



Paul R. LePage
GOVERNOR

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION
16 STATE HOUSE STATION
AUGUSTA, MAINE 04333-0016

David Bernhardt
COMMISSIONER

September 8, 2014
Subject: **Durham & Lisbon**
State WIN: 018239.00 &
018382.00
Amendment No. 4

Dear Sir/Ms:

Make the following changes to the Bid documents:

In the Bid Book (pages 71-77) **REMOVE** "Special Provision Section 105 General Scope of Work (Environmental Requirements)", seven pages, dated 8/27/14 and **REPLACE** with the attached new "Special Provision Section 105 General Scope of Work (Environmental Requirements)", seven pages, dated 9/5/14.

In the Bid Book, **INSERT** the attached new "Special Provision Section 203 Excavation and Embankment (Controlled Blasting)", 10 pages, dated 9/5/14.

In the Plans on Plan Sheet Number 83 of 87, WIN 18239.00, in the "Trough Section" detail, **DELETE** " 1/4" " from the "1/4" Fabric Trough For Finger Joint" callout. Make this change in pen and ink.

In the Plans on Plan Sheet Number 18 of 87, WIN 18239.00, in the "APPROACH SECTION Durham Route 9 Approach" and "APPROACH SECTION Lisbon Approach STA. 56+00± to STA. 57+75±", **ADD** "Guardrail Type 3C with Rub Rail" to "7' Post with Reduced Berm Offset" callout. Make this change in pen and ink.

In the Plans on Plan Sheet Number 20 of 87, WIN 18239.00, **DELETE** "STA. 50+00 RT. TO STA. 51+98 RT. INSTALL GUARDRAIL TYPE 3C" and **REPLACE** with "STA. 50+00 RT. TO STA. 51+68 RT. INSTALL GUARDRAIL TYPE 3C". Make this change in pen and ink.

In the Plans on Plan Sheet Number 28 of 87, WIN 18239.00, **DELETE** "STA. 55+50 LT. TO STA. 57+75 LT. INSTALL GUARDRAIL TYPE 3C" and **REPLACE** with "STA. 55+81 LT. TO STA. 57+75 LT. INSTALL GUARDRAIL TYPE 3C with Rub Rail". Make this change in pen and ink.

In the Plans on Plan Sheet Number 37 of 87, WIN 18239.00, **DELETE** "STA. 25+00 LT. TO STA. 52+10 LT. INSTALL GURADRAIL TYPE 3C" and **REPLACE** with "STA. 25+40 LT. TO STA. 25+79 LT. INSTALL GUARDRAIL TYPE 3C with RUB-



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RAIL". **ADD** note "STA. 25+00 LT. TO STA. 25+40 LT. INSTALL 350 TERMINAL END". Make this change in pen and ink.

In the Plans on Plan Sheet Number 41 of 87, WIN 18239.00, **DELETE** "STA. 55+45 RT. TO STA. 102+23 RT. INSTALL GUARDRAIL TYPE 3C" and **REPLACE** with "STA. 55+58.5 RT. TO STA. 102+23 RT. INSTALL GUARDRAIL TYPE 3C". Make this change in pen and ink.

The following questions have been received:

Question: Do you have any details for Item # 606.551 GR type 3 – Single Rail with Rub Rail?

Response: The rub rail material, installation, and attachment shall be as per the guardrail manufacturer's recommendations, and shall meet MaineDOT specifications for Guardrail Type 3C – Single Rail and the attached standard AASHTO details RLR01 and SGM06a-b. The SGM06a-b shows a median barrier application; apply the mounting height of rub rail and connection details to the Type 3C guardrail. Be aware that Item 606.551 GR Type 3 – Single Rail with Rub Rail contains guardrail on a radius.

Question: Would you consider using item 609.161 Concrete Slipform Curb as a bid alternate to item 609.31 Bituminous Curb Type 3?

Response: Yes, so long as it meets the requirements of the attached Special Provision Section 609 STRUCTURAL CONCRETE (Concrete Slipform Curb), and a contract modification is executed at no additional cost.

Question: French Drain Item 512.08 – Generally 18+00 to 25+00; will "Ledge Shattering" for the French drain structure be paid under Shatter Solid Rock Subgrade Item 203.213?

Response: MaineDOT does not anticipate that any ledge shattering will be required for the installation of the French Drain, as it is outside the existing rock area and within the proposed roadway embankment area.

Question: There is no Perimeter Control Blasting Item (Commonly 203.212). Will the DOT require any such methods to be employed at Station 50+00 thru 51+00 and 23+00, where this item is usually requested for such excavation depths?

Response: Please see the attached new Special Provision 203 Excavation and Embankment (Controlled Blasting).

Question: Addendum 3 revision of Section 105, page SP 105-4 Section IV Blasting. Will Hydroacoustic Monitoring and Attenuation be enforced for the Road work? Specifically Items 203.21, 203.213, 203.216 and 206.07?

Response: Please see the attached new Special Provision 105 General Scope of Work (Environmental Requirements).

Question: For whatever it's worth, MD&B experience is not good with the 206 SEL and 207 SEL water hammer spec (SP105). It is nearly impossible to meet in a dewatered cofferdam and even worse in the wet. We have battled through a hand full of projects with the Owner at risk. MD&B and our consultants were on T&M etc. What typical happens is you go through all the blast plan rigmarole, shoot a shot and exceed the limits. Then sequentially reduce the lbs. per delay and the blast sizes, until you can't even break the rock and you have to ask to up the lbs... Hopefully by then the jobs almost done, if not then add costs like bubble curtains or rock berms etc. so that the hydro phones go as far as they can away from you.

There is quite a substantial amount of ledge to remove in the abutments and piers; hopefully the road work is not under this spec (as questioned above). I could suggest that the DOT require the Bridge rock be removed by mechanical means. And then negotiate with the low bidder if some savings can be had by going down the road of blasting.

Response: Please see the attached new Special Provision 105 General Scope of Work (Environmental Requirements).

Question: The existing utility lines are in significant conflict with the excavation / rock removal. We see existing and final locations of the poles on the plans. If there is no temporary relocation plan for these utilities, we expect a significant amount of the ledge to be removed via non-blast methods. The Solid Rock Shattering may be impossible to complete at Station 25+00 pole area, in other areas it will require second and third passes to work around the lines.

Is there a temporary relocation plan that is not published in the bid documents? Or is the Contractor to assume all work is to be completed before and after relocation as shown?

Response: As shown in the contract documents, no temporary aerial utility relocations are proposed. The Contractor should plan his work to maintain the existing utilities, which may require some level of mechanical rock excavation in addition to controlled blasting until such time relocation to new poles can be completed. This may require phasing of the Contractor's work, including some remobilization for the drilling and blasting.

The Contractor shall coordinate with utility companies to provide access to set new poles, install aerial lines, and remove existing poles.

Question: Bid Amendment 3 revises SP Section 105, the first paragraph was revised. We note that: Part IV title "Blasting (applies to all blasting, not just in the water)" remained the same. Can the title line be revised to remove (applies to all blasting, not just in the water)? We ask because Abutment 1 and 2 will likely have rock subgrade well above the water elevation.

If we understand the intent of the Blasting Section SP 105: "Any blasting in the wet or in a dewatered cofferdam requires the acoustic monitoring", perhaps a similar phase can be added if question 1 is acceptable.

The revision would at least allow firm blasting unit pricing for abutment 1 and 2, that is without acoustic monitoring. We would not submit blasting method unit prices for the abutments if acoustic monitoring is required. We might "try it", but have a hoe ram budget if readings were high.

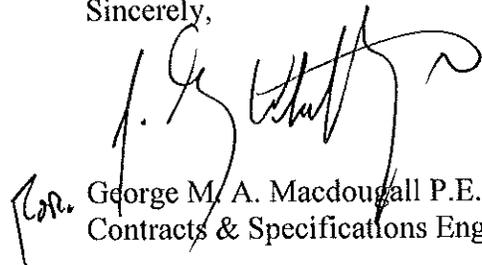
Response: Please see the attached new Special Provision 105 General Scope of Work (Environmental Requirements).

Question: Are the shop drawings for the precast concrete block gravity wall slope buttress, required to be prepared and signed by a Maine Licensed Engineer?

Response: No.

Consider this information prior to submitting your bid on September 10, 2014.

Sincerely,


George M. A. Macdougall P.E.
Contracts & Specifications Engineer

SPECIAL PROVISION
SECTION 105
General Scope of Work
(Environmental Requirements)

In-Water work consists of any activity conducted in the water.

Definitions:

1. **“Significant sound level”** is defined as noise levels as measured at 10 meters from the source as above the behavioral threshold of 150 dB re 1 μ Pa RMS SPL.
2. **“Injury threshold”** is defined as 206 dB PEAK re 1 μ Pa or 187 dB CSEL re 1 μ Pa. For sustained noise activities such as vibratory pile driving, hoe ramming or rock drilling, sound levels are more likely to approach the 187dB re 1 μ Pa CSEL. For short-duration, peak noise activities such as blasting and impact pile driving, sound levels are more likely to approach 206 PEAK dB re 1 μ Pa
3. **“Noise Buffer Zone”** is defined as the area between 200 feet downstream of existing bridge and 200 feet upstream of the proposed bridge)
4. **“In-water noise producing activities”** is defined as those likely to generate significant sound level. Includes but is not limited to hoe ramming, rock drilling, rock blasting, pile-driving with impact or vibratory hammers
5. **“Atlantic Salmon Tracking”** refers to MaineDOT coordination with Maine Department of Marine Resource to collect data on tagged salmon presence in the project vicinity to minimize impacts to Atlantic salmon. MaineDOT will inform the contractor when Atlantic salmon are known to be within the area bounded by 300 feet downstream of the existing bridge and 300 upstream of the proposed bridge. When this occurs, coordination with MaineDOT, hydroacoustic monitoring and attenuation for in-water noise producing activities will be required.

If Atlantic salmon enter the Noise Buffer Zone, all in-stream noise producing activities shall cease until there are no longer Atlantic salmon present in the Noise Buffer Zone or until attenuation and hydroacoustic monitoring ensure that sound levels are maintained below 187 dB re 1 μ Pa²-s cSEL and 206 dB re 1 μ Pa Peak SPL.

I. In-water work

1. In-water work is allowed between July 15 and March 31 with conditions for in-water noise-producing activities. In-water work is prohibited between April 1 and July 14.
2. In-water noise producing activities shall be conditionally allowed between July 15 and March 31.
 - a) Sound levels shall be maintained at levels below 187 dB re 1 μ Pa²-s cSEL and 206 dB re 1 μ Pa Peak SPL (injury threshold).
 - b) In-water noise levels greater than 150dB RMS re 1 μ Pa measured at any hydrophone must not persist in excess of 12 consecutive hours on any given day, and a 12 hour recovery period (i.e., in-water noise below 150dB RMS re 1 μ Pa, or a return to ambient levels) must be provided between work days.

3. The following additional conditions apply to in-water noise-producing activities:

<p>April 1 to July 14</p>	<p>1. No in-water noise producing activities. No hoe ramming, rock drilling, rock blasting, pile-driving with impact or vibratory hammers or any activity expected to generate significant sound levels.</p>
<p>July 15 to August 14</p>	<p>1. Hydroacoustic monitoring and attenuation required. See Section II.</p>
<p>August 15-September 14</p>	<p>1. Hydroacoustic monitoring and attenuation required. See Section II.</p> <p>2. MaineDOT will use Atlantic Salmon Tracking to determine Atlantic salmon presence in the project area.</p> <p>3. Contact MaineDOT Environmental Office (Eric Ham, 215-7356, eric.ham@maine.gov) to determine if monitoring, attenuation, and tracking can be suspended based on seasonal water temperature.</p>
<p>September 15 to September 30</p>	<p>1. Hydroacoustic monitoring and attenuation required. See Section II.</p> <p>2. MaineDOT will use Atlantic Salmon Tracking to determine Atlantic salmon presence in the project area.</p>
<p>October 1 to November 30</p>	<p>1. Hydroacoustic monitoring and attenuation required. See Section II.</p> <p>2. MaineDOT will use Atlantic Salmon Tracking to determine Atlantic salmon presence in the project area.</p> <p>3. In-water noise producing activities shall be limited to the daylight period between October 1 and November 30. The daylight period is defined as 0.5 hours after sunrise and 0.5 hours before sunset based on the <i>U.S. Naval Observatory Data</i> (Eastern Standard Time).</p>
<p>December 1 to March 31</p>	<p>1. Attenuation for pile driving through the use of driving shoe(s), cushion(s), etc. is required at all times.</p> <p>2. MaineDOT will use Atlantic Salmon Tracking to determine Atlantic salmon presence in the project area.</p> <p>3. If Atlantic salmon enter the Noise Buffer Zone, (and river temperature is below 23 degrees Celsius), all in-stream noise producing activities shall cease until there are no longer Atlantic salmon present in the Noise Buffer Zone <u>or</u> until attenuation and hydroacoustic monitoring ensure that sound levels are maintained below 187 dB re 1μPa²-s cSEL and 206 dB re 1 μPa Peak SPL.</p>

II. Hydroacoustic Monitoring & Attenuation

1. The contractor shall retain the services of a qualified person or firm to prepare and implement a hydroacoustic monitoring plan. A list of pre-qualified noise monitoring persons and firms can be found at the following link (Item 502.30) :

<http://www.maine.gov/tools/whatsnew/attach.php?id=94083&an=2>. The contractor shall provide MaineDOT a draft hydroacoustic monitoring plan at least 30 days prior to implementation for review. The monitoring plan shall describe monitoring locations, equipment and protocols, and personnel and shall describe how the contractor will complete the following:

- a) Monitor Sound Pressure Level (SPL) during all pile driving, rock drilling, and pier removal using a series of hydrophones and a digital recorder capable of operating at a minimum of 600,000 samples per second for a minimum of one second, with an adjustable trigger level, and a range of at least 30 psi.

Initially, a minimum of three hydrophones must be used, located approximately 10, 20, and 40 meters from the in-stream sound producing activity. Additional hydrophones may be required to document sound levels remain below the previously established thresholds at mid-stream, and at the farthest bank.

- b) Ensure that the sound pressure levels at all hydrophones be maintained below 206 dB PEAK re 1 μ Pa and below 187 dB CSEL re 1 μ Pa. In-water noise levels greater than 150dB RMS re 1 μ Pa measured at any hydrophone must not persist in excess of 12 consecutive hours on any given day, and a 12 hour recovery period (i.e., in-water noise below 150dB RMS re 1 μ Pa, or a return to ambient levels) must be provided between work days.
- c) Acoustic monitoring will be required at the beginning of each activity and activity location. If noise intensity levels approach the published threshold for having the potential to injure listed species (187 dB re 1 μ Pa CSEL and/or 206 PEAK dB re 1 μ Pa), noise minimization measures shall be used during that noise-producing activity. Should recorded underwater noise fall below the threshold for indication of potential injury of listing species (187 dB re 1 μ Pa CSEL and/or 206 PEAK dB re 1 μ Pa) during the activity, then persistent acoustic monitoring can be replaced with intermittent subset monitoring for the remainder of the activity at that location. Monitoring will continue until recorded underwater noise is shown to be consistently below the threshold for potential behavioral modification by listed species. This decision will be made in conjunction with FHWA, USACE, and USFWS.
- d) Mitigate excessive underwater noise (>206 dB PEAK re 1 μ Pa, 187 dB SEL re 1 μ Pa, or 150dB RMS re 1 μ Pa in excess of 12 hours) through passive measures such as changing hammer type, reducing driving duration, reducing force settings on the hammer, or through active measures such as but not limited to cushions, blast mats, or bubble curtains. The contractor shall employ all reasonable and prudent measures including but not limited to those listed above. If underwater noise continues to exceed noise limits, the contractor shall the stop noise-producing activity and shall contact MaineDOT to determine next steps.

2. The planning, design, execution, and reporting of all noise monitoring activities, including any noise attenuation countermeasures necessary to meet threshold and permitting requirements, shall be incidental to related contract items.

IV. Requirements for Blasting. The following requirements apply to all structural excavation blasting for the bridge (WIN 18239.00), including blasting both in the wet and in the dry.

1. If blasting is necessary, the contractor shall submit a blasting plan to MaineDOT at least 45 days prior to planned detonation. MaineDOT will review and submit to U.S. Fish and Wildlife Service (USFWS) and Army Corps of Engineers (ACOE) for review and written approval. USFWS will target 30 days for review and approval of the blasting plan; however, this timeframe is not guaranteed. The plan shall address the following items:

- a) Design information on each charge (e.g., type of explosive and detonation velocity (burn rate), type of blasting technique used, borehole dimensions, spacing, charge weights, delay intervals, method of initiation, and noise mitigation plans).
- b) Sound Pressure Level (SPL) blast monitoring using a hydrophone and digital recorder capable of operating at a minimum of 600,000 samples per second for a minimum of one second, with an adjustable trigger level and a range of at least 30 psi. Calculate Sound Exposure Level (SEL) from the SPL waveform, and report results prior to loading for the next blast, so that adjustments can be made if necessary. A minimum of three hydrophones shall be utilized, located approximately 30, 65, and 200 feet from the source/water interface;
- c) Details of the blast loading for each blast, and require that initial test blasting utilize small charge weights;
- d) The peak SPL, at the closest hydrophone, shall be maintained below 206 dB re 1 uPa (3.6 psi), and below an SEL of 187 dB re 1 uPa sq.-sec

2. In-water blasting. Sound attenuation (such as, but not limited to, bubble curtain(s)) will be required for all in-water blasting. The contractor shall propose and implement a method of attenuation to ensure that sound pressure levels do not exceed 206 dB PEAK re 1 μ Pa, or 187 dB SEL re 1 μ Pa. The method of attenuation must be reviewed and approved by MaineDOT as part of the blasting plan required in Item 1 of this section.

3. Blasting activities in the dry will require hydroacoustic monitoring at the beginning of each blast activity and activity location. If noise intensity levels approach the published threshold for having the potential to injure listed species (187 dB re 1 μ Pa CSEL and/or 206 PEAK dB re 1 μ Pa), attenuation shall be implemented. Should recorded underwater noise fall below the threshold for indication of potential injury of listing species (187 dB re 1 μ Pa CSEL and/or 206 PEAK dB re 1 μ Pa) during the activity, then persistent acoustic monitoring can be replaced with intermittent subset monitoring for the remainder of the activity at that location. Monitoring will continue until recorded underwater noise is shown to be consistently below the threshold for behavioral modification of listed species. This decision will be made in conjunction with MaineDOT, FHWA, USACE, and USFWS.

4. After each blast, the contractor shall submit a monitoring update to USFWS (Thomas Davidowicz, thomas_davidowicz@fws.gov) and MaineDOT (Eric Ham, Eric.Ham@maine.gov) within 5 days by electronic mail that includes the date, time, distance, peak pressure (with rise and fall time), the number of detonation, the dB, the SPL level and the SEL level;
5. At the completion of each blasting period, the contractor shall provide a monitoring report that will include a summary of each blast with maximum charge weight per delay, and the resulting SPL 13 and SEL. Blast reports, including hole spacing depths, loading, stemming, and delay sequence will also be included, as well as pressure time histories (graphs and data) for each blast.
6. During all blasts, the contractor shall allow a MaineDOT observer to be present on site to monitor for the presence of fish in the work area. The observer(s) will monitor for the presence of dead or wounded fish. In the event that dead or wounded fish of any species is observed from the blast activities, the permittee shall contact USFWS and blasting shall cease immediately and shall not resume until approval has been received from the Service.

V. Approvals:

1. Temporary Soil Erosion and Water Pollution Control Plan
2. Army Corps of Engineers Category 2 Programmatic General Permit Standard and Special Conditions apply.
3. DEP Permit-by-Rule and Section 11 Standards Apply.
4. USFWS Section 7 Informal Section 7 Consultation conditions apply (summarized in this Special Provision 105).
5. Blasting Plan (See Section IV of this Special Provision)
6. Permitted Resource Impacts (square feet), see ACOE permit for locations:

Wetland:

Permanent: 700

Stream:

Permanent: RUS-2,200

Temporary: RUS- 1,500 (Riverbed impacts.

Surface area of work trestle not jurisdictional)

VI. Other Conditions:

1. The contractor shall employ containment methods for all ledge and bridge removal activities. Measures could include blast mats, turbidity curtains, or work within the constructed cofferdams. Any material that is to be removed from the river with a clamshell shall be done promptly.
2. The contractor shall hold a pre-construction meeting for each project with appropriate MaineDOT Environmental Office staff, other MaineDOT staff, and the MaineDOT construction crew or contractor(s) to review all procedures and requirements for avoiding and minimizing effects to Atlantic salmon and to emphasize the importance of these measures for protecting salmon and their habitat. ACOE (Jay Clement, Jay.l.clement@usace.army.mil) and Service staff (Thomas Davidowicz, thomas_davidowicz@fws.gov) shall be invited to attend these meetings.
3. If cofferdams are placed within the water column, they will be installed in a manner so as to avoid trapping significant amounts of water or any fish. The contractor (through the resident) shall contact MaineDOT's Environmental Office (Eric Ham, 215-7356 and Mike Clark, 592-8242) to coordinate dewatering and fish evacuation. The contractor shall partially construct the cofferdam and MaineDOT Biologist(s) (or approved consultants) will capture and carefully remove as many fish species as possible from within the work area prior to cofferdam closure. Once the final sheets are installed and the cofferdam is closed, MaineDOT Biologist(s) will inspect for trapped fish before dewatering begins. If any Atlantic salmon are observed, the contractor will be notified and shall immediately stop all work associated with the cofferdam until MaineDOT can coordinate with USFWS, NMFS, or Maine Department of Marine Resources to remove the fish.
4. The contractor shall minimize the potential for effects to Atlantic salmon and their habitat by conducting all construction activities for each project in accordance with the MEDOT-approved Soil Erosion and Water Pollution Control Plan. In stream turbidity shall be visually monitored and all erosion controls will be inspected daily to ensure that the measures taken are adequate. If inspection shows that the erosion controls are ineffective, immediate action shall be taken to repair, replace, or reinforce controls as necessary.

5. A migratory fish passage shall be available at all times throughout the duration of construction.
 6. If water control pumps are necessary, in order to prevent Atlantic salmon juvenile entrainment related to dewatering water diversions, the contractor shall use a screen on each pump intake designed such that the approach velocity does not exceed 0.20 foot/second (6.10 cm/s). Square or round screen face openings are not to exceed 3/32 inches (2.38 mm) measured on a diagonal. Criteria for slotted face openings shall not exceed 1/16 inches (approximately 1.75 mm) in the narrow direction. Intake hoses shall be regularly monitored while pumping to minimize adverse effects to Atlantic salmon or other species of management concern.
 7. Disturbed areas adjacent to the stream shall be stabilized and re-vegetated with a seed mix appropriate for riparian areas in Maine, except in areas where riprap has been placed.
 8. To minimize the spread of noxious weeds into the riparian zone, all off-road equipment and vehicles (operating off of existing open and maintained roads) shall be cleaned prior to entering the construction site to remove all soil, seeds, vegetation, or other debris that could contain seeds or reproductive portions of plants. All equipment shall be inspected prior to off-loading to ensure that they are clean.
 9. As a component of the SEWPCP required for each project, MaineDOT or their contractor will develop and implement a Spill Prevention Control and Countermeasure Plan (SPCCP) designed to avoid any stream impacts from hazardous chemicals, such as diesel fuel, oil, lubricants, and other hazardous materials. All refueling or equipment maintenance will take place away from the stream and in a careful manner that prohibits chemical or other hazardous materials from entering the stream. These measures include the following:
 - a) All vehicle and equipment refueling activities shall occur more than 100 feet from any water course.
 - b) All vehicles carrying fuel shall have specific equipment and materials needed to contain or clean up any incidental spills at the Project site. Equipment and materials would include spill kits appropriately sized for specific quantities of fuel, shovels, absorbent pads, straw bales, containment structures and liners, and/or booms.
 - c) During use, all pumps and generators shall have appropriate spill containment structures and/or absorbent pads in place.
 - d) All equipment used for in-stream work shall be cleaned of external oil, grease, dirt, and mud. Any leaks or accumulations of these materials would be corrected before entering areas that drain directly to streams or wetlands.
- VII. All activities are prohibited (including placement and removal of cofferdams unless otherwise permitted by Regulatory Agencies) below the normal high water mark if outside the prescribed in-water work window, except for the following:
1. Work within a cofferdam constructed according to MaineDOT's Standard Specifications and in adherence with the contractors approved "Soil Erosion and Water Pollution Control Plan".

VIII. No work is allowed that completely blocks a river, stream, or brook without providing downstream flow.

WIN: 18239.00

Durham-Lisbon

9/05/14

SP 105-8

NOTE: Regulatory Review and Approval is required to modify the existing In-Water work windows. Approval of modifications is not guaranteed and may result in delays that are the sole responsibility of the contractor.

SPECIAL PROVISION
SECTION 203
EXCAVATION AND EMBANKMENT
(CONTROLLED BLASTING)

SECTION 203 – EXCAVATION AND EMBANKMENT is amended to include the following:

PART 1 - GENERAL

1.01 SUMMARY

A. Section includes:

1. The work to be done under this Special Provision includes furnishing all labor, equipment, materials and services and performing operations required to fragment and excavate materials classified as rock utilizing controlled blasting procedures specified herein to the grades and limits indicated on Drawings. The work shall be performed such that damage is prevented to adjacent structures, utilities, and work. The work shall be performed such that damage is minimized to adjacent rock, and such that the resulting ground vibrations and air blast overpressures are consistently maintained below the maximum levels specified in this Special Provision.
2. The purpose of the controlled blasting is to create a stable rock face with a fall zone to protect the traveling public from rock fall hazard.
3. Protecting existing structures, adjacent property, workers, Department personnel and consultants, and the general public from damage or injury from improper handling of explosives, flyrock, excessive ground vibrations and/or excessive air blast overpressure levels.
4. Furnishing, installing, and implementing an audible warning system to indicate impending blasting and familiarizing workers, Department personnel and consultants, and the general public with the system implemented.

1.02 SYSTEM DESCRIPTIONS

A. Definitions:

1. Earth is defined as all materials not classified as rock.
2. Rock excavation: Definition in Standard Specification Section 203.01.b shall apply.

1.03 QUALITY ASSURANCE

A. Qualifications:

1. Persons responsible for blasting shall be licensed blasters in the State of Maine. The Contractor shall document, with project descriptions, blast plans and references outlining successful experience performing controlled blasting for slopes greater than 15 ft. in height adjacent to a highway facility that included careful perimeter control blasting, measures to prevent damage to pavement or other structures, and measures to eliminate the need for or to minimize the length of traffic stoppage. The Blasting Subcontractor shall demonstrate at least three similar projects in the last six (6) years.

B. Codes, Permits and Regulations:

1. The Contractor shall comply with all applicable Federal, State, and Local laws, rules, ordinances

and regulations governing the transportation, storage, handling and use of explosives. All labor, materials, equipment and services necessary to make the blasting operation comply with such requirements shall be provided without additional cost to the Department.

2. The Contractor shall obtain and pay for all permits and licenses required to complete the work of this Special Provision.
3. In case of conflict between regulations or between regulations and Specifications, the Contractor shall comply with the strictest applicable codes, regulations, or Specifications.

C. Blasting Limit Criteria:

1. Existing Occupied Structures:

- a) Peak Particle Velocity Limits - At nearby existing occupied structures, the maximum Peak Particle Velocity (PPV) shall not exceed the United States Bureau of Mines (USBM) Safe Limits (see Figure 1).

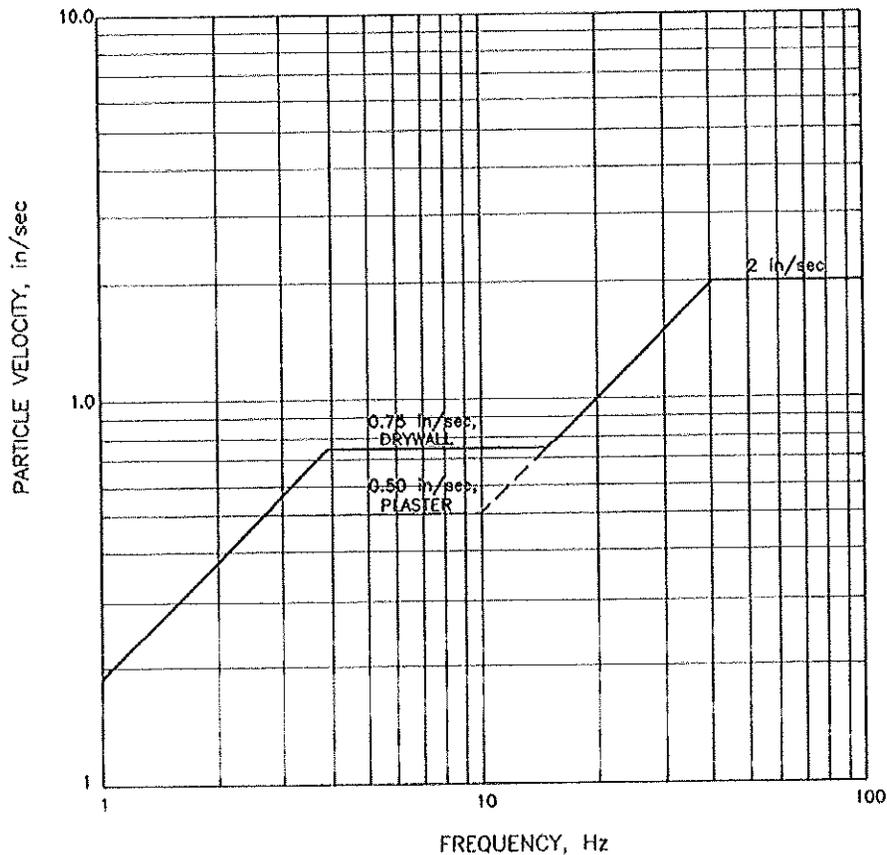


Figure 1 – Blasting Limit Criteria

- b) Airblast Overpressure Limits – Maximum sound pressure level of 133 dB (peak, impulsive), measured with a seismograph.

2. Utilities: The PPV shall not exceed 3 in/sec at existing utilities.
3. The Contractor shall comply with the Blasting Limit Criteria during all blasting and rock excavation. Adjustments to the drilling and blasting program and procedures, to comply with the Blasting Limit Criteria, shall be made by the Contractor during execution of the work at no expense to the Department.

D. Blast Monitoring:

1. The Contractor shall conduct blast vibration monitoring of every blast round required to excavate rock during the conduct of construction. Monitoring shall include one seismograph at the closest utility, one seismograph at the nearest segment of the Railroad and one seismograph adjacent to the nearest occupied structure.
2. The Contractor shall notify the Resident one hour prior to each blast.
3. The Contractor may perform additional blast monitoring at no additional cost to the Department.
4. Blast monitoring shall be conducted by qualified professionals trained in the use of a seismograph, and records shall be analyzed and results reported by persons familiar with analyzing and reporting the frequency content of a seismograph record.
5. All instrumentation proposed for use on the project shall have been calibrated within the previous twelve (12) months to a standard which is traceable to the National Bureau of Standards. Characteristics of required instrumentation are listed below:
 - a) Measure and report the three (3) mutually perpendicular components of particle velocity in directions vertical, radial, and perpendicular to the vibration source.
 - b) Measure and display the maximum peak particle velocity component and airblast overpressure, and the frequencies of each. The readings must be displayed and be able to be read in the field, immediately after each blast.
 - c) Furnish a permanent time history record of particle velocity waveforms and airblast overpressure waveforms.
 - d) Furnish a printout of USBM limits with vibration data.
6. The Contractor shall film each blast from a minimum of two (2) locations and shall submit films to the Resident within 24 hours of each blast event.

E. Blast Monitoring Reports:

1. Generally within 24 hours following each blast, a Blast Monitoring Report shall be submitted to the Resident. Any vibrations close to or exceeding the specified limits will be immediately reported to the Resident by the Contractor.

F. Notification: The Contractor shall be responsible for notification of representatives of the railroad and utilities prior to each blast.

G. The Contractor shall cooperate with the Resident in permitting observation of the Contractor's drilling and loading procedures, as well as in providing detailed information on blasting operations.

H. The Contractor shall be completely responsible for all damages resulting from the blasting operations and shall, as a minimum, take whatever measures are necessary to maintain peak particle velocities within the specified limits. Modifications to blasting and excavation methods required to meet these requirements shall be undertaken at no additional cost to the Department.

- I. Airborne Dust and Noise Limits: The Contractor shall take precautions, such as the use of water, vacuums and mufflers to minimize noise and dust from air track drilling operations.

1.04 SUBMITTALS

A. Advance Blasting Plan Submittal:

The Contractor shall submit a Blasting Plan containing the following information to the Resident no more than ten (10) business days after removal of overburden soil and at least ten (10) business days prior to commencing the drilling/blasting operations. It is the Department's intent to respond to the major items in the Contractor's submittal within five (5) business days after receipt. A Blasting Plan shall also be submitted at any time the Contractor proposes to change the drilling and blasting methods. If the location of faces change or other conditions change, the Contractor is required to submit a new Blasting Plan.

1. Sequence and schedule of blasting rounds, including the general method of developing the excavation, lift heights, etc.
2. Listing of inclinometer device to be used to accurately position drill angle on all drill rigs, complete with catalog cuts, specifications and operation procedures.
3. Specifics of a typical blast round to be implemented in each of the following areas:
 - a. At a test blast area within the excavation limits.
 - b. At the highest rock cut area.
4. Include the following blast round details:
 - a. Plan of a typical round design showing hole spacing and delay pattern, including test blasts and production blasts.
 - b. Diameter, spacing, burden, depth and orientation of each blast hole for a typical round design, including test blasts, production blasts and blasts where controlled blasting techniques are required.
 - c. Nomenclature and amount (in terms of weight and number of cartridges) of explosives and distribution of charge to be used within each hole, on each delay, and the total for the blast.
 - d. Nomenclature and type of detonators; typical delay pattern wiring diagram for the round: type and capacity of firing source, size, type and location of safety switches and lightning gap.
 - e. Type and amount of stemming to be used in holes.
 - f. Calculations of anticipated vibration levels at the nearest adjacent structures, utilities or railroad siding.
5. Manufacturer's data sheets for all explosives, primers and initiators to be employed.
6. Methods of matting or covering of the blast area in open excavations to prevent excessive throw of rock.
7. Written evidence of the licensing, experience and qualifications of the blasters who will be directly responsible for the loading of each shot and for firing it.
8. Name and qualifications of the person(s) responsible for design and directing the blasting. This submittal shall document by project lists and samples of blasting round design calculations that the person has the required experience in controlling open-cut blast vibrations in blasting rounds of the type required on the project.

9. Details of a traffic control plan specific to blast events.
 10. Details of an audible advance signal system to be employed at the job site as a means of informing workers, Department personnel or its representatives, and the general public that a blast is about to occur.
 11. Submit a certificate of insurance documenting that liability insurance coverage in an amount no less than \$2,000,000 will be in force for the duration of blasting at the site. The Contractor shall ensure that all approved damage claims will be honored, pursuant to the terms of the insurance policies and/or applicable state law.
 12. Listing of instrumentation proposed for use in profiling rock face and for surveying as-drilled locations of blast holes, complete with catalog cuts, performance specifications and operating procedures.
 13. Submit a copy of the blasting permit(s) obtained to conduct blasting on the site (when received).
- B. Blast Monitoring Report Submittals:
1. Within 24 hours following each blast, the Contractor shall submit to the Resident a Blast Monitoring Report. Each Blast Monitoring Report shall include all of the following applicable items:
 - a. Blast round design data, as indicated in Section 1.04.A.4 above.
 - b. Blast Monitoring Location Plan, indicating the location from the blast to the monitoring locations.
 - c. Vibration data from each seismograph, including a copy of the strip charge (or other permanent record of velocity/time waveform) with calibration and monitoring record marked with the date, time and location of the blast.
- C. Progress Submittal:
1. In the event that the Contractor's design round results in ground vibrations which exceed the blasting limit criteria specified in this Special Provision, the Contractor shall immediately revise the round design appropriately and submit the revised round design to the Resident for review. The Contractor shall allow sufficient time for review, and shall not conduct additional blasting until the revised blast round design is approved.
 2. Review by the Department of blast designs and techniques shall not relieve the Contractor of responsibility for the accuracy, adequacy and safety of the blasting, exercising proper supervision and field judgment and producing the results within the blasting limits required by this Special Provision.
 3. The Contractor shall report to the Resident in writing all blasting complaints received by the Contractor within 24 hours of receipt. Each blast complaint report shall include the name and address of the complainant, time received, date and time of blast complained about and a description of the circumstances which led to the complaint.
 4. The time period(s) specified for submittal are the minimum required by the Resident to review, evaluate and respond to the Contractor. If, after review, the Resident requires re-submission for any reason, the specified time period(s) shall commence upon the date of receipt of the re-submittal(s). The Contractor is responsible for scheduling specified submittal and re-submittal so as to prevent delays in the work.

PART 2 - PRODUCTS

Not Applicable.

PART 3 - EXECUTION

3.01 MINIMUM SAFETY PRECAUTIONS

- A. Clearing the Danger Area Before Blasting: No blasting shall be permitted until all personnel in the danger area have been removed to a place of safety. A loud, audible, warning system devised and implemented by the Contractor shall be sounded before each blast. The Contractor shall familiarize all personnel on the project and the general public with the implemented system. The danger area shall be patrolled before each blast to make certain that it has been completely cleared, and guards shall be stationed to prevent entry until the area has been cleared by the blaster following the blast.
- B. Explosives shall be stored, handled and employed in accordance with Federal, State, and Local regulations including 29 CFR 1926 Subpart U – Blasting and the Use of Explosives. All other Standard Specification Section 105.2.6 – Use of Explosives shall apply.
- C. No explosives, caps, detonators or fuses shall be stored on the site during non-working hours.
- D. The Contractor shall be responsible for determining any other safety requirements unique to blasting operations on this particular site so as not to endanger life, property, utility services, any existing or new construction, or any property adjacent to the site.
- E. No requirement of, or omission to require, any precautions under this Contract shall be deemed to limit or impair any responsibility or obligations assumed by the Contractor under or in connection with this Contract; and the Contractor shall at all times maintain adequate protection to safeguard the public and all persons engaged in the work, and shall take such precautions as will accomplish such end, without undue interference to the public. The Contractor shall be responsible for and pay for any damage to adjacent structures including all utilities and the adjacent railroad, resulting from work executed under this Special Provision.

3.02 TEST BLASTING

- A. The initial blasting at the site shall consist of at least one test blast, for the purpose of assessing the vibration attenuation characteristics at the site and the effectiveness of perimeter controlled blasting measures. The test blast shall take place in the area designated by the Resident.
- B. Requirements for controlled and production blasting operations covered elsewhere in this specification shall also apply to blasting control carried out in conjunction with the test shots.
- C. Blast rock shall be removed from the face at the test blast locations to allow for inspection of perimeter controlled blasting.
- D. Contractor will not be allowed to drill ahead of the test blast area until the test section has been excavated and the results evaluated by the resident.
- E. If at any time during the progress of the work, the methods of drilling and blasting do not produce the desired result of a uniform slope and shear face, within the tolerances specified, the Contractor shall be required to drill, blast and excavate in short sections, not exceeding 100 ft. in length, until a technique is arrived at that will produce the desired results. Extra cost resulting from this requirement shall be borne entirely by the Contractor.

3.03 GENERAL BLASTING PROCEDURES

- A. Pre-blast meeting: A pre-blast meeting shall be held prior to the start of any drilling or blasting activities. The purpose of the meeting shall be to review the blasting procedures and vibration monitoring requirements and to facilitate coordination between all parties involved. Individuals attending the pre-blast meeting should include the Resident, the Contractor, the Contractor's blaster, any utility affected by the blasting operation and any other personnel the Department deems appropriate.
- B. Blasting shall be limited to between sunrise and sunset Monday through Friday or as otherwise restricted by the Department. No blasting shall be conducted on Saturdays, Sundays, holidays, or other times unless prior written permission is received from the Resident.
- C. The Contractor shall notify the Resident at least 48 hours before blasting operations are to commence, and at least 24 hours prior to recommencing blasting if operations are suspended for any reason.
- D. The Contractor shall conduct blasting operations such that damage is prevented to adjacent improvements including existing utilities, property and work, and such that peak particle velocity levels do not exceed the maximum specified limits at the locations specified herein.
- E. Production blast holes shall be drilled on the patterns submitted by the Contractor and approved by the Resident. The production blast holes shall be drilled within two (2) blasthole diameters of the staked collar location. If more than 5% of the holes are drilled outside of this tolerance, at the option of the Resident, the Contractor may be required to refill these holes with crushed stone and redrill them at the proper location.
- F. First-row-in production blast holes (adjacent to perimeter blast holes) shall be drilled and loaded such that no portion of these holes are closer than 5 ft. to the presplit lines to avoid overbreak of the design rock face. Spacing and loading of the first-row-in holes should be 0.5 to 0.75 times the production hole loading and spacing.
- G. Roadway subgrade areas shall be shatter blasted to the limits shown on the plans in accordance with SP Section 203, Excavation and Embankment, and shall be paid under Pay Items 203.213, Fracturing Solid Rock Subgrade, and 203.216, Exploratory Drilling.
- H. Blasthole Drilling: Drilling logs shall be kept on each blasthole to show open bedding, jointing and open or mud filled seams, zones of soft or weathered rock, mud pockets, etc. These logs shall be provided to the Resident before any blastholes are loaded. The logs shall be used to properly design and load blastholes and protect from hazardous blasting effects.
- I. Blastholes shall be stemmed with dry angular crushed stone material with a maximum particle size of ½ in.
- J. No free-flowing, pourable or pumpable explosives shall be used unless approved in writing by the Resident. All explosives shall be in cartridges or other semi-rigid containers.
- K. Immediately after blasting, the Contractor shall have sufficient equipment available at the site to clear the roadway of all blastrock and debris. The Contractor shall also use, as required, a mechanical sweeper to control dust and small stones.
- M. At the completion of each blast round, the Contractor shall collect the fragmented rock and dispose of all material outside the limits of the Rock Cut area as indicated on the drawings (reuse on project) or as otherwise determined by the Contractor.

- N. If the blasting and rock excavation is performed using multiple lifts, any remaining bench shall be less than 15 in. in width.
- O. Blasting agent limitations: Blasting agents that contain perchlorates shall not be used for any blasting for the project.

3.04 SPECIAL CONTROLLED BLASTING PROCEDURES

- A. Controlled blasting is defined as a blasting method which utilizes a line of closely spaced, lightly loaded blastholes that are fired either before or after the main production blast to define a break line on the perimeter of the excavation.
- B. Cushion Blasting:
 - 1. Cushion (trim) blasting shall be used where the designed slope is 1:2 (horizontal to vertical) or steeper and the rock cut is 7 ft. or greater.
 - 2. Prior to drilling, all soil and loose and disintegrated rock shall be removed down to solid rock for a distance of at least 30 ft. beyond the end of the production hole drilling limits, or to the end of the cut, before drilling the cushion blast line.
 - 3. Cushion blast holes shall be loaded and fired separately after the main round to create a fracture plane along the perimeter of the excavation. Alternatively, they may be fired as the last delay(s) of a round, a minimum of 25 milliseconds after detonation of adjacent production holes. In general, the cushion blast row should be detonated with a row-to-row timing of 1.5 to 3 times the production hole row-to-row timing.
 - 4. Cushion blast holes shall be 4 in. or less in nominal diameter, spaced no greater than eight (8) times the hole diameter on-center, and shall be drilled along the cushion blast line and at the required slope inclination to the full depth of the cut or to a predetermined stage (lift.) elevation.
 - 5. Drilling 24 in. below the payment line will be allowed to facilitate removal of the toe berm.
 - 6. Continuous column charge explosives manufactured especially for cushion blasting shall be used for all cushion blasting. The top of the hole, for a minimum distance of 1.5 ft. or 0.7 times the burden, whichever is greater, shall be unloaded and stemmed. The bottom charge concentration within the bottom 1 to 3 feet of hole shall be no greater than three (3) times the column charge concentration.
 - 7. The maximum diameter of explosives used in cushion blast holes shall be not greater than $\frac{1}{2}$ the diameter of the cushion blast hole. The maximum column charge concentration shall be 0.4 lbs/ft.
 - 8. The upper portion of all cushion blast holes, from the top most charge to the hole collar, shall be stemmed. Stemming materials shall be dry angular granular material with a maximum particle size of $\frac{1}{2}$ in.
 - 9. Cushion blast charges shall be fired with detonating cord extending the full depth of each hole.
 - 10. The Contractor shall control drilling operations by the use of proper equipment and technique to ensure that no hole shall deviate from the plane of the planned slope by more than 9 in. either parallel or normal to the slope. Cushion blast holes exceeding these limits shall not be paid for unless, in the Resident's opinion, satisfactory slopes are being obtained.
 - 11. Cushion blast holes shall be drilled within 3 in. of the staked collar location. If more than 5% of the cushion blast holes are outside of the 3 in. tolerance, they will be filled with crushed stone, stemmed and re-drilled.

- B. Presplitting: Presplit blast holes shall be loaded and fired separately before the main round to create a fracture plane along the perimeter of the excavation. Alternatively, they may be fired as the first delay(s) of a round, a minimum of 25 milliseconds prior to detonation of adjacent production holes. With the exception of the above criteria, requirements given in Section 3.04.B for cushion blasting also apply to presplitting.

3.05 BOREHOLE DEVIATION MEASUREMENTS

- A. In order to assure adequate rock fragmentation, minimize the damage to remaining rock beyond the excavation limits, and minimize the possibility of excessive throw of rock onto the highway, the Contractor shall utilize borehole deviation techniques in order to determine the actual burden (distance to free face) for selected production and perimeter holes.
- B. Borehole deviation survey shall be completed for every other production hole and every fourth perimeter hole. The borehole deviation survey system shall be capable of measuring deviation along two axes: one parallel to the excavation limits, and one perpendicular to the excavation limits. It should be able to survey a 2 in. to 4 in. diameter hole, up to 100 ft. deep, to approximately 30 degrees, at an accuracy of 0.10 degrees. One acceptable system would be the "Boretrack" borehole deviation survey system.

3.06 SCALING

- A. The primary purpose of the scaling effort is to remove potentially unstable blocks of rock and rock fragments from the top and face of the slope. Scaling shall be accomplished by the manual method using a suitable standard steel mine scaling rod or other hand-held means to detached partially loosened blocks and loose rock fragments. Subject to the Resident's approval, other methods such as machine scaling, hydraulic splitters, or light blasting may be used in lieu of or to supplement hand scaling.
- B. The scaling operations must be conducted by personnel experienced in scaling work, so as to minimize damage to the surrounding sound rock. Scaling shall start at the top of the slope and work down. The scaling operations shall be sufficient to only remove the loose surficial rock surface and loose rock blocks.
- C. Scaling should be completed to remove loose or hanging rock during or upon completion of excavation in each lift. of rock removed to the Resident's satisfaction. Drilling of the next lift. will not be allowed until this work has been completed.
- D. The Resident or an approved representative must be present on site during all scaling activities. The Resident's representative will a) approve the method of scaling, b) determine the limits of scaling and c) inspect the new rock face after scaling and determine if additional scaling or other remediation is required.

3.07 MEASUREMENT AND PAYMENT

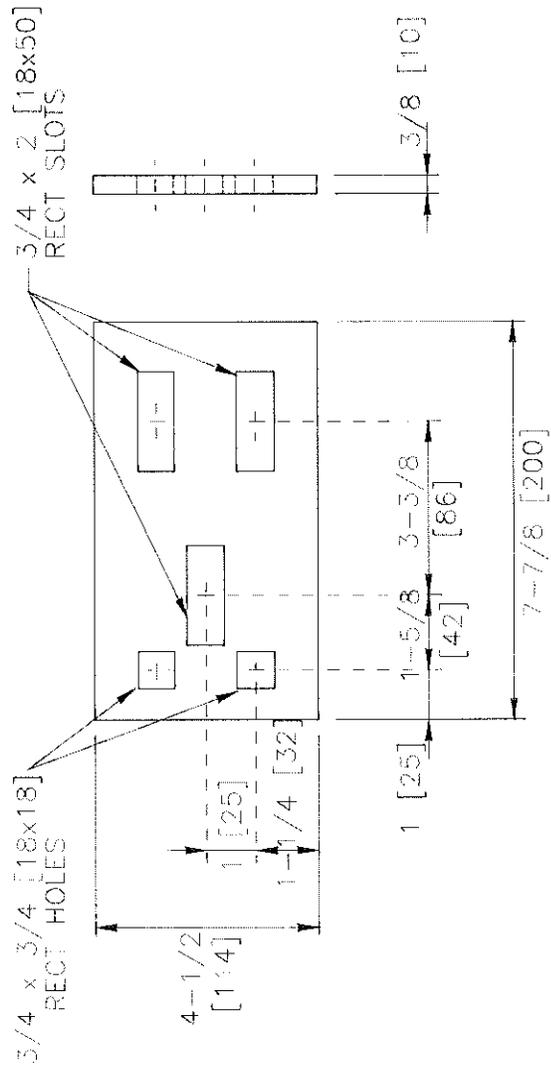
- A. Measurement
 - 1. Rock removed in accordance with this Special Provision will be paid using the neat lateral and horizontal limits indicated on the Drawings, and the measured quantity shall be an in place measurement. If the blasting and rock excavation is performed using multiple lifts, any remaining bench shall be less than 1.5 ft. wide and any additional excavation required as a result of the benching shall not be measured for payment.
 - 2. There will be no separate measurement for installing, maintaining and monitoring blast instrumentation, borehole deviation surveys, collecting blast debris, disposal of materials, scaling

and all other work noted above all cost in connection there with will be considered incidental.

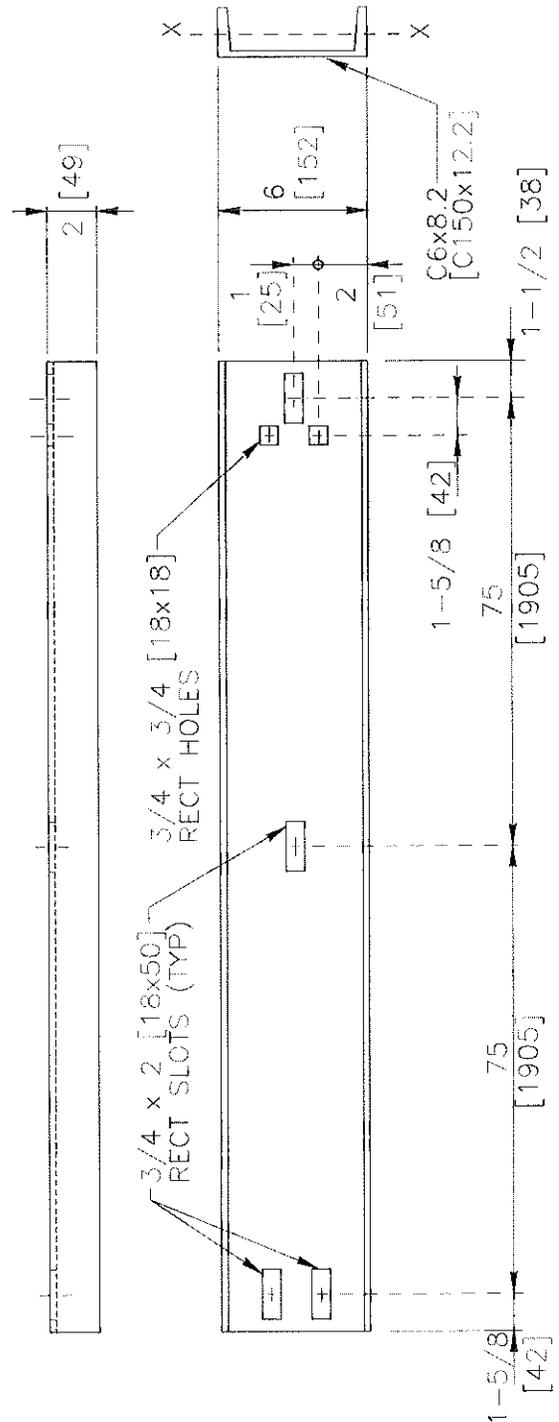
B. Payment

1. Rock removed in accordance with this Special Provision will be paid for at the contract unit price per cubic meter for Pay Item 203.21 – Rock Excavation. Work associated with conducting pre-blast surveys, blast monitoring, borehole deviation surveys, collecting blast debris, scaling, disposal of materials and all other work noted above will not be paid for separately but are considered incidental to the contract unit price for Pay Item 203.21 – Rock Excavation.
2. Payment for special perimeter control blasting (3.05) will be considered incidental to Pay Item 203.21, Rock Excavation.

<u>Pay Item</u>		<u>Pay Unit</u>
203.21	Rock Excavation	Cubic Yard



SPLICE PLATE



RUB RAIL

CHANNEL-SECTION RUB RAIL AND SPLICE

RLR01

SHEET NO.	DATE:
1 of 2	7/25/2005

SPECIFICATIONS

Channel section rub rails shall be manufactured from C6x8.2 [C150x12.2] channel sections as defined in AASHTO M 160/M 160M (ASTM A 6/A 6M). Rub rails and splice plates shall be manufactured from AASHTO M 270 / M 270M (ASTM A 709 / A 709M) Grade 36 [250] steel unless corrosion-resistant steel is required, in which case AASHTO M 270 / M 270M (ASTM A 709 / A 709M) Grade 50W [345W] steel shall be used. Unless rub rails and splice plates are made of corrosion-resistant steel, all hardware shall be zinc-coated according to AASHTO M 111 (ASTM A 123) unless corrosion-resistant steel is required. Corrosion-resistant steel shall conform to AASHTO M 222/M 222M (ASTM A 588/A 588M) after all punching and cutting are complete.

Inertial properties shown below are based on the gross cross-section dimensions without a reduction for splice and bolt holes.

Designator	Area in ² [10 ³ mm ²]	I _x in ⁴ [10 ⁶ mm ⁴]	I _y in ⁴ [10 ⁶ mm ⁴]	S _x in ³ [10 ³ mm ³]	S _y in ³ [10 ³ mm ³]
RLR01	2.48 [1.6]	0.69 [0.288]	13.09 [5.45]	0.49 [8.04]	4.38 [71.7]

Dimensional tolerances not shown or implied are intended to be those consistent with the proper functioning of the part, including its appearance and accepted manufacturing practices.

INTENDED USE

This rub rail is used in the SGM06a-b strong-post w-beam median barrier. Sections of this rub rail are connected using the splice plate and four 1.5-inch [40-mm] long FBX16a bolts and nuts. The rub rail can be attached to the PDE15 timber post using an FBB04 bolt and nut or to the PWE05 steel post using an FBB03 bolt and nut.

CHANNEL-SECTION RUB RAIL & SPLICE

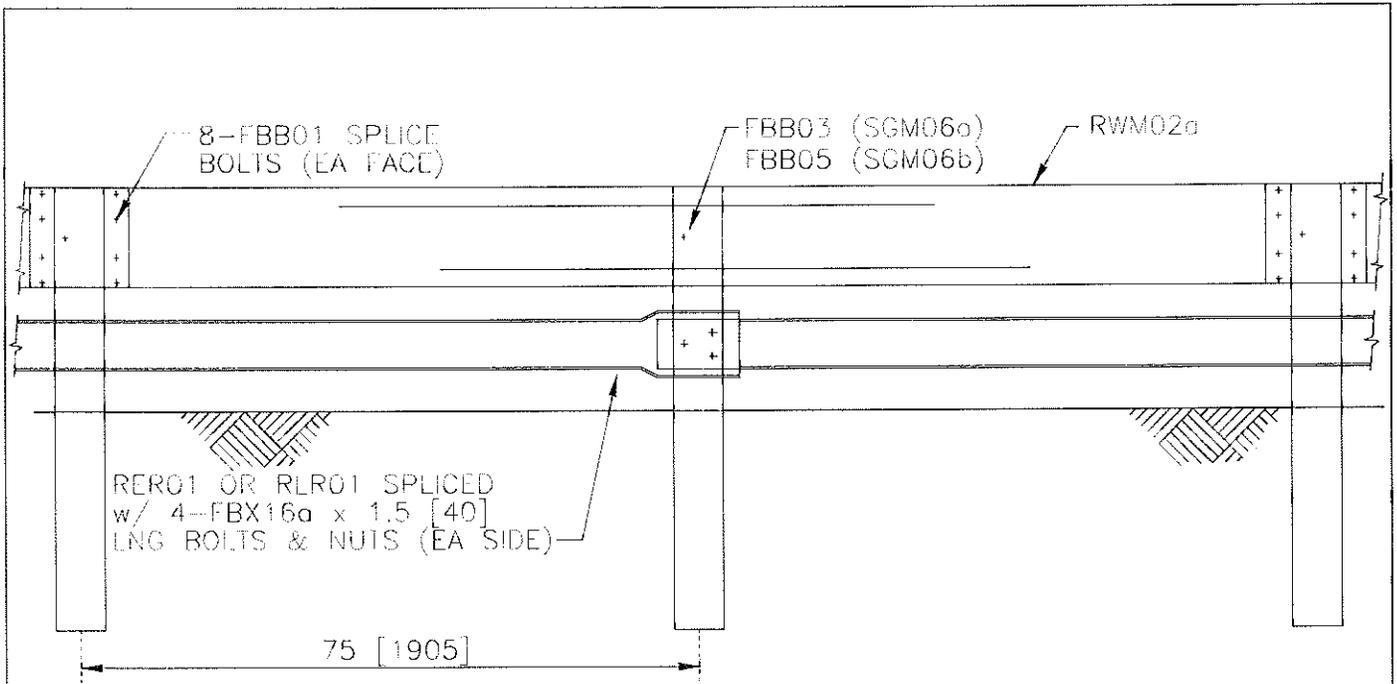
RLR01

SHEET NO.

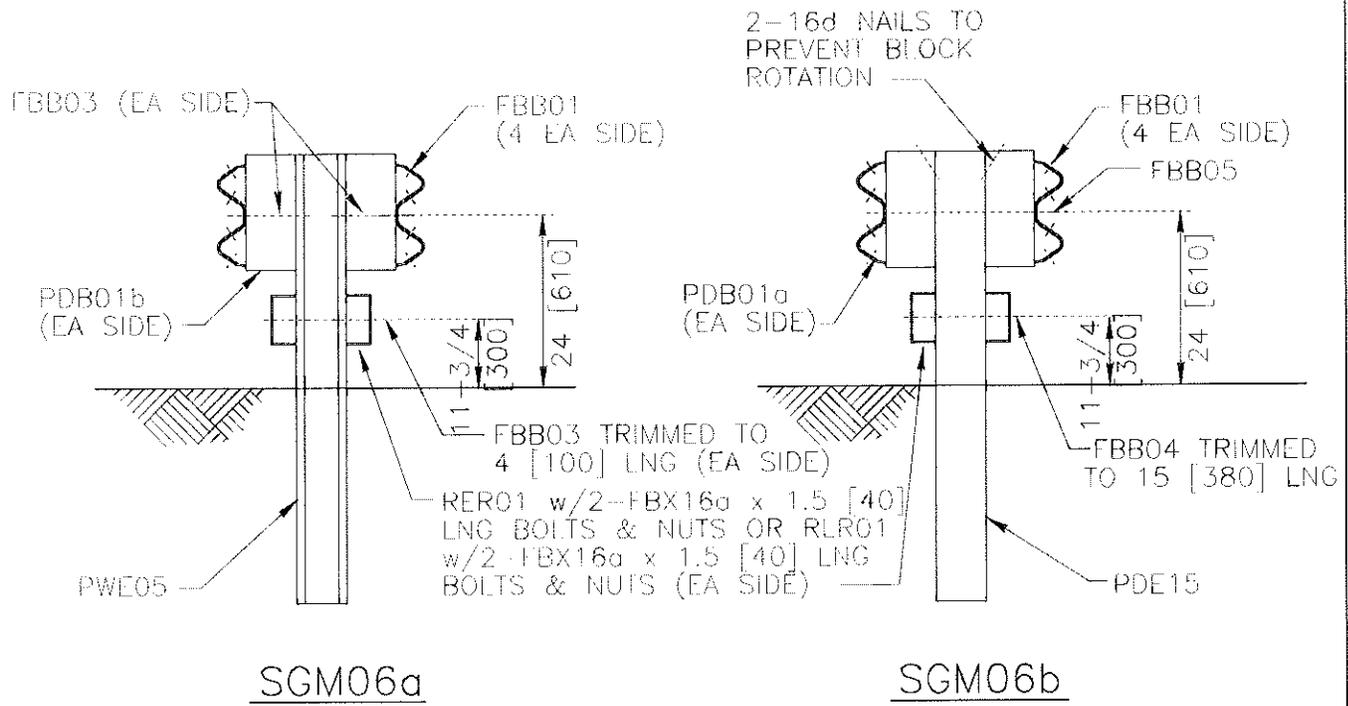
DATE

2 of 2

7/25/2005



ELEVATION



1994

STRONG-POST MEDIAN BARRIER WITH RUB RAIL

SGM06a-b

SHEET NO.	DATE:
1 of 2	7/25/2005

INTENDED USE

Strong-post W-beam median barriers should be used in locations where a maximum dynamic deflection of 24 inches [600 mm] or less is acceptable. W-beam barriers should be anchored and terminated using a suitable end treatment. Both SGM-06a (steel posts) and SGM-06b (timber posts) with wood or approved plastic blockouts are Test Level 3 barriers.

COMPONENTS

Unit length = 150 inches [3810 mm]

Designator	Component	System	Number
FBB01	Splice bolt and nut	a-b	16
FBB03	Guardrail-post bolt and nut	a	4
FBB03	Bolt trimmed to 4 in [100 mm]	a	4
FBB04	Bolt trimmed to 15 in [380 mm]	b	2
FBB05	Guardrail-post bolt and nut	b	2
FBX16a	Rub rail splice bolts (1.5 in [40 mm]) and nuts	a-b	8
PDB01a	Timber post blockout	b	4
PDB01b	Timber post blockout	a	4
PDE15	Timber post	b	2
PWE05	Steel post	a	2
RER01	Bent-plate rub rail	a-b	2
or RLR01	Channel rub rail	a-b	2
RWM02a	W-beam rail	a-b	2

APPROVALS

FHWA Acceptance Letter B-64.

REFERENCES

M.E. Bronstad, J.D. Michie, and J.D. Mayer, Jr., *Performance of Longitudinal Traffic Barriers*, National Cooperative Highway Research Program Report 289, Transportation Research Board, 1987.

J.D. Michie and M.E. Bronstad, *Location, Selection and Maintenance of Highway Traffic Barriers*, National Cooperative Highway Research Program Report 118, Highway Research Board, 1971.

R.N. Field and R.H. Prysok, *Dynamic Full-Scale Impact Tests of Double-Block-out Metal Beam Carriers and Metal Beam Guard Railing*, California Division of Highway, 1965.

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STRONG-POST MEDIAN BARRIER WITH RUB RAIL

SGM06a-b

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