Red and Bonita Mine Bulkhead Construction Requirements and Specifications

Prepared for the United States Environmental Protection Agency
by
The Colorado Division of Reclamation, Mining and Safety
Inactive Mine Reclamation Program

PROJECT LOCATION

The Red and Bonita Mine is located on the east side and approximately 200 vertical feet above Cement Creek, ten miles north of Silverton, in San Juan County, Colorado (Figure 1). The site is accessed from Silverton via County Road 110, north 6.4 miles to County Road 52, then County Road 52 northbound along the east side of Cement Creek to the Red and Bonita Mine.

WORK SUMMARY

The project work will involve construction of a hydraulic bulkhead in the Red and Bonita adit. Bulkhead construction will consist of ventilation of the working area of the mine to minimum 19.5 percent oxygen at all times (vent bag has been installed to the bulkhead location), mucking out sections of the adit, coffer dam construction, bypass pipe installation, cleaning and scaling at the bulkhead location, inner and outer bulkhead form construction, placement of concrete in formwork, and bulkhead contact grouting after the concrete has cured. The PROJECT MANAGER, as that terms is used in this document, shall be the U.S. Environmental Protection Agency On Scene Coordinator, or the On Scene Coordinator's designee.

PROJECT WORK DESCRIPTION

ITEM 1.0: PREPARE BULKHEAD LOCATION AND BYPASS PIPE

Preparation of the Bulkhead Location includes construction of the upstream cofferdams, installation of the bypass pipe, and cleanup, scaling and preparation of the bulkhead location, all in accordance with these specifications, and drawings as follows:

- Plate 1. Longitudinal Cross Section of Forms, Steel Beam Supports and Contact Grout Holes,
- Plate 2. Plan View of Bulkhead Forms with Steel Beam Supports,
- Plate 3. Air Side Form Face,
- Plate 4. Air Side #9 Rebar Cage Plus Contact Grout Holes

Muck working areas of Red and Bonita Mine

The first 300 feet of the main Red and Bonita crosscut heading and the first 25 feet of the 275-drift must be mucked-out (Figure 2). The floor of the mine has accumulated metal hydroxide precipitates and silt deposits to a thickness of up to three feet. The CONTRACTOR will muck these deposits into the 300-plus gallon per minute mine discharge such that the deposits will flow out of the mine as a slurry, which will be routed to a water treatment system and retention ponds that will be operated by others. The CONTRACTOR must coordinate mucking operations with the operator of the water treatment system such that the system is not overwhelmed and the discharge from the ponds is adequately clarified as determined by the PROJECT MANAGER.

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Install Injection Pipe

The CONTRACTOR will provide and install a 3/4-in. Schedule 80 PVC or HDPE injection pipe from the upstream end of the bulkhead to easternmost safely accessible location in the north the Red and Bonita Mine shown on Figure 2. The heading of injection pipe will have threaded connections and will be carried by hangers spaced every ten-feet installed in the back (roof) of the adit. The hangers will be installed into holes drilled into the mine roof and secured with epoxy or compression fittings. The injection pipe will be clamped to the hangers. At the bulkhead location, a stainless steel "Y" connection will be threaded to the injection pipe and will eventually be threaded to the 3/4-in. Schedule 80 water sampling and pressure measurement stainless steel pipe shown on the Plates. The other port on the "Y" connector will be fitted with a stainless steel check valve rated to 600 psi minimum that will prevent backflow through the check valve during fluid injection operations and force injected fluid into the injection pipe. When injection is not occurring, the check valve will remain open to allow pressure reading and water sampling of the mine pool at the water side of the bulkhead. Approximately 700-feet of injection pipe will be required, with sufficient hangers, clamps, angles and fittings to route the pipe to the east end of the adit.

Construct Two Upstream Cofferdams

The upstream end of the bulkhead will be sited as close to the intersection of the main crosscut heading and the 275-drift as possible. Construct upstream concrete or plastic sheeting covered sandbag cofferdams in the main crosscut beyond Station 2+75, and in the 275-drift, at locations chosen by the CONTRACTOR. The cofferdams will have a height at least 3-ft. above the existing adit floor. Water passing under, around or through the cofferdams must be eliminated in order to facilitate construction and concrete filling of the bulkhead form. Include a 8-in. nominal inside diameter, Schedule 40, type 316-stainless steel bypass pipe penetration through the cofferdam centered approximately 1-ft. 6-in. above the tunnel rock invert (floor), a minimum of 1-ft. 6-in. below the top of the cofferdam, and extending at least 1-ft. into the upstream pond. The pipe inlet will be protected from blockage by a fully-enclosed screened metal trash rack or perforated plastic pipe connected to the bypass pipe that rises at least 2-ft. above the top of the cofferdam.

Install Bypass Pipe

The entire length of the construction bypass pipe from cofferdam inlets to the downstream outlet shall be completed using flanged connections throughout, before starting construction of the bulkhead forms. A "Y" connector will be required to combine the pipes from each coffer dam into a single pipe through the bulkhead location. Clearing the broken rock ballast below the bypass pipe alignment through the bulkhead construction area is required so that the entire length of, 8-in. nominal inside diameter (ID), Schedule 40, type 316-stainless steel pipe, stainless steel fittings and fixtures through the bulkhead and the 8-in. stainless steel gate valve can be supported from solid rock at approximately 5-ft. intervals along the pipe. Steel rebar chairs or solid concrete blocks are to be utilized for pipe support within the bulkhead and stabilized by wire ties to resin anchored eyebolts embedded approximately 1-ft. into the floor and adjacent rib. All bypass pipe tie-downs must be able to resist uplift force generated during concrete placement in bulkhead forms. If the pipe supports or wire ties within the bulkhead are disturbed during construction of the bulkhead forms they shall be reinstalled before the final bulkhead form inspection and filling.

A temporary 8-in. diameter steel, wrought iron, HDPE or other downstream (air side) water diversion pipe must be completed, connected and functioning to bypass the flow of acid mine drainage before starting work on the bulkhead forms. See plans and sections noted above. The

length of the water diversion tail-pipe must extend to a discharge location outside the adit portal selected by the PROJECT MANAGER. The permanent connection between the stainless steel pipe and gate valve shall include Teflon tape, or other thread sealant.

The 8-in. stainless steel pipe through the bulkhead will include two (2) 14.5-in. by 14.5-in. square, 1/2-in. thick stainless steel thrust plate/water-stops that have been continuously fillet welded, on both sides of the plates, around the bypass pipe 4-ft. and 11-ft. inside the bulkhead from the water side (upstream) bulkhead form. The 8-in. stainless steel gate valve should be centered approximately 2-ft. from the air side (downstream) face of the concrete bulkhead.

Prepare Rock Surfaces in Bulkhead Location

Scale loose rock from the roof and walls, exposing fresh, clean and sound rock. The mine rails, if present and all broken rock ballast and ties will be removed from the floor in the bulkhead construction area, in the vicinity of Station 2+75. Solid rock will be exposed by scaling, prying up loose rock, and washing the floor and ribs clean to permit measuring the maximum tunnel height and width through the length of the bulkhead location. Four drill holes into the ribs of the adit (2-in. diameter, 12-feet long) must be grouted full with Type V neat cement grout at a minimum pressure of 90 psi.

Bulkhead Surface-Profiling

After scaling and washing are completed and loose rock, ballast, ties, and rail are removed, the bulkhead area will be inspected, measured and profiled in reference to tunnel centerline on 0.5 -ft. stationing. The profiling is to verify that the bulkhead design parameters remain valid, and to verify measurement for payment of Concrete placement. The rock surface irregularity along a parallel marked string-line shall be profiled along each tunnel rib, the back (roof) and the floor on 0.5 -ft. stationing. The PROJECT MANAGER shall inspect the rock surfaces for geologic structures and weaknesses that could compromise the design. A copy of the completed bulkhead surface profile shall be provided to the PROJECT MANAGER.

ITEM 2.0: CONSTRUCT UPSTREAM BULKHEAD FORM

Construct the upstream (waterside) bulkhead form. No. 1 grade Douglas Fir, or equivalent, is required for the timber lagging, post and sill supports. This form design is based on designs that have previously proven successful.

Construction of the upstream bulkhead shall be in accordance with these specifications, and drawings as follows:

- Plate 1. Longitudinal Cross Section of Forms, Steel Beam Supports and Contact Grout Holes,
- Plate 2. Plan View of Bulkhead Forms with Steel Beam Supports,
- Plate 3. Air Side Form Face,
- Plate 4. Air Side #9 Rebar Cage Plus Contact Grout Holes

The contractor may alter the construction sequence or specifications for the form work only with prior approval of the PROJECT MANAGER, providing a demonstration to the PROJECT MANAGER's satisfaction that the integrity of the final reinforced concrete bulkhead is not compromised.

The upstream bulkhead form construction sequence is as follows:

2.1 Cut a roughly level slot perpendicular to the tunnel axis, directly across the floor for the approximately 9-ft. long W 4x13 steel sill beam. Smooth irregularities in the slot using concrete grout as necessary. The sill beam will be cut in the field to assure that both ends of the beam are in close proximity, less than 1-in., of the tunnel wall on each end, assuring that the base of the outer 8-in. x 8-in. posts (or the four 2-in. x 10-in. composite posts) will bear against one flange of the W 4x13 beam. This is essential because the sill beam will align the three 8-in. x 8-in. posts across the tunnel on the water side form. The central 8-in. x 8-in. post shall be no more than 2-ft. 11-1/2-in. apart, center-to-center or 2-ft. 4-in. skin-to-skin. The recommended minimum center-to-center distance between the central post and one of the side posts is 2-ft. 7-1/2-in. or 2-ft. 0-in. skin-to-skin. This minimum spacing permits minimal access through the bulkhead form to the cofferdam, if required. The maximum 2-ft. 4-in. skin-to-skin distance between posts is, controlled by the strength of the 3 x 10-in. nominal (2-1/2 x 9-1/4-in. dressed) lagging.

2.2 Two 1-3/8-in. or 1-1/2-in. diameter holes will be drilled at least 6-in. apart, directly in line in front of the beam, three foot deep into the floor rock at each end of the beam. The holes will contain Grade 75 #8 resin-grouted threadbar dowels. The threadbar dowels are to project at least 3-in. upward through holes cut through the 6-in. leg of an at least 1-ft. long L 6x4x1/2 angle bracket. Threadbar nuts with washers will be attached and tightened to restrain the beam during filling of the form. The locations are as close as reasonable to the ends of the beam, as indicated on attached plates.

2.3 Stand the central 8-in. x 8-in. roof-to-floor post vertically near the tunnel centerline. Stand the two outside posts to minimize the distance the 3-in. x 10-in. lagging is cantilevered beyond the outside posts and as close as reasonably possible, but not more than 6-in.. The outside posts can be tilted to reduce the cantilevered distance, but only to the extent that the open span between the central post and the outside post does not anywhere exceed 2-ft. 4-in.

Hitches are to be cut into the back and floor for all posts to provide relatively flat bearing surfaces. Wedges will be used as needed to further tighten the posts. Bolt a 9-in. long 6-in. x 4-in. angle iron (L6x4x1/2) to the roof on the upstream side and against the top of each 8-in. x 8-in. post with one #8 fully resin-grouted threadbar un-tensioned dowels embedded at least 3-ft. into holes into the roof. Threadbar nuts with washers will be attached and tightened to restrain the post during filling of the form. See the attached plates.

2.4 Position the center of a cut-to-fit approximately 6-ft. long W 6x20 beam 2-ft. up from the floor of the tunnel and across the upstream face of the three 8-in. x 8-in. or the composite 4 each 2 x 10-in. posts. This is indicated on attached plates. Securely fasten the beam to all three posts, possibly with a lag screw anchored plate or bracket. Two 8-in. long L6x4x1/2 angle-iron will be fillet welded to beam, before the beam is taken into the tunnel, to stiffen the central post. If it is possible to determine the positions of the outer posts before moving the beam into the tunnel similar angles should be fillet welded to also brace the outer posts. These short angles are indicated on the attached plates.

2.5 Position the center of a similar cut-to-fit approximately 6-ft. long W 6x20 beam 4-ft. 6-in. up from the floor of the tunnel and across the upstream face of the three 8-in. x 8-in. or the composite 4 each 2 x 10-in. posts. This is indicated on attached plates. Securely

fasten the beam to all three posts, possibly with a lag screw anchored plate or bracket. Two 8-in. long L6x4x1/2 angle-iron will be fillet welded to beam, before the beam is taken into the tunnel, to stiffen the central post. If it is possible to determine the positions of the outer posts before moving the beam into the tunnel similar angles should be fillet welded to also brace the outer posts. These short angles are indicated on the attached plates.

2.6 Position the top of the third cut-to-fit 6-ft. long W 6x20 beam 6-ft. 9-in. up from the floor of the tunnel and across the upstream face of the three 8-in. x 8-in. or the composite 4 each 2 x 10-in. posts. This is indicated on the attached plates. Securely fasten the beam to all three posts, possibly with a lag screw anchored plate or bracket. Two 8-in. long L6x4x1/2 angle-iron will be fillet welded to beam, before the beam is taken into the tunnel, to stiffen the central post. If it is possible to determine the positions of the outer posts before moving the beam into the tunnel similar angles should be fillet welded to also brace the outer posts. These short angles are indicated on the attached plates.

2.7 Tunnel rib brackets, roughly 1-ft. 2-in. long L6x4x1/2 angle iron, anchored with two fully resin-grouted Grade 75 threadbar bolts in 1-3/8-in. or 1-1/2-in. diameter holes drilled 4-ft. deep and approximately 7-1/2-in. apart into the ribs at positions centered approximately 2-in. above and 2-in. below both ribside ends of the three W 6x20 beams. The rib brackets will also be centered approximately 2-ft., 4-ft. and 6-ft. above the floor. The irregularity of the tunnel ribs will necessitate individually installing the angle iron rib brackets. The attached plates indicate the bracket and locations. The #8 resin-grouted threadbar bolts are to project upward at least 3-in. through holes cut through the 6-in. leg of a L 6x4x1/2 angle bracket. Threadbar nuts with washers will be attached and tightened to support the design loading on the beam ends during filling of the form.

2.8 Bolt an approximately 8-in. long 6-in. x 4-in. angle iron (L6x4x1/2) to the roof on the upstream side and against the top of each 8-in. x 8-in. post with one #8 fully resin-grouted threadbar dowel embedded at least 3-ft. into a hole drilled in the roof. Threadbar nuts with washers will be attached and tightened to restrain the post during filling of the form. See attached plates.

2.9 The PROJECT MANAGER will make a final inspection of the waterside cofferdam, bypass pipe, W 4x13 sill beam, posts, W 6x20 bulkhead support beams, bolting and angle iron brackets will be inspected and must be approved before proceeding.

2.10 Place individual 3-in. x 12-in. nominal (2-1/2-in. x 11-1/4-in. dressed) or 2-in. x 4-in. (1-1/2-in. x 3-1/2-in. dressed) boards laid flat as lagging (form planks) from tunnel rib to tunnel rib, completely across the tunnel and against the 8-in. x 8-in. post supports, starting at the floor. The lagging boards are to be individually cut to fit the ribside profile. The lagging is to be stacked skin-to-skin on top of each other from the floor to the roof. The lowest and uppermost pieces of lagging will have to be cut to fit the floor and back profiles. The uppermost piece of lagging will require additional restraint between the posts by the #8 resin-grouted threadbar bolt brackets, indicated on the attached plates.

Wherever it is not possible to span the tunnel width with a single piece of lagging the lagging pieces will be butted together at the center of one of the central post. Lag bolt or nail each continuous piece of 3-in. x 12-in. lagging to at least two posts. Wherever possible wedges are to be driven between the ends of each piece of 3-in. x 12-in. lagging and the adjacent tunnel ribsides from the water side, before the next piece of lagging is cut to fit, placed, and fastened. If 2-in. x 4-in. lagging is employed the individual boards will

have to be nailed to the underlying board and the stack fastened to the central posts approximately every 12-in. Wedges are to be driven from the water side wherever gaps develop between the boards and the adjacent rock to tighten and support the cantilevered ends.

The pieces of lagging that contain the 8-in. nominal ID (4.500-in. OD) Schedule 40 stainless steel bypass pipe will have to be cut or slotted to fit as closely as possible around the bypass pipe, caulked and reinforced as necessary. Similarly, the lagging penetration for the upstream portion of the 3/4-in. nominal ID (1.050-in. OD) Schedule 40 water sampling and pressure measurement stainless steel pipe through the water side bulkhead needs to be drilled or cut, caulked and reinforced as necessary. The 3/4-in. pipe is to be positioned no closer than 2-ft. from either tunnel rib and at least 3.5-ft. up from the floor. The 3/4-in. pipe can contain two, at most, threaded union connections within the bulkhead provided these permanent connections include Teflon tape, or other thread sealant.

Drive or inject caulking material continuously between the lagging and the rock around the perimeter of the bulkhead form and the tunnel rock. Before the last of the lagging is placed between the central posts the final inspection of the cofferdam and bypass water inlet through the access opening must be performed. After that inspection, close the access opening.

2.11 Provide and install vibrating wire piezometer, cabling and data logger. CONTRACTOR will provide and install rst Instruments model PPA0094, 5.0 MPa piezometer, 300-FT. of armored cable, and model DT2055B ten-channel data logger as directed by the PROJECT MANAGER. **Armored cable is required.** Information on the rst Instruments equipment is included as Appendix D. Equivalent equipment from alternative manufacturers is acceptable if approved by the PROJECT MANAGER.

The piezometer will be hung on the water side of the bulkhead form and cable strung through the bulkhead location such that it will not be damaged during pouring of the concrete bulkhead. The cable will then be run on existing or newly installed hangers to the adit portal, and connected to the data logger installed in a secure location designated by the PROJECT MANAGER.

2.12 Nail the 1/2-in. thick plywood, or particle board, against the inner form face of the lagging (form planks). The plywood, or particle board, will have to be cut to fit the tunnel roof, ribs and floor perimeter profiles and around the bypass and water sampling and pressure measurement pipes.

Drive or inject caulking material into open spaces and continuously between the plywood, or particle board, and the rock around the perimeter of the tunnel.

2.13 Install DeNeef tube as described in Item 10.1.

2.14 Erect the two-way, shrinkage and temperature, 12-in. center-to-center, waterside, #6 rebar cage, with minimum 3.5-in. and maximum 9-in. clearance from the plywood form face, for eventual concrete cover as long-term protection against potential sulfate attack.

2.15 Stockpile the #9 steel reinforcing bars, 1/2-in. plywood or particle board and 3-in. x 12-in. or 2-in. x 4-in. lagging for the air side bulkhead form and the 3/4-in. Schedule 40 stainless water sampling and pressure measurement pipe sections necessary to complete

the water sampling and pressure measurement pipe in the bulkhead construction area before proceeding with construction of the air side bulkhead form.

ITEM 3.0: CONSTRUCT DOWNSTREAM BULKHEAD FORM

Construct the downstream (air side) bulkhead form. No. 1 grade Douglas Fir, or equivalent, is required for the timber lagging, post and sill supports. This form design is based on designs that have previously proven successful.

The downstream bulkhead form is nearly a mirror image of the upstream form. **The construction sequence for ITEM 3.0 principally repeats ITEM 2.0 as set forth above.** The same drawings as referenced in Item 2.0 above shall govern this section of the work. There are certain differences in the form and rebar cage construction as shown on the drawings, and in construction procedures as described in this section as follows:

3.1 It will not be possible to close the access opening through the two central posts into the bulkhead until:

a) The lagging, except for the access opening, is erected, wedged tight from the air side and caulked to the adjacent rock,

b) The air side lagging is fitted, caulked and reinforced around the 8-in. bypass pipe and the air side water sampling and the 3/4-in. water sampling and pressure measurement pipe penetration are made through the lagging.

c) The plywood or particle board is nailed to the lagging outside the access opening with a penetration hole for the 3/4-in. water sampling and pressure measurement pipe and the pipe sections then connected and inserted through the form, caulked and reinforced,

d) The concrete form release compound is applied to the plywood or particle board outside the access opening,

e) The two-way #9 rebar cage is erected, on 9-in. spacing, center-to-center, with minimum 3.5-in. and maximum 9-in. of clearance from the plywood form face, as long-term protection against potential sulfate attack, outside the access opening area,

f) The vertical #9 rebars in front of the access opening are tied to the lowest horizontal bar and temporarily tied to the vertical bars alongside the access opening,

g) The horizontal #9 bars, that will eventually be positioned in front of the access opening, will be hung from the uppermost horizontal bar, that has been carefully tied into all crossing vertical bars, so that the other two or three bars can be lowered into their final positions and tied into the cage from outside the access opening,

h) The PROJECT MANAGER's final inspection of the interior of the bulkhead to verify that the bulkhead forms, rebar cages, and pipes have been constructed as designed and the rebar cages and pipes are placed, supported and tied down as specified and

i) A final wet vacuum cleaning of the bulkhead floor has been completed immediately before starting to fill the bulkhead form.

3.2 NOTE: Pulling and lowering the rebar into position in front of the access opening and closing the access opening between the two central posts by inserting the lowest piece of precut lagging, complete with the plywood and form releasing compound, can only begin when the concrete filling of the form approaches that level of the lowest open lagging position. This delay is necessary in case there is a breakdown of some kind requiring entry into the bulkhead form.

ITEM 4.0 INSTALL AND REMOVE CONCRETE PUMPING AND CONVEYANCE SYSTEM

The bulkhead concrete will be pumped from the base of the mine waste rock dump through a slick-line. The contractor shall furnish and install a concrete pumping and conveyance system that is sufficient and capable of handing the pressures and pumping dynamics associated with the physical project constraints and the project requirements. The pump must be capable of pumping the mix at a sufficient pressure to completely fill the bulkhead forms. The pumping and conveyance system must be sized, configured and installed to prevent blockages (i.e. through appropriate line sizing and pre-screening concrete ahead of the pump), and allow fast and easy cleanout of blockages if they occur.

After the concrete is placed into the bulkhead forms, the Contractor shall remove the temporary conveyance system including removal of all piping and hoses.

ITEM 5.0 PROVIDE AND PLACE CONCRETE INTO BULKHEAD FORM

The CONTRACTOR shall fill the bulkhead form as a monolithic, single pour by continuously pumping the form full with approximately 27-cu.yd. of 4,000psi concrete. The profiling completed under Item 1.0 will be the basis for calculating the actual cubic yard volume for concrete required.

The CONTRACTOR must use the concrete mix design in Appendix A for 4,000 psi, self compacting concrete (SCC), or equivalent as approved by the PROJECT MANAGER. **Portland-cement used in the mix shall be type V Sulfate resistant cement. Additionally, Xypex Admix C-1000 or equivalent shall be added to the mix design as concrete waterproofing.** Xypex shall be added to the mix design per manufacturer's specifications included in Appendix C.

It is critical that the concrete be placed to prevent honey combing. It is also critical that the bulkhead be completed in a single, continuous concrete pour, but if the concrete filling process is interrupted for more than 6 hours, the Contractor must prepare a construction (cold) joint before resuming concrete filling by:

a) Entering the bulkhead and using a plywood support, move roughly to the center of the form,

b) Shoveling an approximately 1-ft. deep trench across the surface of the fresh concrete and

c) Applying a bonding agent to the surface of the fresh concrete (such as ThoRoc's "Epoxy adhesive 24LPL").

ITEM 6.0 CONCRETE TESTING

A set of three 6-in diameter by 12-in long cylindrical test samples are to be collected from each 5 cubic yards of concrete pumped to the bulkhead location. Sampling may occur at the concrete trucks, and is not required at the bulkhead location.

Approximately 6 sets of three samples each are to be collected. The concrete test samples are to be prepared in accordance with ASTM Designation C 31/C 31M-98, *Standard Practice for Making and Curing Concrete Test Specimens in the Field*. The 6-in diameter by 12-in long test specimens will be molded and rodded in plastic molds, marked for identification, placed in heavyweight plastic bags and stored on a level surface in the tunnel near the bulkhead location. After 7 days, two samples from each set will be transported in carefully packed boxes to a testing lab for final curing in a moist room. One test sample from each set will be tested for the seven-day compressive strength and the other for the 28-day compressive strength. The final sample from each set for the second 28-day test will remain underground in a safe location as near to the bulkhead location as possible. After 28 days they will be transported to the testing lab for the final set of test beaks.

ITEM 7.0 CONTACT GROUTING

If the PROJECT MANAGER approves the 7-day mean concrete compression strength test results as equal or exceeding 3,000psi, the upper 4-ft. of the downstream bulkhead form can be stripped to provide access for drilling and contact grouting.

ITEM 7.1 DRILL CONTACT GROUT HOLES

Once approval of the minimum 3,400 psi, 28-day compressive strength is received from the PROJECT MANAGER, the CONTRACTOR can establish the Contact Grouting operations. Drilling equipment and supplies are set up at the downstream bulkhead location. The upper 4-ft. of the downstream bulkhead form can be stripped to provide access for drilling and contact grouting. Hole size chosen must be compatible with the contractor's packer size and grouting equipment. Jackleg drilling may be used to advance the contact grout holes. Drilling must be done wet; water for drilling can be supplied by a jack-tank arrangement.

Drilling Logs

Contractor must log contact-grout drill holes on a pre-printed drilling log form, which must include the date the hole was drilled, the number or designation of the hole, the total depth drilled, and the position of the concrete-bedrock contact in the drill hole. Copies of contact grout hole drilling logs shall be provided to the PROJECT MANAGER.

Drilling Procedure

Drill one or more of the three longer concrete/bedrock contact grout holes toward known high locations in the adit roof area (as established by profiling in Item 1.0 above), between approximately 7.5-ft. and 14-ft. from the downstream bulkhead face, as directed by the PROJECT MANAGER. Otherwise follow the pattern shown on the attached plates. The length of these grout holes must be sufficient to penetrate about 6-in. into the rock, as indicated by a decrease in the drilling advance rate and by a change in the color of the circulation water and cuttings. NOTE: THE POSITION OF THE CONCRETE-BEDROCK CONTACT MUST BE RECORDED ON THE DRILL LOG FOR ALL HOLES. These longer holes must be grouted first.

Following grouting of the longer holes, drill the four shorter concrete/rock contact grout holes toward high locations in the granite roof area between approximately 1-ft. and 7.5-ft. from the downstream bulkhead face, if any are known from the profiling conducted in Item 3.0. The length of these grout holes must be sufficient to penetrate about 6-in. into the rock, as indicated by a decrease in the drilling advance rate and by a change in the color of the circulation water and cuttings. NOTE: THE POSITION OF THE CONCRETE-GNEISS CONTACT MUST BE RECORDED ON THE DRILL LOG FOR ALL HOLES.

ITEM 7.2 ESTABLISH CONTACT GROUT OPERATIONS

The contractor shall establish and conduct the Contact Grouting Program in conformance with these specifications, and generally accepted industry practice, as set forth by the Portland Cement Association Handbook, *Cementitious Grouts and Grouting*. Grout shall consist of a neat type-V cement grout. Mix water must be free of deleterious substances (mine discharge water is not permitted to be used for mixing grout). Water must be supplied from clean sources and pumped in from surface, or via at least two portable tanks that can be brought into the tunnel during grouting.

Upon completion of the Contact grouting work, the Contractor shall remove all equipment and materials from the underground work area, including any un-used cement.

Grouting Logs

The Contractor must record all grouting activities on pre-printed grout logs approved beforehand by the PROJECT MANAGER. The log must include the date, hole number, grout mix data (W:C ratio and density), injection pressure, grout take in cubic feet, and all other variables used to grout the hole.

Grouting Equipment

The Contractor must batch, mix, and inject cement grout at the bulkhead location. Neat cement grout may not be mixed and batched at surface or pumped through the slick line installed under Item 4.0. A high-shear colloidal mixer unit specifically designed for batching and mixing neat-cement grouts is required (e.g. *ChemGrout CG-600/8CF/A, CG-620/A or equivalent specification coloidal unit*). Pumping units may be positive displacement piston-type or progressive-cavity (Moyno) type (e.g. Chem Grout *CG-600/8CF/A, CG-030, CG-L4A etc.)* The unit must supply grout to a maximum pressure of 450 psi. (www.chemgrout.com)

A re-circulating-type grout delivery manifold system is required. The manifold and valve system must allow for continuous recirculation of grout back to the grout holding tank. Pressure to the hole being grouted is controlled by closing/opening the return-circulation valve. Suitable diaphragm-protected pressure gauges with appropriate dial scales are required, and headers on the mechanical packers at each hole must be equipped with a gauge and shut-off or holding valve that will maintain grout pressure in the hole when the delivery manifold is disconnected.

ITEM 7.3 PROVIDE AND INJECT CONTACT GROUT

The PROJECT MANAGER must be present during all grout-injection work. The Contractor must record all grouting activities on pre-printed grout logs, format of which is approved beforehand by the PROJECT MANAGER. The log must include the date, hole number, grout mix data (W:C ratio and density), injection pressure, grout take, and all other variables used to grout the hole.

Grout Mix Design and Density Measurement

Grout shall consist of a neat Type-V cement grout (Type-V cement and water). Cement must be Type-V sulfate resistant. Mix water must be free of deleterious substances (mine discharge water is not permitted to be used for mixing grout). Water must be supplied from clean sources and pumped in from surface, or via at least two portable tanks that can be brought into the tunnel during grouting.

The injected mix shall have a water-cement ratio of 2:1 by weight. Depending on take and pressure, the contractor's mixing and pumping equipment must be capable of varying the water-cement ratio from 0.6:1 to 3:1 as directed by the PROJECT MANAGER. Admixtures that control bleed, improve flowability, reduce water content, and retard set may be used in the grout, subject to review and acceptance by the PROJECT MANAGER.

Grout specific gravity and density must be measured per ASTM C109 or API RP-13B-1, at a frequency of no less than one test per-batch conducted prior to injection, and recorded on grouting logs. The Baroid Mud Balance used in accordance with API RP-13B-1 is an approved device for determining grout density.

Grouting Procedure

A mechanical or inflatable packer compatible with the hole size used in Item 7.1 above is to be set at least 6 inches outboard of the concrete/bedrock contact and roughly halfway up the grout hole. Grout injection pressure should reach at least 90 psi, but not more than 450 psi. The minimum grout pressure is to be maintained for three minutes or until three bags (3-cubic feet) of grout have been injected, or whenever grout returns from an adjacent grout hole.

If the grout take in one hole reaches three cubic feet without reaching the minimum 90 psi injection pressure, grouting is to be stopped, the packer pressure released, the packer removed and the grout allowed to reach initial set for 8 hours. The CONTRACTOR will make an immediate written record of the grout take after each grouting cycle for each hole.

If grout refusal occurs, or when the minimum grout pressure is reached and held for three minutes, the hole is to be grouted full and not re-grouted. If other grout holes have been drilled they can be grouted during the initial set time. After initial set in each grouted hole, the packer will be reset at the face of the bulkhead and the remainder of the hole filled with grout using a vent-tube return through the packer.

A hole that had greater than 3 cubic feet of take will be re-drilled and the grouting process repeated after the initial grout set, as directed by the PROJECT MANAGER. The set time can be shortened provided the measured tunnel temperature indicates that this is reasonable, and the PROJECT MANAGER concurs. The grout holes will be re-drilled and re-grouted until the minimum grout pressure can be maintained for three minutes.

ITEM 8.0 DENEEF TUBE GROUTING

In addition to contact grouting, DeNeef tubes will be installed and grouted to reduce any additional leakage along the concrete/bedrock contact. CONTRACTOR must use DeNeef products or approved equivalent as described below and included in Appendix B. Consultation with the manufacturer's representative is required. A site inspection by the manufacturer's representative

may be required by the PROJECT MANAGER. DeNeef tube grouting shall not take place until all contact grout operations have been completed.

ITEM 8.1 SUPPLY AND INSTALL DENEEF TUBE

CONTRACTOR must supply and install 1/2-in. DeNeef Injecto® tube per manufactures guidance and recommendations. The tube must be continuously tight against the rock. Two complete rings shall be installed along the adit perimeter at locations established by the PROJECT MANAGER . Grout tube must be installed prior to completing the downstream bulkhead form, and must be attached to the rock perimeter per manufacture's specification. The injection point for each ring shall penetrate the formwork at the edge of the form.

ITEM 8.2 PROVIDE AND INJECT DENEEF GROUT

Following certification by the PROJECT MANAGER that all 28-day concrete breaks have met design compressive strength, DeNeef grout tubes shall be grouted. Contractor must supply and inject DeNeef Injecto® PURe grout and Flex Cat PURe or alternate grout product recommended by the manufacturer and approved by the PROJECT MANAGER. Grout shall be injected into both grout tube rings to reduce or eliminate any seepage along the concrete/bedrock contact. Grout and catalyst shall be mixed and injected in accordance with manufacturer's recommendations. Manufacturer's mix recommendations of 1% catalyst to resin shall be adhered to.

CONTRACTOR shall supply and setup all equipment required to inject the grout tubes. Grout tube injection pressures must reach a minimum of 90 psi, but shall not exceed 450 psi.

ITEM 9.0 STRIP FORMS AND INSTALL VALVE AND PRESSURE GAUGE EQUIPMENT

After completion of the contact grouting program, permanent protective supports will be placed under and around the valve manifold for its protection. The remainder of the downstream (air side) form will be also be stripped, and all the removed materials taken outside for proper disposal during project de-mobilization. A stainless steel globe valve rated to 600 psi will be permanently attached to the threaded end of the 3/4-in. water sampling and pressure measurement pipe. Provide and install a stainless steel analog pressure gauge with a psi range of 0-600, 20 psi major graduations, and 2 psi minor graduations. All pipe and valve connections will be made using Teflon tape, or other thread sealant. All fittings, pipe, and valves are schedule-40 stainless steel.

PROJECT OBSERVATION

The PROJECT MANAGER will be at the project site periodically to monitor construction activities and ensure that each work item is completed and constructed to design specifications. It is the Contractor's responsibility to schedule inspections with the PROJECT MANAGER so as not to delay the work. The following items must be observed and approved by the PROJECT MANAGER before proceeding with the next step of the work:

Item/Task	INSPECTION ITEM
ITEM 1.0	Prepared bulkhead area will be inspected, measured and profiled. Profile provided to the PROJECT MANAGER.

ITEM 2.0 The PROJECT MANAGER will make a final inspection of the cofferdams, bypass pipe, bulkhead sill, posts, bracing, bolting and angle iron brackets and this must be approved before placing the last of the lagging, closing the water side access opening.

The PROJECT MANAGER must perform final inspection of the interior of the bulkhead to verify that the bulkhead forms, rebar cages, and pipes have been constructed as designed and the rebar cages and pipes are placed, supported and tied down as specified, and a final wet vacuum cleaning of the bulkhead floor has been completed immediately before starting to fill the bulkhead with concrete.

ITEM 3.0 The PROJECT MANAGER will make a final inspection of the waterside cofferdam, bypass pipe, W4x13 sill beam, posts, W6x20 bulkhead support beams, bolting and angle iron brackets will be inspected and must be approved before closing the waterside access opening.

The PROJECT MANAGER's final inspection of the interior of the bulkhead to verify that the bulkhead forms, rebar cages, and pipes have been constructed as designed and the rebar cages and pipes are placed, supported and tied down as specified, and a final wet vacuum cleaning of the bulkhead floor has been completed immediately before starting to fill the bulkhead form.

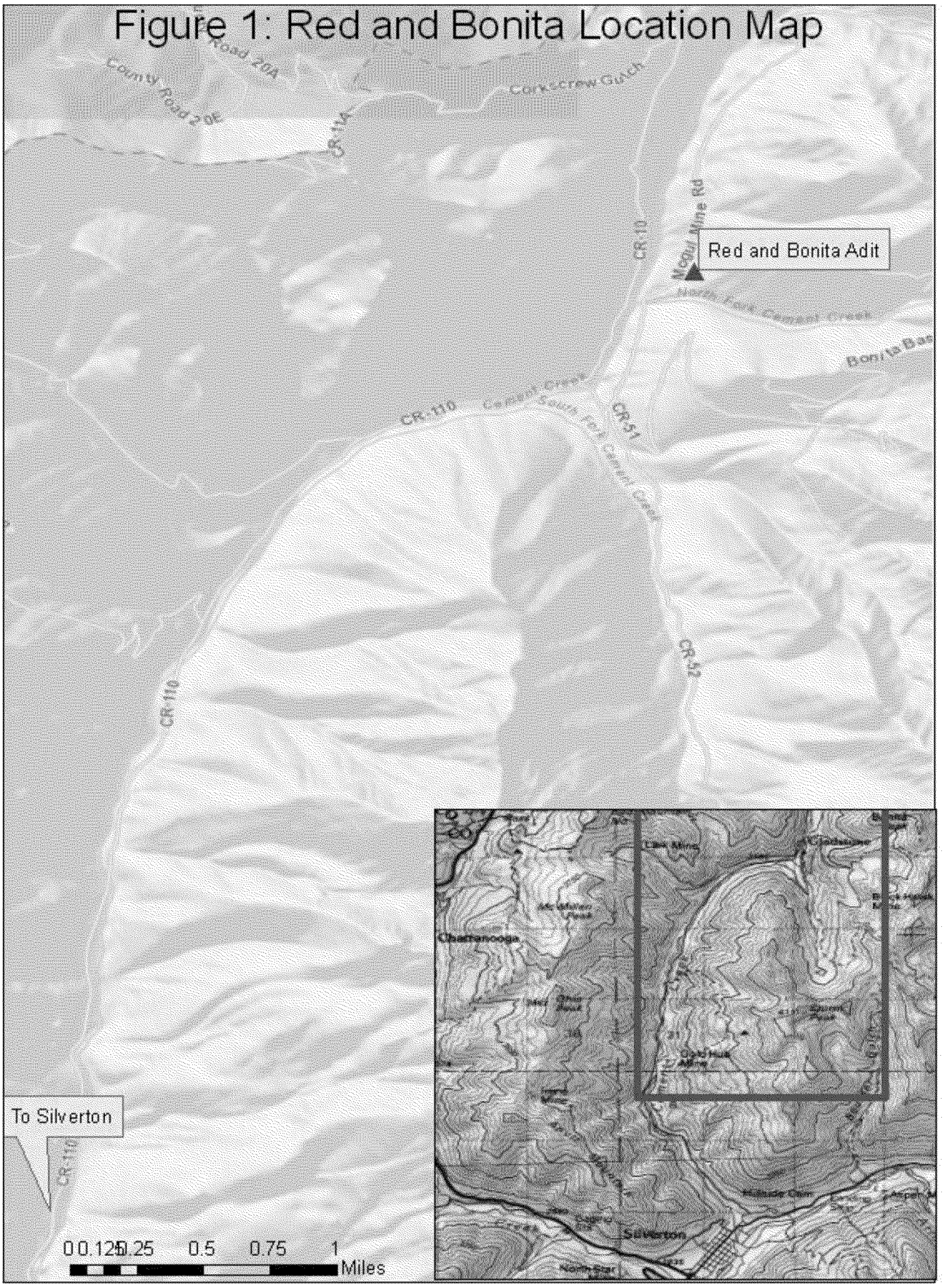
ITEM 5.0 The PROJECT MANAGER must be present during all concrete placement into the Bulkhead forms.

ITEM 6.0 After all the seven day test results have been received from the lab, the gate valve can be closed and the temporary air side (downstream) bypass pipe can be disconnected, provided the mean 7-day concrete compression strength test results exceed 3,000 psi and if approved by the PROJECT MANAGER.

ITEM 7.0 The PROJECT MANAGER must be present during all grout injection work. Grout holes can be re-drilled and the grouting process repeated after the initial set time as directed by the PROJECT MANAGER. The set time can be shortened provided the measured tunnel temperature indicates that is reasonable, and the PROJECT MANAGER concurs. Drilling and Grouting Logs must be provided to the PROJECT MANAGER.

ITEM 8.0 The PROJECT MANAGER must be present during all DeNeef grout tube injection.

Figure 1: Red and Bonita Location Map



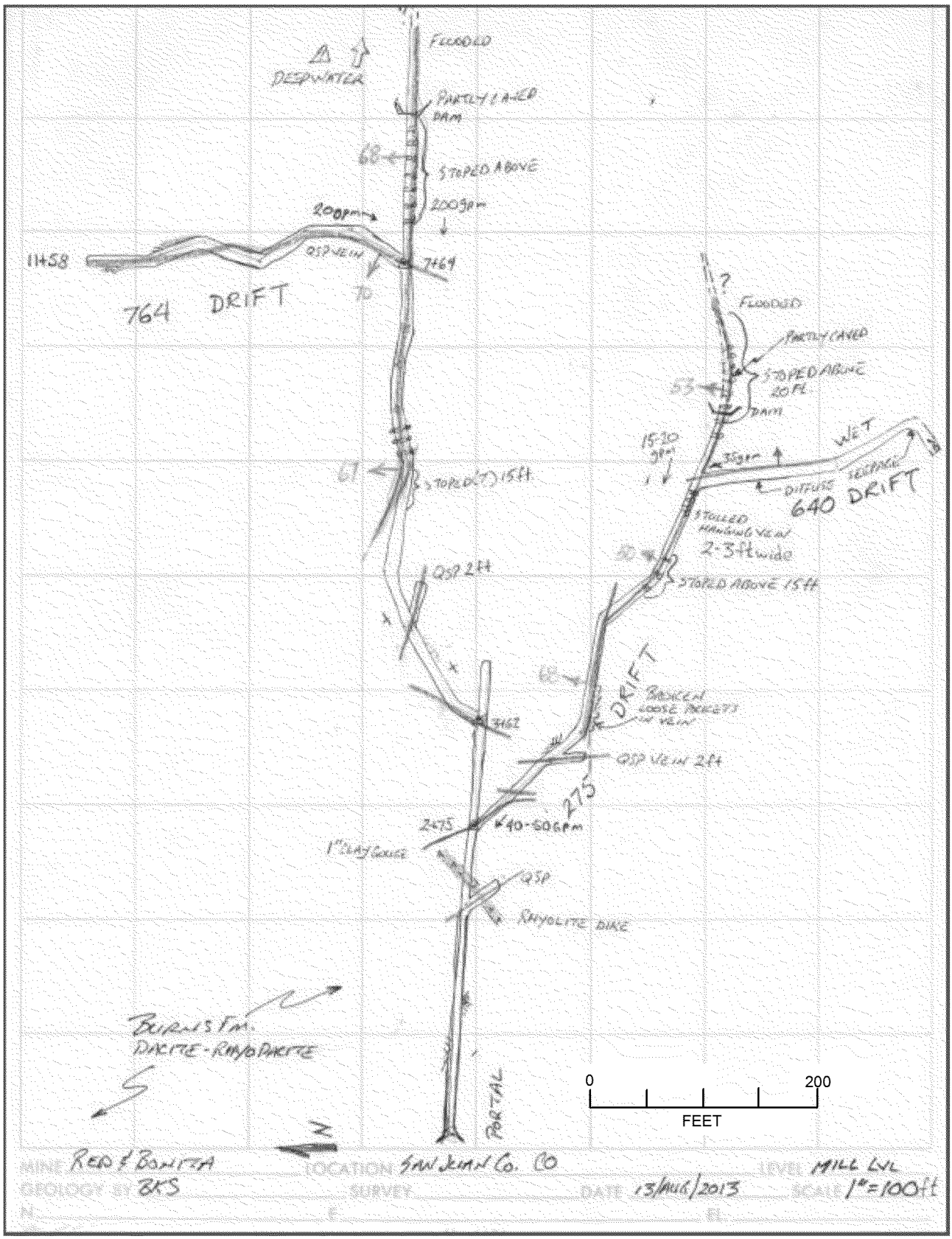


Figure 2: Red and Bonita Mine Map

LONGITUDINAL CROSS SECTION OF BULKHEAD

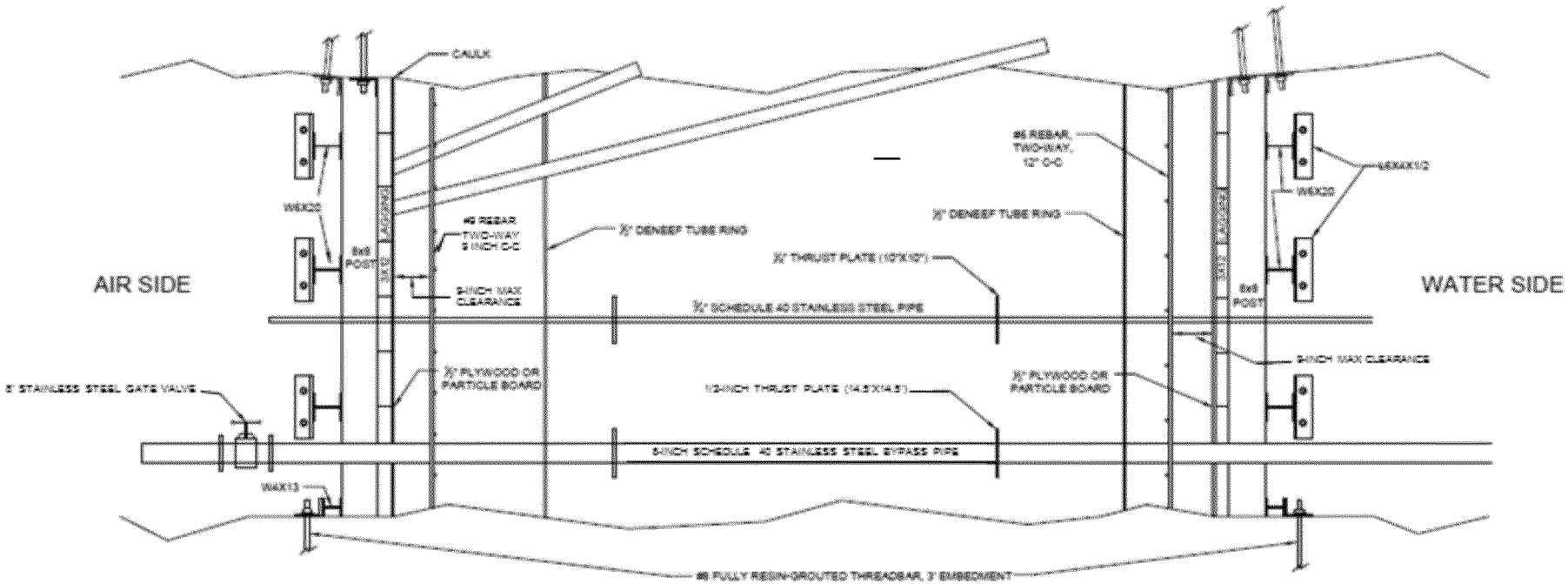


PLATE 1	RED AND BONITA MINE BULKHEAD
SCALE 0 FT — 5 FT	COLORADO Division of Reclamation, Mining and Safety Department of Natural Resources

PLAN VIEW OF BULKHEAD

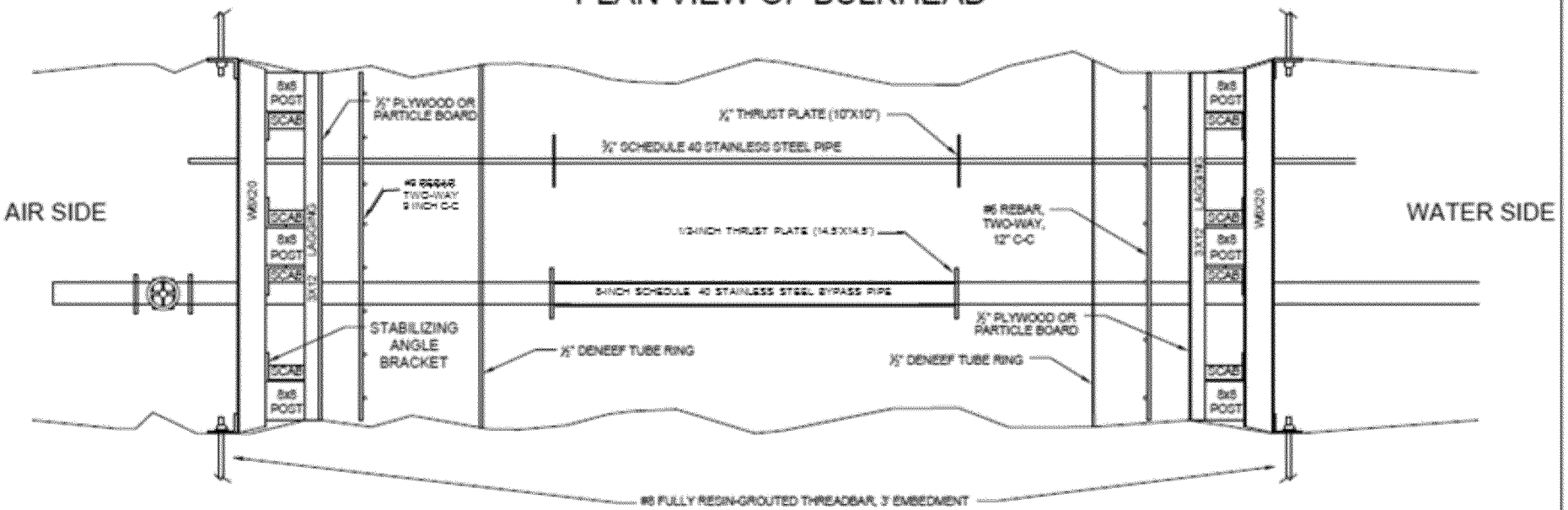


PLATE 2	RED AND BONITA MINE BULKHEAD
SCALE 0 FT — 5 FT	COLORADO Division of Reclamation, Mining and Safety Department of Natural Resources

AIR SIDE FORM FACE

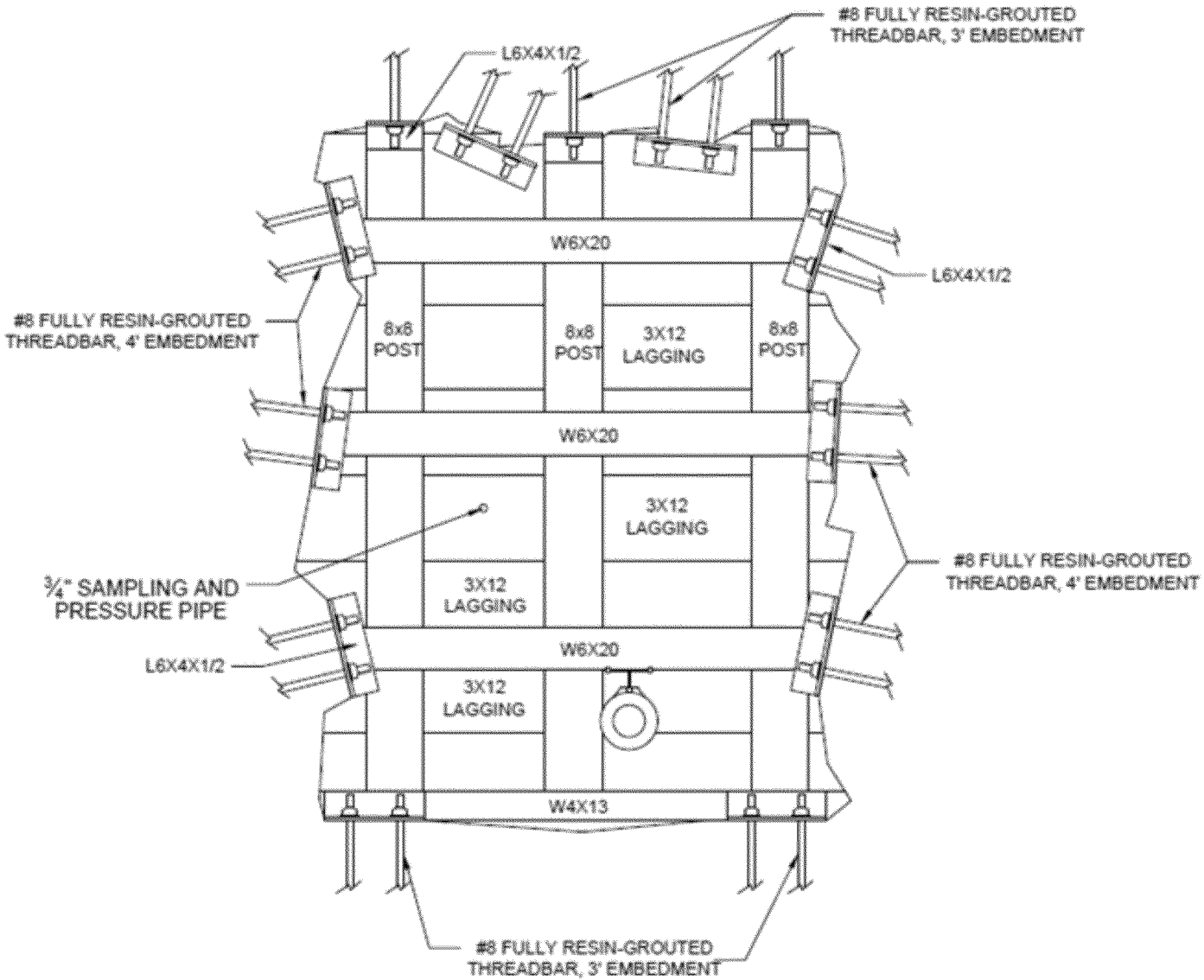


PLATE 3	SCALE 0 FT – 2 FT	RED AND BONITA MINE BULKHEAD	COLORADO Division of Reclamation, Mining and Safety Department of Natural Resources

AIR SIDE #9 REBAR CAGE AND CONTACT GROUT HOLES

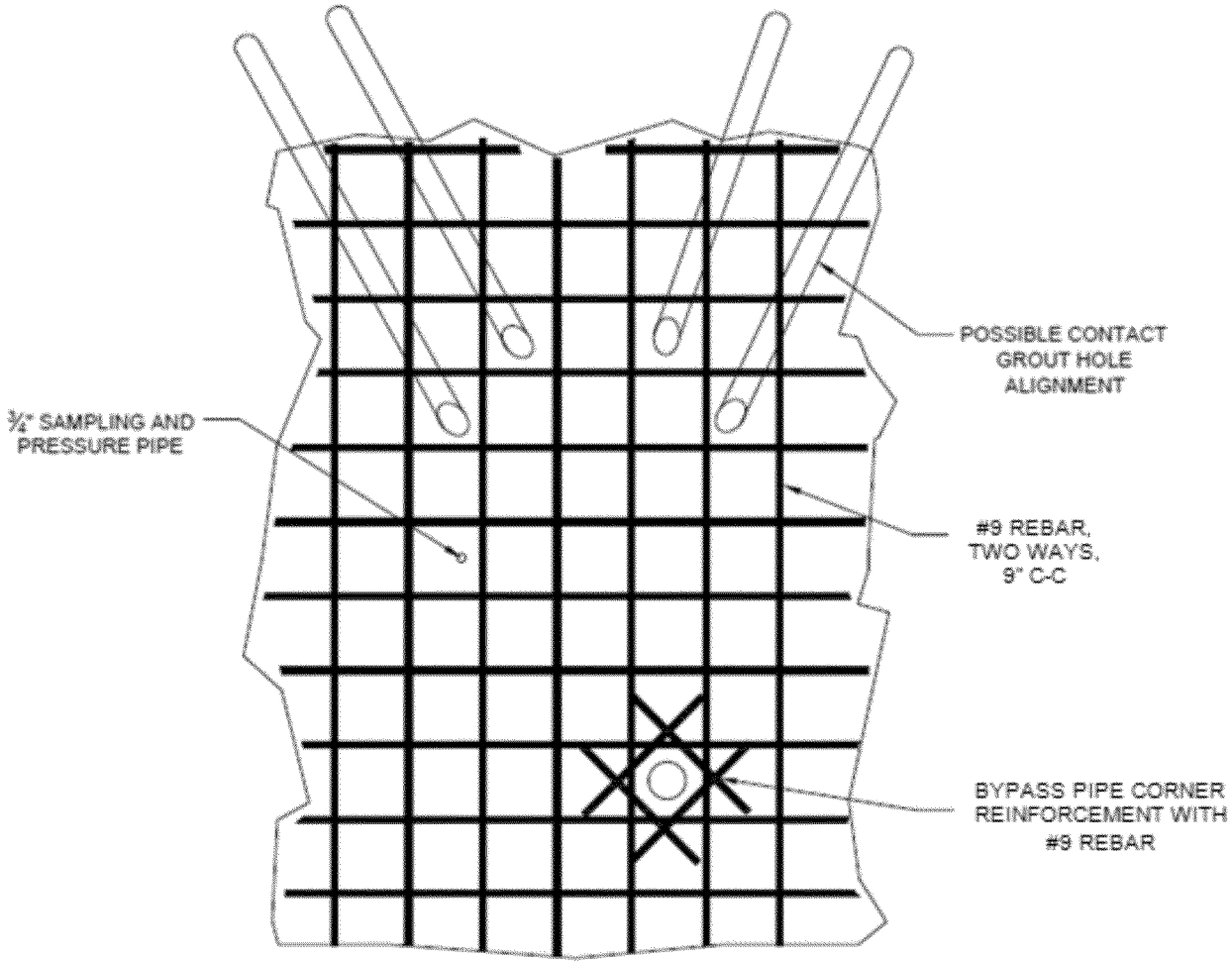


PLATE 4	SCALE 0 FT – 2 FT	RED AND BONITA MINE BULKHEAD	COLORADO Division of Reclamation, Mining and Safety Department of Natural Resources

APPENDIX A
CONCRETE MIX SPECIFICATION

Cement:	ASTM C 150 - Type V
Fly Ash:	ASTM C 618 - Class F
Admixtures:	ASTM C 494 - Type F
	Viscosity Modifying Admixture
Aggregates:	ASTM C 33 - Coarse Aggregate – No. 57/67
	ASTM C 33 - Fine Aggregate – Washed Concrete Sand
Water:	ASTM C 94

CONCRETE MIX INFORMATION

Identification No: 640300SC

MIX PROPORTIONS (Per one cubic yard of Concrete)

Cement	559 lbs.
Fly-Ash	240 lbs.
Coarse Agg.	1160 lbs.
Fine Agg.	1750 lbs.
Type F	5oz/cwt - 10oz/cwt
VMA	2oz/cwt - 4oz/cwt
Water	293 lbs. (35 gal.)

These weights are based on S.S.D. condition and will be adjusted accordingly as the moisture varies in the aggregates.

PHYSICAL PROPERTIES OF CONCRETE

Unit Wt. Of fresh Concrete, (ASTM C 138), pcf:	145.0 to 150.0
Slump, (ASTM C143), inches:	25 - 30"
Air Content, (ASTM C 231, Pressure Method), %:	1 - 3%
Water/Cementations Materials Ratio:	0.40

COMPRESSIVE STRENGTH

<u>56-DAY</u>

4000 PSI

APPENDIX B
DE NEEF GROUT INFORMATION

de neef

INJECTO®PURe

Product Description

Injecto PURe is an ultra low viscosity hydrophobic polyurethane designed to be used with INJECTO® Grout Tube for sealing construction joints. Injecto PURe grout expands on contact with water and quickly cures to a tough, flexible foam that is resistant to most organic solvents, mild acids, alkali, petroleum and micro-organisms.

Phthalate free- no phthalate-based plasticizers

Unregulated for transport- no hazmat shipping

Reformulated TDI free-all MDI based technology.

environmentally friendly-NSF/ANSI 61 approved.

C USA

INJECTO PURe when combined with Flex Cat PURe is certified by WQA to NSF/ANSI 61 for materials safety only, as verified and substantiated by test data.
Please refer to WQA website(www.wqa.org) for use ratios and limitations

Product Advantages

Contains no volatile solvents

Single Component

Controlled reaction time

Improved low temperature performance

Flex Cat PURe liquid to -40°F

Applications

•Repairing existing leaky joints
•Waterstop for new concrete structures
•Injection through these grout tubes to form a flexible waterstop in concrete joints:

INJECTO® Tube
SIS INJECTO® Tube
BENTOJECT
TRIOJECT

Properties

Injecto PURe Grout		
Solids	100%	ASTM D2369
Viscosity	200 cps at 77°F	ASTM D2196
Color	Pale Yellow	
Density	1.02 g/cm^3	ASTM D4659
Flashpoint	>270°F	ASTM D93
Corrosiveness	Non-corrosive	
Flex Cat PURe		
Viscosity	15 cps at 77°F	ASTM D2196
Color	Clear to pale gray	
Flashpoint	221°F	ASTM D93
Injecto PURe Cured		
Density free	about 3 PCF	ASTM D3574
Tensile	>174 psi	ASTM D3574
Elongation %	100	ASTM D3574

Packaging & Handling

Injecto PURe: 5 gallon metal pail
50 gallon metal drum
Flex Cat PURe: 25 fl.oz. in 1 qt. metal cans

Injecto PURe is sealed under dry nitrogen because it is sensitive to moisture, and should be stored in original containers in a dry area. Storage temperature must be between 40°F and 90°F. Once the packaging has been opened, the useful life of the material is greatly reduced and should be used as soon as possible. Shelf life: 2 years.

Installation Guidelines

Warning: Consult the Technical Data Sheets and MSDS before using.

Installation Instructions: For detailed installation instructions refer to the DeNeef technical bulletin for your application.

Catalyst: Shake catalyst can 2-3 minutes. Pour the desired amount of Injecto PURe into a clean dry pail. Measure 1% Flex Cat PURe and pour it into the pail. Stir until adequately mixed. Exceeding the recommended amount of catalyst may adversely affect the reaction and quality of the cured foam. (1 catalyst can capful=0.5 oz; 1.3 oz/gal resin = 1%)

Injection: Injectable tubes should be adequately flushed with water prior to the injection of grout. During injection the grout will follow the path of least resistance. When the material has stopped penetrating it will continue to expand against the limits of the confined space and compress within itself,forming a dense, closed cell foam. See INJECTO Grout Tube Installation procedures for more detail.

Extreme conditions: For application procedures in extreme temperatures and specific environments or equipment recommendations call the DeNeef Technical Service Department.

Cleaning: Clean all tools and equipment which have been in contact with the resin with DeNeef Washing Agent before resin has cured. Products should be disposed of according to local, state, and federal laws.

Health and Safety

Always use protective clothing, gloves and goggles consistent with OSHA regulations. Avoid eye and skin contact. Do not ingest. Refer to MSDS. For emergencies, call CHEMTREC 1-800-424-9300.

Limitations

Low temperatures will significantly affect viscosity. Injecto PURe is not designed for void filling and must be used in compression. If site temperatures are extremely low, heat bands or heated water baths may be used on the pails before and during installation to maintain the product's temperature. Avoid splashing water into open containers, as the material is water activated. Avoid exceeding 90°F when warming.

CAUTION: pH NOTICE. Water used to activate PURe Grouts must be in the pH range of 3-10 for optimum foam quality.

Rev. 02/2013

www.deneef.com

Technical Service 1-800-732-0166

We hope the information here will be helpful. It is based on data and knowledge considered to be true and accurate and is offered for the users' consideration, investigation and verification, but we do not warrant the results to be obtained. Please read all statements, recommendations or suggestions in conjunction with our conditions of sale, which apply to all goods supplied by us. No statement, recommendation or suggestion is intended for any use which would infringe any patent or copyright. W. R. Grace & Co.–Conn., 62 Whittemore Avenue, Cambridge, MA 02140.

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GRACE

de neef®

INJECTO® Tube
Groutable Hose Waterstop System

Product Description

INJECTO is an injectable waterstop system that provides a conduit for the placement of DeNeef chemical grouts. The ½" (12mm) permeable tube is installed before the concrete pour, but not injected until after the shrinkage associated with the curing concrete process is complete. This allows the cracks to open fully before permanently sealing the interfaces and voids within construction joints, pipe penetrations, slurry walls, and slab connections with chemical grout.

Figure 1. Injecto Tube Kit.

Product Advantages

Fast, simple installation

No special tools required

Low pressure injection

Permanent seal after injection

Injectable anytime after concrete cure

INJECTO System Warranty

Applications

- Sealing cold and construction joints
- Sealing pipe penetrations
- Sealing joints between slurry walls and slabs

INJECTO Tube may be used with the following chemical grouts:

- Flex SLV PURe with 1% Flex Cat PURe
- Flex LV PURe with 1% Flex Cat PURe
- Superflex AR Acrylate prepared according to data sheet.

Properties

Typical Properties	
Outside Diameter	1/2 inch
Inside Diameter	5/16 inch
Length	Maximum 25 ft.
Weight	4.5 lbs per 25 ft.
Operating temperature	Up to 158°F
Tensile strength steel wire	Approx. 261,000 psi
Diameter filter pores	35 microns

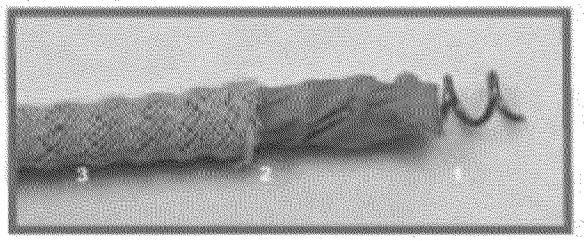
Note: The data shown above reflects typical results based on laboratory testing under controlled conditions. Reasonable variations from the data shown above may result.

Packaging & Handling

INJECTO Tube is supplied in 100 ft. kits to allow the system to be cut to length on site. The maximum recommended cut length of **INJECTO Tube** to be installed between packers is 25 ft. (see figure #1)
Yellow INJECTO Tube: 100 ft.
Clear PVC Packer Tubing : 18 ft.
Blue trumpets: 12 pieces.
Anchoring clips: 100 pieces.
1 Pallet = 40x100 ft. kits = 4000 ft.

Unlimited shelf life when stored in a dry place.

Injecto Tube Construction



A high strength spiral wire coil (1) prevents collapse during concrete placement, while the non-woven filter membrane (2) prevents the tube from being clogged with concrete particles. A bright yellow reinforced mesh sleeve (3) protects the tube and allows for easy inspection before the pour. Wherever old to new concrete surfaces join, the INJECTO Tube system can be easily installed.

Installation Guidelines

The yellow INJECTO Tube is installed onto the hardened concrete during formwork installation. In case of rough surfaces, any gap between INJECTO Tube and the surface should be filled with SWELLSEAL®WA.

The yellow INJECTO Tube is cut to the required length on the job site. (recommended length 25 ft. or less). The cut ends are smoothed with a twist; then the blue trumpets are installed over the yellow INJECTO Tube and screwed down to the stop mark inside the trumpet.(Figure 3)

The yellow INJECTO Tube is attached to the concrete with the anchoring clips between the inner and outer reinforcing bars. Attach the anchoring clips to the concrete every 12 inches with concrete anchors or nails applied with a powder actuated system (see figures 5, 6 & 7)

The blue trumpets provide a connection between the yellow INJECTO Tube and the clear packer tubing. Trumpets on adjacent runs should be installed with the wide ends of the trumpets (where the yellow INJECTO Tube is attached) in line with each other and the two trumpets separated by 2-3 inches (see figure 8). This will help avoid cross contamination of the yellow INJECTO Tubes during the grouting operation.

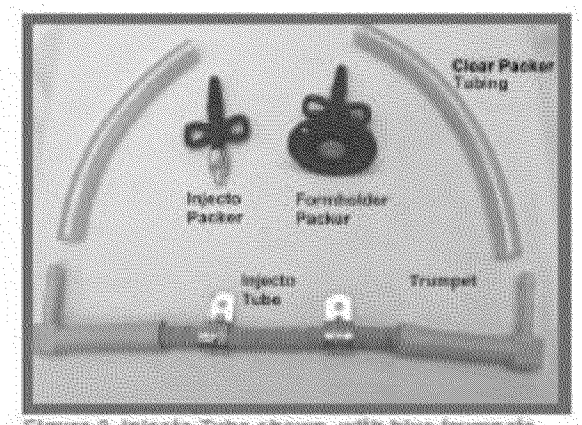


Figure 3. Injecto Tube shown with blue trumpets

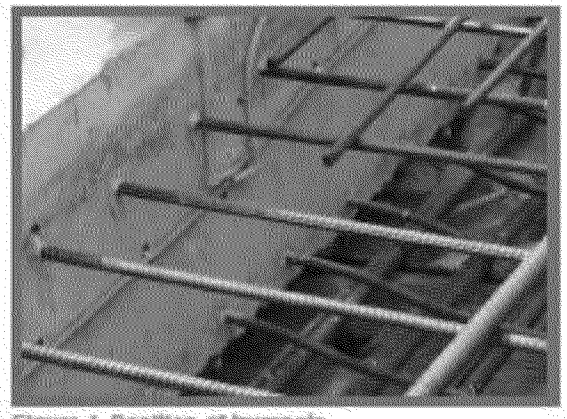


Figure 4. Position of trumpets.

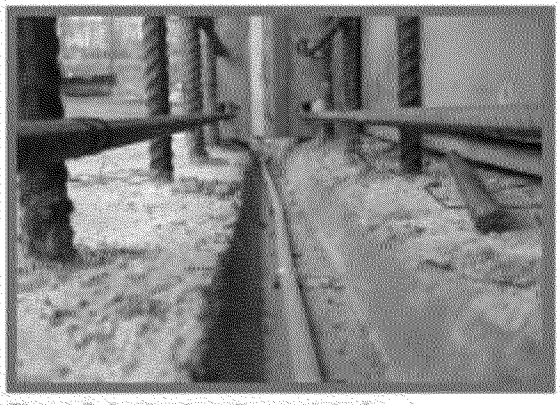


Figure 5. Anchoring clips on injecto.

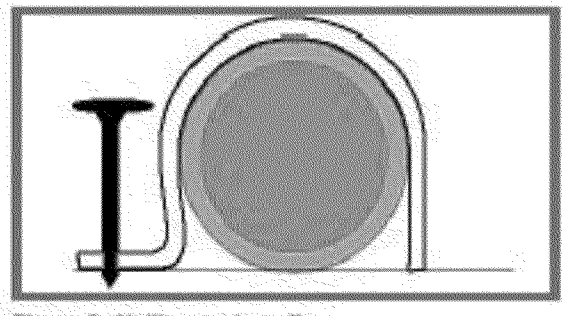


Figure 6. Nailing anchor clips

Always terminate the yellow INJECTO Tube into a trumpet and allow for a minimum of 2-1/2" of concrete cover. **Do not run the yellow INJECTO Tube outside the formwork.**

Attach the clear packer tubing over the serrated end of the trumpets. Then cut the appropriate length of packer tubing as required to reach a formholder packer or to extend outside the formwork. The clear packer tubing should be secured with tie wire to the rebar to prevent movement during the pour.

The formholder packers can be either nailed to wooden formwork or attached to the rebar with steel tie wire if metal forms are used. If formholder packers are used, attach the clear packer tubing directly to them If the clear packer tubing is being run outside the formwork, protect the open ends with a plastic cap or tape and take measures to protect them from damage during formwork installation and stripping.

The INJECTO Tube System is ideal for unique and problem details such as pipe penetrations and attaching to conventional PVC waterstops that may encounter very high head pressures (see figures 9 and 10).

CAUTIONS:

1. The yellow INJECTO Tube must be installed in direct contact with the joint over its full length, to allow proper and complete distribution of the injection resin. If the concrete is not smooth enough to allow full contact, use SWELLSEAL® WA to create a smooth surface. Press INJECTO into the SWELLSEAL WA.

2. Do not cross the yellow INJECTO Tubes. Yellow should never touch yellow or cross contamination could occur during the grouting operation.

3. The ends and beginnings of yellow INJECTO Tube lengths should be done as in figures 4 and 8 to prevent cross contamination during the resin injection process.

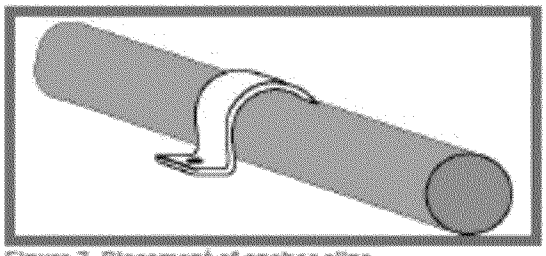


Figure 7. Placement of anchor clips

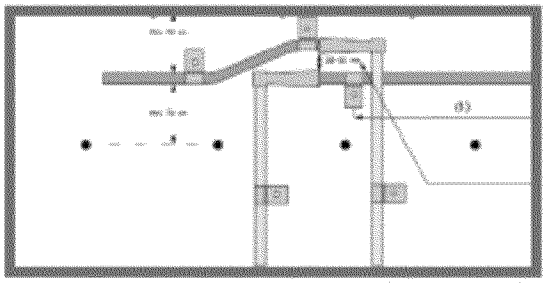


Figure 8. End and beginning of Injecto Tube lengths.

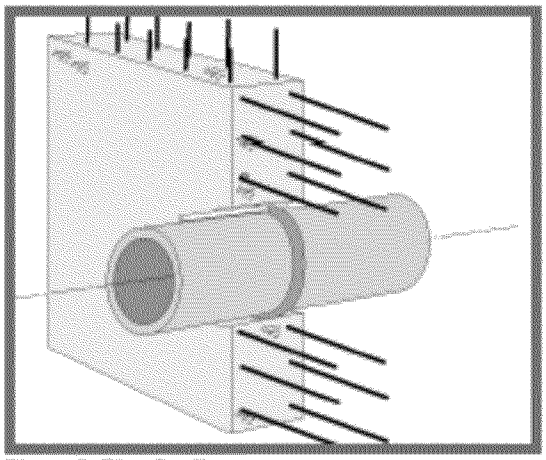


Figure 9. Pipe Sealing

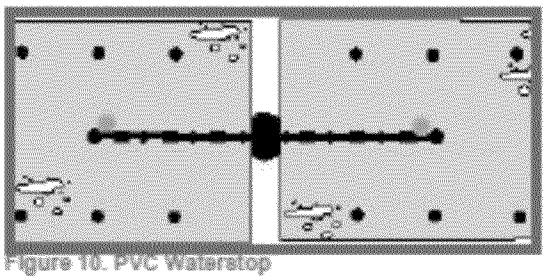


Figure 10. PVC Waterstop

4. Concrete coverage must be a minimum of 2 ½" on all sides. After concrete has cured for the recommended 28 days, any water infiltrating into the joint will be collected by the system and appear through the clear packer tubing. The tubing should either protrude out of the concrete at easily accessible places or be connected to a formholder packer.

The INJECTO Tube system is designed to provide a delivery system for waterproofing resins, which are injected into the structure in accordance with the instructions found in the selected injection resins technical data sheets. Consult with the DeNeef Technical Department for assistance in selecting the appropriate sealing resin for each condition.

Always use protective clothing, gloves and goggles consistent with OSHA regulations during use. Avoid eye and skin contact. Do not ingest. Refer to Safety Data Sheet (SDS) for detailed safety precautions.

In the event of an EMERGENCY call:

CHEMTREC 800-424-9300.

Limitations

INJECTO Tube waterstop system must be installed by an Approved DeNeef **INJECTO** Applicator in accordance with the **INJECTO** Manual for Warranty to be effective. Concrete cover must be a minimum of 2 ½" on all sides.

Revised 04/2013

Health and Safety

www.deneef.com

Technical Service 1-800-732-0166

We hope the information here will be helpful. It is based on data and knowledge considered to be true and accurate and is offered for the users' consideration, investigation and verification, but we do not warrant the results to be obtained. Please read all statements, recommendations or suggestions in conjunction with our conditions of sale, which apply to all goods supplied by us. No statement, recommendation or suggestion is intended for any use which would infringe any patent or copyright. W. R. Grace & Co.–Conn., 62 Whittemore Avenue, Cambridge, MA 02140.

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GRACE

APPENDIX C
XYPEX CONCRETE ADMIXTURE INFORMATION

ADMIX C-1000

07160 | CEMENTITIOUS CRYSTALLINE

Concrete Waterproofing

Description

Xypex is a unique chemical treatment for the waterproofing, protection and improvement of concrete. XYPEX ADMIX C-1000 is added to the concrete mix at the time of batching. Xypex Admix C-1000 consists of Portland cement, very fine treated silica sand and various active, proprietary chemicals. These active chemicals react with the moisture in fresh concrete and with the by-products of cement hydration to cause a catalytic reaction which generates a non-soluble crystalline formation throughout the pores and capillary tracts of the concrete. Thus the concrete becomes permanently sealed against the penetration of water or liquids from any direction. The concrete is also protected from deterioration due to harsh environmental conditions.

Xypex Admix C-Series

The Admix C-Series has been specially formulated to meet varying project and temperature conditions. **Xypex Admix C-500** is specifically formulated to meet modern concrete practices that incorporate additives such as fly ash and slag. For most concrete mix designs adding the Admix C-500 will have minimal or no effect on setting time. **Xypex Admix C-1000** is designed for typical Portland cement-rich concrete, where normal to a mild retarded set is desired. **Xypex Admix C-2000** is designed for projects where extended retardation is required due to high ambient temperatures or long ready-mix delivery times. See Setting Time and Strength for more details. Consult with a Xypex technical services representative for the most appropriate Xypex Admix for your project.

Recommended for:

- Reservoirs
- Sewage and Water Treatment Plants
- Secondary Containment Structures
- Tunnels and Subway Systems
- Underground Vaults
- Foundations
- Parking Structures
- Swimming Pools
- Precast Components

Advantages

- Resists extreme hydrostatic pressure from either positive or negative surface of the concrete
- Becomes an integral part of the substrate
- Highly resistant to aggressive chemicals
- Can seal static hairline cracks up to 0.4 mm
- Allows concrete to breathe
- Non-toxic
- Less costly to apply than most other methods
- Permanent
- Added to the concrete at time of batching and therefore is not subject to climatic restraints
- Increases flexibility in construction scheduling

Packaging

Xypex Admix C-1000 is packaged in 60 lb. (27.2 kg) pails and 50 lb. (22.7 kg) bags. Admix C-1000 is also available in cartons containing 10 lb. (4.5 kg), 12 lb. (5.5 kg), and 15 lb. (6.8 kg) soluble bags. For specific projects, contact the manufacturer for availability of custom sized packaging.

Storage

Xypex products must be stored dry at a minimum temperature of 45ºF (7ºC). Shelf life is one year when stored under proper conditions.

Dosage Rates

Xypex Admix C-1000:
2% - 3% by weight of cement

Xypex Admix C-1000 NF (No Fines Grade):
1% - 1.5% by weight of cement

NOTE: Under certain conditions, the dosage rate for No Fines Grade may be as low as 0.8% depending on the quantity and type of total cementitious materials. The maximum use level is 2% by weight of cement for potable water applications.

Consult with Xypex's Technical Services Department for assistance in determining the appropriate dosage rate and for further information regarding enhanced chemical resistance, optimum concrete performance, or meeting the specific requirements and conditions of your project.

Test Data

PERMEABILITY

U.S. Army Corps of Engineers CRD C48-73, "Permeability of Concrete", Aviles Engineering Corp., Houston, USA

Two concrete samples containing Xypex Admix at 3% and 5% respectively, and an untreated control sample

were tested for water permeability. Both the treated and untreated samples were subjected to a pressure of 150 psi (350 ft. water head). Results showed moisture and permeated water throughout the untreated sample after 24 hours. However, the Xypex Admix samples showed no leakage, and water penetration of only 1.5 mm after 120 hours (5 days).

U.S. Army Corps of Engineers CRD C48-73, "Permeability of Concrete", Setsco Services, Pte Ltd., Singapore

Six Xypex Admix-treated and six untreated concrete samples were tested for water permeability. Pressure was gradually increased over five days and then maintained at 7 bars (224 ft. water head) for 10 days. While the six reference samples showed water leakage beginning on the fifth day and increasing throughout the test period, the Xypex Admix samples showed no water leakage at any time during the test.

DIN 1048, "Water Impermeability of Concrete", DICTU S.A., Dept. of Engineering and Construction Mgt., Santiago, Chile

Concrete samples 120 mm thick containing Xypex Admix were tested with the same size reference samples for water impermeability. Samples were subjected to hydrostatic pressure for 28 days. Water totally permeated the untreated samples but no water penetration was detected in any of the Xypex Admix-treated samples.

COMPRESSIVE STRENGTH

ASTM C 39, "Compressive Strength of Cylindrical Concrete Specimens", HBT Agra, Vancouver, Canada

Concrete samples containing Xypex Admix at various dosage rates (1%, 2% and 5%) were tested against an untreated concrete control sample. Compressive strength test results after 28 days indicated a significant strength increase in the samples incorporating Xypex Admix. The compressive strength increase varied between 5% and 20% (depending on the Xypex Admix dosage rate) over that of the reference sample.

ASTM C 39, "Compressive Strength of Cylindrical Concrete Specimens", Kleinfelder Laboratories, San Francisco, USA

At 28 days, the compressive strength test of the concrete containing Xypex Admix measured 7160 psi as compared to the reference sample at 6460 psi (a 10% increase).

CHEMICAL RESISTANCE

JIS, "Chemical Durability Test", Japanese Utility Company, In-house Test Report, Tokyo, Japan

Concrete samples containing Xypex Admix were tested against five samples containing other admixtures and against a control sample, to determine resistance to corrosion and deterioration caused by contact with aggressive chemicals. All samples were soaked in a 5% sulfuric acid solution at 20ºC for six months. Various evaluations and measurements were assessed every month during the test period, including: photographic comparisons, relative dynamic modulus of elasticity, percentage change in length, weight and flexural rigidity. Although the Xypex Admix sample was subjected to acid conditions well outside its published range, the results confirmed Xypex with the best performance among the seven samples tested.

"Sulfuric Acid Resistance Test", Aviles Engineering Corporation, Houston, USA

Concrete samples containing Xypex Admix at different dosage rates (3%, 5% and 7%) were tested against untreated control samples for sulfuric acid resistance. After immersion in the sulfuric acid, each sample was tested for weight loss on a daily basis until a weight loss of 50% or a definite response trend was obtained. The percentage weight loss of the samples containing Xypex Admix tested significantly lower than the control samples.

"Sulphate Resistance Test", Taywood Engineering Ltd., Perth, Australia

Xypex Admix-treated concrete samples were immersed in an ammonium-sulphate solution and tested for "resistance in a harsh environment". The performance of the Xypex crystalline technology was compared with five other concretes, including one containing a sulphate-resistant cement. Each of the test samples was cured for seven days and then placed in an ammonium-sulphate solution (132 g/litre) for 180 days. The rate of corrosion was determined by measuring weight loss, and length change was noted on a weekly basis. The Xypex crystalline technology substantially improved concrete performance as compared to the reference concrete and tested very similar to the sulphate-resistant concrete. The Xypex Admix-treated samples also provided the highest level of protection as measured by change in length.

FREEZE/THAW DURABILITY

ASTM C 666, "Freeze/Thaw Durability", Independent Laboratory, Cleveland, USA

After 300 freeze/thaw cycles, the Xypex Admix-treated samples indicated 94% relative durability.

POTABLE WATER EXPOSURE

NSF 61, "Drinking Water System Component-Health Effects", NSF International, Ann Arbor, USA

Exposure testing of potable water in contact with Xypex-treated samples indicated no harmful effects.

Directions for Use

Xypex Admix C-1000 must be added to the concrete at the time of batching. The sequence of procedures for addition will vary according to the type of batch plant operation and equipment:

1. **READY MIX PLANT - DRY BATCH OPERATION** Add Xypex Admix in powder form to the drum of the ready-mix truck. Drive the ready-mix truck under the batch plant and add the balance of the materials in accordance with standard concrete batching practices. Mix materials for a minimum of 5 minutes to ensure that the Xypex Admix has been thoroughly dispersed throughout the concrete.

2. **READY MIX PLANT - CENTRAL MIX OPERATION** Mix Xypex Admix with water to form a very thin slurry (e.g. 15 - 20 lb./6.75 - 9 kg of powder mixed with 3 U.S. gallons/ 13.6 litres of water). Pour the required amount of material into the drum of the ready-mix truck. The aggregate, cement and water should be batched and mixed in the plant in accordance with standard practices (taking into account the quantity of water that has already been placed in the ready-mix truck). Pour the Admix slurry into the truck and mix for at least 5 minutes to ensure even distribution of the Xypex Admix throughout the concrete.

3. **PRECAST BATCH PLANT** Add Xypex Admix to the rock and sand, then mix thoroughly for 2 - 3 minutes before adding the cement and water. The total concrete mass should be blended using standard practices.

NOTE:

i. It is important to obtain a homogeneous mixture of Xypex Admix with the concrete. Therefore, do not add dry Admix powder directly to wet concrete as this may cause clumping and thorough dispersion will not occur.

ii. Concrete containing the Xypex Admix does not preclude the requirement for design of crack control, construction joint detailing and measures for repairing defects in concrete (i.e. honeycombing, tie holes, cracks beyond specified limits).

For further information regarding the proper use of Xypex Admix for a specific project, consult with a Xypex technical services representative.

Setting Time and Strength

The setting time of concrete is affected by the chemical and physical composition of ingredients, temperature of the concrete and climatic conditions. Xypex Admix C-1000 is designed for typical Portland cement-rich concrete, where normal to a mild retarded set is desired. Concrete containing the Xypex Admix C-1000 may develop higher ultimate strengths than plain concrete. Trial mixes should be carried out under project conditions to determine the setting time and strength of the concrete dosed with Xypex Admix C-1000. Consult with a Xypex technical services representative for the most appropriate Xypex Admix for your project.

Limitations

When incorporating Xypex Admix, the temperature of the concrete mix should be above 40ºF (4ºC).

Technical Services

For more instructions, alternative installation methods, or information concerning the compatibility of the Xypex treatment with other products or technologies, contact the Technical Services Department of Xypex Chemical Corporation or your local Xypex representative.

Safe Handling Information

Xypex is alkaline. As a cementitious powder or mixture, Xypex may cause significant skin and eye irritation. Directions for treating these problems are clearly detailed on all Xypex pails and packaging. The Manufacturer also maintains comprehensive and up-to-date Material Safety Data Sheets on all its products. Each sheet contains health and safety information for the protection of workers and customers. The Manufacturer recommends you contact Xypex Chemical Corporation or your local Xypex representative to obtain copies of Material Safety Data Sheets prior to product storage or use.

Warranty

The Manufacturer warrants that the products manufactured by it shall be free from material defects and will be consistent with its normal high quality. Should any of the products be proven defective, the liability to the Manufacturer shall be limited to replacement of the product ex factory. The Manufacturer makes no warranty as to merchantability or fitness for a particular purpose and this warranty is in lieu of all other warranties expressed or implied. The user shall determine the suitability of the product for his intended use and assume all risks and liability in connection therewith.

APPENDIX D
RST INSTRUMENTS INFORMATION

Vibrating Wire Piezometers

The RST Vibrating Wire Piezometer provides excellent long-term accuracy, stability of readings and reliability under demanding geotechnical conditions. Vibrating Wire Piezometers are the electrical piezometers of choice as the frequency output of VW devices is immune to external electrical noise, and able to tolerate wet wiring common in geotechnical applications.

operating principle

Vibrating Wire Piezometers contain a high tensile steel wire with a fixed anchor at one end and are attached to a diaphragm in contact with water pressure at the other end. The wire is electrically plucked, with the resonant frequency of vibration proportional to the tension in the wire. This frequency induces an alternating current in a coil which is detected by the readout unit, such as the VW2106 Vibrating Wire Readout, and can then be converted to a pressure. The frequency output is immune to external electrical noise, and able to tolerate wet wiring common in geotechnical applications. Highly reliable lightning protection is incorporated in the vibrating wire transducer.

The frequency signal is exceptionally immune from cable effects, including length (to several kilometers), splicing, resistance, noise pickup, and moisture. The vibrating wire coil circuit contains no semiconductor devices and has built-in ionized gas discharge device protection against transient damage. As a result, the vibrating wire piezometer provides excellent reliability in typical geotechnical situations – i.e. long outdoor cables buried in saturated soil.

The piezometer is equipped with a standard sintered stainless steel porous filter to prevent soil particles from contacting the diaphragm. A thermistor is built into the piezometer body to permit temperature measurement and temperature compensation of the piezometer. Standard construction is all stainless steel. RST vibrating wire piezometers are shipped with extremely tough polyurethane-jacketed foil-shielded cable for maximum endurance in field conditions.

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applications

- Assessing performance and investigating stability of earth fill dams and embankments.
- Slope stability investigations.
- Monitoring water levels in wells and standpipes.
- Monitoring pressures behind retaining walls and diaphragm walls.
- Monitoring pore pressures during fill or excavation.
- Monitoring pore pressure in land reclamation applications.

features

- Field proven reliability and accuracy.
- Will tolerate wet wiring common in geotechnical applications.
- Immune from external electrical noise.
- Signal transmission of several kilometers.
- Cable lengths may be changed without affecting the calibration.
- High accuracy, IE a low pressure vented model will measure water level changes as small as 0.5 mm (0.02 in.).
- Thermistor for temperature measurement is standard.
- Negligible displacement of pore water during the measurement process.
- Hermetically sealed, stainless steel construction.
- Heavy case to minimize reading errors caused by overburden pressure.
- Data logger compatible.
- Integral lightning protection.

specifications + ordering info

Vibrating Wire Piezometers

vibrating wire piezometer specs

DESCRIPTION	SPECIFICATION
Over range	2 X F.S.
Resolution	0.025% F.S. minimum
Accuracy	0.1% F.S.
Operating Temperature	-20 to 80°C (-4 to 176°F)
Diaphragm Displacement	<0.001 cc at F.S.
Thermal Zero Shift	<0.05% F.S./°C
Materials	Hermetically sealed stainless steel housing
Thermistor Type	NTC 3K Ohms @ 25°C
Thermistor Interchangeability	±0.2°C
Thermistor Resolution	0.1°C
Filter	50 micron sintered filter. (High air entry alumina filter 1, 3, 5 Bar available)

vibrating wire piezometer options

- Heavy-duty bodies for embankment use.
- Push-in drive points for soft soils
- High air entry ceramic filters to exclude air
- Low range and vented piezometers
- Titanium construction for use with corrosive fluids
- Multi-point/mixed type sensor strings
- Kevlar® reinforced cable

optional equipment

- VW2106 Vibrating Wire Readout
- Dataloggers
- Terminal stations
- Electrical cable
- Cable splice kits
- Installation geotextile and socks
- Increased lightning protection

electrical cable specs

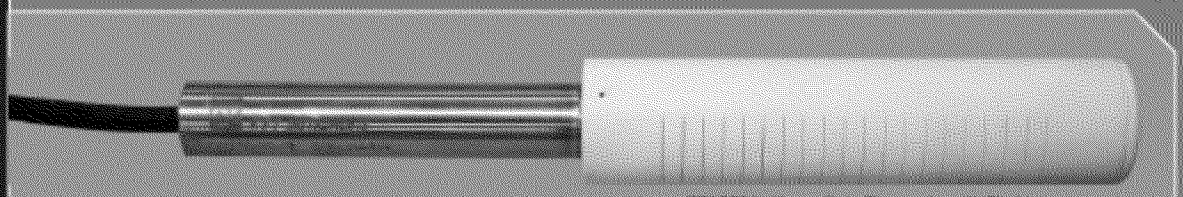
PART #	DESCRIPTION
EL380004	Two twisted pairs cable with polyurethane jacket.

Other types of cables, depending on site conditions and atmospheric reference requirements, are available upon request. These include vented, FEP, PVC, polyurethane, and armored varieties.

ordering info

PART #	DESCRIPTION	PRESSURE RANGE	DIMENSION
VW2100	Standard model for general applications.	0.35, 0.7, 1.0, 2.0, 3.0 MPa	19 mm Ø X 130 mm
VW2100-HD	Heavy duty piezometer for direct burial in fills and large dam embankments.	0.35, 0.7, 1.0, 2.0 3.0, 5.0, 7.5, 10 MPa	25.4 mm Ø X 146 mm
VW2100-XHD	Heavy duty piezometer for direct burial in fills and large dam embankments.	1.0, 2.0 3.0, 5.0, 7.5, 10 MPa	38.1 mm Ø X 146 mm
VW2100-HHP	High pressure transducer with NPT port.	5.0, 7.5, 10, 25, 50, 75, 100 MPa	25.4 x 143 mm
VW2100-DP	Drive point model with CPT adapter.	0.07, 0.175, 0.35, 0.7, 1.0, 2.0, 3.0, 5.0, 7.5 MPa	33 mm Ø X 432 mm
VW2100-L	Low Pressure, unvented.	70, 175 kPa	25 mm Ø X 133 mm
VW2100-LV	Low Pressure vented.	70, 175 kPa	25 mm Ø X 133 mm
VW2100-M	Miniature version – 17.5 mm diameter.	0.35, 0.7, 1.0, 2.0, 3.0 MPa	17.5 mm Ø X 133 mm
VW2100-MM	Micro-miniature version – 11.1 mm diameter.	0.35, 0.7 MPa	11.1 mm Ø X 105 mm
PPA0094	Heavy duty piezometer with bladder.	0.35, 0.7, 1.0, 2.0 3.0, 5.0, 7.5, 10 MPa	25.4 mm Ø X 146 mm Bladder O.D.: 1.65 in

High temperature models and metallic cable are available by special order. High temperature ranges include: 0 to 100°C; 0 to 150°C; and 0 to 200°C.



PPA0094 - Heavy Duty Piezometer with Bladder

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» readouts | datalogers | terminal stations

DT2055B Ten Channel Data Logger

The DT2055B Ten Channel Data Logger is a low cost, battery powered data logger, designed for reliable, unattended monitoring of up to 10 sensors which may be any mix of vibrating wire sensors and thermistors, typically 5 vibrating wire sensors with their associated thermistors.

It is a purpose built logger ideal for remote locations or instruments that require frequent reliable data recording. It connects to all vibrating wire sensors including piezometers, crack meters, and strain gauges. However, the DT2055B Ten Channel Data Logger will not connect to vibrating wire sensors with auto resonant circuitry.

Vibrating wire sensors have unique advantages in geotechnical applications, as the frequency output of the gauge is immune to external electrical noise, able to tolerate wet wiring without signal degradation, and able to transmit the signal up to 1.6 kilometers without loss.

Data logger setup and data collection is done using the Ultra-Rugged Field PC® or a laptop. Multi-Channel Host Software is also included.

A single gland option (DT2055B-T) is also available for Multi-point Vibrating Wire Piezometer Strings or Thermistor Strings.

As shown here, the DT2055B can also be equipped with an optional radio antenna (L900) to incorporate it into an rstar wireless system. RST's rstar system uses wireless technology to provide continuous data acquisition.

rst INSTRUMENTS

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applications

Ideal for applications that require reliable, unattended monitoring of up to five vibrating wire sensors.

features

HARDWARE

- Option for radio antenna for incorporation into an RST rstar wireless system for acquiring data.
- Robust construction.
- 4MB memory.
- Weather resistant NEMA 4X (IP65) enclosure.
- Battery powered for remote sites.
- 100 year memory backup.
- Compatible with all VW sensors - excluding those with auto resonant circuitry.
- -40°C to 60°C (-40°F to 140°F) operating range.
- 0.01µs vibrating wire resolution.
- 16 bit analog/digital converter.

SOFTWARE

- User friendly Windows® host software included at no additional cost.
- Compatible with most spreadsheet software.
- Data stores in CSV format, and opens in Microsoft® Excel.

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ISO 9001

specifications + ordering info

DT2055B Ten Channel Data Logger

general specifications

DESCRIPTION	SPECIFICATION
Frequency Accuracy	0.01% Full Scale
Resolution	1 part in 65,000
Memory	Over 120,000 records including: time, 5 channels frequency, frequency², 5 channels temperature
Power Source	1 "D" lithium primary battery
Battery Life	Over 5 years / 2 memory fills depending on temperature and use
Communication	USB type B connector
Dimensions	120 x 122 x 91 mm (4.7 x 4.8 x 3.6 in.)
Temperature Range	-40°C to 60°C (-40° to 140°F)
Enclosure	NEMA 4X (IP65)

data storage specifications

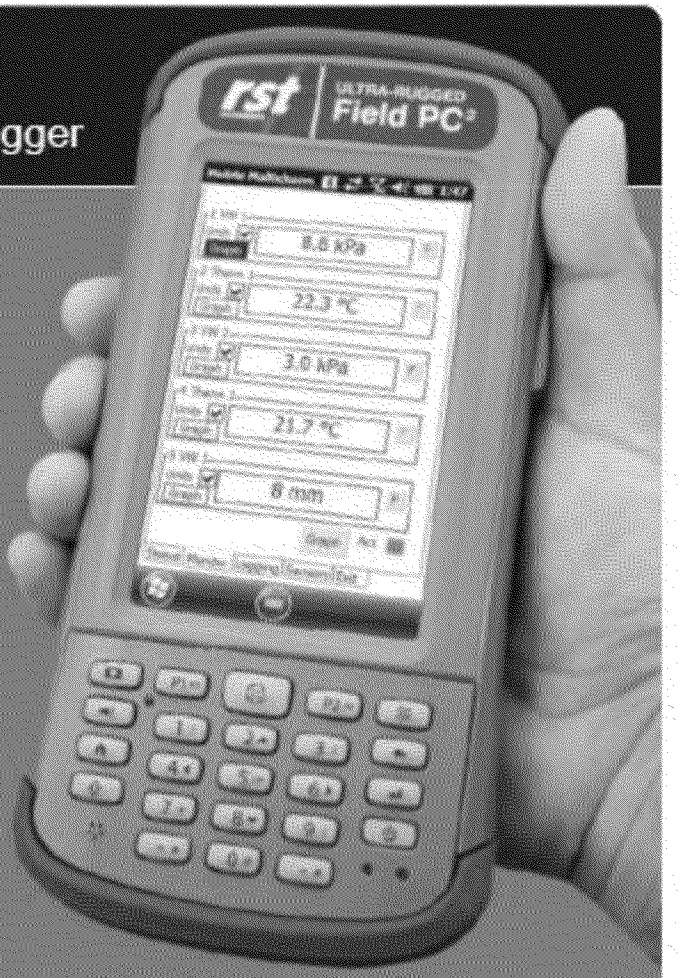
DESCRIPTION	SPECIFICATION
Memory	4 MB
Data Transfer	5,000 data points per second
Interval Mode	10 seconds to 1 day
Variable Rate Mode	16 user programmable sampling rates
Time Format	Month / day / year Hour / minute / second
Memory Full Behaviour	"Wrap around" or "fill & stop" option

optional equipment

Communications cable
LR30 radio option

ordering info

PART #	DESCRIPTION
DT2055B	Ten Channel Data Logger
DT2055B-T	Ten Channel Data Logger - Single Gland
IC32000-AR2-RST3	Ultra-Rugged Field PC³



Setup the data logger and collect data using the Ultra-Rugged Field PC³.

Screenshot of DT2055B Mobile software as shown on the Ultra-Rugged Field PC³.

Ten Channel Data Logger with Single Gland; optional connector available, contact RST for complete details.

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