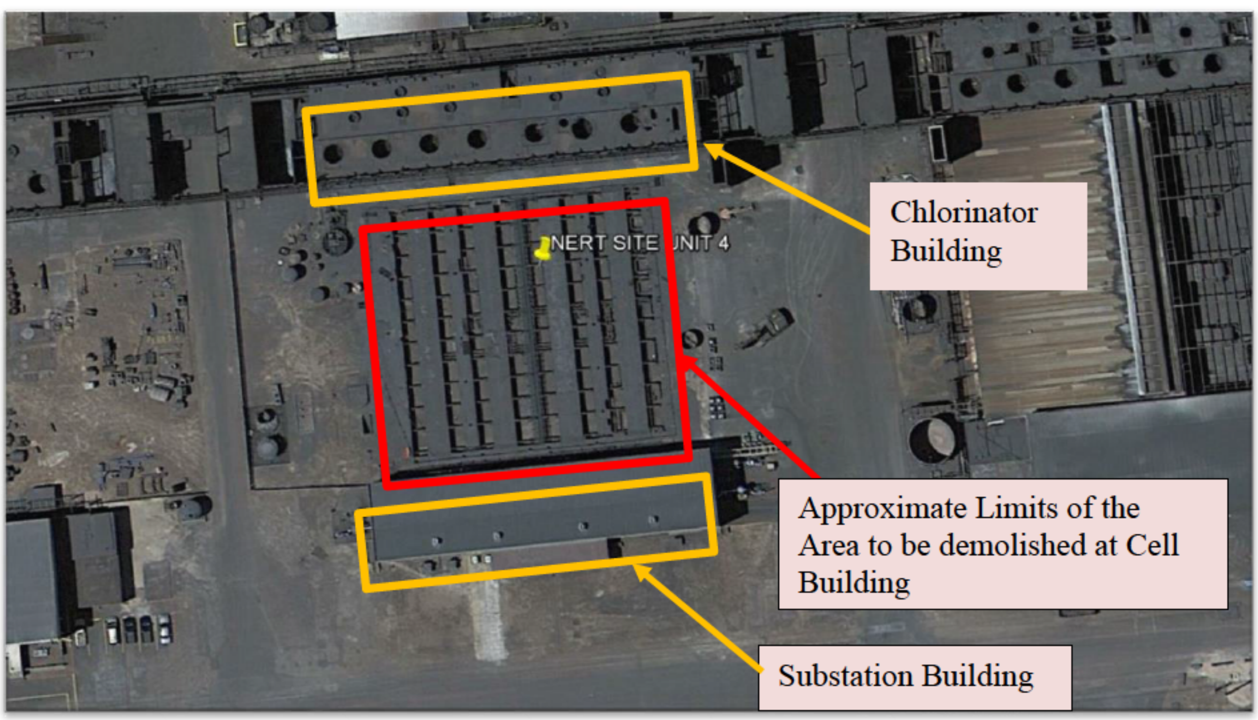

Figure 1. Building Locations at Unit 4

EXECUTIVE SUMMARY

The objective of this construction/demolition vibrations study is to develop recommendations for protection of the adjacent structures, the Chlorinator Building and the Substation Building, i.e., the protected structures, during the demolition of the Unit 4 Cell Building. The superstructure of the Unit 4 Cell Building has already been removed and the remaining demolition includes removal of the concrete basement ceiling over the entire Unit 4 Cell Building footprint of approximately 180 x 180 feet. The Substation Building has a basement located along the zero-lot-line to the south of the demolition area. The concrete ceiling is assumed to be about 6 inches thick and is supported on steel columns estimated to be on a 13 by 13-foot grid. The Unit 4 Cell Building concrete basement floor is approximately 8 feet below the adjacent grade. The basement perimeter is formed by a concrete wall.

The proposed demolition sequence consists of the ceiling concrete being broken using a hydraulic hammer, the concrete will fall on the concrete basement floor, the supporting steel beams and columns will be cut, and all debris will be hauled away from the basement.

It is understood that the Substation Building and the Chlorinator Building are to be protected from structural damage during the demolition activities. Minor cracking, spalling, and loosening of the masonry units and concrete is acceptable.

Structure protection against vibrations is conventionally based on the control of vertical peak particle velocity (PPV). Although the vibrations generated by construction have several components, the surface waves, also known as Rayleigh waves, are best correlated to the severity of the impact on structures. The method of structure protection design is based on determining the source of vibrations, development of associated attenuation relationships, establishing the threshold/acceptable PPV for the protected structures, and subsequently developing a plan to monitor the generation of the vibrations and procedures to control them within acceptable limits.

The following sections of this document provide detailed discussion on the development and use of the recommended attenuation relationships and on the selection of threshold PPVs.

The relevant characteristics of the Substation and Chlorinator Building protection and the key PPV threshold recommendations are presented in Table 1.

Table 1
Summary of Protected Structures and Protection Recommendations

	Chlorinator Building	**Substation Building**
Location	About 8 feet from the demolition area perimeter to the north	Zero-lot-line basement to the south of the demolition area
Building type	Steel frame and columns and steel/concrete beam system with unreinforced masonry/brick infill.	Concrete frame structure.
Building appearance		
Protection concept	General protection of the building to reduce potential for significant/excessive damage. The objective is not to prevent damage, the objective is to limit the potential damage within an acceptable level.	
Protection level	Protection level similar to protection of "historic buildings" to control vibrations within "minor" range.	
Recommended PPV threshold levels	Structural Damage 0.25 in/sec for continuous vibrations (hydraulic hammer, equipment traffic) 0.6 in/sec for transient event (slab drop)	
Expected effects of vibrations	Minor loosening, raveling, and falling of bricks and spalling of concrete, minor concrete cracking.	

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SITE CONFIGURATION

Environmental activities are planned for the Unit 4 area that will require the demolition of the remaining portions of the Unit 4 Cell Building above the basement slab. Tetra Tech has developed a Demolition Plan using best practices approaches learnt from previous unit building demolition activities at the site. Tetra Tech is also considering the effects of the vibrations caused by the demolition equipment on the existing structures and equipment, as well as on the safety of personnel working at the installations.

The protected buildings are presently leased to Tronox. The Chlorinator Building houses several large compressors and related equipment that produce compressed air for Tronox operations at the NERT Facility. The Substation Building houses Tronox processing and electrical equipment. It is understood that the equipment housed in the Chlorinator Building will be protected by temporary scaffolding as described in the Demolition Plan (Tetra Tech, 2015b). Furthermore, the piping that is attached to the south wall of the Chlorinator Building will also be protected by temporary scaffolding, and the equipment will not be operational during demolition activities. Therefore the effects of vibrations on operations of the equipment do not need to be considered.

A schematic view of a conceptual cross-section of the site is shown in Figure 2. The concrete basement ceiling slab to be demolished is currently connected to both the Substation Building and the Chlorinator Building. The demolition plan indicates that prior to the demolition the concrete basement ceiling slab along the north wall of the Substation Building and the ground level concrete slab/flatwork at the base of the south wall of the Chlorinator Building will be cut. These cuts will be at least 12 inches wide and are intended to isolate the buildings from the vibrations generated in the basement ceiling slab during the demolition process.

It is understood that the majority of the basement celling slab is already physically isolated from the surrounding level, including the Substation and Chlorinator Buildings, as part of the original design. This isolated ceiling slab area is referred to as the Cell Island (see Figure 3). The Cell Island and the adjacent concrete ceiling slab that surrounds it, referred to as the Curtain Slab are supported by steel beams resting on steel columns (see Figure 4) that are in turn supported by concrete pedestals built on top of the basement slab (see Figure 5). The curtain slab is also supported by the basement walls. The steel beams, the columns, and the concrete pedestals will be all be removed to the floor grade as a part of the demolition process.

Subsurface conditions at the site were evaluated by Tetra Tech in the Unit 4 and 5 Buildings Investigation Work Plan (March, 2015a). The site at Unit 4 is underlain by alluvial deposits described as reddish-brown discontinuous layers of sand and gravel with minor amounts of silt, clay and caliche. Up to 10 feet of fill has been encountered in some locations. The contact between the base of the sandy alluvium and the top of the underlying silty Upper Muddy Creek Formation is encountered at approximately 27 to 45 feet below ground surface at the site.

According to previous work at the site the depth to groundwater at the site ranges from approximately 27 to 80 feet. Therefore it is anticipated that groundwater will not have any effect on the transmission of vibrations to the protected structures.

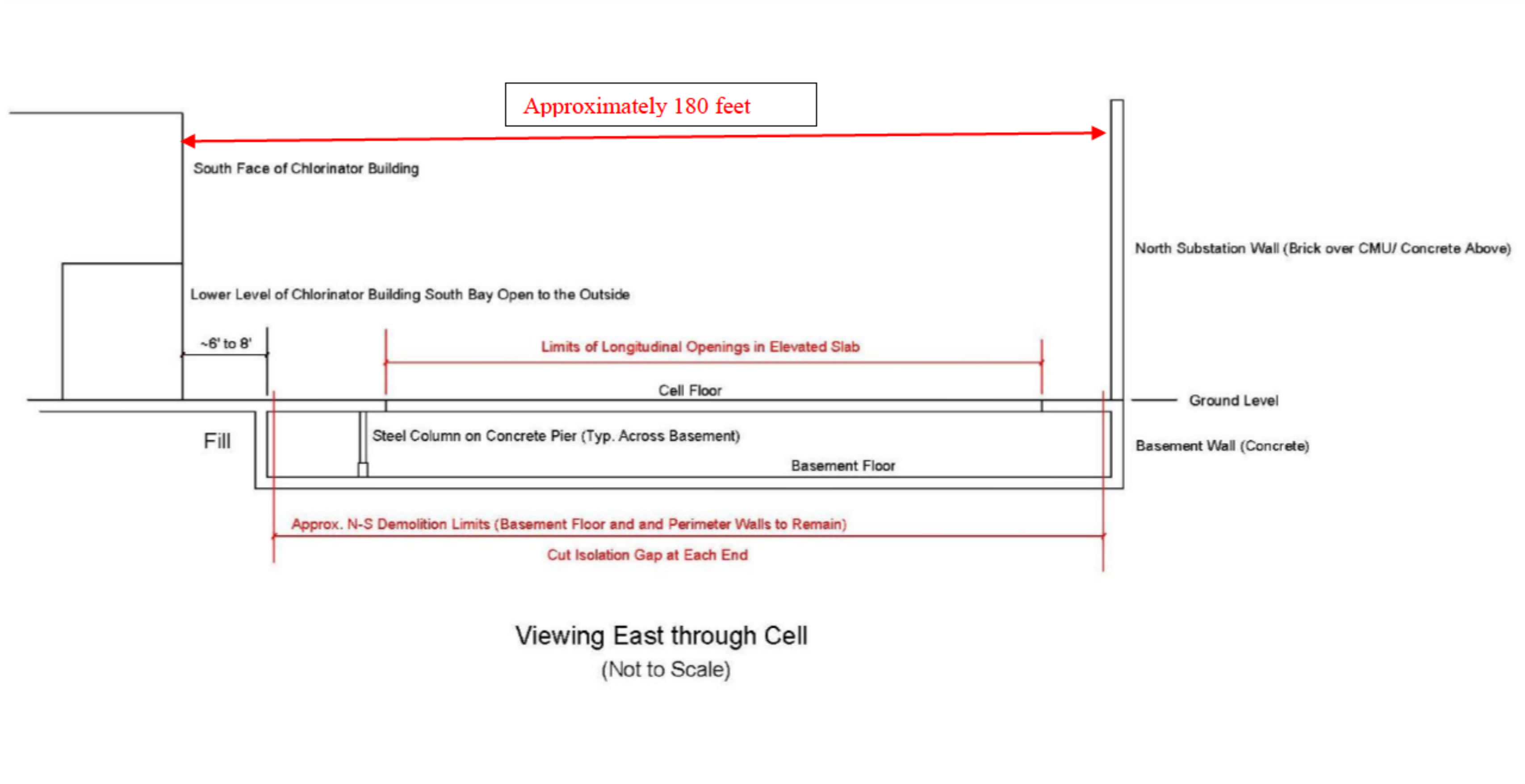

Figure 2. Schematic cross-section looking east through Unit 4 Cell Building

Figure 3. Unit 4 Cell Island Slab and separation

Figure 4. View of the Concrete Slab looking south towards the Substation Building

Figure 5. Steel Column Concrete Pedestal on the Unit 4 Cell Building basement floor

SOURCES OF VIBRATIONS

The most significant generator of vibrations is expected to be generated by breaking down the Unit 4 Cell Building concrete basement ceiling by the excavator equipped with a Sandvik hydraulic breaker BR4099 (see Figure 6). This piece of equipment (also known as hoe-ram, hydraulic hammer, or mounted impact hammer) is expected to be the primary source of continuous demolition vibrations at the site. The energy per strike is rated at 11,000 lbs-ft, and the expected frequency of operation ranges between 400 and 560 beats per minute. This equipment is expected to be used mainly for the demolition of the concrete ceiling slab. To minimize the effects of adverse vibrations, the excavator is planned to be equipped with rubber tires instead of steel tracks.

The second most significant generator of vibrations is expected to be the fall of the broken concrete ceiling on the basement floor. Based on the estimated spacing of the support columns, it is conservatively estimated that the vibrations-inducing energy will be generated by a concrete ceiling piece up to 6.5 feet by 6.5 feet and 6 inches thick falling from a height of 8 feet. This impact will generate an instantaneous impulse that will produce transient ground vibrations. The energy generated by a falling concrete slab with these dimensions is estimated to be about 25,350 lbs-ft.

The movement of the equipment on the basement slab, i.e., haul trucks, excavator with hydraulic hammer, excavator with steel shear jaws (see Figure 7) to remove the steel elements, and skid loader used to move the debris and to load the trucks, will generate lower level of continuous vibrations.

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Figure 6. Sandvik BR 4099 Hydraulic Breaker

Figure 7. Steel Cutters

VIBRATION PROPAGATION AND ATTENUATION

The estimate of vibration propagations around the subject demolition area is complicated. Conventionally, construction vibrations propagation from the vibrations source and through the soil are evaluated but in this case, the transfer of the vibrations to the ground is through the concrete ceiling slab, then through the steel column supports, and then through a large concrete basement floor slab and the perimeter basement walls. The vibrations propagation in this highly discontinuous and heterogeneous environment may be affected by localized effects, resonance, refraction, and presently unknown structural detailing that cannot be readily anticipated, qualified, and quantified. For instance, the continuity of the concrete basement slab and/or connection of the concrete basement floor in the Unit 4 Cell Building with the basement floor slab in the Substation Building may provide a direct path for the vibrations to propagate into the basement of the Substation Building. Consequently the herein presented analyses should be considered estimates that need to be verified in the field by direct measurements.

The vibrations generated by the hydraulic hammer breaking down the concrete ceiling will propagate through the supporting steel beams columns into the basement floor slab. Because of the relatively high stiffness of the concrete basement floor slab, the high frequency components of the vibrations will be primarily conveyed by the slab with relatively little attenuation and secondarily transferred to the surrounding soil. These vibrations generated by the hydraulic hammer are considered continuous and therefore are subject to the most stringent PPV threshold criteria which are expected to govern the impact on the adjacent structures. The vibrations caused by the fall of the broken concrete ceiling is an isolated/discreet transient event and therefore higher threshold PPV limits may be adopted. The movement of the equipment on the basement slab will generate lower level continuous vibrations and is not expected to govern the protection procedures.

In describing vibrations in the ground and in structures, the motion of a particle (i.e., a point in or on the ground or structure) is used. Vibratory motion is commonly described by identifying the peak particle velocity (PPV), which is the maximum zero-to-peak amplitude of the particle velocity at a given location over time. Vibration amplitude can be described in terms of a vertical component, a horizontal longitudinal component; a horizontal transverse component, and by the resultant vector, which is the vector sum of the horizontal and vertical components.

When the ground is subject to vibratory excitation from a vibratory source, a disturbance propagates away from the vibration source. The waves generated are a combination of compressional primary body waves (P-waves), shear secondary body waves (S-waves) and Rayleigh surface waves (R-waves). These waves travel at different speeds: P-wave is the fastest, followed by the S-wave, then the R-wave. For a single short-duration excitation about 67% of the energy is transmitted in the R-wave, 26% in the S-wave and 7% in the P-wave. Therefore the R wave is the most significant disturbance along the surface of the ground. Furthermore, the R wave decays much more slowly with distance than body waves, thus R-waves are the primary concern for impact on foundations and structures on or near the ground surface.

Caltrans (2013) and other agencies and researchers use the vertical PPV component for assessing the vibrations because vibration amplitude along the ground surface is usually the greatest in the vertical direction and the vertical component is usually representative of the vibration in all three orthogonal directions. Most of the published criteria are therefore based on the correlations with the vertical PPV.

The general form of the equation to predict PPV attenuation is given below:

$$PPV_{D_x} = PPV_{ref}(D_{ref}/D_x)^n \text{ (in/sec)}$$

Where:

PPV_{D_x}	…	is the PPV at a distance from the vibration source D_x
PPV_{ref}	…	is the PPV measured at a reference distance from the vibration source D_{ref}
D_{ref}	…	is a reference distance from the vibration source
D_x	…	is a distance from the vibration source at which the PPV is estimated
n	…	is the slope or attenuation rate

The value of n is a function of the soil type and it usually ranges between 1 and 1.5. Caltrans recommends that for competent soils such as the soils encountered at the site a value of 1.3 be used, whereas for hard competent rock a value of 1.0 is recommended. Since the construction vibrations are likely to be influenced by the presence of the stiff concrete basement slab and the upper subsurface soils a value of 1.0 suitable for competent rock has been used in this document.

Furthermore, in order to modify the attenuation relationship for different levels of source energy E_1 and E_2, the PPV amplitude changes from PPV_1 to PPV_2 according to the following equation:

$$PPV_2 = PPV_1 \, (E_2/E_1)^{0.5}$$

These equations assume that the n coefficient which represents material damping is independent of the vibration frequency. This is considered acceptable because damage levels correlated to the PPV in the frequency range of 1-80 Hz tend to be independent of the frequency.

To estimate the PPV attenuation for the hydraulic breaker the following equation recommended by Caltrans (2013) was used:

$$PPV_{D_x} = PPV_{ref}(D_{ref}/D_x)^n(E_{equip})/E_{ref})^{0.5} \text{ (in/sec)}$$

Where:

PPV_{ref}	…	is 0.24 in/sec for a reference hydraulic breaker at a distance D_x of 25 feet from the vibration source
E_{ref}	…	is 5,000 lbs-ft (rated energy of the reference hydraulic breaker)
E_{equip}	…	is 11,000 lbs-ft (rated energy for Sandvik hydraulic breaker BR4099)
n	…	is 1.0

To estimate the PPV attenuation for the haul trucks the following equation recommended by Caltrans (2013) was used:

$$PPV_{D_x} = PPV_{ref}(D_{ref}/D_x)^n \text{ (in/sec)}$$

Where:

PPV_{ref} … is 0.076 in/sec for a reference haul truck at a distance D_x of 25 feet from the vibration source

To estimate the PPV attenuation generated by the piece of falling concrete the attenuation relationship recommended by Wiss (1981) for a 2-ton ball falling 40 feet to the ground was modified to account for the different level of energy using the above-provided scaling equation:

$$PPV_2 = PPV_1 \, (E_2/E_1)^{0.5}$$

Where,

PPV_1 … is the *PPV* determined for a 2-ton ball falling 40 feet (from Wiss, 1981)
E_1 … is the energy delivered by the 2-ton ball falling 40 feet, i.e., 160,000 lbs-ft
E_2 … is the energy delivered by the concrete slab falling 8 feet, i.e., 25,350 lbs-ft

and PPV_1 is given by the following equation:

$$PPV_1 = 28.714 \, (D_x)^{-1.501} \text{ (in/sec)}$$

The estimated PPV attenuation for these three primary sources of vibration are plotted in Figure 8 as a function of distance D_x from the source. This chart is to be used for the estimate of the vibrations generated during the demolition activities and for evaluation of the demolition vibration impact on the adjacent structures. This chart can be used to answer questions regarding the magnitude of PPV at any distance from the source of vibration for any of the selected demolition activities simply by selecting the demolition activity and the distance of the investigated point from the demolition activity and then reading of the estimated PPV on the vertical axis. This PPV can then be compared against the threshold PPV levels discussed later in this document.

Figure 8 indicates that the vibrations produced by the hydraulic breaker (red line) will be the controlling vibrations for the project. The vibrations produced by the falling concrete slab (blue line) and by the haul trucks (orange line) are provided for comparison purposes and are, as expected, much lower than the vibration amplitudes of the hydraulic breaker.

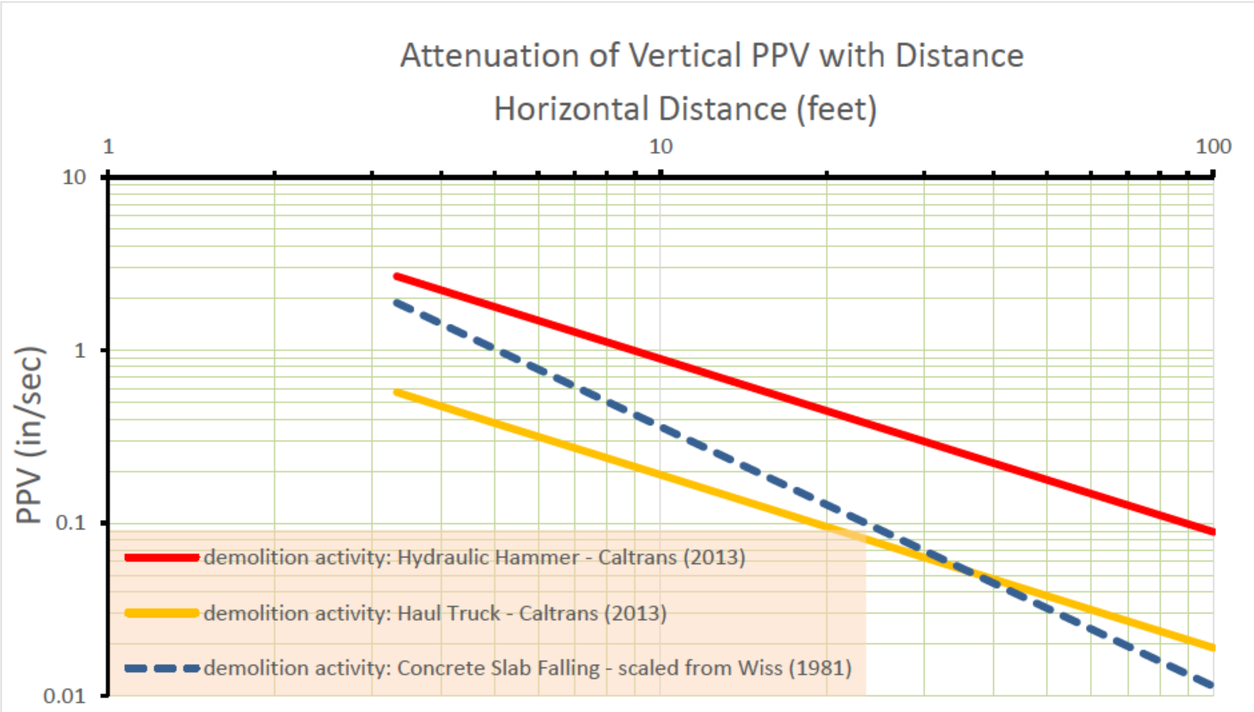

Figure 8. PPV Attenuation with Distance for the considered vibration sources

VIBRATION IMPACT CRITERIA

Vibration criteria were developed by various agencies and researches to establish threshold PPV levels that would cause different levels of damage to different types of structures subject to different vibration sources. The relevant distinction for this project is the differentiation between transient vibrations (single event), such as those produced by the falling concrete slab, and continuous vibrations, such as those produced by the hydraulic breaker and haul trucks. Based on the review of the published criteria, the following PPV threshold limits to prevent structural damage are recommended for the Chlorinator and the Substation Buildings:

- A threshold PPV of 0.6 in/sec is recommended for transient (falling slab) vibrations.
- A threshold PPV of 0.25 in/sec is recommended for continuous (hydraulic hammer, equipment traffic) vibrations.

The recommended threshold PPV values are plotted in Figure 9.

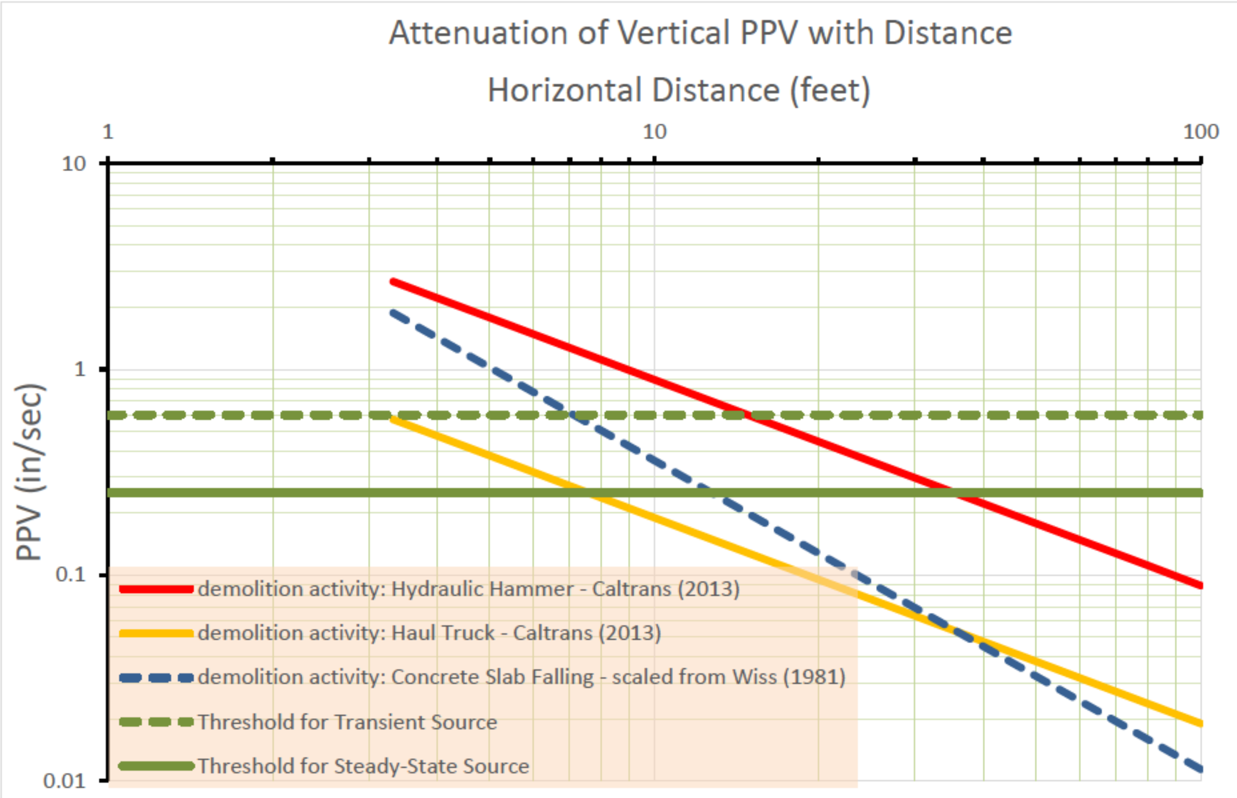

Figure 9. PPV attenuation with thresholds for Structural Damage

RECOMMENDATIONS

Based on the data provided in Figure 9, it is recommended that to prevent structural damage during demolition activities when using the hydraulic breaker should be set back at a minimum horizontal distance of 35 feet from the north-facing wall of the Substation Building and/or the south-facing wall of the Chlorinator Building. Large pieces of concrete may be allowed to fall to the ground and haul trucks may be allowed as close as 7 feet from the closest north-facing wall of the Substation Building and/or the south-facing wall of the Chlorinator Building.

These setback distances may be modified during demolition activities if the vibration monitoring program confirms that the PPV threshold values are not being exceeded and the performance of the structures is deemed satisfactory.

MONITORING

The complexity of the vibration propagation estimate is given by the presence of the concrete basement slab and basement walls which will convey the vibrations farther and attenuate less than the underlying soil. Although this is an unfavorable phenomenon, these concert elements will also absorb most of the vibrations and distribute it over a relatively large area and therefore less of the vibration energy may actually be transferred to the soil, which is a favorable phenomenon. There is also a potential for unfavorable augmentation of the vibrations when simultaneous activities are performed, i.e., several hydraulic hammers, hammer and slab fall and equipment traffic at the same time, etc.

Given this complexity, the provided attenuation relationships are intended to be reasonably conservative. This means that measured vibrations along the basement perimeter are expected to be generally lower than those predicted by these attenuation relationships, but some outliers and exceedance of the estimated PPVs should be anticipated. As previously discussed, the herein presented analyses should be considered estimates that need to be verified in the field by direct measurements. In order to calibrate the provided attenuation relationships, an initial and subsequent production monitoring program should be implemented to verify the presented recommendations and refine them as appropriate as outlined in Table 2.

Table 2
Recommended Vibrations Monitoring Program

	Initial Monitoring	Production Monitoring
Duration	2 days, best prior to start of production demolition activities	Entire demolition duration or until sufficient understanding is gained to ensure the required level of protection
Location of demolition	Along the east or west perimeter of the demolition area away from the protected structures. Work limited to only one area at a time.	Entire demolition area. Several work areas may be utilized.
Monitoring array	Set of 4 Instantel Seismograph Micromate/Blastmate units to form an attenuation measurement array.	Set of 2 to 6 Instantel Seismograph Micromate/Blastmate units to measure threshold PPV along the work perimeter.
Operated by	Engineer and a technician	Technician
Interpretation	It will take about a week to process and interpret the collected data	Maximum PPV and exceedance of PPV threshold levels interpreted continuously

The monitoring program during demolition is intended to be implemented by placing an array of seismographs in the basement of the Substation Building and another array in front of the Chlorinator Building. The array should be set up so that at least one seismograph of the array is offset laterally no more than 8 feet from the line connecting the location of the demolition activity with the nearest building wall. This offset can be increased by 8 feet for each 20-foot distance increment from the nearest wall, i.e., 16-foot offset for demolition activity distance between 20 to 40 feet from the wall. The actual number of seismographs in the arrays can be specified in the Monitoring Plan based on prescribed/anticipated coordination between the operator of the demolition equipment and the vibration monitor to minimize the resetting of the arrays during a work day.

This office can prepare a detailed Vibration Monitoring Plan upon request and in coordination the anticipated/preferred operation scheme at the site.

The seismographs will be monitored by an engineer/technician during the demolition activities and depending on the magnitude of the measured PPVs during demolition several levels of action would be triggered as shown in Figure 10.

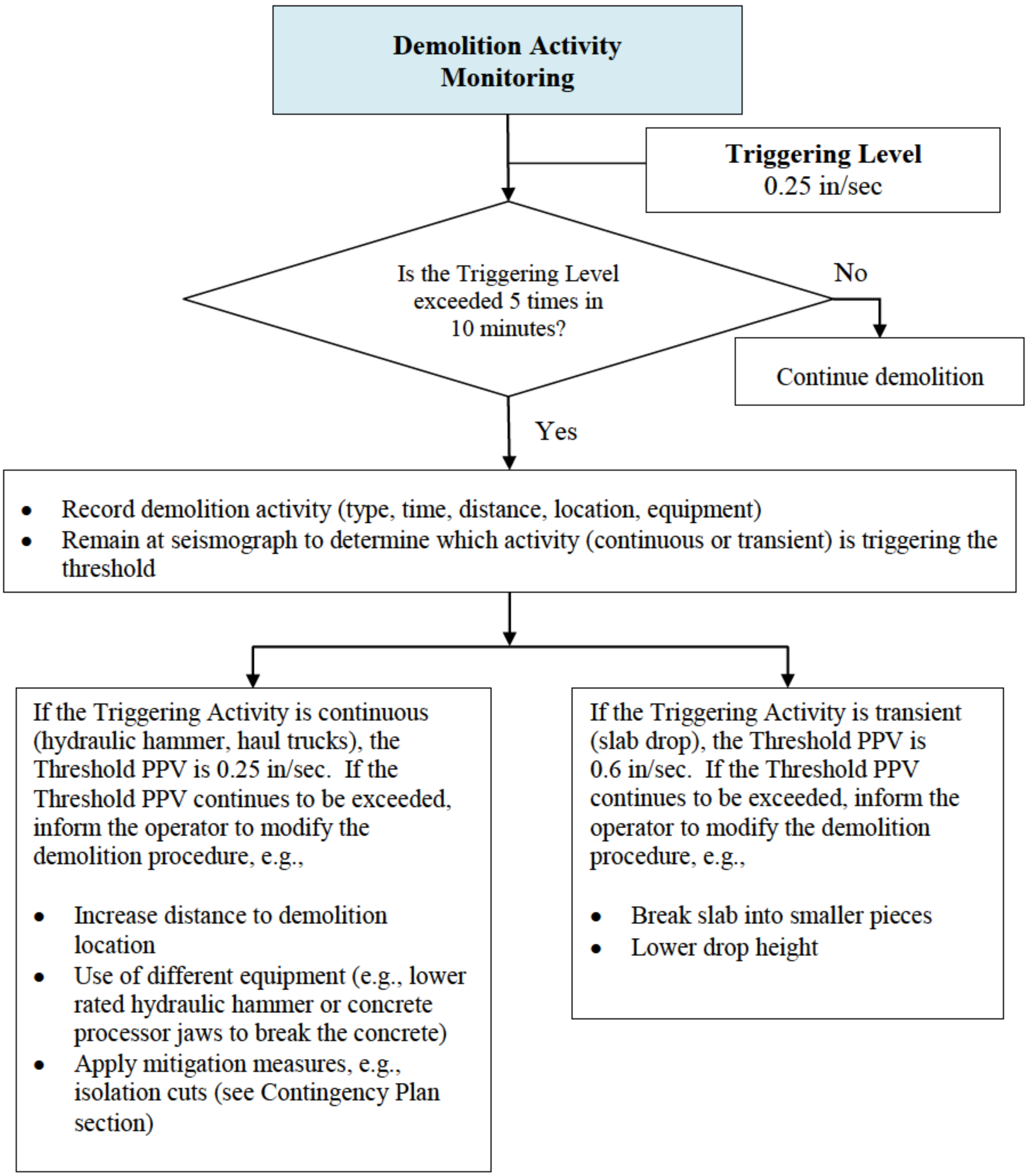

Figure 10. Demolition Monitoring

CONTINGENCY PLAN

Because of the already discussed complexity of the vibrations propagation prediction, it is recommended to consider contingency measures to augment, if needed, the protection of the protected structures. Specifically, it is recommended that if the vibrations at the protected structures are exceeding the acceptable PPV thresholds or if better control and/or damping of the vibrations is desired, that at least a 5 feet wide swath of concrete basement slab be cut along the perimeter of the basement to separate the basement walls from the basement floor slab and thus reduce the vibrations transfer into the basement walls. Additionally, to further augment the control of the vibrations, a trench about 3 feet deep and 3 feet wide may be excavated in the soil in the cut-out swath along the basement perimeter to intercept some of the the surface waves and confine the vibrations propagation.

LIMITATIONS

The recommendations and opinions expressed in this report are based on Tetra Tech BAS GeoScience's review of provided background documents prepared by others at the site.

Conditions not observed and described in this report may be present on the site. Uncertainties relative to vibration propagation through the concrete basement slab and the adjacent conjoined structures can be resolved through a well devised monitoring program.

Tetra Tech BAS GeoScience's recommendations for this site are dependent upon appropriate quality control of the vibration monitoring program. Accordingly, the recommendations are made contingent upon the opportunity for Tetra Tech BAS GeoScience to observe and monitor the vibrations due to demolition activities at the Unit 4 Cell Building. If parties other than Tetra Tech BAS GeoScience are engaged to provide such services, such parties must be notified that they will be required to assume complete responsibility for the vibration monitoring and evaluation.

This document is intended to be used only in its entirety. No portion of the document, by itself, is designed to completely represent any aspect of the project described herein. Tetra Tech BAS GeoScience should be contacted if the reader requires additional information or has questions regarding the content, interpretations presented, or completeness of this document. Reliance by others on the data presented herein or for purposes other than those stated in the text is authorized only if so permitted in writing by Tetra Tech BAS GeoScience. It should be understood that such an authorization may incur additional expenses and charges.

Tetra Tech BAS GeoScience has endeavored to perform its evaluation using the degree of care and skill ordinarily exercised under similar circumstances by reputable geotechnical professionals with experience in this area in similar soil conditions. No other warranty, either expressed or implied, is made as to the conclusions and recommendations contained in this report.

CLOSURE

Thank you for the opportunity to be of service on this project. If you have any questions or if we can be of further assistance, please do not hesitate to contact the undersigned at (909) 860-7777.

Sincerely,
Tetra Tech BAS GeoScience

Fernando Cuenca, Ph.D., P.E
Project Engineer.

Peter Skopek, Ph.D., G.E.
Principal Engineer

Filename: 2016-01-22 NERT Unit 4 Cell Building Vibrations Estimate.docx

Distribution: Addressee - (pdf to Dan.Pastor@tetratech.com and Greg.Farrell@tetratech.com)
Todd Garrett – (pdf to Todd.Garrett@tetratech.com)

SELECTED REFERENCES

CALTRANS, 2004. Transportation Related Earthborne Vibrations. Technical Advisory, Vibration TAV-04-01-R0201. Sacramento, January 23, 2004.

__________ 2013. Transportation and Construction Vibration Guidance Manual, Division of Environmental Analysis, Sacramento, CA. September 2013.

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Appendix C

Structural Protection and Monitoring Specifications

TETRA TECH	FALLING DEBRIS MITIGATION TECHNICAL SPECIFICATION	**SPECIFICATION NUMBER:** 01 35 23 SPE **PROJECT NAME:** NERT Task – M02

SPECIFICATION REVISION INDEX

Revision No.	Revision Date	Issued for	Signatures				
			Prepared By	Reviewed By	Project Engineer	Project Manager	Client
0	10/20/2015	Issued For Construction	SBH	SAB			NERT
1	12/11/2015	Reissued for Construction	SAB	RWB			NERT
2	01/12/2016	Reissued for Construction	GTF	GTF			NERT
3	02/02/2016	Reissued for Construction	SAB	GTF			NERT

SECTION 01 35 23 SPE

FALLING DEBRIS MITIGATION

PART 1 - GENERAL

1.01 SUMMARY

A. This Specification describes the use of temporary scaffolding to protect equipment and piping from falling debris at the Unit 4 Chlorinator Building and caution tape and warning signs to cordon off the area below the north face of the Substation Building to block access to workers to protect them from falling bricks.

B. This specification describes the area of the site cordoned off from pedestrian access north of the Substation building.

C. The work includes, but is not limited to, designing, providing and erecting the scaffolding, providing caution tape and warning signs to cordon off the designated area, maintaining the scaffolding and barriers throughout the course of the project, and removal at the conclusion of the project.

1.02 SUBMITTAL

A. An installation plan for the scaffolding and barriers shall be submitted to the Engineer for review prior to installation.

1.03 HEALTH & SAFETY

A. Site–specific health and safety training, provided by Tronox and Tetra Tech, is required for all personnel who will be onsite.

B. Contractor shall coordinate access to active work areas with Tronox and other Contractors on the site.

PART 2 - PRODUCTS

2.01 MANUFACTURER

A. The Contractor shall select the appropriate manufactures for the scaffolding and barriers. This information shall be included in the required submittal.

2.02 PERFORMANCE CRITERIA

A. The purpose of the scaffolding is to protect the elevated piping suspended off the south wall of the Chlorinator Building from damage that may result from CMU blocks dislodging and falling during the demolition activities.

1. The scaffolding shall be designed for a distributed load of 150 pounds per square foot.

B. The purpose of the concrete barriers is to prevent pedestrian access to the area indicated in Part 3. The contractor shall supply temporary concrete roadway barriers that can be readily moved using a forklift or small crane.

1. Barriers shall be located along the perimeter of the indicated area and shall not have more than three inches between adjacent barriers (end to end).

2.03 CODES AND STANDARDS

A. Unless noted otherwise, the latest issues of the following Specifications, Codes and Standards, including revisions and supplements in effect as of September 1, 2015, form a part of this Specification in their entirety, except as modified by this Specification.

B. American Society for Testing and Materials (ASTM)

C-825	Standard Specification for Precast Concrete Barriers
E661-03	Standard Test Method for Performance of Wood and Wood-Based Floor and Roof Sheathing Under Concentrated Static and Impact Loads
E695-03	Standard Test Method of Measuring Relative Resistance of Wall, Floor, and Roof Construction to Impact Loading

C. ANSI/ASSE A10.8 – Scaffolding Safety Requirements

D. Occupational Safety and Health Administration (OSHA), Department of Labor

1. Title 29 - Part 1910 - Occupational Safety and Health Standards.

2. Title 29 - Part 1926 - Safety and Health Regulations for Construction.

E. Should a conflict be found between the listed codes and standards and this Specification, the conflict shall be submitted to the Engineer for resolution prior to proceeding with the affected work.

F. Related Sections: 01 71 33

PART 3 - EXECUTION

3.01 INSTALLATION

A. Scaffolding shall be installed along the south side of the Chlorinator building and shall extend up approximately twenty feet, or as needed to protect the elevated piping. See Figure 1.

B. Concrete barriers shall be installed at ground level north of the Substation Building and shall prevent pedestrian access to the area between the Substation Building and the Cell Building area. Barriers shall not be located in the Cell Floor area basement or on top of the Cell Floor itself. See Figure 1.

1. After barriers are installed, Contractor shall carefully remove all visibly loose Façade Bricks from the north wall of the Substation Building. If other deficiencies in the building wall are identified as a result of or during this brick removal, the Contractor shall notify Tetra Tech personnel immediately.

C. Method of installation shall be determined by the Contractor and submitted to the Engineer for approval prior to installation.

3.02 MAINTENANCE

A. Scaffolding and barriers shall be inspected at the beginning and end of each work shift, by the Contractor, in order to verify that each are still intact and in compliance with the performance requirements of this specification.

B. Debris that may collect on the scaffolding shall be removed immediately after discovery. Debris shall be disposed of in accordance with project specifications.

C. If it is observed that debris has fallen outside the perimeter of the cordoned off area north of the Substation Building, the Contractor shall immediately notify Tetra Tech personnel. The perimeter shall be reevaluated by the Contractor and Tetra Tech for the likelihood of future debris falling outside of the perimeter. If such potential exists, the perimeter shall be extended as required to contain all falling debris within the perimeter of the warning tape.

D. Any defects that are noted must be repaired immediately following the inspection by the Contractor.

3.03 DEMOBILIZATION

A. At the end of the project all scaffolding, barriers and associated attachments shall be removed and disposed of by the Contractor.

PART 4 - EXHIBIT A

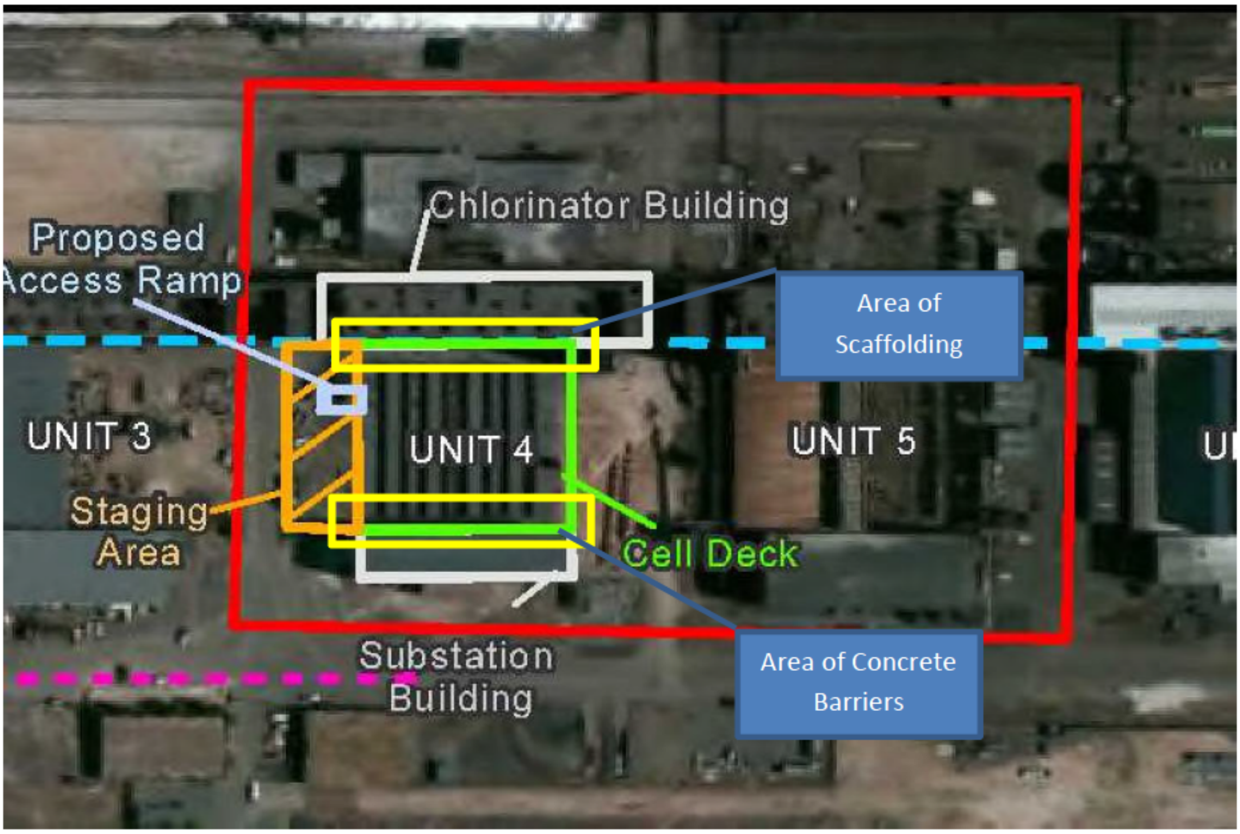

Figure 1: Site Map

Figure 1: North Wall of Substation Building

Figure 2: South Wall of Chlorinator Building

END OF SECTION

TETRA TECH	EXISTING EQUIPMENT PROTECTION TECHNICAL SPECIFICATION	**SPECIFICATION NUMBER:** 01 71 33 SPE **PROJECT NAME:** NERT Task – M02

SPECIFICATION REVISION INDEX

Revision No.	Revision Date	Issued for	Signatures				
			Prepared By	Reviewed By	Project Engineer	Project Manager	Client
0	10/20/2015	Issued For Construction	SBH	SAB			NERT
1	01/12/2016	Reissued for Construction	GTF	GTF			NERT

Confidentiality

Waiver of Liability

SECTION 01 71 33 SPE

EXISTING EQUIPMENT PROTECTION

PART 1 - GENERAL

1.01 SUMMARY

A. This Specification describes the temporary shielding of equipment in the Unit 4 Chlorinator Building.

B. The Work includes, but is not limited to, providing the temporary structure materials, constructing the temporary structures, maintaining the structures throughout the life of the project, and removing the structures at the conclusion of the project.

1.02 SUBMITTAL

A. A design and installation plan for the temporary shielding structures shall be submitted to the Engineer prior to installation.

1.03 HEALTH & SAFETY

A. Site–specific health and safety training, provided by Tronox and Tetra Tech, is required for all personnel who will be onsite.

B. Contractor shall coordinate access to active work areas with Tronox and other Contractors on the site.

PART 2 - PRODUCTS

2.01 MANUFACTURER

A. The temporary structures shall be constructed out of scaffolding unless another solution is approved by the Engineer.

B. Substitutions: The use of other than the specified structure will be considered, providing the contractor requests its use in writing to the Engineer. This request shall be accompanied by a design and installation plan for the alternative structure.

2.02 PERFORMANCE CRITERIA

A. The purpose of the temporary structures is to protect the equipment in the Chlorinator Building from damage that may result from concrete spalling that is actively occurring from the existing concrete structure above the equipment and other falling debris.

B. The temporary structures shall be designed to absorb an impact load of 10,000 pounds (force).

C. The temporary structures will be maintained during the course of the project and dismantled at the completion of the project.

2.03 CODES AND STANDARDS

A. Unless noted otherwise, the latest issues of the following Specifications, Codes and Standards, including revisions and supplements in effect as of September 1, 2015, form a part of this Specification in their entirety, except as modified by this Specification.

B. ANSI/ASSE A10.8 – Scaffolding Safety Requirements.

C. American Society for Testing and Materials (ASTM)

E661-03	Standard Test Method for Performance of Wood and Wood-Based Floor and Roof Sheathing Under Concentrated Static and Impact Loads
E695-03	Standard Test Method of Measuring Relative Resistance of Wall, Floor, and Roof Construction to Impact Loading

D. Occupational Safety and Health Administration (OSHA), Department of Labor

1. Title 29 - Part 1910 - Occupational Safety and Health Standards.

2. Title 29 - Part 1926 - Safety and Health Regulations for Construction.

E. Should a conflict be found between the listed codes and standards and this Specification, the conflict shall be submitted to the Engineer for resolution prior to proceeding with the affected work.

F. Related Sections – N/A

PART 3 - EXECUTION

3.01 INSTALLATION

A. The temporary structures shall be provided by the Contractor and installed over the equipment that is located in the Unit 4 Chlorinator Building. The equipment includes two (2) compressors, (3) receivers and (1) air dryer as shown in Exhibit A of this specification.

B. The temporary structure designs and installations shall be the responsibility of the Contractor and shall be approved by the Engineer prior to installation.

3.02 MAINTENANCE

A. The temporary structure shall be inspected at the beginning and end of each work shift, by the Contractor, in order to verify that it is still capable of protecting the equipment. These inspections shall be recorded and submitted to the Engineer each day.

B. Debris that may collect on the scaffolding shall be removed immediately after discovery. Debris shall be disposed of in a rolloff container provided by the contractor and the contents shall be disposed of in accordance with site requirements.

C. Repairs shall be made immediately by the Contractor if required. When repairs are deemed necessary the Contractor shall notify the onsite representative of the Engineer immediately.

3.03 DEMOBILIZATION

A. At the completion of the project the temporary structures shall be disassembled and removed from the site by the Contractor.

PART 4 - EXHIBIT A

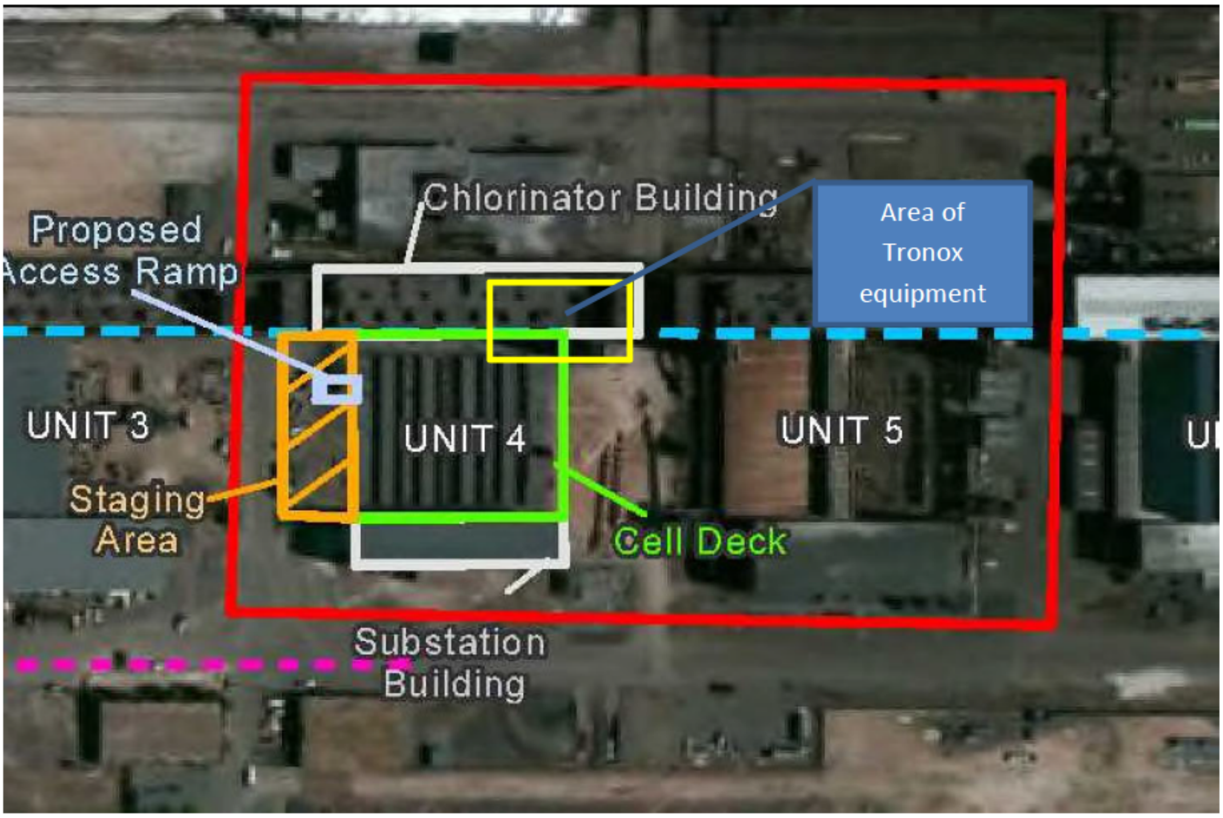

Figure 1: Site Map

Figure 2: Some of the Tronox Equipment with Spalling Concrete Above

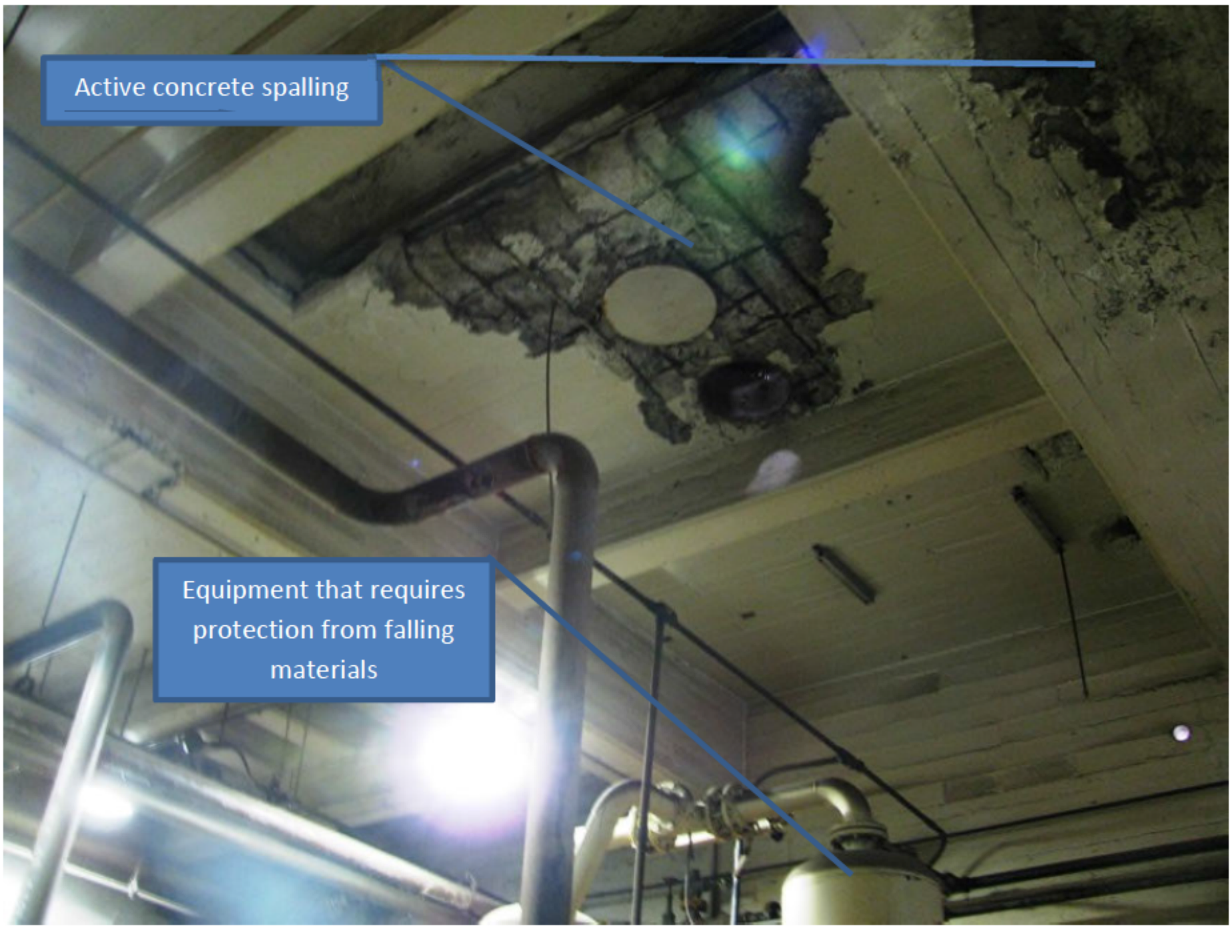

Figure 3: Active Spalling Above Tronox Equipment

Figure 4: More Tronox Equipment

END OF SECTION

TETRA TECH	VIBRATION AND CRACK MONITORING TECHNICAL SPECIFICATION	SPECIFICATION NUMBER: 02 22 13 SPE PROJECT NAME: NERT Task – M02

SPECIFICATION REVISION INDEX

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SECTION 02 22 13 SPE

VIBRATION AND CRACK MONITORING

PART 1 - GENERAL

1.01 SUMMARY

A. This Specification describes the vibration and crack monitoring equipment that shall be installed in and on the Unit 4 Substation Building during the demolition work in the Cell Deck Area, see Exhibit A.

B. The Work includes, but is not limited to, developing a monitoring plan, supplying all required vibration and crack monitors, monitoring equipment, notification systems, installing and monitoring the system, and removing all equipment at the conclusion of the project.

C. Protection of monitoring equipment and AC power sources shall be provided by the Owner.

1.02 QUALITY ASSURANCE

A. Contractor qualifications: Contractor shall be qualified in the field of vibration and crack monitoring with a successful track record of 5 years or more. Contractor shall maintain qualified personnel who have received proper training on the equipment being used.

1.03 SUBMITTAL

A. Contractor shall submit one (1) electronic copy of their monitoring plan, to include: list of equipment, locations of monitors, description of notification process, established vibrational and crack movement limits that shall result in work limitations or stoppages and supporting documentation for these limits.

B. Contractor shall submit weekly reports summarizing and interpreting the vibration and crack monitoring results.

1.04 HEALTH & SAFETY

A. Site–specific health and safety training, provided by Tronox and Tetra Tech, is required for all personnel who will be onsite.

B. Contractor shall coordinate access to active work areas with Tronox and other Contractors on the site.

PART 2 - PRODUCTS

2.01 PERFORMANCE CRITERIA

A. Performance thresholds have been established as follows:

1. Peak particle velocity (PPV) of 0.25 inches per second (in/sec) for continuous vibrations (hydraulic hammer use, equipment traffic); and

2. PPV of 0.60 in/sec for transient event (slab drop).

3. The Final Demolition Work Plan Unit 4 Cell Building, Nevada Environmental Response Trust Site Henderson, Nevada provides a Vibration Monitoring Decision Matrix that describes how to respond to vibration readings that exceed the PPV threshold values listed above.

B. Thresholds shall be determined after baseline data has been evaluated by the Contractor.

2.02 CODES AND STANDARDS

A. Unless noted otherwise, the latest issues of the following Specifications, Codes and Standards, including revisions and supplements in effect as of September 1, 2015, form a part of this Specification in their entirety, except as modified by this Specification.

B. Occupational Safety and Health Administration (OSHA), Department of Labor

1. Title 29 - Part 1910 - Occupational Safety and Health Standards.

2. Title 29 - Part 1926 - Safety and Health Regulations for Construction.

C. Should a conflict be found between the listed codes and standards and this Specification and/or Project Design Drawings, the conflict shall be submitted to the Engineer for resolution prior to proceeding with the affected work.

D. Related Sections

1. Section 02 25 16 SPE – Existing Concrete and CMU Crack Survey

PART 3 - EXECUTION

3.01 METHOD

A. Baseline vibration shall be measured and evaluated for at least two days prior to the commencement of demolition work.

B. A monitoring plan and thresholds shall be established by the Contractor, in conjunction with the structural engineer, based on the baseline data and a site walk through.

C. The Contractor shall monitor vibration and crack movement continuously using seismographs, tri-axial geophones, and crack monitoring devices during the demolition work.

D. If the type of crack monitor used requires manual reading then the monitors shall be read, and the data recorded and compared to the previous reading, at the start and end of every work day and immediately after any threshold alarm events.

E. The monitoring instrumentation shall provide alerts via text message or email when a threshold level is exceeded. It shall also indicate a threshold exceedance using a local siren and/or an alarm light.

F. Interpretation of the results shall be provided by the Contractor and submitted to the Engineer.

G. If required, vibration mitigation techniques shall be designed and implemented by the Contractor and the Engineer.

3.02 CLEANING

A. At the end of the project all equipment and monitors shall be removed from the project by the Contractor.

B. If damage is done to the building when monitors are removed the Contractor shall be responsible for any required repairs.

PART 4 - EXHIBIT A

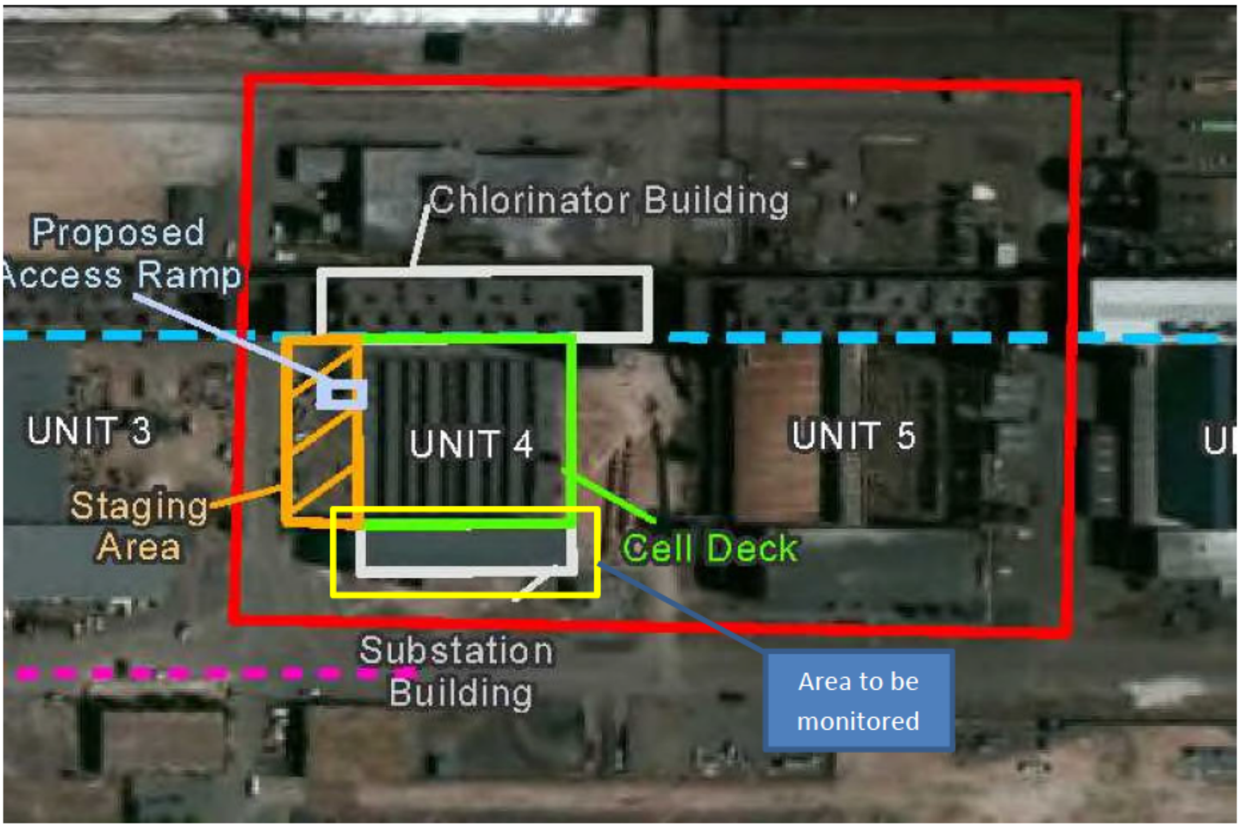

Figure 1: Unit 4 Site Map

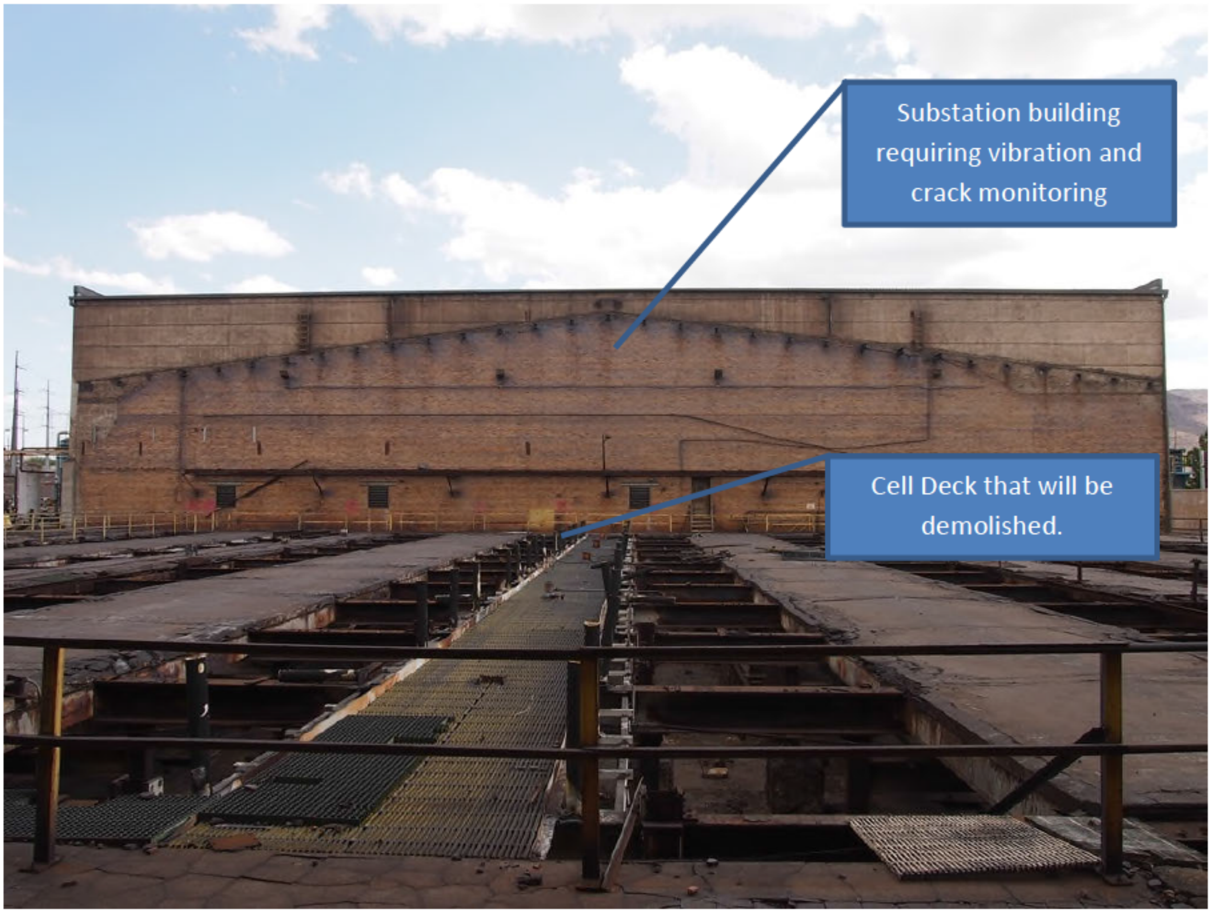

Figure 2: North Wall of Unit 4 Substation Building with Cell Deck in Foreground

Figure 3: Structure in Basement of Substation Building

Figure 4: Structure in Basement of Substation Building

Figure 5: Existing Cracks in Basement of Substation Building at Eastern Doorway

Figure 6: Main Floor of Substation Building

END OF SECTION

TETRA TECH	EXISTING CONCRETE AND CMU CRACK SURVEY TECHNICAL SPECIFICATION	**SPECIFICATION NUMBER:** 02 25 16 SPE **PROJECT NAME:** NERT Task – M02

SPECIFICATION REVISION INDEX

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2	02/02/2016	Reissued for Construction	SAB	GTF			NERT

SECTION 02 25 16 SPE

EXISTING CONCRETE AND CMU CRACK SURVEY

PART 1 - GENERAL

1.01 SUMMARY

A. This Specification describes the assessment of existing structural concrete and concrete masonry unit (CMU) walls in the Unit 4 Substation Building.

B. The Work includes, but is not limited to, visual inspection of structural components of the north wall of the Substation Building, measurements (depth, width, and length) of all cracks (greater than 1/32" in width) observed, ultrasonic pulse velocity (UPV) mapping of the structural concrete in the north wall of the Substation Building in order to identify any potential delaminations or other defects, determination of mitigation techniques where required, and correlation of all of the gathered data into a usable spreadsheet or database.

1.02 SUBMITTAL

A. An inspection plan shall be submitted to the Engineer prior to the beginning of the survey work.

B. Once the survey is complete a report summarizing the findings of the survey shall be prepared and submitted to the Engineer. This report shall include, at a minimum:

1. A summary that identifies all observed cracks (greater than 1/32" in width) and other defects in the walls including locations.

2. Measurements of all defects and cracks (greater than 1/32" in width).

3. A comprehensive list of all cracks (greater than 1/32" in width) and defects that have been identified by the Contractor as requiring mitigation, and the method determined by the Contractor to mitigate said cracks and defects.

4. Recent calibration data for equipment used in the survey.

1.03 HEALTH & SAFETY

A. Site–specific health and safety training, provided by Tronox and Tetra Tech, is required for all personnel who will be onsite.

B. Contractor shall coordinate access to active work areas with Tronox and other Contractors on the site.

PART 2 - PRODUCTS

2.01 CODES AND STANDARDS

A. Unless noted otherwise, the latest issues of the following Specifications, Codes and Standards, including revisions and supplements in effect as of September 1, 2015, form a part of this Specification in their entirety, except as modified by this Specification.

B. American Society for Testing and Materials (ASTM)

C597-09	Standard Test Method for Pulse Velocity Through Concrete
C823	Standard Practice for Examination and Sampling of Hardened Concrete in Constructions

C. Occupational Safety and Health Administration (OSHA), Department of Labor

1. Title 29 - Part 1910 - Occupational Safety and Health Standards.

2. Title 29 - Part 1926 - Safety and Health Regulations for Construction.

D. American Society for Nondestructive Testing (ASNT)

1. ASNT CP-189, Standard for Qualification and Certification of Nondestructive Testing Personnel.

2. ASNT Recommended Practice No. SNT-TC-1A, Personnel Qualification and Certification in Nondestructive Testing.

E. Should a conflict be found between the listed codes and standards and this Specification, the conflict shall be submitted to the Engineer for resolution prior to proceeding with the affected work.

F. Related Sections

1. Section 03 62 13 SPE – Grout Crack Repair

2. Section 03 64 23 SPE – Epoxy Injected Crack Repair

PART 3 - EXECUTION

3.01 VISUAL INSPECTIONS

A. Inspect every concrete and CMU wall, in the Unit 4 Substation Building, and identify all cracks greater than 1/32” in width.

B. Measure width, length, and, when possible, depth of all identified cracks.

C. Identify all cracks that will require mitigation.

D. Recommend whether epoxy injection (generally less than 1/4” width) or grout shall be used to mitigate each crack.

E. Document all information and submit to the Engineer.

3.02 ULTRASONIC PULSE VELOCITY (UPV) MAPPING

A. Calibrate equipment per the manufacturer’s instructions.

B. Take readings of all concrete and CMU wall surfaces.

C. Determine locations of defects using data attained.

D. Recommend mitigation method and extent for defects that require it.

E. Document all information and submit to the Engineer.

PART 4 - EXHIBIT A

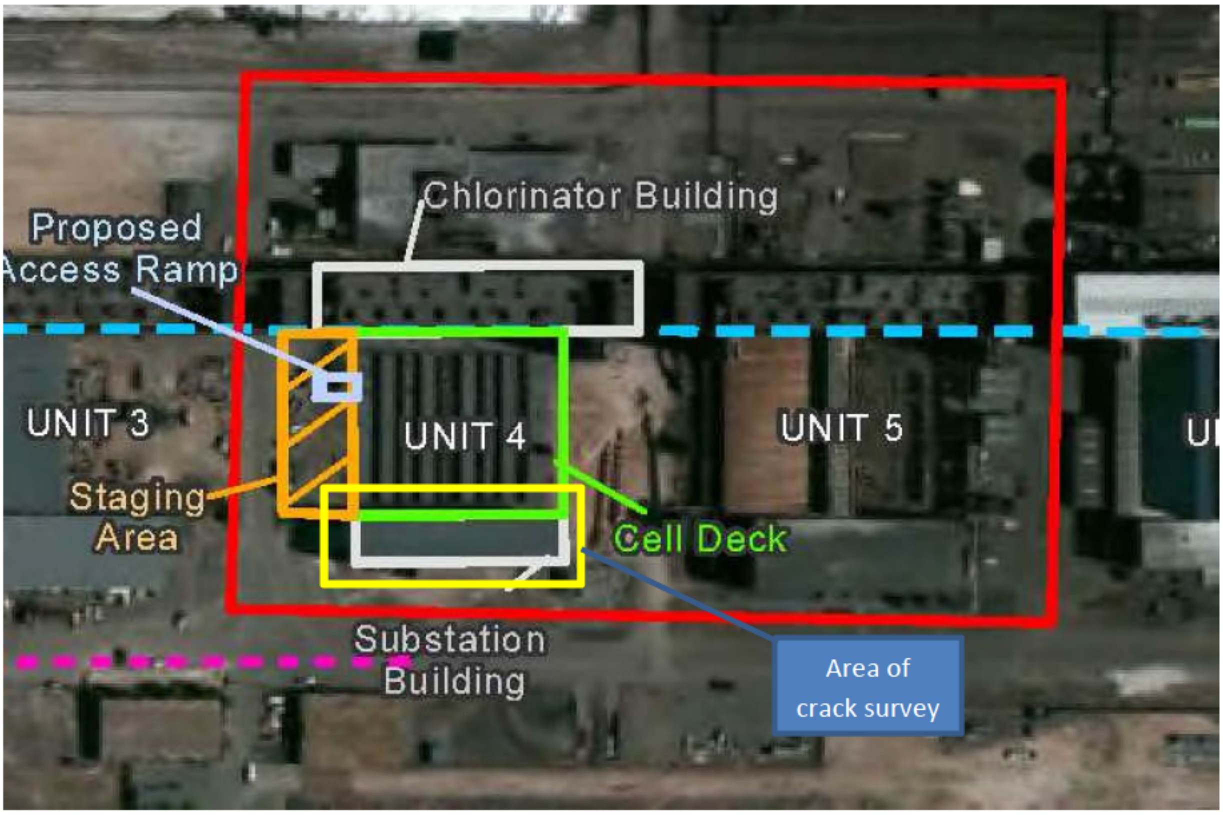

Figure 1: Site Map

Figure 2: Small Cracks in Substation Building

Figure 3: Medium Sized Cracks in Substation Building

Figure 4: Large Sized Cracks in Substation Building

END OF SECTION

TETRA TECH	GROUT CRACK REPAIR TECHNICAL SPECIFICATION	**SPECIFICATION NUMBER:** 03 62 13 SPE **PROJECT NAME:** NERT Task – M02

SPECIFICATION REVISION INDEX

Revision No.	Revision Date	Issued for	Signatures				
			Prepared By	Reviewed By	Project Engineer	Project Manager	Client
0	10/20/2015	Issued For Construction	SBH	SAB			NERT
1	01/12/2016	Reissued for Construction	GTF	GTF			NERT

SECTION 03 62 13 SPE

GROUT CRACK REPAIR

PART 1 - GENERAL

1.01 SUMMARY

A. This Specification describes the grouting of cracks and voids with a Portland cement, non-shrink, non-metallic grout to provide structural repair of concrete members. Cracks that require repair will be identified as described in 02 25 16 SPE.

B. The Work includes, but is not limited to, supplying all required labor, materials, and tools required to complete the repair of all identified cracks, that require repair.

1.02 QUALITY ASSURANCE

A. Manufacturing qualifications: The manufacturer of the specified product shall be ISO 9001:2000 certified and have in existence a recognized ongoing quality assurance program independently audited on a regular basis.

B. Contractor qualifications: Contractor shall be qualified in the field of concrete repair and protection with a successful track record of 5 years or more. Contractor shall maintain qualified personnel who have received product training by a manufacturer's representative.

C. Install materials in accordance with all safety and weather conditions required by manufacturer or as modified by applicable rules and regulations of local, state and federal authorities having jurisdiction. Consult Material Safety Data Sheets for complete handling recommendations.

1.03 DELIVERY, STORAGE, AND HANDLING

A. All materials must be delivered in original, unopened containers with the manufacturer’s name, labels, product identification, and batch numbers. Damaged material must be removed from the site immediately.

B. Store all materials off the ground and protect from rain, freezing or excessive heat until ready for use.

C. Condition the specified product as recommended by the manufacturer.

1.04 JOB CONDITIONS

A. Environmental Conditions: Do not apply material if it is raining or snowing or if such conditions appear to be imminent. Minimum application temperature 45ºF (7ºC) and rising, or as recommended by grout manufacturer.

B. Protection: Precautions should be taken to avoid damage to any surface near the work zone due to mixing and handling of the specified material.

1.05 SUBMITTAL

A. Contractor shall submit one (1) electronic copy of manufacturer's literature, to include: Product Data Sheets, appropriate Material Safety Data Sheets (MSDS), and schematic drawing showing area of work.

B. Contractor shall submit documentation verifying that all specified cracks have been repaired.

1.06 WARRANTY

A. Provide a written warranty from the manufacturer against defects of materials for a period of one (1) years, beginning with date of substantial completion of the project.

1.07 HEALTH & SAFETY

A. Site–specific health and safety training, provided by Tronox and Tetra Tech, is required for all personnel who will be onsite.

B. Contractor shall coordinate access to active work areas with Tronox and other Contractors on the site.

PART 2 - PRODUCTS

2.01 MANUFACTURER

A. **SikaGrout 212**, as manufactured by Sika Corporation, or an approved equivalent, shall be used as the crack repair grout.

B. Substitutions: The use of other than the specified product will be considered providing the contractor requests its use in writing to the Engineer. This request shall be accompanied by (a) A certificate of compliance from an approved independent testing laboratory that the proposed substitute product meets or exceeds the specific performance criteria, tested in accordance with the specified test standards; and (b) Documented proof that the proposed substitute product has a five year proven record of performance of grouting cavities, voids, key ways, etc.

as confirmed by actual field tests and five successful installations that the Engineer can investigate.

2.02 MATERIALS

A. The portland cement grout shall be a non-shrink, non-metallic composition containing a blend of selected portland cements, plasticizing/water-reducing admixtures and shrinkage compensating agents. The shrinkage agents shall compensate for shrinkage in both the plastic and hardened state.

B. The material shall be non-combustible, both before and after cure.

C. The material shall be supplied in a factory-blended bag.

D. Materials for forming, as required for the designated work, shall be approved by the Engineer.

E. Curing compound, conforming to ASTM C-309, as required for the designated work, shall be approved by the Engineer.

2.03 PERFORMANCE CRITERIA

A. Properties of the mixed portland cement grout:

1. Time of Set:
    a. Initial Set: 3.0 hours min.
    b. Final Set: 6.5 hours max.
2. Flow:100-124%
3. Color: concrete gray
4. The grout shall not exhibit bleeding.
5. The grout shall be segregate.
6. The grout shall be pumpable through standard grout pumping equipment.

B. Properties of the cured portland cement grout:

1. Compressive Strength at 28 days:
    a. 1 day: 3800 psi min.

b. 28 day: 7600 psi min.

2. Splitting Tensile Strength at 28 days: 500 psi min.

3. Flexural Strength at 28 days: 1200 psi min.

4. Bond Strength Plastic grout to hardened concrete at 28 days (moist cure):1950 psi min.

5. Expansion at 28 days: +0.015% min.

6. The grout shall not produce a vapor barrier.

7. The grout shall exhibit positive expansion when tested in accordance to ASTM C-827.

8. The grout shall conform to ASTM C-1107.

2.04 CODES AND STANDARDS

A. Unless noted otherwise, the latest issues of the following Specifications, Codes and Standards, including revisions and supplements in effect as of September 1, 2015, form a part of this Specification in their entirety, except as modified by this Specification.

B. American Society for Testing and Materials (ASTM)

C-109	Standard Test Method for Compressive Strength of Hydraulic Cement Mortars
C-191	Standard Test Method for Time of Setting of Hydraulic Cement by Vicat Needle
C-266	Standard Test Method for Time of Setting of Hydraulic-Cement Paste by Gillmore Needles
C-293	Standard Test Method for Flexural Strength of Concrete
C-309	Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
C-496	Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens
C-827	Standard Test Method for Change in Height at Early Ages of Cylindrical Specimens of Cementitious Mixtures
C-882 (modified)	Standard Test Method for Bond Strength of Epoxy-Resin Systems Used With Concrete By Slant Shear
C-939	Standard Test Method for Flow of Grout for Preplaced-Aggregate Concrete
C-1107	Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink)

C. United States Army Corps of Engineers Specification

1. CRD C-621 – Specification for Non-Shrink Grout.

D. Occupational Safety and Health Administration (OSHA), Department of Labor

1. Title 29 - Part 1910 - Occupational Safety and Health Standards.

2. Title 29 - Part 1926 - Safety and Health Regulations for Construction.

E. Should a conflict be found between the listed codes and standards and this Specification and/or Project Design Drawings, the conflict shall be submitted to the Engineer for resolution prior to proceeding with the affected work.

F. Related Sections

1. Section 02 25 16 SPE – Existing Concrete and CMU Crack Survey

2. Section 03 64 23 SPE – Epoxy Injected Crack Repair

PART 3 - EXECUTION

3.01 MIXING AND APPLICATION

A. Mixing of the portland cement grout: Mix manually or mechanically. Manually mix in a wheelbarrow or mortar box. Mechanically mix with a low-speed (400-600 rpm) drill and jiffy paddle or in an appropriate sized mortar mixer. Add an appropriate quantity of water to the mixing container to achieve the desired consistency. DO NOT OVERWATER. While mixing the bag of powder shall be slowly added to the mixer. Mix to a uniform consistency for a minimum of 2 minutes. Mix temperature should be maintained at 70-75° F, using cold or warm water accordingly.

B. Placement Procedure:

1. Spalls: Within 15 minutes of mixing, pour the grout into the prepared form. Work in a manner to avoid air entrapment. Vibrate the form as required to achieve flow and compaction. Flowable grout must be confined in either the horizontal or vertical direction, leaving a minimum of exposed surface. After the grout has achieved its final set, remove any forms and trim or shape exposed mortar/concrete to the desired profile, if required.

2. Cracks: Within 15 minutes of mixing pour the grout into prepared crack. Continue pouring until the crack has been completely filled. Alternatively grout can be hand packed into cracks in a manner to avoid air entrapment.

C. Wet cure for a minimum of 3 days or apply a curing compound that conforms to ASTM C-309 as approved by the Engineer.

D. Adhere to all limitations and cautions for the polymer-modified portland cement coating in the manufacturer's printed literature.

3.02 CLEANING

A. The uncured polymer-modified portland cement coating can be cleaned from tools with water. The cured polymer-modified portland cement coating can only be removed mechanically.

B. Leave finished work and work area in a neat, clean condition without evidence of spillovers onto adjacent areas.

END OF SECTION

TETRA TECH	EPOXY INJECTED CRACK REPAIR TECHNICAL SPECIFICATION	**SPECIFICATION NUMBER:** 03 64 23 SPE **PROJECT NAME:** NERT Task – M02

SPECIFICATION REVISION INDEX

Revision No.	Revision Date	Issued for	Signatures				
			Prepared By	Reviewed By	Project Engineer	Project Manager	Client
0	10/20/2015	Issued For Construction	SBH	SAB			NERT
1	01/12/2016	Reissued for Construction	GTF	GTF			NERT

SECTION 03 64 23 SPE

EPOXY INJECTED CRACK REPAIR

PART 1 - GENERAL

1.01 SUMMARY

A. This Specification describes the pressure injection of cracks with an epoxy resin. This injection is to provide structural repair to the concrete members. Cracks that require repair will be identified as described in 02 25 16 SPE.

B. The Work includes, but is not limited to, supplying all required labor, materials, and tools required to complete the repair of all identified cracks, that require repair.

1.02 QUALITY ASSURANCE

A. Manufacturing qualifications: The manufacturer of the specified product shall be ISO 9001/9002 certified and have in existence a recognized ongoing quality assurance program independently audited on a regular basis.

B. Contractor qualifications: Contractor shall be qualified in the field of concrete repair and protection with a successful track record of 5 years or more. Contractor shall maintain qualified personnel who have received product training by a manufacturer's representative.

C. Install materials in accordance with all safety and weather conditions required by the manufacturer, or as modified by applicable rules and regulations of local, state and federal authorities having jurisdiction. Consult Material Safety Data Sheets for complete handling recommendations.

1.03 DELIVERY, STORAGE, AND HANDLING

A. All materials must be delivered in original, unopened containers with the manufacturer's name, labels, product identification, and batch numbers. Damaged material must be removed from the site immediately.

B. Store all materials off the ground and protect from rain, freezing or excessive heat until ready for use.

C. Condition the specified product as recommended by the manufacturer.

1.04 JOB CONDITIONS

A. Environmental Conditions: Do not apply material if it is raining or snowing or if such conditions appear to be imminent. Minimum application temperature 40ºF (5ºC) and rising, or as recommended by epoxy manufacturer.

B. Protection: Precautions should be taken to avoid damage to any surface near the work zone due to mixing and handling of the specified product.

1.05 SUBMITTAL

A. Contractor shall submit one (1) electronic copy of manufacturer’s literature, to include: Product Data Sheets, appropriate Material Safety Data Sheets (MSDS), and schematic drawings showing area of work.

B. Contractor shall submit documentation verifying that all specified cracks have been repaired.

1.06 WARRANTY

A. Provide a written warranty from the manufacturer against defects of materials for a period of one (1) years, beginning with date of substantial completion of the project.

1.07 HEALTH & SAFETY

A. Site–specific health and safety training, provided by Tronox and Tetra Tech, is required for all personnel who will be onsite.

B. Contractor shall coordinate access to active work areas with Tronox and other Contractors on the site.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. **Sikadur 35 Hi-Mod LV**, as manufactured by Sika Corporation, or an approved equivalent, shall be used as the injected epoxy grout.

B. **Sikadur Injection Gel**, as manufactured by Sika Corporation or an approved equivalent, shall be used as the crack and porting devices sealer.

C. Substitutions: The use of other than the specified product will be considered providing the contractor requests its use in writing to the Engineer. This request shall be accompanied by (a) A certificate of compliance from an approved independent testing laboratory that the proposed substitute product meets or exceeds the specific performance criteria, tested in accordance with the specified test standards; and (b) Documented proof that the proposed substitute product has a five year proven record of performance of grouting cavities, voids, key ways, etc. as confirmed by actual field tests and five successful installations that the Engineer can investigate.

2.02 MATERIALS

A. Epoxy resin adhesive for pressure injection of cracks shall be **Sikadur 35 Hi-Mod LV**, or an approved equivalent:

1. Component "A" shall be a modified epoxy resin of the diglycidiether bisphenol A Type containing suitable viscosity control agents. It shall not contain butyl glycidyl ether.

2. Component "B" shall be primarily a reaction product of a selected amine blend with an epoxy resin of the diglycidiether bisphenol A Type containing suitable viscosity control agents, pigments, and accelerators.

3. The ratio of component A: component B shall be per manufacturer's recommendations.

4. The material shall not contain asbestos.

B. Epoxy resin adhesive for sealing of cracks & porting devices shall be **Sikadur Injection Gel**, or an approved equivalent:

1. Component "A" shall be a modified epoxy resin of the diglycidiether bisphenol A Type containing suitable viscosity control agents. It shall not contain butyl glycidyl ether.

2. Component "B" shall be primarily a reaction product of a selected amine blend with an epoxy resin of the diglycidiether bisphenol A Type containing suitable viscosity control agents, pigments, and accelerators.

3. The ratio of component A: component B shall be per manufacturer's recommendations.

4. The material shall not contain asbestos.

C. Porting devices as required for either manual or automated application. Porting devices for automated application shall be supplied from manufacturer of the pressure injection equipment.

2.03 PERFORMANCE CRITERIA

A. Properties of the mixed epoxy resin adhesive used for the pressure injection grouting:

1. Minimum Pot Life: 25 minutes (60 gram mass) @ 73° F

2. Tack-Free Time: 90° F (32° C) 1.5 to 2 hours
   75°F (24° C) 3 to 3.5 hours
   40°F (5° C) 14-16 hours

3. Viscosity: Approx. 375 cps. (mixed)

4. Color: Clear, pale yellow

B. Properties of the cured epoxy resin adhesive used for pressure injection grout:

1. Minimum Compressive Strength (ASTM D-695)
   a. 3 day: 10,700 psi (73.8 MPa)
   b. 7 day: 11,000 psi (75.8 MPa)
   c. 28 day: 13,000 psi (89.6 MPa)
   d. Compressive Modulus, 7 day min: 320,000 psi (2,200 Mpa)

2. Minimum Shear Strength (ASTM D-732)
   a. 14 day: 5,100 psi (35 MPa)

3. Minimum Flexural Strength (ASTM D-790)
   a. 14 day: 14,000 psi (97.0 MPa)
   b. Tangent Modulus of Elasticity in Bending, 14 day min: 370,000 psi (2,600 Mpa)

4. Minimum Bond Strength (ASTM C-882), 14 days (moist cure):
   a. Hardened Concrete to Hardened Concrete = 2,900 psi (20 Mpa)

5. Maximum Water Absorption (ASTM D-570), 7day
   a. 24 hour immersion = 0.27%

6. Minimum Tensile Properties (ASTM D-638) min.
   a. 7 day Tensile Strength = 8,900 psi (61 Mpa)
      Elongation at Break = 5.4%
   b. 14 day Modulus of Elasticity = 410,000 psi (2800 Mpa)

C. Properties of the mixed epoxy resin adhesive used for sealing of cracks & porting devices:

1. Minimum Pot Life: 30 minutes (60 gram mass) @ 73° F

2. Tack-Free Time: 75° F (24° C) 2 to 3.5 hours
   40° F (5° C) 14-16 hours

3. Consistency: Smooth, Non-sag paste

4. Color: Gray

D. Properties of the cured epoxy resin adhesive used for sealing of cracks & porting devices:

1. Minimum Compressive Strength (ASTM D-695) @ 73F
   a. 1 day: 8,000 psi (55.1 MPa)
   b. 3 day: 10,000 psi (68.9 MPa)
   c. 28 day: 10,000 psi (68.9 MPa)
   d. Compressive Modulus, psi : 7 day min: 270,000 psi (Mpa)

2. Minimum Shear Strength (ASTM D-732)

   a. 14 day: 3,700 psi (25.5 MPa)

3. Minimum Flexural Strength (ASTM D-790)
   a. 14 days: 6,700 psi (46.2 MPa)
   b. Tangent Modulus of Elasticity in Bending 14 day min: 750,000 psi

4. Minimum Bond Strength ASTM C-882, 14 days (moist cure):
   a. Hardened Concrete to Hardened Concrete = 2,600 psi (17.9 Mpa)

5. Maximum Water Absorption (ASTM D-570), 7 day
   a. 24 hour immersion = 0.11%

6. Minimum Tensile Properties (ASTM D-638) min.
   a. 7 day Tensile Strength = 4,300 psi (29.7 Mpa)
      Elongation at Break = 1.3%
   b. b. 14 day Modulus of Elasticity = 410,000 psi (2800 Mpa)

2.04 CODES AND STANDARDS

A. Unless noted otherwise, the latest issues of the following Specifications, Codes and Standards, including revisions and supplements in effect as of September 1, 2015, form a part of this Specification in their entirety, except as modified by this Specification.

B. American Society for Testing and Materials (ASTM)

C-881	Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete
C-882	Standard Test Method for Bond Strength of Epoxy-Resin Systems Used With Concrete By Slant Shear
D-570	Standard Test Method for Water Absorption of Plastics
D-638	Standard Test Method for Tensile Properties of Plastics
D-648	Standard Test Method for Deflection Temperature of Plastics Under Flexural Load in the Edgewise Position
D-695	Standard Test Method for Compressive Properties of Rigid Plastics
D-732	Standard Test Method for Shear Strength of Plastics by Punch Tool
D-790	Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials

C. Occupational Safety and Health Administration (OSHA), Department of Labor

1. Title 29 - Part 1910 - Occupational Safety and Health Standards.
2. Title 29 - Part 1926 - Safety and Health Regulations for Construction.

D. Should a conflict be found between the listed codes and standards and this Specification and/or Project Design Drawings, the conflict shall be submitted to the Engineer for resolution prior to proceeding with the affected work.

E. Related Sections

1. Section 02 25 16 SPE – Existing Concrete and CMU Crack Survey
2. Section 03 62 13 SPE – Grout Crack Repair

PART 3 - EXECUTION

3.01 MIXING AND APPLICATION

A. Mixing the epoxy resin adhesive for sealing the cracks & porting devices:

1. Premix each component. Proportion Component “A” and Component “B” into a clean, dry mixing pail according to manufacturer’s recommendations.
2. Mix thoroughly as recommended by manufacturer or dispense from a ready to use prepackaged coaxil cartridge.
3. Mix only that quantity of material that can be used within its pot life.

B. Mixing of the epoxy resin adhesive used for the pressure injection grouting:

1. Premix each component. Proportion Component "A" and Component "B" into a clean, dry mixing pail according to manufacturer's recommendations.

2. Mix thoroughly as recommended by manufacturer.

3. Mix only that quantity of material that can be used within its pot life.

C. Placement procedure:

1. Set the porting devices as required by the equipment manufacturer. Spacing of the porting devices shall be accomplished as required to achieve the travel of the epoxy resin for the pressure injection grouting between ports to fill the cracks to the maximum. On structures open on both sides, provide porting devices on opposite sides at staggered elevations.

2. Apply the mixed epoxy resin adhesive for sealing over cracks and around each porting device to provide an adequate seal to prevent the escape of the epoxy resin adhesive for the injection grouting.

3. Allow epoxy resin adhesive for sealing to dry as specified by the manufacturer.

4. Load the mixed epoxy resin adhesive for grouting into a disposable caulking cartridge or bulk-loading caulking gun.

5. Inject the prepared cracks with a constant pressure in order to achieve maximum filling and penetration without the inclusion of air pockets or voids in the epoxy resin adhesive.

6. Begin the pressure injection at the widest part of the crack being injected and continue until there is the appearance of epoxy resin adhesive at an adjacent port, thus indicating travel.

7. When travel is indicated, the decision to discontinue or continue the pressure injection from that port should be made by the contractor based on experience, with the approval of the Engineer.

8. Continue procedure until pressure injectable crack has been filled.

D. If penetration of any crack is impossible, consult the Engineer before discontinuing the injection procedure. If modification of the proposed procedure is required to fill the cracks, submit said modification in writing to the Engineer for acceptance prior to proceeding.

E. Adhere to all limitations and cautions for the epoxy resin adhesive in the manufacturer’s current printed literature.

3.02 CLEANING

A. After the epoxy resin adhesive for grouting has cured, the epoxy resin adhesive for sealing cracks and porting devices shall be removed as required by the Engineer. Clean the substrate in a manner to produce a finish appearance acceptable to the owner.

B. The uncured epoxy resin adhesive can be cleaned from tools with approved solvent. The cured epoxy resin adhesive can only be removed mechanically.

C. Leave finished work and work area in a neat, clean condition without evidence of spillovers onto adjacent areas.

END OF SECTION