Department of Fisheries and Oceans, Pacific Region

ISSUED FOR USE

RE-INSPECTION OF WATER SUPPLY TUNNELS & RELATED FACILITIES FOR THE FULTON RIVER SPAWNING CHANNEL, BABINE LAKE, B.C.
DFO PURCHASE ORDER: F1700-070271

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1.0 INTRODUCTION

At the request of Mr. Gregg Morris, P.Eng., Senior Engineer with the Department of Fisheries and Oceans (DFO), EBA Engineering Consultants Ltd. (EBA) re-inspected the water supply tunnels and related facilities for the Fulton River Spawning Channel facility near Babine Lake, B.C. The water supply tunnels supply water to Spawning Channel #2. Spawning Channel #1 is fed directly from the river, which is regulated by Fulton Dam.

Since construction in the late 1960's, the water supply tunnels at this facility have been periodically inspected to assess their condition and provide early identification of deterioration that could jeopardize reliable operation of the spawning channels. Previous inspections of the water supply tunnels were completed in 1988, 1995, and 2002.

The 2007 inspection of the Fulton River facility has been detailed in two reports. This report details the water supply tunnels, tunnel bulkheads, pipeline, and adjacent slopes. Inspection of the dam and overall dam safety aspects are addressed in a separate report (2007 Inspection Fulton Dam, by EBA, February 2008 – Issued for Use).

The Fulton River spawning channel facility includes the following key infrastructure:

- 17 m high concrete gravity dam with low level outlet gate and overflow spillway.
- 150 m long, 3.6 m high horseshoe shaped concrete lined regulating tunnel in rock (including intake structure and outlet structure with cone valves).
- West water supply tunnel including bulkhead near its eastern portal at Beaver Creek.
- Beaver Creek aqueduct consisting of a 1200 mm diameter steel pipeline extending between concrete bulkheads in the West and East water supply tunnels.
- East water supply tunnel including western portal at Beaver Creek, the east tunnel portal (shaft) and two bulkheads.
- Water supply pipeline (1200 mm diameter) leading from the east tunnel portal to Spawning Channel #2. This includes an above grade trestle section in an area where slope instability occurred shortly after construction. Otherwise, the pipeline is at or below grade.

The east and west water supply tunnel sections total 1175 m in length and are entirely in rock. These tunnels have a 1.8 m wide x 2.4 m high cross section and are supported with rock bolts and shotcrete where deemed necessary at the time of construction.

Complete details of the Fulton River facilities are provided in numerous existing reports and drawings for the project and are not repeated herein.

2.0 DETAILS OF 2007 INSPECTION

The first part of the 2007 inspection of the Fulton River facility was carried out on August 15 when the spillway was overtopping and the water supply tunnels were drained. Subsequent inspections were made on October 9 and 10 when the tunnels were in operation and with the reservoir at El. 776.2 m (about 0.12 m below spillway crest).

Messer's Greg Brooke, Wai Leung, Sam McNeil, and Dylan Stavre of DFO accompanied Messers Scott Sylte and Carlos Chaparro of EBA during the August 15 inspection. During this inspection, the regulating tunnel and western water supply tunnel were accessed via the cone valves at the regulating tunnel outlet. The centre section of the eastern supply tunnel (between the bulkheads) was accessed from Beaver Creek via a hatch in the 1200 mm diameter steel pipeline.

Messrs Sam McNeil and Dylan Stavre accompanied Messers Scott Sylte and Chris Grapel of EBA during the October 9 and 10 inspections. During these inspection, the dam and various water release facilities were examined. In addition, the atmospheric sides of the three tunnel bulkheads were examined to assess potential leakage past the bulkheads while the water supply tunnels were in operation and pressurized. During previous inspections of the Fulton River tunnels made by Mr. Sylte in June 1995 and August 2002, it was not possible to assess whether leakage past the tunnel bulkheads was occurring because the tunnels were drained during the inspection. The above grade trestle section of the water supply pipeline was also examined.

For purposes of the 2007 tunnel inspections, EBA supplied a gas monitor (LEL, O2, H2S and CO). Monitoring indicated no significant deviation of O2, CO, H2S and LEL concentrations in the tunnels from ambient atmospheric levels.

During the inspections, the bare rock and shotcrete lined surfaces in the tunnels were sounded with a hammer to detect any extensive "drummy" or hollow sounding areas. These indicate either a loss of bond between rock and shotcrete, loosened rock behind the shotcrete, or gradual loosening of the rock in unlined portions of the tunnels. Other in-situ measurements and observations were carried out as detailed in this report.

3.0 OBSERVATIONS AND RECOMMENDATIONS

EBA's observations and assessment of the key infrastructure associated with the spawning channel water supply tunnels/pipeline at Fulton River are detailed in the following sections, beginning with the regulating tunnel, and progressing downstream towards the spawning channels. The terms "upstream" and "downstream" refer to the water flow direction, and the terms "left" and "right" are used relative to the downstream water flow direction (unless specifically noted otherwise).

Where applicable, detailed recommendations have been provided following our observations for each component of the water supply system. For convenience, all recommendations are also briefly summarized in Section 4.0.

3.1 SLOPE ADJACENT TO REGULATING TUNNEL OUTLET STRUCTURE

Observations

The rock slope above the regulating tunnel outlet structure and access stairs is shown in Photos 1 and 2. This slope is comprised of poor quality thin-bedded chert bedrock that is prone to weathering causing rockfalls. The height of the slope above the access stairs and outlet structure varies from about 20 m to 35 m as shown in Photo 1.

This slope presents a hazard of rockfall that could damage the access stairs and/or injure personnel accessing the regulating tunnel outlet building. Most loose rock fragments on the slope are cobble size or smaller but several areas near the middle to top of the slope could produce larger rockfalls. Rockfalls large enough to damage the outlet structure itself are unlikely. The potential for a large-scale slope instability that could potentially affect the outlet structure is discussed separately (2007 Inspection Fulton Dam, by EBA, December 2007 – Issued for Review).

The slope was scaled in 1994 as part of regular maintenance and was observed to be in good condition during the 1995 inspection. DFO's maintenance personnel indicated that scaling was required every 5 to 10 years to control the rockfall hazard. EBA are not aware if the slope has been scaled since 1994 but there is currently a significant quantity of loose material on some areas of the slope that is a potential source of rockfall.

Recommendations

EBA recommends that stabilization/mitigation measures to reduce the rockfall hazard be implemented. As a minimum, the slope should be scaled to remove loose rock fragments as was done in 1994. This should be repeated every approximately 10 years to maintain a relatively low hazard.

Scaling (using roped access techniques) is expected to be done by hand using scaling (pry) bars. Scaling may include selective removal of small material (< 100 mm dimension) using compressed air where this is more efficient. It is important that scaling be performed by experienced personnel to avoid excessive and unnecessary removal of the weak rock present in this area.

Consideration should be given to implementing a more permanent solution that would reduce future requirements for scaling, and reduce the rockfall hazard. Improved protection against rockfalls can be provided by installing a rockfall catchment fence across the slope a short distance above the access stairs and outlet structure as described in EBA's 2002 inspection report, or by installing a draped slope mesh in the area shown on Photo 1.

Draped Mesh (Slope Mesh) consists of a galvanized steel mesh of appropriate specifications draped over the rock face and anchored at several locations along the crest of the slope. The purpose of the mesh is not to stop rockfalls, but to trap the falling rock between the mesh and the rock face so that it falls in a controlled fashion without gaining high impact energy. A copy of the BC Ministry of Transportation Specification for Slope Mesh, which is suitable for this type of installation, is attached in Appendix A. Note that the slope must be scaled prior to slope mesh installation.

3.2 REGULATING TUNNEL

Observations

As in 2002, the concrete lining of the regulating tunnel appeared to be in good condition. Several radial cracks extending from the invert diagonally up the tunnel walls were evident, but these showed no dilation or offset.

During the current inspection some leakage was observed beneath the right side of the Main Service Gate, and from the Low Level Gate, both of which were shut to allow inspection of the tunnels. The leakage is shown in Photo 3 and is not deemed sufficient to justify remedial work such as gate seal replacement at this time.

Although the regulating tunnel outlet Cone Valves were not examined in detail during the current inspection, Sam McNeil of DFO noted that the epoxy coating had not been repaired in several years (formerly done annually) and that pitting of the steel had now developed in several areas

Recommendations

Maintenance of the regulating tunnel outlet Cone Valves including filling pitted areas of the steel and patching the protective epoxy coating should be planned for 2008.

3.3 WEST WATER SUPPLY TUNNEL

Observations

In general, the entire length of the west tunnel appears to be in good condition, and no remedial work is required at present. No significant changes were observed in comparison to the 2002 inspection.

In shotcrete lined portions of this tunnel, the shotcrete lining was free of visible cracks. Occasional small "drummy" sounding areas were noted, but not of significant size or concern.

Some areas of the unlined tunnel sections were observed to be sound and with negligible loose material as shown in Photo 5. However, as in the 2002 inspection, the 2007 inspection identified some areas in unlined portions of the tunnel were loose or "drummy" rock fragments could be removed easily with a geologic hammer as shown in Photo 4. Localized small rock fall fragments (smaller than 10 to 15 cm) were observed along the tunnel invert in isolated areas as shown in Photo 6. However, there does not appear to be any areas where a rockfall larger than about 0.05 m3 in aggregate (multiple pieces) could occur.

There were no scars from fresh rockfall or significant accumulations of rockfall debris on the tunnel invert with the exception of the area shown in Photo 7 (also shown in Photo 2 of EBA's 2002 inspection report). However, there has been no change in this area since 2002 and it is probable that this material has been present since construction of the tunnel and is unrelated to rockfall.

It should be noted that the tunnel invert is very rough and irregular (no concrete invert slab) and is covered with loose rock, shotcrete rebound and some wood and other debris from the original construction. An approximately 0.5 m x 0.5 m piece of plywood was removed during the 2007 inspection.

As in the 1995 and 2002 inspections, during the 2007 inspection a light coloured biological growth shown in Photos 8 and 9 was observed throughout the length of the water supply tunnel on both shotcrete and bare rock surfaces. The growth is gradually becoming more extensive as time passes and is suspected to be a freshwater sponge. Unlike previous inspections, this growth was also noted to be present on the tunnel invert in isolated areas during 2007 as shown in Photo 10. The growth was less prevalent near the upstream end of the tunnel, where turbulence due to the sharp entrance from the regulating tunnel may limit growth, and was also less prevalent in the east tunnel, again possibly due to increased turbulence downstream of the steel pipe section crossing Beaver Creek.

Recommendations

Although there is various rock and construction debris on the tunnel invert as well as local areas of loosened rock in unlined sections of the tunnel, this does not appear to pose any danger to the reliability of the water supply, hence no remedial work is recommended at present. It is unknown if the biological growth poses a water quality concern for the fisheries operations. Although this seems unlikely, a biological study would be required to properly assess the potential for adverse impacts.

3.4 BEAVER CREEK- WEST TUNNEL AND BULKHEAD

Observations

This 142 m long section of tunnel provides access from the concrete framed tunnel portal door on the west side of Beaver Creek to the west tunnel bulkhead. The water supply is carried through this section of tunnel in a 1200 mm diameter steel pipe. As in other areas, there are occasional "drummy" areas in the shotcrete lining lower on the walls, and also some loose rock on the left wall of the tunnel (looking downstream) within 1.0 m of the tunnel invert, but nothing of concern. This section of tunnel was generally in good condition despite considerable seepage entering the tunnel.

The total quantity of water flowing from the tunnel portal was visually estimated (based on flow width, depth, and velocity) to be 10 to 15 litres/minute. Virtually all of this flow originates as natural groundwater seepage entering the tunnel within about 40 m of the portal and is not associated with leakage from the pressurized section of the tunnel upstream of the bulkhead.

Minor seepage visually estimated to be less than 0.05 litres per minute (less than 3 tablespoons/minute) was evident on the left side (with respect to downstream flow direction) of the concrete bulkhead when the tunnel was pressurized. This area of seepage is shown in Photo 11 and is not considered to be of concern.

Recommendations
The bulkhead should be checked for evidence of leakage on an annual basis when the tunnel is pressurized. Consideration should also be given to installing a flow measurement weir about 3 m downstream from the bulkhead so that the total quantity of seepage/leakage past the bulkhead can be accurately measured.

3.5 BEAVER CREEK TUNNEL PORTAL SLOPES

Observations
The rock slope above the portal on the west side of Beaver Creek is shown in Photo 12. This slope has been bolted to improve stability with seven rock bolts of approximately 22 mm diameter. Although there is a potential for small (<0.3 m) rockfalls to occur, there is no evidence of recent rockfall and there does not appear to be any immediate danger of large rockfalls that could pose a threat to the concrete encased water supply pipeline.

The slope above the Beaver Creek Valve House tunnel portal on the east side of Beaver Creek consists of overburden and appears stable, posing no apparent risk to the pipeline at present.

Recommendations
EBA recommends that the slope above the west portal at Beaver Creek should be check scaled to remove any potential rockfall material the next time a rock scaling crew is at site to address the slope above the regulating tunnel outlet.

3.6 BEAVER CREEK- EAST TUNNEL AND BULKHEAD

Observations
This 117 m long section of tunnel leads from the Beaver Creek Valve House on the east side of Beaver Creek to the western bulkhead in the east tunnel. The water supply is carried through this section of tunnel in a 1200 mm diameter steel pipe. This section of tunnel is completely shotcrete lined. The lining is in good condition and no “drummy” or cracked areas of concern were observed.

Inspection of the bulkhead on October 9, 2007 (while the tunnel was pressurized) revealed that the bulkhead was leaking from the concrete to rock contact at the top left side of the bulkhead as shown in Photo 13. The leakage rate was visually estimated to be about 0.35 litres per minute (approximately one to two cups per minute).

EBA understand that pressure grouting to reduce leakage at this bulkhead was completed in about 1990. The effectiveness of this work in terms of reduced leakage is not documented to our knowledge. During the two subsequent inspections of the bulkhead by EBA on June 22, 2005 and August 13, 2002, the water supply tunnel was not in operation (not pressurized) hence no leakage should have been or was noted. Therefore, it is unknown if the leakage observed on October 9, 2007 represents the conditions after remedial work in 1990, or if there has been an increase in leakage since that time.

Although the bulkhead seepage rate is not yet considered sufficient to warrant remedial pressure grouting, it is considered to be significant and may indicate there is a relatively continuous void extending over some portion of the rock/concrete contact area. As such, there may be relatively high seepage gradients in some areas that could potentially cause leakage rates to increase.

Recommendations

The rate of leakage past the westernmost bulkhead in the east tunnel should be closely monitored for evidence of deterioration (increased leakage) when the tunnel is pressurized to determine if the rate of leakage is stable or increasing over time. In order to facilitate a more repeatable quantitative measurement than is possible by visual means, it is recommended that a small gutter be installed against the face of the bulkhead below the leakage area to collect the seepage for measurement in a graduated container. The gutter could for example consist of 25 mm diameter PVC tubing that is cut in half lengthwise, sealed against the concrete with caulking, and held in place with conduit straps/clamps screwed to the concrete.

Initially, seepage should be monitored bi-monthly for one year to establish a baseline. This frequency can then be gradually decreased if monitoring indicates conditions are stable.

If conditions are deteriorating, then remedial pressure grouting should be carried out. Since the presence of the 1200 mm diameter pipeline will severely limit or prevent drilling grout holes on the optimal alignment from the atmospheric side of the bulkhead, grouting would need to be scheduled for a July – August window when the tunnel can be drained, allowing drilling/grouting from the pressure side of the bulkhead.

3.7 EAST WATER SUPPLY TUNNEL- CENTRE SECTION

Observations

This 172 m long centre section of the east tunnel between the two concrete bulkheads is entirely shotcrete lined. As in our 2002 inspection, the 2007 inspection detected minor areas where the lining was “drummy”, but there were no areas of concern with respect to potential instability or rockfall. The invert in this tunnel section is roughly paved with concrete with the result that the tunnel height is often closer to 2.0 m rather than the 2.4 m design height (noticeably lower than the west tunnel).

The light coloured biological growth that is suspected to be a freshwater sponge was also present in the east tunnel, but is less extensive than the west tunnel.

In general, the centre section of the east tunnel between the two concrete bulkheads appears to be in good condition. No significant changes were observed in comparison to our 2002 inspection and no remedial work is required at present.

3.8 EAST WATER SUPPLY TUNNEL DRAIN PIPE

3.8.1 Background

The downstream portal of the eastern tunnel is situated below grade and is accessed via an 8 m deep vertical concrete shaft of 0.76 m x 1.68 m dimension. Water that accumulates on the east side of the downstream bulkhead in the east tunnel at the base of the east portal access shaft, either from leakage past the bulkhead or from groundwater seepage entering the access shaft and tunnel on the east side of the bulkhead, is drained to Beaver Creek via a 178 m long, 100 mm diameter steel drain pipe. This drain pipe, shown in Photos 14 through 21, passes through the east bulkhead and then through the central portion of the tunnel on concrete cradles resting on the tunnel invert, and then through the west bulkhead.

The exterior of the steel drain pipe appears badly corroded as noted during previous inspections. Consequently, there has been an ongoing concern that the pipe could rust through, allowing water under pressure in the centre section of the east supply tunnel to enter the drainage system. This could result in a substantial discharge of water at the Beaver Creek portal, and possibly also from the east portal of the tunnel. This water might cause significant erosion of the steep slopes down to Fulton River until the water supply could be shut down to effect repairs.

However, it should be noted that the potential for detrimental erosion at Beaver Creek may not be that severe since this natural drainage course has likely experienced large flows in the past (a previous very large flow during failure of an upstream beaver dam is reported to have occurred). Drainage from the east portal would flow down steep slopes towards Fulton River where there is a significant erosion potential.

3.8.2 External Inspection of Drain Pipe

During the 2007 inspection, EBA measured the outside diameter of the drain pipe at two representative locations with veneer callipers (two measurements were made at each location). To allow measurement of the sound pipe material, the rust scale on the pipe surface was first scraped off (removal of this rust material took only a moderate effort). The exposed pipe surface had a silvery, almost aluminium-like appearance.

The first measurement location was approximately 12 m downstream from the western concrete bulkhead, and 0.4 m upstream from the first concrete pipe cradle (see Photos 14 to 16). The second measurement location was approximately 1.2 m upstream from the third pipe cradle (see Photos 17 to 19). The measurements are summarized as follows:

Measurement Location	Outside Diameter of Pipe*
Location 1 – 1st Measurement	114.22 mm (4.497 inch)
Location 1 – 2nd Measurement	113.97 mm (4.487 inch)
Location 1 – 1st Measurement	114.45 mm (4.506 inch)
Location 1 – 2nd Measurement	114.17 mm (4.495 inch)
Average Pipe O.D.	114.20 mm (4.496 inch)

* Outside diameter of sound pipe material with corrosion scale removed. Measurement accuracy is +/- 0.05 mm (0.002 inch).

The rust scale thickness varies considerably due to the rough "blistered" surface (see Photo 20). The diameter of the pipe including the rust scale was measured at the first location as 118.75 mm (4.675 inches) which indicates the rust scale is approximately 2.5 mm (0.10 inch) thick. However, individual blisters were estimated to be upwards of 5.0 mm (0.20 inch) thick. The corrosion of the drain pipe appeared to decrease gradually moving downstream.

The inlet of the drain pipe at the base of the downstream face of the east bulkhead is shown on Photo 21. The total flow exiting the drain pipe upstream of the west bulkhead was visually estimated to be less than 0.05 litre/minute (three tablespoons per minute) with the tunnel pressurized. This appears to be similar to the flow entering the pipe as shown in Photo 21. Therefore, there appears to be little if any pressurized water within the tunnel leaking in to the drain pipe.

3.8.3 Video Inspection of Drain Pipe

Northern Lites Technology Limited were retained by DFO to carry out a video inspection of the interior of the drain pipe in the east supply tunnel. The inspection was carried out on May 22, 2007, and a written copy of the inspection report along with the video footage was provided to EBA for review. This section of EBA's report provides only a general summary of the inspection; the original video should be consulted for further details.

It should be noted that the drain pipe has a very gentle grade (downhill) from the inlet to the outlet of about 1%, hence visibility was often poor due to water ponded in the pipe behind localized debris accumulations or in areas where the pipe had a slight adverse grade. Beginning at the east portal bulkhead (upstream entrance to the drain pipe with respect to flow direction in the drain) the video camera was extended 17.4 m (57 feet) into the drain before reaching the end of the available camera cable. It should be noted that a screen on the drain pipe inlet (shown in Photo 7 of EBA's December, 2002 report) had to be removed (pried open) to facilitate the inspection and could not practically be reinstalled.

Subsequently, the western (downstream) end of the drain pipe was inspected by inserting the camera into the pipe outlet at the western bulkhead near Beaver Creek. From this point, the camera was pushed 53.3 m (175 feet) into the drain before further advance became difficult due to gradually increasing friction. From about 30 m to 45 m the image was largely obscured by water, but otherwise a reasonable, although sometimes intermittent or blurred image was obtained.

Although the central approximately 107 m section of the drain pipe was not inspected, the video appears to give a good overview of conditions within the pipe. Several observations noted by EBA during review of the video inspection records are as follows:

- Several pipe joints were visible but there was no evidence of point source inflow at these or other locations.
- The heaviest scale build-up within the pipe, both in the upstream and downstream sections, appeared to be at or up to 25 mm above the water level in the pipe.
- In the upstream pipe section, the scale at and just above the water level often had the appearance of calcite or carbonate rich crystals, possibly precipitated from dissolved minerals in groundwater seepage entering the adjacent east portal tunnel section. Scale at and just above the water level in the downstream pipe section seemed to have a more rusty character.
- Corrosion blisters estimated to be 5 mm to 10 mm thick were conspicuous in the downstream pipe segment on the pipe walls and crown. Corrosion blisters appeared to be much less developed in the upstream section.
- Isolated pieces of debris on the pipe invert (up to a maximum of about 30 mm in dimension) often appeared to consist of detached pieces of the scale material present at and just above the water level.

Based on the presence of some loose debris and sediment, it appears the water velocity through the drain pipe has been low and therefore insufficient to flush out this material for an extended period of time.

3.8.4 Discussion of Remedial Options for the Drain Pipe

In addition to considering various means of rehabilitating the existing drain pipe, EBA observed the area adjacent to the 8 m deep east portal access shaft to make a preliminary assessment of the feasibility of different drainage alternatives. A preliminary assessment of all potential means of rehabilitation or replacement that were considered is provided below.

Rehabilitation Alternatives

- Continue Use of Existing Drain Pipe – Confirm remaining thickness of pipe using an ultrasonic thickness measuring device and continue to use the pipe as-is provided there is adequate thickness. As part of this option, the risk of a failure of the drain pipe should be assessed in further detail.
- Slip-Line Existing Drain Pipe - Pull through a 75 mm diameter (or similar) HDPE pipe and grout the annulus formed between the exterior of the HDPE pipe and the interior of the existing steel pipe.

- Cured-in-Place Pipe (CIPP) Lining of Existing Drain Pipe – Use CIPP technology to restore the corroded pipe. This involves inserting a resin-saturated flexible lining into the existing pipe using air or water under pressure. Hot air, steam, or water is then circulated through the lining tube to expand it against the existing steel pipe and cure the resin.

Replacement Alternatives

- Replace Existing Drain Pipe – Replace the existing drain pipe with either a new steel pipe or a heavy wall HDPE pipe. The new pipe would need to be anchored (tied down) at intervals to prevent flotation. This would be a difficult and potentially costly undertaking due to the considerable work required within the centre section of the east tunnel which has poor construction access.
- Abandon Existing Drain Pipe – Permanently abandon the drain pipe by filling both ends with grout. Then, the east portal shaft could be left to fill with seepage water, which would need to be pumped out to facilitate any inspection or maintenance work (about 270 cu.m or 60,000 Igal of water).
- Directional Drill New Drain for East Portal – Use Horizontal Directional Drilling (HDD) either from surface or underground to drill a new drain hole extending from the base of the shaft to part way down the slope adjacent to Fulton River. This alternative would require a bore length of up to 90 m. Construction would be complicated due to the lack of working space on the steep slope down to the river. There are also environmental risks associated with potential loss of drilling mud. This alternative is considered to be feasible, but technically challenging, and costly.
- Open Cut Installation of New Drain for East Portal – Use 8 m (+) deep open cut excavation to install a culvert from the bottom of the shaft to the Fulton River slope. The excavation volume would be about 7,000 cu.m with a culvert length of about 45 m. Costs may be in the order of $ 250,000. This alternative is feasible, but expensive.

3.8.5 Recommended Remedial Option

In the short term, EBA recommends that additional investigation be carried out to verify that the existing drain pipe can continue to be used safely. The required work to justify this option would include:

- Ultrasonic measurement to confirm the remaining thickness of the drain pipe and loss due to corrosion that has occurred since construction.
- Review of relevant background information (video inspection record, outside diameter measurements and exterior condition photographs in this report, pipe wall thickness measurements, pipe material specifications, etc.) by a corrosion specialist to obtain an opinion regarding the condition of the pipe and expected life span.

- Hydraulic analyses to estimate the worst case magnitude of leakage that could occur due to a complete failure of the drain pipe located close to either the east or west bulkhead (ie: maximum head with minimal friction losses).
- Assessment of the slopes adjacent to Fulton River at both Beaver Creek and the east portal to determine if uncontrolled leakage from a ruptured drain pipe would have unacceptable consequences. Reducing the pipe diameter at the inlet and outlet might be an method of limiting the potential magnitude of discharge to an acceptable level.

In addition to the foregoing, a new inlet screen should be installed on the drain pipe inlet and a means should be devised to accurately measure the flow rate at the drain pipe outlet.

In the event that the consequences of a failure of the drain pipe are unacceptable, or the remaining service life is limited, remedial alternatives such as slip lining or a cured in place lining of the existing pipe should be investigated further. The next most favourable alternative from a construction risk and cost perspective is likely to be replacement of the drain pipe with a culvert installed within a deep open cut trench excavation.

3.9 EAST WATER SUPPLY TUNNEL - DOWNSTREAM SECTION AND EAST BULKHEAD

Observations

Downstream from the east bulkhead, the water supply is carried within a 1200 mm diameter steel pipe on pipe cradles, resting on the tunnel invert. The tunnel is shotcrete lined and no significant "drummy" or cracked areas of concern were noted. Access to this section is via an 8 m deep concrete lined shaft and short tunnel section which also showed no areas of concern.

Although the downstream face of the bulkhead and adjacent rock was damp to wet, there were no distinct areas of seepage or concentrated flow, although there was a substantial deposit of efflorescence and/or calcite originating from the contact between the rock and concrete on the left (north) side of the bulkhead (left side relative to flow direction). Near the base of the left wall contact approximately 250 mm above the invert, there is a 60 mm high x 13 mm wide hole in the rock tunnel wall (see Photo 21). Photo 7 of EBA's 2002 inspection report also shows this hole, as well as the inlet for the drain pipe leading to Beaver Creek. During 2002 it was thought this hole might be a potential source of leakage, but this could not be verified at the time as the tunnel was not pressurized. However, no leakage was detected at this area during the October 9, 2007 inspection when the tunnel was pressurized hence this feature is considered to be insignificant.

On the right (south) side of the tunnel, there is a depression up to 300 mm deep in the concrete invert adjacent to the downstream face of the bulkhead. During the 2002 inspection, it was suspected this could be a scour hole caused by leakage beneath the bulkhead. However, re-inspection of this area on October 9, 2007 with the tunnel pressurized revealed no discernable seepage from this area, suggesting the depression may have been associated with formwork for the bulkhead. Despite this, there is anecdotal information suggesting that a significant leak had occurred at this bulkhead some time prior to 1995. This depression in the invert may be the result of that leak, which has apparently since been repaired. Although details of the repair are unknown, a shotcrete fillet has been applied around the perimeter of this bulkhead on the upstream (pressure) side after the concrete bulkhead was poured.

Recommendations

Concerns arising from the 2002 inspection regarding two features that were thought to be potential indicators of leakage past the bulkhead have proven to be unfounded based on inspection in 2007 with the supply tunnel pressurized. However, the bulkhead should continue to be checked for evidence of leakage on an annual basis when the tunnel is pressurized.

3.10 TRESTLE SUPPORTED SECTION OF SUPPLY PIPELINE

The section of the supply pipeline situated between 650 m to 930 m downstream from the east tunnel portal experienced slope instability during and shortly after construction. This instability was addressed with various remedial measures installed in about 1970. These included a 46 m long section where the pipeline is supported on an elevated steel trestle structure, excavation to unload the crest of the slide area, installation of approximately 29 horizontal drains, and installation of approximately 300 m of 200 mm diameter perforated drain pipe.

The area of the subsurface drainage measures is now largely obscured with vegetation and as far as we know, there has been no monitoring of the flow from these drains since they were installed.

Observations

EBA only inspected the trestle supported section of the pipeline shown in Photo 22 during the recent inspection. As noted in previous inspections, the pipeline insulation coating has minor damage in a number of areas, but it is doubtful this has any measurable effect on water supply temperatures.

The 1200 mm steel pipe rests on horizontal I-beam bents between steel pile pairs. The pipeline rests on a horizontal timber on top of the I-beams and is centred on this timber with wood wedges on both sides of the pipe as shown in Photo 23. The wooden timbers and wedges were inspected in a few random areas by striking then with the pick end of a geologists hammer, which caused at most 10 mm of indentation, indicating relatively minor decay considering the age of the timber. The manner in which the wood wedges are secured to the horizontal timbers, or the timbers to the I-beams, was not readily apparent due to the spray-on insulation covering. This should be reviewed.

In the 2002 inspection, a gap not exceeding 2 cm was noted at the ground surface between the soil and several of the steel piles for the trestle section. At that time it was considered unlikely that recent slide movement had occurred. A similar separation at two piles as shown in Photo 24 was noted during the 2007 inspection, but again, this did not appear to be recent.

Discussion

The trestle supported pipeline section is reported to have been routinely surveyed since installation in about 1970 up until sometime in the 1990's by Mr. J. Beyers of DFO, who has since retired. Although anecdotal and visual inspection records suggest that no significant movement of the trestle supported section has occurred since construction no quantitative survey data is available to confirm this. Attempts by DFO to locate the survey records have been unsuccessful.

Although the general condition of the steel trestle structure appears to be good, the condition of the subsurface geotechnical remedial works implemented in 1970 are unknown. In particular, stability analysis methodology employed at that time, particularly for soil-structure and seismic analysis, was limited. Given that the trestle structure, as well as the stability of the general slide area has not been reviewed since 1970, and that stability of this area is critical for reliable water supply to Spawning Channel #2, a detailed review of the stability is warranted.

Recommendations

EBA recommends that a new baseline survey of the trestle supported section of the water supply pipeline be carried out, and that this should be compared with subsequent surveys at two year intervals to verify that no ongoing movement is occurring.

In conjunction with the baseline survey, available investigation, design and construction records should be reviewed. EBA have a copy of Ripley, Klohn & Leonoff International Ltd. Dwg. No. D-1367-1 dated October 13, 1970 which suggests that at least thirteen investigation drillholes were completed in the slide area in 1969. The investigation may have included some basic stability analyses, or at least laboratory testing of soil samples.

Following review of available information, detailed reconnaissance of the slide area should be carried out, to assess for example whether drainage measures are still intact and functional. Soil samples could also be collected at this time if necessary.

If review of the available information, including a simple stability analyses indicates that stability of the remediated slope is marginal, then more detailed investigation and analysis (including an allowance for seismic loading) may be warranted to determine the margin of safety against renewed slope movement.

The structural design of the trestle should also be reviewed, with emphasis on the likely seismic performance and potential for lateral displacement of the pipeline on the horizontal pile bents.

4.0 SUMMARY OF RECOMMENDATIONS

All aspects of the water supply tunnels and pipeline appear to be operating reliably, although there appears to be deterioration of some components that could in time necessitate repairs rather than routine maintenance. In addition, there are a number of components such as the concrete tunnel bulkheads that require ongoing monitoring or further investigation to ensure that maintenance and remedial measures can be planned and implemented in a timely fashion.

This section briefly summarizes the main recommendations arising from the 2007 inspection. Reference should be made to the preceding sections of the report for additional details.

1. The slope above the regulating tunnel outlet structure should be scaled to remove loose rock fragments that pose a rockfall hazard. At the same time, the rock face above the west tunnel portal at Beaver Creek should be check scaled. Consideration should be given to implementing a more permanent solution such as a rockfall catchment fence across the slope a short distance above the access stairs and outlet structure, or draped slope mesh covering the entire slope to reduce future requirements for scaling, and reduce the rockfall hazard.
2. Maintenance of the regulating tunnel outlet Cone Valves including filling pitted areas of the steel and patching the protective epoxy coating should be planned for 2008.
3. Consider commissioning a biological study to assess whether the biological growth (suspected to be a freshwater sponge) within the supply tunnels poses a water quality concern for the fisheries operations.
4. The west supply tunnel bulkhead should be checked for evidence of leakage on an annual basis when the tunnel is watered up. Consideration should be given to installing a flow measurement weir about 3 m downstream from the bulkhead so that the total quantity of seepage/leakage past the bulkhead can be accurately measured.
5. The westernmost bulkhead in the east tunnel shows evidence of significant leakage at the rock-concrete contact and should be monitored on a bi-monthly basis when the tunnel is in operation to determine if the rate of leakage is stable or increasing over time. In order to facilitate a repeatable quantitative measurement, it is recommended that a smaller gutter be installed against the face of the bulkhead to collect the seepage for flow measurement.
6. Although the east supply tunnel drain pipe may eventually require rehabilitation or replacement, in the short term EBA recommends that additional investigation be carried out to assess whether the drain pipe can continue to be used safely. The required work to justify this option would include; ultrasonic measurement to determine the remaining thickness of the drain pipe, review of relevant background information by a corrosion specialist to obtain an opinion regarding the condition of the pipe and expected life span, hydraulic analyses to estimate the worst case magnitude of leakage that could occur due to a rupture of the drain pipe, and assessment of the slopes adjacent to Fulton River at both Beaver Creek and the east portal to determine if uncontrolled leakage would have unacceptable consequences. In addition to the foregoing, a new inlet screen should be installed on the drain pipe inlet and a means should be devised to accurately measure the flow rate at the drain pipe outlet.

7. The easternmost bulkhead in the east supply tunnel should be checked for evidence of leakage on an annual basis when the tunnel is watered up.

8. EBA recommends that a new baseline survey of the trestle supported section of the water supply pipeline be carried out, and that this should be compared with subsequent surveys at two year intervals to verify that no ongoing movement is occurring. In addition, the available investigation, design and construction records for the remedial works in the slide area, as well as the structural design of the trestle, should be reviewed. If the review indicates that stability of the slope, or performance of the trestle under seismic loading may be marginal, more detailed investigation and analyses may be warranted

5.0 CLOSURE

Recommendations presented in this report are based on engineering judgement and have been prepared in accordance with generally accepted geotechnical engineering practice. Use of this report is subject to the General Conditions attached in Appendix B.

EBA trusts that this report satisfies DFO's present requirements. We will be pleased to provide any further assistance that may be needed to implement the recommendations presented in this report. Please feel free to contact our office should you require additional information.

Respectfully submitted,
EBA Engineering Consultants Ltd.

Prepared by:

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Reviewed by:

PROFESSIONAL ENGINEER S. A. SYLTE BRITISH COLUMBIA

March 19, 2008

Scott Sylte, P.Eng.
Senior Rockwork Engineer

PHOTOGRAPHS

NOTE:

Note Regarding Photograph Orientations:

For photographs associated with the Regulating Tunnel and Water Supply Tunnels and Pipeline, "upstream" and "downstream" refer to the water flow direction, and the terms left and right are relative to the downstream flow direction (unless specifically noted otherwise)

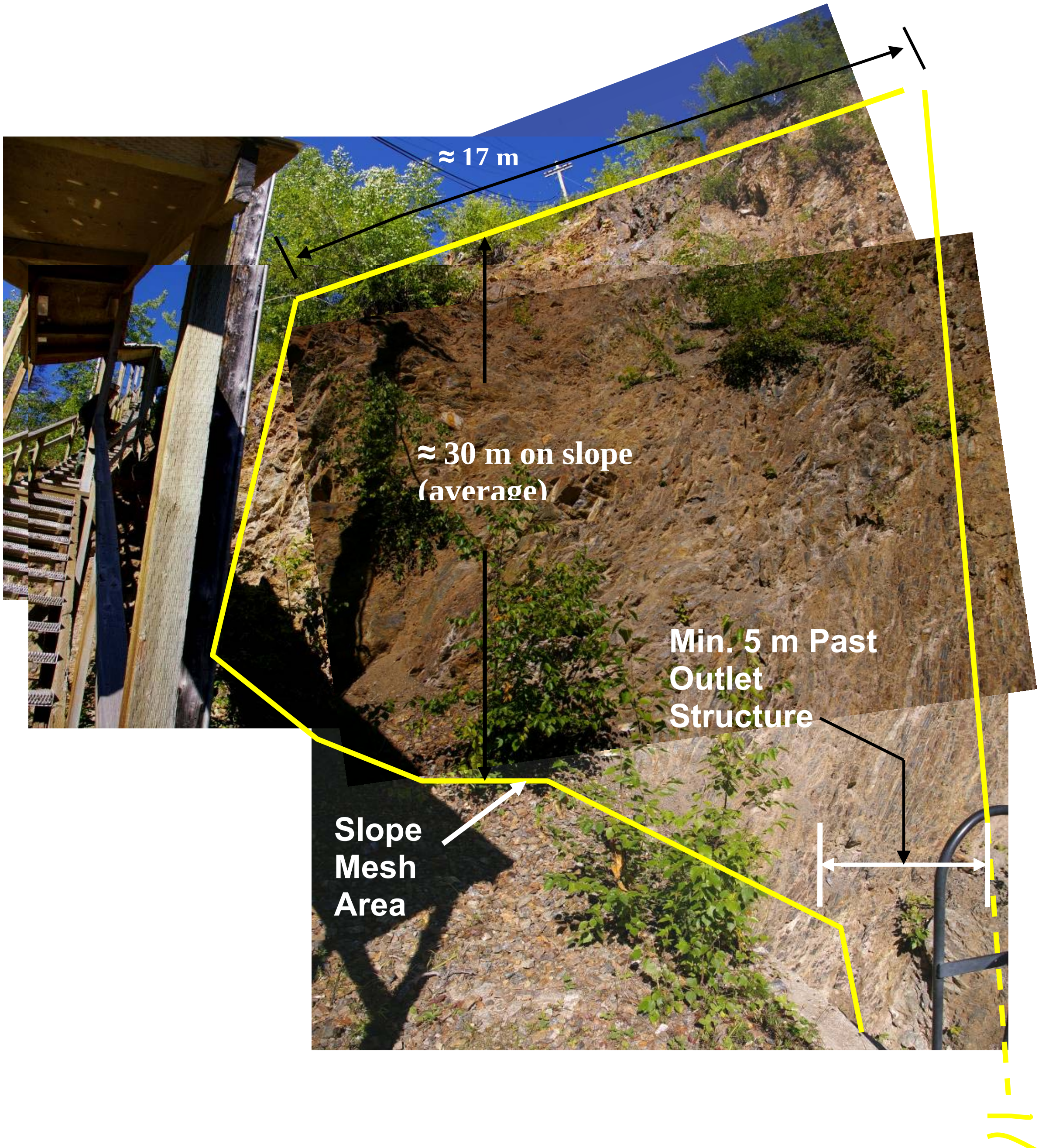


Photo 1 (August 15, 2007) Slope above Regulating Tunnel Outlet Structure – Scale slope above outlet structure and access stairway and install slope mesh in area approximately as shown.

Photo 2 (August 15, 2007) Slope above Regulating Tunnel Outlet Structure – Side view of slope shown in Photo 1.

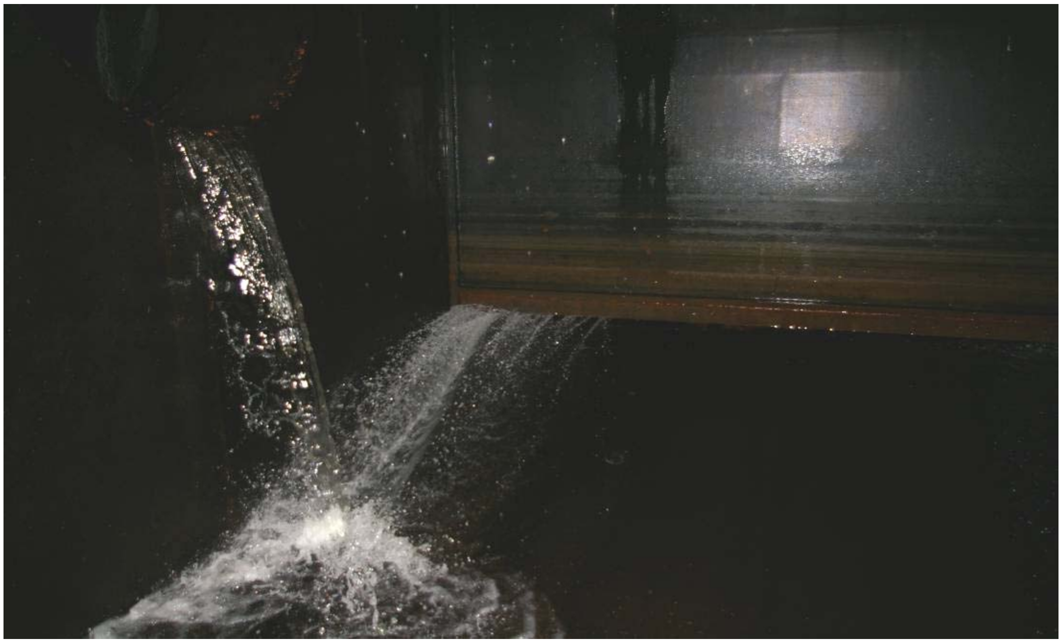


Photo 3 (August 15, 2007) Regulating Tunnel – Leakage beneath right side of Main Service Gate. Flow on left side of photo is leakage past the 1500 mm diameter Low Level Intake Gate.

Photo 4 (August 15, 2007) West Supply Tunnel – Typical areas of loosened "drummy" rock on lower wall of tunnel (below shotcrete lining).

Photo 5 (August 15, 2007) West Supply Tunnel – Unlined tunnel section in chert (?) rock. Rock is sound with negligible loose material.

Photo 6 (August 15, 2007) West Supply Tunnel – Minor (≤ 150 mm) rockfall on tunnel invert below unlined tunnel section (shotcrete visible on left).

Photo 7 (August 15, 2007) West Supply Tunnel – Localized “wind-row” of rocks just downstream of small refuge bay on left side of tunnel (compare with Photo 2 of EBA December, 2002 report - no change noted in 2007).

Photo 8 (August 15, 2007) West Supply Tunnel – Typical biological growth (possibly freshwater sponge) on shotcreted tunnel wall.

Photo 9 (August 15, 2007) West Supply Tunnel – Typical area of extensive biological growth (possibly freshwater sponge) on upper walls and crown of tunnel.

Photo 10 (August 15, 2007) West Supply Tunnel – Localized areas of biological growth (possibly freshwater sponge) on tunnel invert that were not noted during previous inspections.

Photo 11 (October 10, 2007) West Supply Tunnel Bulkhead (looking upstream) – Minor seepage (<0.05 l/min by visual estimate) evident on left side of bulkhead with tunnel pressurized.

Photo 12 (October 10, 2007) West Supply Tunnel portal at Beaver Creek –
No change noted since previous inspection; slope should be checked scaled.

Photo 13 (October 9, 2007) East Supply Tunnel, Beaver Creek Bulkhead (Looking downstream) - The seepage rate (approximately 0.35 l/min by visual estimate) from crown of bulkhead on left side with tunnel "watered-up" should be monitored regularly for evidence of deterioration.

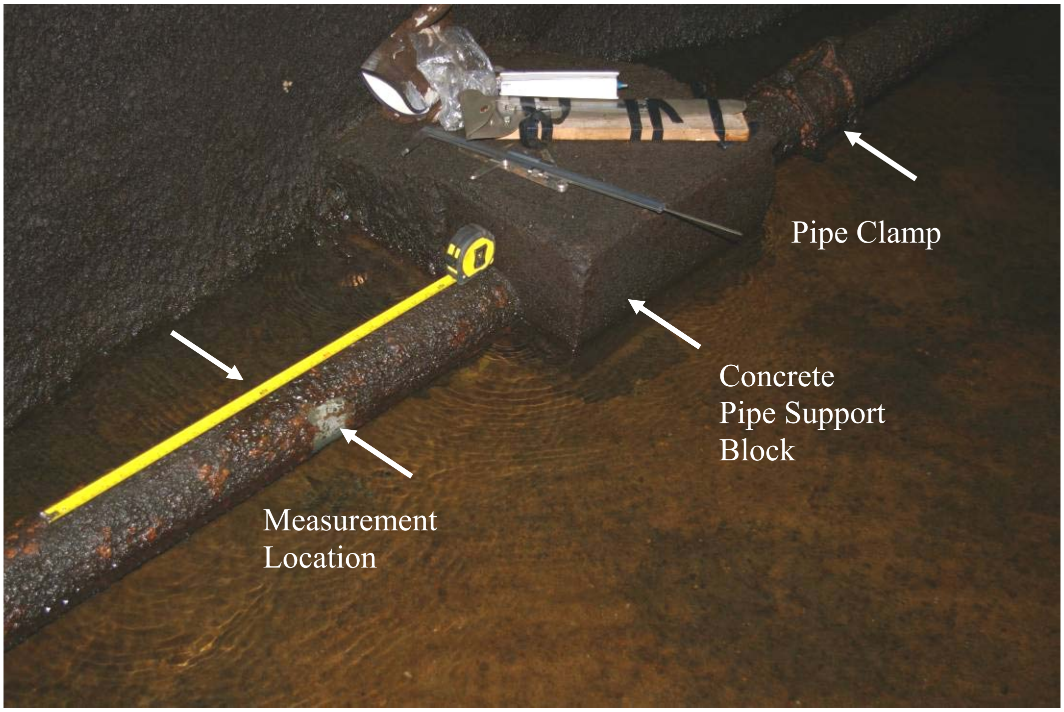


Photo 14 (August 15, 2007) East Supply Tunnel – Drain pipe measurement Location #1 (approx. 12 m downstream from Beaver Creek Bulkhead).

Photo 15 (August 15, 2007) East Supply Tunnel – Drain pipe measurement Location #1 – close up view. Pitting of pipe appears relatively shallow.

Photo 16 (August 15, 2007) East Supply Tunnel – Typical condition of clamp connections on drain pipe.

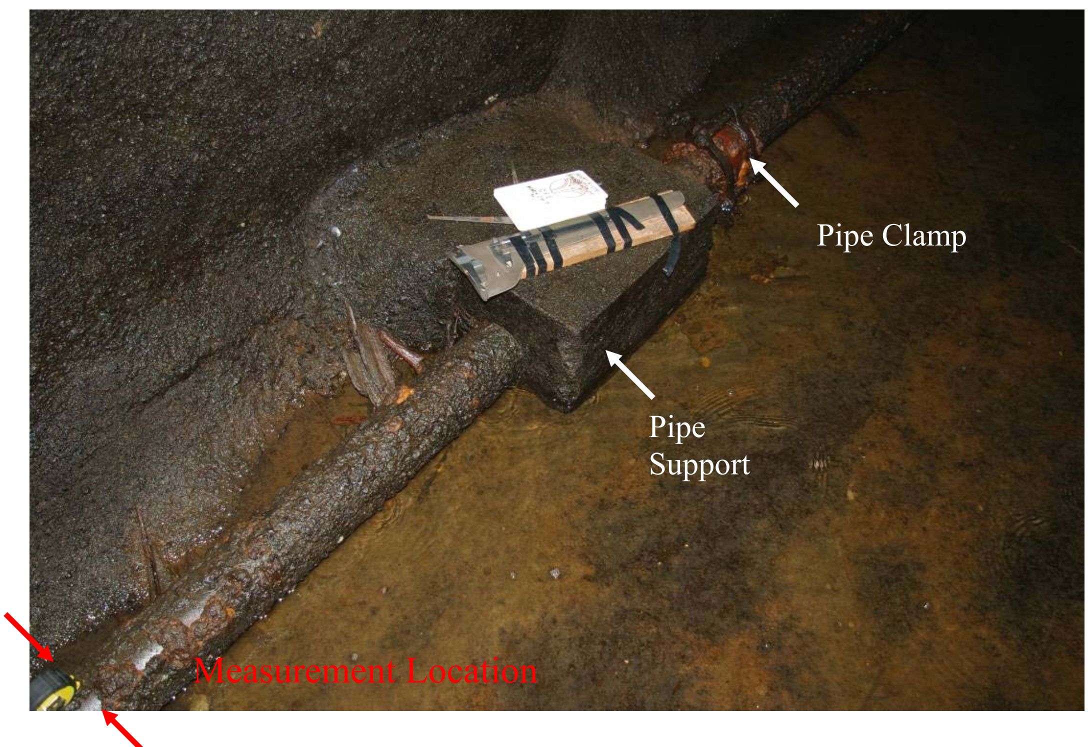


Photo 17 (August 15, 2007) East Supply Tunnel – Drain pipe measurement Location #2 (1.2 m upstream from third pipe support).

Photo 18 (August 15, 2007) East Supply Tunnel – Drain pipe measurement Location #2 – close up view.

Photo 19 (August 15, 2007) East Supply Tunnel – Pipe clamp at drain pipe measurement Location #2.

Photo 20 (August 15, 2007) East Supply Tunnel – Typical corrosion blisters on drain pipe.

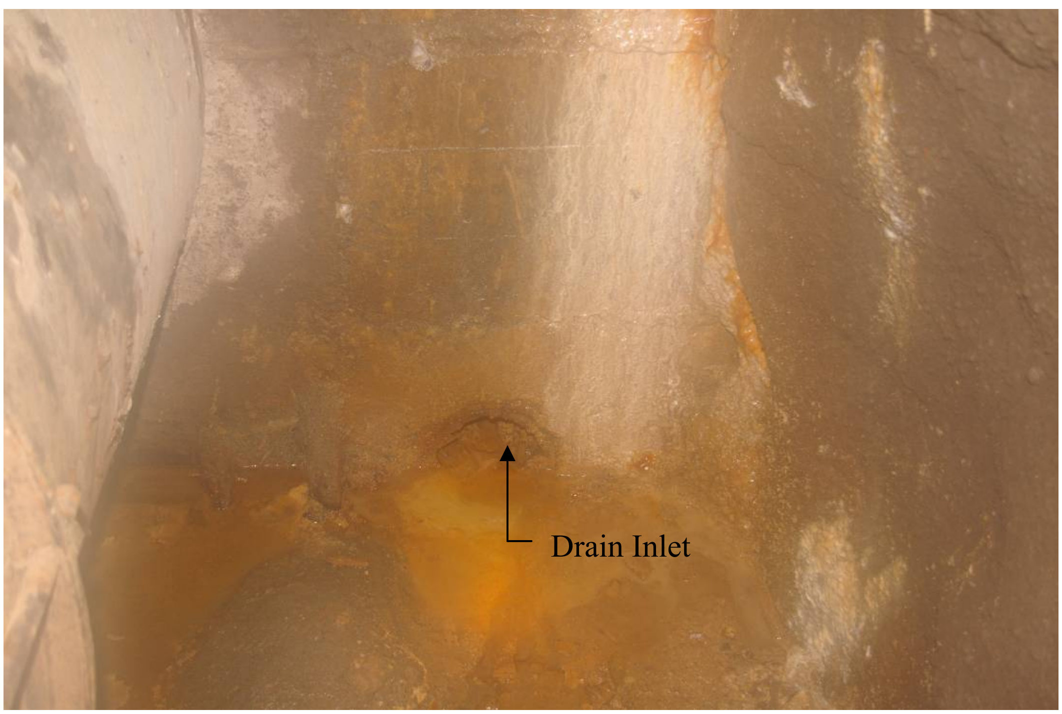


Photo 21 (October 9, 2007) East Supply Tunnel, East Bulkhead (looking upstream) – Inlet of drain pipe at east portal bulkhead. Bulkhead is damp to wet but no distinct areas of seepage were noted.

Photo 22 (October 9, 2007) Pipeline Trestle (looking downstream)

Photo 23 (October 9, 2007) Pipeline Trestle – Typical wood wedges used to support the supply pipeline on trestle show only relatively minor decay.

Photo 24 (October 9, 2007) Pipeline Trestle – Minor separation of soil noted adjacent to two piles does not appear to be recent.

APPENDIX

APPENDIX A BC MINISTRY OF TRANSPORTATION SPECIFICATION FOR SLOPE MESH

SECTION 207

SLOPE MESH FOR ROCK CUTS

DESCRIPTION

207.01 Scope - This Section applies to slope mesh structures which are installed to provide rockfall protection.

207.01.01 Rock slope scaling and tree removal, performed in conjunction with slope mesh installation, shall be considered incidental to slope meshing. Rock slope scaling and tree removal shall be completed before the mesh support system is installed unless otherwise authorized by the Ministry Representative. Trees to be removed will be detailed by the Ministry Representative.

207.01.02 Discarded mesh components, scaled rock, trees and debris generated by the slope meshing work shall be removed from the ditches and disposed of by the Contractor. Temporary storage of felled trees in ditches will not be permitted.

207.01.03 The contractor shall layout in the field all anchor and suspension cable locations for each section. Each section will be reviewed by the Ministry Representative prior to installation.

207.01.04 Field conditions may require final anchor, cable and mesh configurations to vary from the Ministry's drawings. All variations must be authorized by the Ministry Representative.

207.01.05 The area to be provided with slope mesh protection shall be divided into sections with a maximum width of 24 m. Each section shall have a separate suspension cable, end main anchors and end anchors. End main anchors of adjacent sections shall be positioned 200 mm apart. The gap between sections shall be closed with mesh.

207.01.06 The maximum mesh length shall be 80 m.

207.01.07 The maximum rock impact energies shall be as follows:

- 3 kJ above cut crest
- 30 kJ below cut crest

207.01.08 Overburden thickness may range from zero to over 1.5 m.

MATERIALS

207.11 Slope Meshing Materials - Unless otherwise specified, preparation and installation of materials shall be according to manufacturer's recommendations.

All components shall be hot-dip galvanized conforming to ASTM A 123 or ASTM A 153 or CSA G164 where appropriate. Damaged galvanizing shall be re-galvanized at the contractor's expense.

207.11.01 Mesh - Mesh shall be 11 gauge (2.95 mm dia.) hexagonal triple twist gabion type mesh. Mesh wire shall meet federal specification QQ-W-461g, possess soft tensile strength with a finish 5 class 3 zinc coating of not less than 260 g/m^2. The weight of zinc coating shall be determined by ASTM A 90. The coating shall withstand four one minute dips by the preece test, ASTM A 239. Mesh opening shall be hexagonal in shape and uniform in size measuring 80 mm by 100 mm.

207.11.02 Threadbar - Threadbar shall conform to CSA G30.18, grade 400 steel, manufactured by Dywidag Systems Int. (DSI) or authorized equivalent.

207.11.03 Eye nuts - Eye nuts shall be cast or manufactured eye nuts by DSI or authorized equivalent.

207.11.04 Cables - All cables shall be fibre core conforming to CSA G4. Cables shall be unspliced.

207.11.05 Thimbles - Thimbles shall meet FF-T-276B Type III (extra heavy G-414).

207.11.06 Clips - Clips shall meet FF-C-450 Type 1, Class 1 (G450 Crosby clip or authorized equivalent).

207.12 Grout

207.12.01 Grout for main anchors shall be Celtite Anchortite. Grout for auxiliary anchors shall be Celtite Lokset cartridges, cement grout or authorized equivalent.

207.12.02 Cement grout shall be Target 1118 or Ocean Microsil anchor grout or equivalent with W/C=0.35. Grout minimum 3 day and 28 day compressive strengths shall be 20 MPa and 40 MPa respectively, tested in accordance with CSA A23.2-1B.

207.13 Conformance Documents - Prior to installation the contractor shall supply documents of conformance to project specifications of all materials upon request.

CONSTRUCTION

207.31 Anchor Installation

207.31.01 Overburden shall be excavated to rock at anchor locations unless specified otherwise. The Contractor shall minimize disturbance of surrounding soil and rock when excavating. Cables shall not contact ground surface.

207.31.02 Anchor holes shall be a minimum of 1.5 times anchor diameter and in strong, competent rock. Anchors shall be centered in the hole and grouted. Anchors shall not be loaded within 3 days of grouting.

207.31.03 Main anchors shall be located at local high points where practicable to maximize clearance between suspension cable and ground surface. Main anchors shall be vertical and centered in the hole unless otherwise authorized by the Ministry Representative. Main anchor height above ground surface may be reduced where authorized by the Ministry Representative for field conditions.

207.31.04 Auxiliary anchors shall be located to minimize potential for main anchor bending.

207.31.05 Main anchors may be substituted, where authorized by the Ministry Representative, with a limited number of guy cables directly connected to the suspension cable where no suitable main anchor locations can be found. Guy cable anchors shall be located to maximize suspension cable elevation. See Section Y-Y, on Drawing. SP207-02 and Detail B on Drawing. SP207-03.

207.31.06 Auxiliary or guy anchor embedded length may require extension if weak rock conditions are encountered.

207.32 Soil Anchors - Soil anchors shall be used where required or as ordered by the Ministry Representative. For soil anchor details see Drawings SP207-04 and SP207-05.

Concrete requirements for soil anchors:

- minimum compressive strength at 28 days = 30 MPa
- maximum nominal size of aggregate = 28 mm
- air content = 5± 1%
- slump = 55± 20 mm
- maximum w/c ratio by mass = 0.45

Upon request by the Ministry Representative, the contractor shall load test one overburden soil anchor to 10 kN to verify capacity.

207.33 Cable and Mesh Installation - Suspension, auxiliary, end, and guy cables shall be installed to nominal tension to remove slack before and after installing mesh.

A maximum of two horizontal mesh seams (200 mm overlap) shall be permitted along the entire mesh height. The upper mesh portion shall be between the slope and lower mesh at the overlap. The horizontal seam connections shall be similar to the vertical seams.

The mesh shall terminate 1500 mm above the highway edge of pavement elevation. The bottom of the mesh shall be evenly trimmed parallel with the highway elevation. The bottom of the mesh shall be bent to remove the curl.

MEASUREMENT

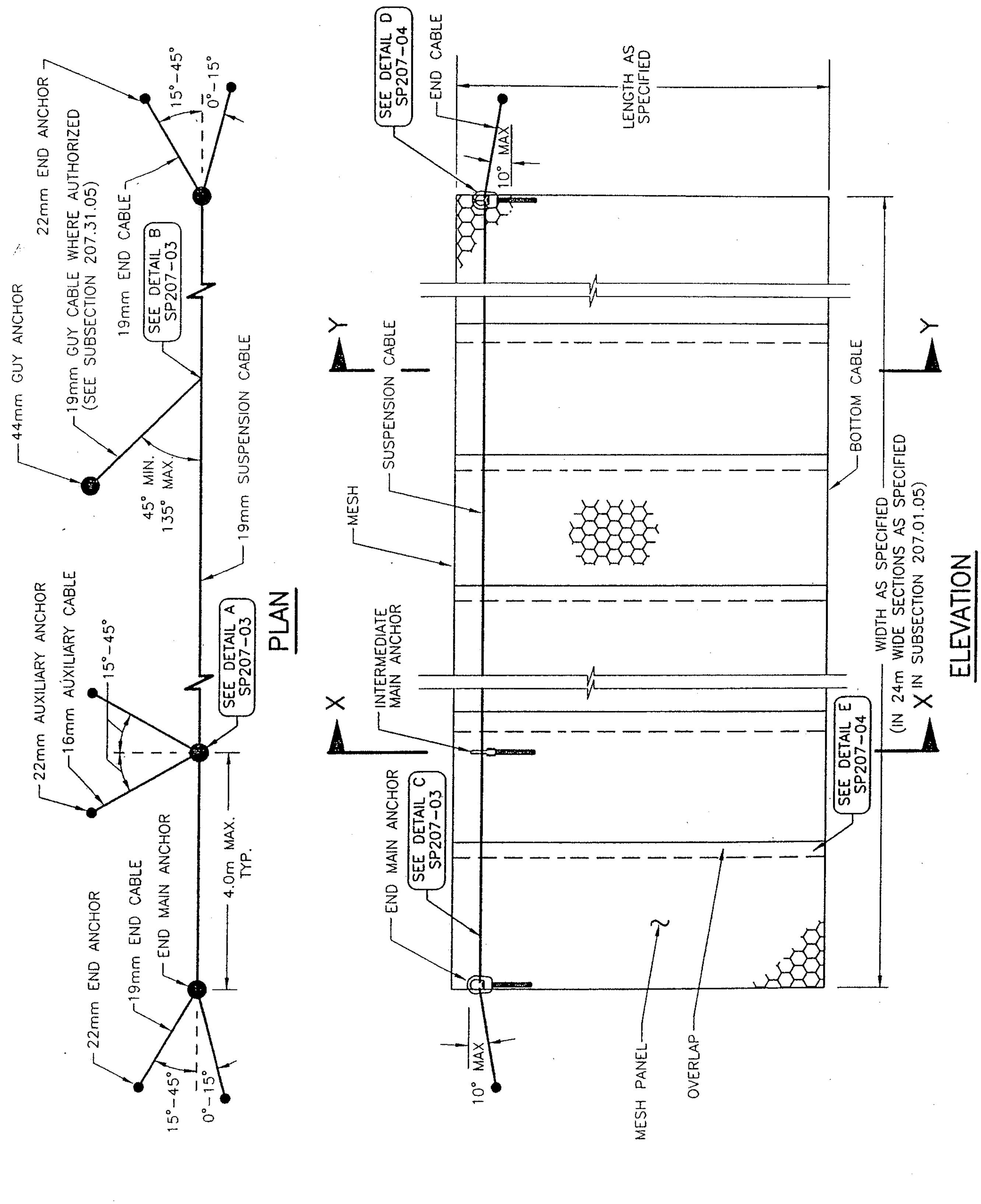
207.81 Slope Mesh - Slope mesh shall be measured by the SQUARE METRE of slope meshed area.

PAYMENT

207.91 Slope Mesh - Payment for SLOPE MESH will be at the Contract Unit Price per square metre. The Unit Price will be full compensation for all requirements in this specification. Partial payment may be authorized where all components have been installed in a portion of the designated slope meshing area. No separate payment will be made for mesh overlap.

SLOPE MESH LAYOUT

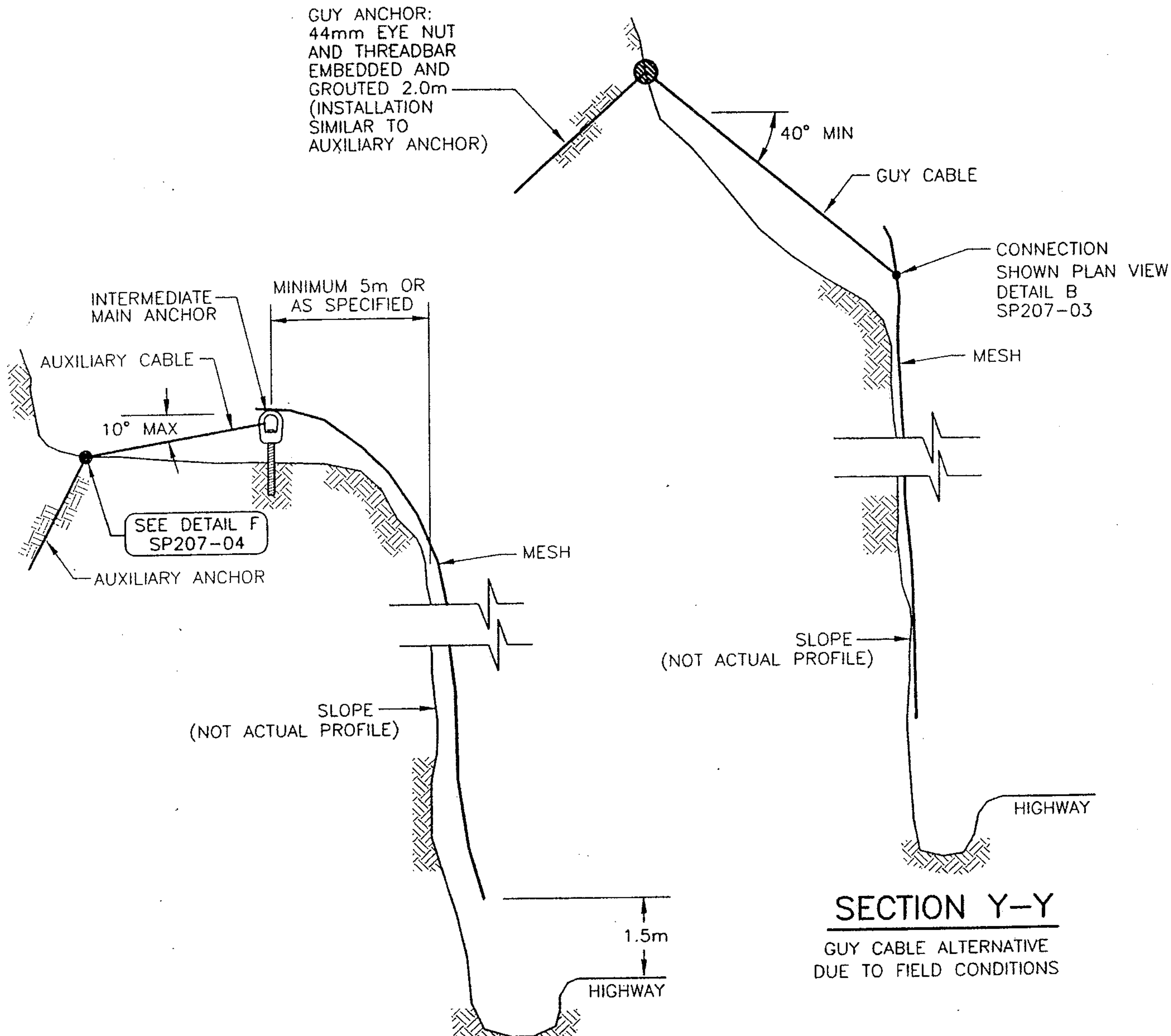
SP207-01



NOT TO SCALE

ALL DIMENSIONS ARE IN MILLIMETRES UNLESS OTHERWISE NOTED

SLOPE MESH – SECTIONS	SP207–02



SECTION Y–Y

GUY CABLE ALTERNATIVE
DUE TO FIELD CONDITIONS

SECTION X–X

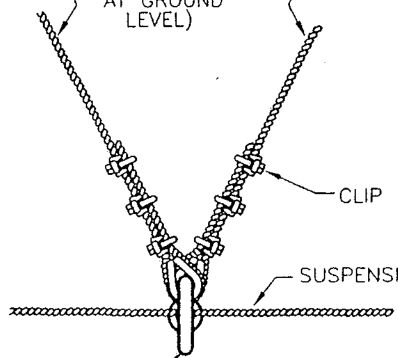
SIDE VIEW AT INTERMEDIATE
MAIN ANCHOR

NOTES:
1. FOR LOCATION OF SECTIONS SEE DWG. SP207–01.

NOT TO SCALE ALL DIMENSIONS ARE IN MILLIMETRES UNLESS OTHERWISE NOTED

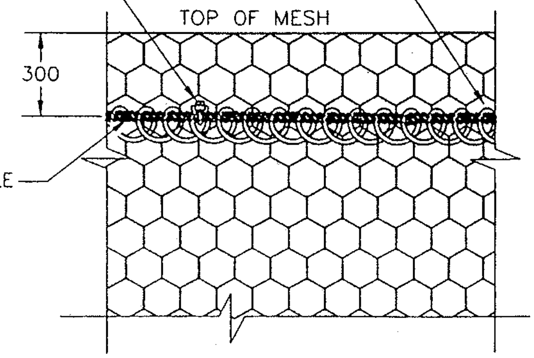
SLOPE MESH – DETAILS

SP207-03



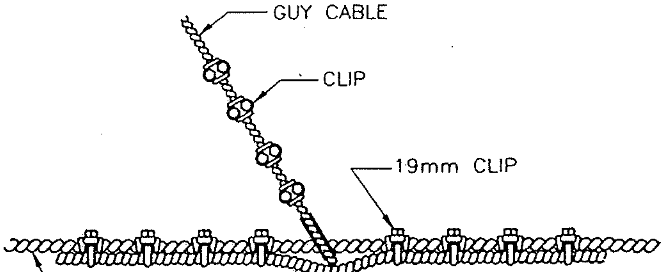
DETAIL A

INTERMEDIATE MAIN ANCHOR



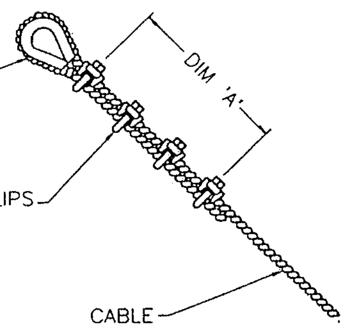
DETAIL C

MESH TO SUSPENSION CABLE CONNECTION



DETAIL B

GUY CABLE ALTERNATIVE DUE TO FIELD CONDITIONS



CABLE LOOP DETAIL

FOR SUSPENSION, END, GUY AND AUXILIARY CABLES (SEE TABLE 1)

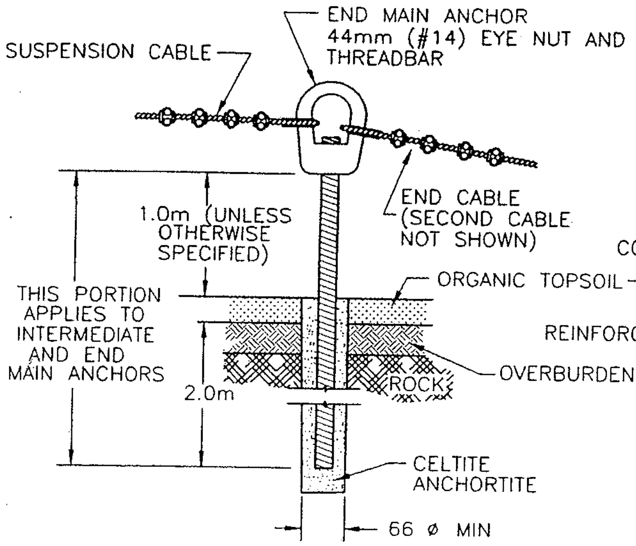
TABLE 1: CLIPS

CABLE TYPE	CABLE SIZE (mm)	CLIP SIZE (mm)	N°. OF CLIPS FOR LOOP	DIMENSION 'A' (mm)	TORQUE Nm (ft. lbs)
Suspension, End, Guy	19	19	4	460	175 (130)
Auxiliary	16	16	3	300	113 (95)
Lacing	10	19	(varies)	N/A	54 (45)

NOTES:
1. FOR LOCATION OF DETAILS SEE DWG. SP207-01.

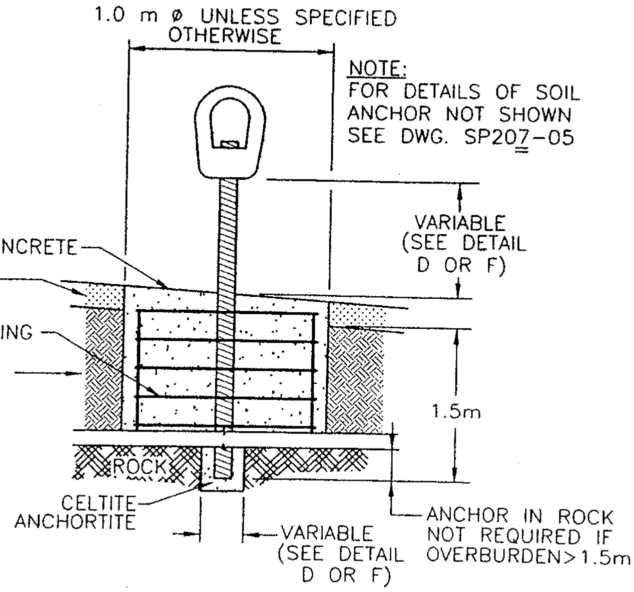
NOT TO SCALE

ALL DIMENSIONS ARE IN MILLIMETRES UNLESS OTHERWISE NOTED



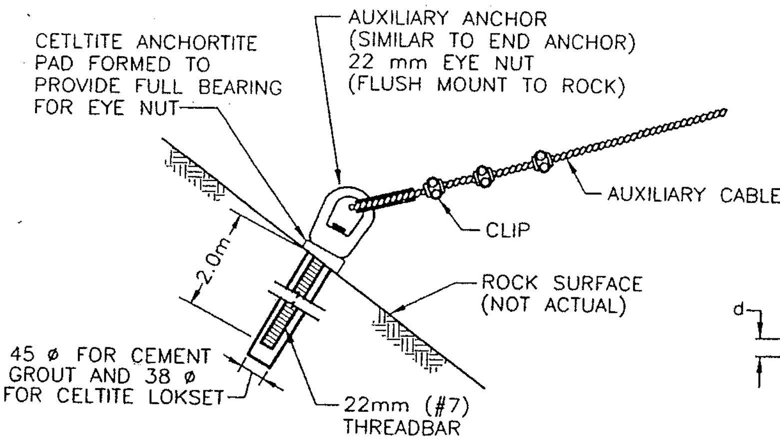
DETAIL D

END MAIN ANCHOR CONNECTIONS
(MESH OMITTED FOR CLARITY)



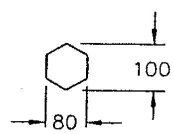
SOIL ANCHOR DETAIL

ALTERNATE ANCHOR DETAIL IN OVERBURDEN.
FOR OVERBURDEN THICKNESS GREATER
THAN 0.6m (SEE SUBSECTION 207.01.08)

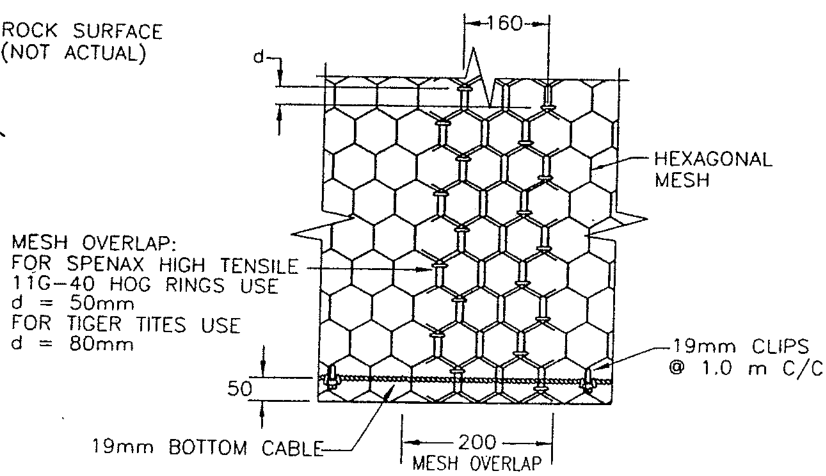


DETAIL F

AUXILIARY ANCHOR
CONNECTIONS



MESH PROPORTIONS



DETAIL E

MESH SEAM CONNECTIONS AND BOTTOM CABLE

NOTES:

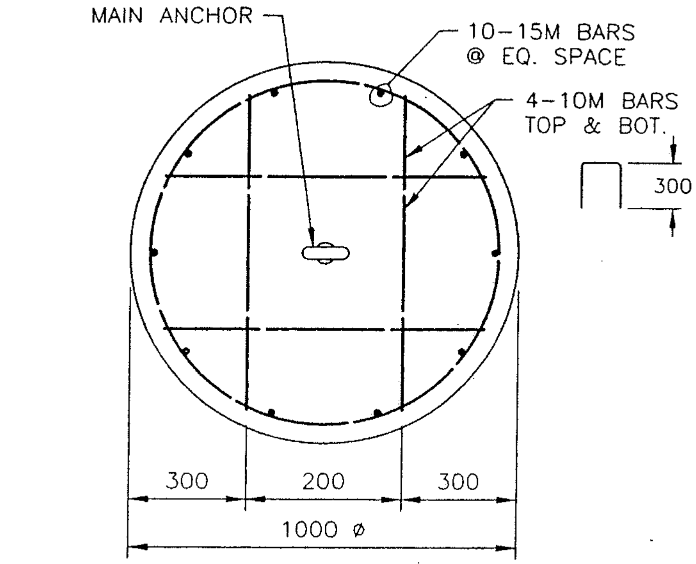
1. FOR LOCATION OF DETAILS SEE DWGS. SP207-01 & 02.

NOT TO SCALE

ALL DIMENSIONS ARE IN MILLIMETRES UNLESS OTHERWISE NOTED

SOIL ANCHOR CONCRETE AND REINFORCEMENT FOR SLOPE MESH INSTALLATIONS

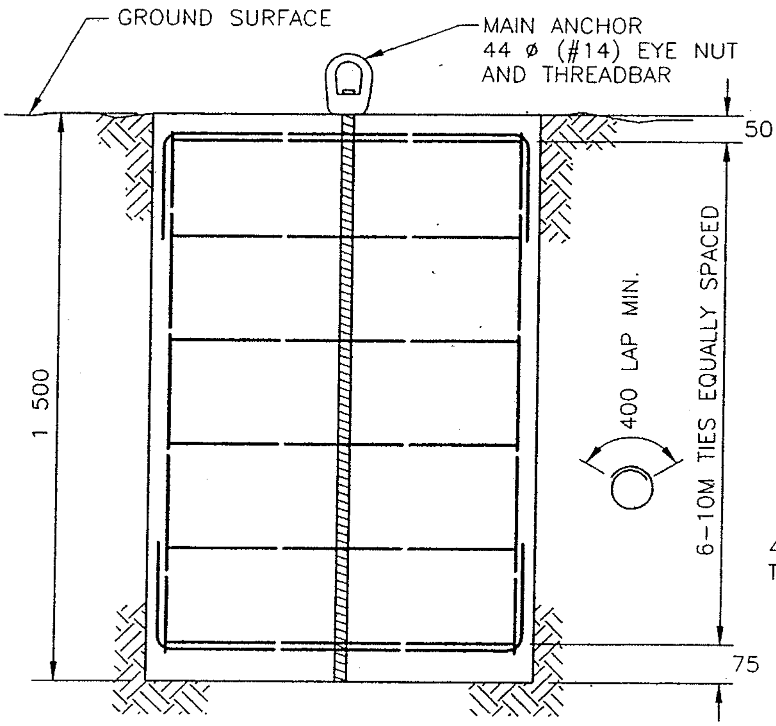
SP207-05



PLAN

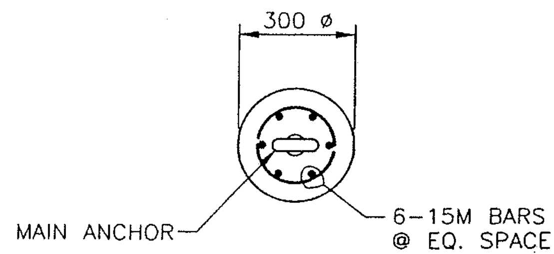
NOTES:

1. INSTALL 300, 600 OR 1000mm ø SOIL ANCHOR AS SPECIFIED.
2. REDUCE SOIL ANCHOR DEPTH WHERE ROCK IS ENCOUNTERED, AND INSTALL MAIN ANCHOR INTO ROCK TO PROVIDE TOTAL 1.5m EMBEDDED LENGTH.
3. CONCRETE REQUIREMENTS SHOWN ON SLOPE MESH DRAWING.
4. ALL REINFORCING STEEL TO MEET C.S.A. SPECIFICATION G30.18-M, GRADE 400R.
5. ALL REINFORCING STEEL TO HAVE 50mm COVER UNLESS SPECIFIED OTHERWISE.
6. PLACE REINFORCING BARS IN ACCORDANCE WITH RECOMMENDED PRACTISES OF THE CONCRETE REINFORCING STEEL INSTITUTE (C.R.S.I.)
7. CONCRETE AND REINFORCING STEEL TO MEET STANDARD SPECIFICATION SECTIONS 412 AND 218 UNLESS SPECIFIED OTHERWISE.



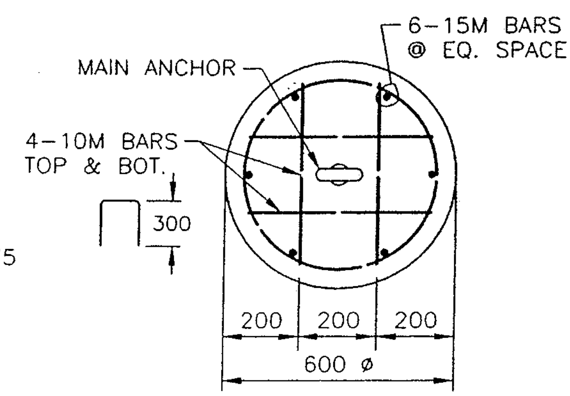
ELEVATION

1000 ø SOIL ANCHOR



300 ø SOIL ANCHOR

(ALL NOT SHOWN SIMILAR TO 1000 ø SOIL ANCHOR)



600 ø SOIL ANCHOR

(ALL NOT SHOWN SIMILAR TO 1000 ø SOIL ANCHOR)

NOT TO SCALE

ALL DIMENSIONS ARE IN MILLIMETRES UNLESS OTHERWISE NOTED

APPENDIX

APPENDIX B GEOTECHNICAL GENERAL CONDITIONS

GEOTECHNICAL REPORT – GENERAL CONDITIONS

This report incorporates and is subject to these "General Conditions".

1.0 USE OF REPORT AND OWNERSHIP

This geotechnical report pertains to a specific site, a specific development and a specific scope of work. It is not applicable to any other sites nor should it be relied upon for types of development other than that to which it refers. Any variation from the site or development would necessitate a supplementary geotechnical assessment.

This report and the recommendations contained in it are intended for the sole use of EBA's client. EBA does not accept any responsibility for the accuracy of any of the data, the analyses or the recommendations contained or referenced in the report when the report is used or relied upon by any party other than EBA's client unless otherwise authorized in writing by EBA. Any unauthorized use of the report is at the sole risk of the user.

This report is subject to copyright and shall not be reproduced either wholly or in part without the prior, written permission of EBA. Additional copies of the report, if required, may be obtained upon request.

2.0 NATURE AND EXACTNESS OF SOIL AND ROCK DESCRIPTIONS

Classification and identification of soils and rocks are based upon commonly accepted systems and methods employed in professional geotechnical practice. This report contains descriptions of the systems and methods used. Where deviations from the system or method prevail, they are specifically mentioned.

Classification and identification of geological units are judgmental in nature as to both type and condition. EBA does not warrant conditions represented herein as exact, but infers accuracy only to the extent that is common in practice.

Where subsurface conditions encountered during development are different from those described in this report, qualified geotechnical personnel should revisit the site and review recommendations in light of the actual conditions encountered.

3.0 LOGS OF TESTHOLES

The testhole logs are a compilation of conditions and classification of soils and rocks as obtained from field observations and laboratory testing of selected samples. Soil and rock zones have been interpreted. Change from one geological zone to the other, indicated on the logs as a distinct line, can be, in fact, transitional. The extent of transition is interpretive. Any circumstance which requires precise definition of soil or rock zone transition elevations may require further investigation and review.

4.0 STRATIGRAPHIC AND GEOLOGICAL INFORMATION

The stratigraphic and geological information indicated on drawings contained in this report are inferred from logs of test holes and/or soil/rock exposures. Stratigraphy is known only at the locations of the test hole or exposure. Actual geology and stratigraphy between test holes and/or exposures may vary from that shown on these drawings. Natural variations in geological conditions are inherent and are a function of the historic environment. EBA does not represent the conditions illustrated as exact but recognizes that variations will exist. Where knowledge of more precise locations of geological units is necessary, additional investigation and review may be necessary.

5.0 SURFACE WATER AND GROUNDWATER CONDITIONS

Surface and groundwater conditions mentioned in this report are those observed at the times recorded in the report. These conditions vary with geological detail between observation sites; annual, seasonal and special meteorologic conditions; and with development activity. Interpretation of water conditions from observations and records is judgmental and constitutes an evaluation of circumstances as influenced by geology, meteorology and development activity. Deviations from these observations may occur during the course of development activities.

6.0 PROTECTION OF EXPOSED GROUND

Excavation and construction operations expose geological materials to climatic elements (freeze/thaw, wet/dry) and/or mechanical disturbance which can cause severe deterioration. Unless otherwise specifically indicated in this report, the walls and floors of excavations must be protected from the elements, particularly moisture, desiccation, frost action and construction traffic.

7.0 SUPPORT OF ADJACENT GROUND AND STRUCTURES

Unless otherwise specifically advised, support of ground and structures adjacent to the anticipated construction and preservation of adjacent ground and structures from the adverse impact of construction activity is required.

8.0 INFLUENCE OF CONSTRUCTION ACTIVITY

There is a direct correlation between construction activity and structural performance of adjacent buildings and other installations. The influence of all anticipated construction activities should be considered by the contractor, owner, architect and prime engineer in consultation with a geotechnical engineer when the final design and construction techniques are known.

9.0 OBSERVATIONS DURING CONSTRUCTION

Because of the nature of geological deposits, the judgmental nature of geotechnical engineering, as well as the potential of adverse circumstances arising from construction activity, observations during site preparation, excavation and construction should be carried out by a geotechnical engineer. These observations may then serve as the basis for confirmation and/or alteration of geotechnical recommendations or design guidelines presented herein.

10.0 DRAINAGE SYSTEMS

Where temporary or permanent drainage systems are installed within or around a structure, the systems which will be installed must protect the structure from loss of ground due to internal erosion and must be designed so as to assure continued performance of the drains. Specific design detail of such systems should be developed or reviewed by the geotechnical engineer. Unless otherwise specified, it is a condition of this report that effective temporary and permanent drainage systems are required and that they must be considered in relation to project purpose and function.

11.0 BEARING CAPACITY

Design bearing capacities, loads and allowable stresses quoted in this report relate to a specific soil or rock type and condition. Construction activity and environmental circumstances can materially change the condition of soil or rock. The elevation at which a soil or rock type occurs is variable. It is a requirement of this report that structural elements be founded in and/or upon geological materials of the type and in the condition assumed. Sufficient observations should be made by qualified geotechnical personnel during construction to assure that the soil and/or rock conditions assumed in this report in fact exist at the site.

12.0 SAMPLES

EBA will retain all soil and rock samples for 30 days after this report is issued. Further storage or transfer of samples can be made at the client's expense upon written request, otherwise samples will be discarded.

13.0 STANDARD OF CARE

Services performed by EBA for this report have been conducted in a manner consistent with the level of skill ordinarily exercised by members of the profession currently practising under similar conditions in the jurisdiction in which the services are provided. Engineering judgement has been applied in developing the conclusions and/or recommendations provided in this report. No warranty or guarantee, express or implied, is made concerning the test results, comments, recommendations, or any other portion of this report.

14.0 ENVIRONMENTAL AND REGULATORY ISSUES

Unless stipulated in the report, EBA has not been retained to investigate, address or consider and has not investigated, addressed or considered any environmental or regulatory issues associated with development on the subject site.

15.0 ALTERNATE REPORT FORMAT

Where EBA submits both electronic file and hard copy versions of reports, drawings and other project-related documents and deliverables (collectively termed EBA's instruments of professional service), the Client agrees that only the signed and sealed hard copy versions shall be considered final and legally binding. The hard copy versions submitted by EBA shall be the original documents for record and working purposes, and, in the event of a dispute or discrepancies, the hard copy versions shall govern over the electronic versions. Furthermore, the Client agrees and waives all future right of dispute that the original hard copy signed version archived by EBA shall be deemed to be the overall original for the Project.

The Client agrees that both electronic file and hard copy versions of EBA's instruments of professional service shall not, under any circumstances, no matter who owns or uses them, be altered by any party except EBA. The Client warrants that EBA's instruments of professional service will be used only and exactly as submitted by EBA.

The Client recognizes and agrees that electronic files submitted by EBA have been prepared and submitted using specific software and hardware systems. EBA makes no representation about the compatibility of these files with the Client's current or future software and hardware systems.