

15.0 Structures

The Contractor shall design and construct all of the Structures required to meet the Project criteria and make the Project fully functional in accordance with the Contract Requirements.

To advance longer-lasting highways, CDOT encourages using innovative technologies and practices to accomplish the fast construction of efficient and safe facilities. Consideration by the Contractor of state-of-the-art technologies and elevated performance standards that result in improved safety, faster construction, reduced congestion from construction, improved quality, and user satisfaction are encouraged.

15.1 Administrative Requirements

15.1.1 Standards

The versions of the referenced software, standards, data, and reports which are current at the time of the Proposal Due Date, including all interim revisions and updates, shall be used unless specified otherwise in this Section.

15.1.2 Software

The Contractor shall use industry standard software for connections to existing concrete structures and any other necessary structural designs.

15.2 Design and Construction Requirements

15.2.1 Materials

15.2.1.1 Concrete

Concrete incorporated into the project shall meet all requirements of Standard Specifications, Section 601. The proposed concrete mix design and procedures shall meet the above requirements and shall be submitted for Acceptance by CDOT at least three weeks prior to the anticipated concrete placement date.

The use of lightweight concrete will not be allowed.

Minimum and maximum design concrete strengths shall meet the requirements of Standard Specifications, Section 601.

15.2.1.2 Reinforcing Steel

All reinforcing steel shall be epoxy-coated. All reinforcing shall consist of deformed bars only per ASTM A 615 and shall conform to the requirements of the Standard Specifications.

15.2.1.3 Structural Steel

Structural steel shall conform to AASHTO M 270, Grades 36, 36W, 50, 50W, 70 or 70W. Structural steel supplied for main load-carrying members or components in tension that are non-redundant shall be designated as fracture-critical, meeting

the Charpy V-notch tests for Zone 2 in AASHTO M 222/M 222M and AASHTO M 223/M 223M.

All structural steel shall be galvanized per Standard Specifications, Section 509.

15.2.2 Design Parameters

15.2.2.1 General

The Contractor shall complete the design in accordance with the applicable design codes including the latest version of AASHTO LRFD and the CDOT Bridge Design Manual.

No additional load shall be applied to the tunnel plenum duct center divider wall and floor system. The maximum capacity of the plenum outside walls and tunnel lining to support additional loading of the pipe distribution network, any section valves, control valves, and sprinkler nozzles, etc., shall be determined by the Contractor and submitted to CDOT for Acceptance prior to any Work being performed. Any proposed temporary loading conditions for the plenum duct shall be submitted to CDOT for Acceptance, including material handling and construction equipment within the plenum, prior to any Work. CDOT has completed some analysis of the plenum duct allowable loading, but due to the sensitive nature of this information, this information will be made available for Contractor review at NTP1.

The EJMT has an existing tunnel ventilation system that operates in a transverse configuration. There are existing centrifugal ventilation fans located above both the east and west portals. Fresh air is supplied to the tunnel from an air duct located above the roadway. In the north tunnel, fresh air is conducted to the roadway level from air ducts located at the sidewall. In the south tunnel, fresh air is supplied to the roadway level via air ports in the floor of the fresh air duct. In both north and south tunnels, ventilated air is removed from the roadway level via ducts located in the floor of the exhaust air duct.

The capacity of the existing tunnel ceiling support system is limited by critical connections at the ceiling hangers embedded in the center divider wall. Service loads applied to the duct floor during construction shall not result in loading on the critical connections that would exceed loading from a uniform load over the plenum floor area equivalent to 36 pounds per square foot (62 pounds per square foot divided by a 1.7 load factor). The determination of equivalent uniform loading shall consider the exhaust and supply sides of the plenum separately. The Contractor shall submit a Construction Sequencing Plan that provides details of service loads applied to the plenum floor during all phases of construction including stockpiling of materials, tools, equipment, labor, and all other loads.

The Construction Sequencing Plan shall be submitted to CDOT, for Approval, a minimum of 30 days prior to NTP2. Particular care shall be taken that the loads established in the Approved Construction Sequencing Plan are not exceeded. The Construction Sequencing Plan shall indicate the procedures that the Contractor will follow to ensure that loadings are not exceeded. Service point loads on the plenum

floor are also limited to the punching shear capacity of the plenum floor section reduced by a 1.7 load factor; maximum anticipated construction and final point loads shall be determined and provided in the Construction Sequencing Plan.

No additional dead load may be applied to the plenum floor (and to the ceiling in the plenum transition areas) by the finished system including the weight of any new piping.

The Tunnel Enhanced Fire Safety System installed within the tunnel plenum shall allow for continued access by EJMT maintenance staff. The ventilation system shall be validated by the Contractor to remain effective when all the Tunnel Enhanced Fire Safety System elements are installed and commissioned.

The Contractor shall consider loading from avalanches and rock slides when designing Structures outside the tunnel, including the emergency backup generator(s) and any associated supporting infrastructure.

The Contractor shall submit the tunnel hanger system design to CDOT for Acceptance with the preliminary Design Package for each separate hanger type.

15.2.2.1.1 Loads and Forces

The Contractor shall design all Structures and connections, for loads and forces in accordance with the referenced design standards.

15.2.2.1.2 Live Loads

The Contractor shall design all Structures and connections for loads and forces in accordance with the referenced design standards.

15.2.2.1.3 Dead Loads

The Contractor shall design all Structures and connections for loads and forces in accordance with the referenced design standards.

15.2.2.1.4 Uplift

The Contractor shall design all Structures and connections for loads and forces in accordance with the referenced design standards.

15.2.2.1.5 Thermal Forces

The Contractor shall design all Structures and connections for loads and forces in accordance with the referenced design standards.

15.2.2.1.6 Seismic

The Contractor shall design all Structures and connections for loads and forces in accordance with the referenced design standards.

15.2.2.1.7 Wind Loads

The Contractor shall design all Structures and connections for loads and forces in accordance with the referenced design standards.

15.2.2.2 Geotechnical Data

The Contractor shall determine the additional geotechnical information required and conduct supplemental investigations as necessary to complete the final design. Any boring logs or laboratory test results shall be presented in accordance with the referenced design standards.

If groundwater observation wells are necessary to monitor water level or water quality, it shall be the Contractor's responsibility to properly abandon, permit, or renew the permits of these wells in accordance with State Engineer's Office requirements.

15.2.2.3 Structure Foundation Analysis and Design Recommendations

The Contractor shall perform geotechnical analysis as required for the design of foundations for generator, storage tanks, pumps, and other items necessary to complete the work. Design recommendations and substantiating analysis shall be documented in a Foundations Design Report as a part of the In-Process Design Packages for Structures as further described in this Section. If existing structures are used for supporting piping, utilities, etc., stamped calculations shall be provided showing they are adequate for additional loading.

15.2.3 Structure Aesthetics

The Aesthetic Concept Plan shall include the necessary details and drawings to illustrate the proposed aesthetic elements identified by the Contractor for the visible Structures, including those meeting the requirements listed below and any additional proposed elements. The Aesthetics and Landscape Concept Plan must be Accepted by CDOT prior to beginning any construction Activities, including any early action items, unless the Activity is Approved by CDOT.

As part of the Concept Plan submittal, the Contractor shall include a visual graphic of each Structure (including components in the roadway spaces, structures, and tanks) to demonstrate aesthetic conformance to the United States Forest Service guidelines. The Concept Plan and associated graphics shall be submitted in both hard and electronic format. In all cases, graphics of proposed structure aesthetics shall include all visible surfaces and shall be submitted to CDOT for Acceptance with the Contractor's proposed general layouts of each Structure. This submittal shall include drawings illustrating form, texture, and color.

All Structures with visible concrete surfaces, including those accessible by graffiti vandals, shall have a surface treatment of structural concrete coating.

Minimum Aesthetic elements for structures are described below.

15.2.3.1 Structures and Tanks

All walls and structures, including any above ground storage tank buildings, constructed as part of the project shall require Governmental Approval.

15.2.3.2 Components

15.2.3.2.1 Fixed Fire Suppression System (FFSS)

The Contractor shall design and construct the FFSS in accordance with all applicable standards.

15.2.3.2.2 Drainage

Drainage systems shall be designed in accordance with Book 2, Section 12.

15.2.3.2.3 Median

The median barriers at both tunnel approaches and portal areas shall be protected during construction.

15.2.3.2.4 Cast-in-Place Walls

Cast-in-place walls for concrete tanks and other structures shall be designed and constructed in accordance with current AASHTO LRFD Bridge Design Specifications, CDOT Bridge Design Manual and other referenced standards.

15.2.3.3 Removal of Existing Tunnel Components

Any existing components of the tunnels shall not be removed.

15.2.3.3.1 Tunnel Wall and Ceiling Panels

The Contractor shall reset any tunnel wall panels or tunnel ceiling panels removed during construction. Any panels broken due to the Contractor's Work, shall be replaced at the Contractor's expense. The porcelain ceiling panels may require specialized tools and/or techniques to drill through without damage and may require resurfacing if damaged.

15.2.4 Submittals and Reviews

Submittals shall be prepared, Reviewed, and submitted in accordance with the requirements set forth in Book 2, Section 3.

15.2.4.1 Technical Concepts

The Contractor shall submit a Structural Concept Report, prior to proceeding with the initial design, for Acceptance by CDOT for any Structure or temporary structure that is proposed for the Project. Suggested submittal contents include plan and elevation views and detailed sections depicting each of the structure components as the Contractor proposes. Also included shall be a maximum two-page description of type, materials, strategy for temporary or permanent dead loads, proposed live loading and lateral loads, and design-life considerations for each proposed Structure.

15.2.5 Design

15.2.5.1 Reviews

Reviews will be conducted in accordance with the Contractor's Approved Quality Management Plan. Shop drawings shall be submitted for review by the Contractor's Engineer. The Contractor is solely responsible for shop drawing accuracy.

Structure drawings shall conform to CDOT CADD Standards as described in the CDOT Bridge Detail Manual. Structure drawing standards shall be addressed in the Contractor's Approved Quality Management Plan.

15.2.5.2 Progress Submittals

When requested by CDOT for review, the Contractor shall submit design packages for the Project in accordance with the Contractor's Approved Quality Management Plan.

15.2.5.2.1 Minor Structural Elements

The Contractor shall submit only a final design document package for minor structural elements.

15.2.5.3 Documentation

Design and design-check calculations shall have pages numbered and shall include a table of contents. All calculations shall identify which code is utilized and shall reference the appropriate section in the right-hand column of each relevant page of calculations. References shall be included in the calculations to computer programs that were used to do the calculations. Computer documentation shall include the name of program, vendor, version, and release date; record of software output and verification of output with manual calculations or other recognized program; clear identification of input and output values and meaning; and check of input.

All calculations shall be signed and sealed by the Contractor's Engineer of Responsible Charge in accordance with the laws for registration of Professional Engineers in the State of Colorado. Copies in PDF format shall be made of all design and design-check calculations for the Project and then submitted to CDOT via the CDOT DCS.

All CAD data used to display information on official project plans must be supplied to CDOT at Project completion. This includes all plan sheet files and references used to display design information on the sheet. The data must be in a MicroStation DGN format, or any other CDOT Accepted format. All CAD data must comply with the CDOT CADD standards in place at the time that the final plans and specifications package is completed. The data must be supplied via the CDOT DCS.

15.2.5.4 As-Built, Falsework, Shoring, and Shop Drawing Plans

Falsework and shoring plans shall be signed and sealed by the Contractor's Engineer of Responsible Charge in accordance with the laws for registration of

Professional Engineers in the State of Colorado. Shop Drawings and Working Drawings shall be reviewed and approved by the Contractor’s structural design engineer, as evidenced by a formal stamp-and-sign procedure that is described in the Contractor’s Approved Quality Management Plan.

The Contractor shall submit As-Built Drawings, with Shop Drawings and Working Drawings for each Structure, in accordance with the Contract Documents. The Contractor shall seal Shop Drawings in accordance with Table 105-1 of the Standard Specifications. Copies in PDF format shall be made of all As-Built and Shop Drawings, and Working Drawings for all Structures on the Project and submitted to CDOT via the CDOT DCS.

The Contractor shall follow the requirements in NFPA 13 for preparation of Working Plans for the FFSS. Working Plans shall be submitted to the AHJ for Approval. The Contractor is solely responsible for the accuracy of the Working Plans.

15.2.5.5 Construction Requirements

CDOT shall be notified one week in advance of reductions in vertical clearances or when lane closures, or lane reductions are put into effect.

15.3 Deliverables

At a minimum, the Contractor shall submit the following to CDOT for Review, Approval, or Acceptance:

Table 15-1: Deliverables by the Contractor

Deliverable	Review, Acceptance, or Approval	Schedule
Determination of maximum capacity of the plenum outside walls and tunnel lining to support additional loading	Acceptance	Prior to any Work
Proposed temporary loading conditions for the plenum structure	Acceptance	Prior to any Work
Concrete mix design and procedures	Acceptance	At least three weeks prior to the anticipated concrete placement date
Construction Sequencing Plan	Approval	A minimum of 30 days prior to NTP2

Deliverable	Review, Acceptance, or Approval	Schedule
Tunnel Hanger System	Acceptance	With the Preliminary Design Package for each separate hanger type
Aesthetic Concept Plan	Acceptance	prior to beginning any construction Activities
Structure aesthetics graphic	Acceptance	With the Preliminary Design Package
Structural Concept Report	Acceptance	Prior to initial design for any proposed structure
Minor structural elements	Review	With the Final Plans and Specifications Package
Fire Standpipe Working Plans	Approval	Prior to equipment installation
Released for Construction documents and associated revisions	Acceptance	According to the Contractor's Quality Management Plan
As-Built Documents	Acceptance	According to Contractor's Quality Management Plan

All deliverables shall also conform to the requirements of Book 2, Section 3.

15.4 Project Special Provisions

The following pages provide the modified standard specifications that shall be applicable to the Project.

**REVISION OF SECTION 203
ROCK EXCAVATION**

Section 203 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

General. This work consists of blasting, scaling, excavation, and disposal of all materials in the excavation areas in accordance with these specifications and in conformity with the limits, lines and grades shown on the plans or as established in the field by the Engineer.

Special Considerations. The Contractor shall utilize controlled blasting techniques for all excavations to reduce flyrock and protect existing structures and other desirable features. The Contractor shall conduct the work in a manner that ensures the safety of employees, CDOT personnel, adjacent properties, and the public.

The Contractor shall prevent damage outside the excavation limits, and shall prevent rocks and blast debris from entering adjacent streams, desirable features, or properties. All damages resulting from rock excavation operations shall be repaired, and items replaced to the satisfaction of the Engineer, at the Contractor's expense.

Definitions.

Production Blasting. The controlled use of explosives and blasting accessories in carefully spaced and aligned drill holes to provide a distribution of charge that will excavate the rock to the required limits and minimize overbreak, stressing and fracturing of the rock beyond the design lines.

Controlled Blasting. The use of explosives and blasting accessories in carefully spaced and aligned drill holes to produce a free surface or shear plane along the controlled blast line.

Trial Blast. A blast or series of blasts to assist in determining the combination of blast parameters that are most appropriate to achieve the desired result as described in this special provision.

Final Wall Face. The remaining exposed surface after all excavation is complete.

CONSTRUCTION REQUIREMENTS

Pre-Construction Submittals. At least two weeks prior to start of excavation, the Contractor shall submit for approval by the Engineer:

- (a) Copies of all Contractor's forms that shall be used to meet the requirements of this specification. At a minimum, these shall include blast design and blast report forms.
- (b) Manufacturers' data sheets for all explosives, primers and initiators to be used.
- (c) The proposed excavation plans and procedures, including:

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ROCK EXCAVATION

- (1) Equipment and methods for accessing the work area.
 - (2) Equipment and methods to be used for drilling, loading and firing blastholes.
 - (3) Equipment and methods to be used for blast monitoring
 - (4) Locations, dimensions and sequence of blasts.
 - (5) Intended direction of rock movement and delay plan.
 - (6) Methods of removing shot rock from the cut bench.
 - (7) Expected excavation rates.
 - (8) Methods of stabilizing or protecting adjacent structures and vegetation.
 - (9) Proposed method of controlling flyrock.
 - (10) Methods for protecting structures, traffic, natural features, and the roadway from debris produced by the Contractor's excavation operations.
 - (11) A description of the pre-blast warning system to be used.
- (d) Procedures for cleaning blast debris in accordance with Book 2, Section 16.
 - (e) Excavation plans, schedules and procedures.
 - (f) Rock Scaling procedures.
 - (g) Proof of current blasting related insurance.
 - (h) Seismographic equipment specifications.
 - (i) Documentation confirming that blasting supervisors have a minimum of five years of experience in designing, supervising, loading and firing of blasts for rock slopes or tunnel excavations, as applicable, and have all licenses and permits required by local agencies and others having jurisdiction.

Construction Submittals. Unless otherwise directed, the following shall be submitted at least one week prior to the initial blast as noted below:

- (a) A blast design for the initial blast at each rock cut shall be submitted not later than seven days prior to beginning drilling at that cut location. A blast design shall be submitted for each subsequent blast at that rock cut or foundation excavation not later than 24 hours prior to drilling for that blast, if there are substantial differences from the original. Blast plans shall include the following:

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- (1) Location of blast. Blast design shall include a plan view of the blast area showing location of seismographs for each blast
 - (2) Drilling pattern, including diameters, spacing, depth, and orientation of drill holes.
 - (3) Types, strengths and quantities of explosives proposed for use in each hole, on each delay and for each blast.
 - (4) Distribution of the charge in the holes, priming of each hole and stemming of holes.
 - (5) Type, sequence and number of delays, delay pattern, diagram for blast, size and type of hookup lines and lead lines and type and capacity of blast initiation device.
 - (6) Name and signature of blasting supervisor.
- (b) Procedures for the control and disposal of water during excavation.
- (c) Daily records of scaling and excavation work shall be maintained, and one copy of the record of each day's work shall be submitted to the Engineer on the following day. Daily records shall include:
- (1) Locations of scaling work.
 - (2) A blast report for each round of blasting that includes a complete description of each blast conducted. The report shall be furnished to the Engineer no later than 24 hours after the round is fired, and shall include:
 - (i) Date, time and limits of blast by station and offset from centerline of roadway.
 - (ii) Diagram of the blast pattern and delay sequence drawn to scale with diameter, spacing, depth and orientation of drill holes. Indicate holes that were not drilled, drilled but not loaded and changes in spacing, pattern, delays or loading of holes.
 - (iii) General response to drilling action (noting especially any soft zones or voids encountered) and what if any, adjustments were made in the blast parameters as a result.
 - (iv) Quantity of explosives used by weight and number of cartridges per hole and per round and distribution of explosives in holes.
 - (v) Total number of delays used, number of holes for each delay period, maximum charge per delay and type of detonators.
 - (vi) Powder factor (the weight of explosives per cubic yard of rock in place as determined from the blast pattern).

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- (vii) Name and signature of blasting supervisor.
- (viii) An evaluation of the blast indicating areas of significant overbreak and planned adjustments to the blast design for the next blast.
- (ix) Unusual occurrences (including rock falls, unstable ground, groundwater problems, equipment malfunction, damages to structures and other desirable features, and the location elevation and time of each occurrence).
- (x) Seismographic data.

Excavation General. Excavation shall not extend beyond the dimensions and elevations established except as specified on the plans or as directed by the Engineer.

The Contractor shall not begin excavation prior to the slope staking of the site.

Excavation carried out below or beyond the lines and grades shown on the plans, below or beyond that established by the Engineer, or for the convenience of the Contractor, shall be at the Contractor's expense.

Any necessary survey work shall be performed under the supervision of a Licensed Professional Land Surveyor in the State of Colorado.

The rock on this project is not homogeneous. The Contractor shall perform trial blasts and or adjust the blast parameters as required by the existing rock conditions, in order to comply with all other specifications.

Blasts shall be conducted in conformance with the following limitations as required by the Engineer. These limitations shall remain in effect unless it is demonstrated through trial blasts that the desired results can be achieved when said limitations are exceeded.

Drilling General. The inclination of vertical holes shall not exceed 1 (Vertical): 4 (Horizontal).

Bench height shall be a maximum of 20 feet.

Blasts shall be sized such that the requirements of the structure and adjacent desirable features are fulfilled.

Maximum depth of sub-drilling for all blastholes at final grade shall be 6 inches.

Drill hole conditions may vary from dry to filled with water. The Contractor shall use explosives or blasting accessories that are appropriate for the hole conditions at no additional cost to the project.

The blast design shall take into consideration the natural joints, seams, fractures and bedding of the slope.

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Production Blasting. Blast parameters such as hole size, hole depth, hole spacing, burden, charge size, charge distribution and delay sequence shall be carefully designed and controlled to provide a distribution of charge that will excavate the rock to the required limits.

Production blastholes shall not exceed 3 inches in diameter when pourable explosives or emulsions are used. Packaged charges shall not exceed 3 inches in diameter when used in production blastholes that exceed three inches in diameter. The production blastholes shall be sequenced to provide the highest degree of relief to the final excavation surfaces.

The burden for production blastholes shall not exceed $\frac{1}{2}$ the bench height.

Production blastholes shall not be drilled closer than 6 feet to the controlled blast line. The bottom of the production holes shall not be drilled deeper than the bottom of the Controlled Blast Line blastholes.

The Contractor shall use blasting mats suitable to prevent flyrock during each round fired. At the request of the Contractor and upon demonstration that flyrock can be prevented by other means, elimination of the blasting mat may be approved by the Engineer. Elimination of the blasting mat requirement shall not relieve the Contractor of responsibility for damages caused by blasting.

Blasts shall be designed so as not to exceed a maximum peak particle velocity (largest single component) of $\frac{1}{2}$ inch per second measured 100 feet from the blast. If peak particle velocity exceeds this value, the Contractor shall modify charge weight per delay, sequence, and other applicable blast parameters to achieve acceptable vibration levels.

Blasting at distances less than 200 feet from concrete that has not developed 0.8 f'c strength will not be permitted.

All blasts shall be drilled, loaded, tied-off, and detonated under the direct charge of the approved blasting supervisor.

Controlled Blasting. Controlled blasting shall be used for all drill and blast operations required to carry out the work. Non-electric detonation systems shall be used.

Pourable explosives and emulsions shall not be used in controlled blast line holes. The maximum charge diameter in controlled blast line holes shall not exceed $\frac{1}{2}$ of the diameter of the hole, unless the Contractor can demonstrate through trial blasting that a greater amount of explosive is acceptable.

Controlled blast line holes shall not deviate from the neat excavation line by more than 12 inches unless directed by the Engineer.

Controlled blast line holes blastholes shall be $2\frac{1}{2}$ to 3 inches in diameter.

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The Contractor shall control drilling operations such that no controlled blast line holes shall deviate from the plane of the planned slope by more than 12 inches.

The length of controlled blast line holes shall not exceed 30 feet, unless otherwise approved.

The burden shall not exceed 1.3 times the spacing of the trim blastholes.

Blast Monitoring. Blast induced vibrations shall be monitored by the Contractor for every blast. Data will be made available to the Engineer no later than the next working day following each blast. The Contractor's seismograph equipment shall, as a minimum:

- (1) Be equipped with a self-triggering device.
- (2) Be capable of measuring vibrations in three planes and overpressures on existing structures.
- (3) Automatically calculate peak resultant particle velocity.
- (4) Be capable of providing a hard copy of the wave form and a summary of the results.

Rock Scaling. Immediately after each blast, the Contractor shall scale loose rock and blast debris and shall inspect rock surfaces.

All rock on the cut face that is loose, hanging, or that creates a potentially dangerous situation shall be removed or stabilized, to the Engineer's satisfaction, during or upon completion of the excavation in each lift. Drilling of the next lift shall not proceed until this work has been completed.

The slopes or excavation walls shall be scaled throughout the duration of excavation and at such frequency as required to remove all hazardous loose rock or overhangs.

The slopes shall be scaled using a suitable standard steel mine-scaling rod. Subject to the Engineer's approval, other methods such as machine scaling, hydraulic splitting, or incidental, low-quantity blasting may be used in lieu of or to supplement hand scaling.

Traffic Control. Traffic control for blasting work shall be in accordance with the Traffic Control Plan.

The time of blast initiation for each blast shall be furnished to the Engineer by the Contractor's Traffic Control Supervisor. This notification shall occur at least 12 hours prior to the blast and shall be confirmed 30 minutes prior to the blast by phone or traffic control radio network.