Esquimalt Lagoon Bridge
North Abutment Area
Storm Damage of January 2010

Prepared by:

Andrew Rushforth , P.Eng.
400 – 655 Tyee Road
Victoria, BC V9A 6X5
T: (250) 388-9161
F: (250) 382-0514

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1.0 INTRODUCTION

The north abutment of the Esquimalt Lagoon Bridge approach fills were exposed to wave action during storms and high winds of mid January 2010, causing erosion of fills that extended to the roadway elevation.

High tides during daylight hours delayed detailed investigation until January 25, 2010 onwards when the beach level became accessible in the late afternoon. The detailed inspection of this report was undertaken starting at 3:30 p.m. of January 26, 2010, with the ebbing tide height of 4 feet.

2.0 INVESTIGATION

The essentials of the investigation are shown on the attached series of noted photographs.

The winter storms have apparently lowered the level of the beach gravels in the vicinity of the north abutment by approximately 300 mm. This lowering of the beach line to below that of the timber framework retaining the backfill material, exposed this material to wave action and the resulting sluicing action washing the finer material from between the larger rocks. The erosion capability of waves in this situation is very high as it is not only the water itself that displaces material but also wave impact causes compression of trapped air in the void spaces with explosive force.

Removal of fines from between the larger rocks has occurred over the full extent of the abutment width and continued along the lagoon side for many metres. Measurements into the voids created show that penetration is at least up to 1900 mm (6 feet plus) as determined by a straight steel tape not meeting any obstruction. In reality the voids can be expected to extend much further than this, at least at the lower levels, into the backfill material.

The extent to which washout has extended vertically upwards toward the roadway asphalt surface has not been determined, but it can be seen to extend up some feet (there is sufficient space to insert a head into the space below the 4 x 12 boards and look up). It is known that in the area of the sidewalk (lagoon side of the abutment) this penetrated to the surface creating clefts up to 400 mm wide and extending under the sidewalk asphalt surface. The potential for similar damage to occur within the roadway width could not be determined. As a precaution, the bridge has been reduced to single lane operation along the seaward facing side.

We were informed that repairs to the approach fills directly behind the abutment were undertaken several years ago. At that time, measures were taken to prevent migration of fines between the larger rocks by a controlled gradation of the material, i.e. slowly reducing the size of the interstitial fill materials from course to finer as these were placed and, we understand, with the use of geotextile fabric as well. Some of this fabric is seen (at one spot between piles) to be retaining material at the beach level.

At the lagoon side, beyond the protection of the piled structure, this gradation is not apparent and with erosion of the beach elevation (and consequent displacement of the large rip-rap) has disappeared, resulting in washout of fines extending to the surface.

3.0 POTENTIAL FOR FURTHER DAMAGE

1. We are of the opinion that the piled structure is not at risk.
2. Further lowering of beach gravels is likely to occur and further displace the rip-rap. Different storm regimes could return beach gravels to the site, but as an ongoing trend we are informed ongoing erosion of the spit has been observed for a number of years.

Development of pot holes within the roadway width cannot be ruled out.

P1 - North Abutment Approach, Lagoon side. Beach gravel erosion (lowering) causing movement of rip-rap.

P2 - North Abutment Approach, Lagoon side, side view. 'X' shows cleft caused by loss of backfill fines into voids between rip-rap blocks.

P3 - North Abutment Approach, Lagoon side. Cleft in backfill fines at edge of pathway asphalt. Cleft approximately 400 mm wide.

P4 - North Abutment Approach, Lagoon side, side view. Shows cleft caused by loss of backfill fines into voids between rip-rap blocks.

P5 - North Abutment, Lagoon side. Showing (on left) large rip-rap and timber 4x12 cantilevering from behind piled abutment. Beach level has been eroded away causing rip-rap to move and promoting erosion of fines into voids.

P6 - 4x12 boards cantilevering from behind piled abutment and flexing up to 250 mm. One board split and not effective. *Note: Voids between rocks in shaded areas.*

P7 - North Abutment face. Shows beach gravel erosion to 250 mm below the lowest 4x12 boards, exposing large rip-rap behind with washout of the finer backfill material causing voids. *Note: 4x12 board on right side has dropped approximately 130 mm (it was probably placed on the old beach level and is not fastened to the back of the piles).*

P8 - North Abutment face. Close up at base of boards. Point A was penetrated by a steel tape (into voids) 1300 mm. Voids also extend up behind the boards towards the roadway surface.

P9 - North Abutment face. Close up at base of boards. Point B was penetrated by a steel tape (into voids) 1900 mm. Voids also extend up behind the boards towards the roadway surface.

P10 - North Abutment face - seaward side below edge of deck.

P11 - North Abutment - seaward side 'wing wall' planking cantilevering from behind pile line.

P12 - Close-up detail of P10 washout. Void behind penetrated to distance of 1300 mm. Beach gravel 300 mm below bottom of lowest board.

P13 - Close-up detail of P11 washout. Void behind penetrated to distance of 1000 mm. Beach gravel 430 mm below bottom of lowest board.

P14 - North Abutment - seaward side. General view of rip-rap beyond edge of wing wall boards.

P15 - Close-up view of lower part of P14. Shows rock with concrete layer above it. This indicates old beach level and extent of gravel erosion that has occurred from underneath.

P16 - Close-up view of rocks behind wing wall showing absence of fine material due to washout.

4.0 RESTORATION WORK

1. The extent of restoration work possible at this time is cost sensitive, with no money having been budgeted.
2. For safety, the bridge was restricted to one-way traffic on January 25/26, 2010 by the City of Colwood.
3. The ideal solution is to take such measures as will permanently fill all the voids in the backfill material and to protect the fills from any further erosion. As the expected life of the existing bridge is uncertain, the high cost of work involved in undertaking such a solution would need justification.
4. As a short to mid-term solution, the problems to be addressed are:
   a. Preventing potholes in the roadway or taking such measures as will mitigate them.
   b. Reducing the effects of further beach erosion and its consequences.

   These two measures cannot be considered in isolation.

For discussion, we suggest the following: (refer also to the attached Sketch #1)

4.a Preventing Potholes/Mitigation

Development of a pothole (or more accurately in this case - a sink hole, that is loss of material from below) would be rapid and create a hazard that is not easily visible to wheeled traffic. *Note that the roadway in this area does not have street lighting and a pothole could develop at night.*

We recommend the roadway immediately behind the abutment be covered with steel roadway plates.

4.b Beach Erosion Effects

Further beach erosion will exacerbate the existing problem, unless this beach erosion (which is a natural occurrence) can be mitigated.

In a new structure the solution would be to site the abutment away from tidal influences or set the bottom of the foundation below any future erosion level. With the existing structure a solution along these lines is not practical.

In the short term, we suggest that:

1. The rip-rap located at the lagoon end of the abutment be re-seated into the beach gravels, by 0.5 m, and all voids filled with graded angular rocks. The upper layer of fines (road base, etc.) being isolated from the rock below with a geotextile fabric.

2. Along the front of the pile structure a barrier could be created to prevent as far as is practical, the wave and sluicing action into the area behind the abutment. This is shown on the attached Sketch #1.

Prepared by:

Andrew Rushforth , P.Eng.
Principal, Structural Engineer

Reviewed by:

Alan Ghanam , P.Eng.
Senior Associate, Municipal Engineer

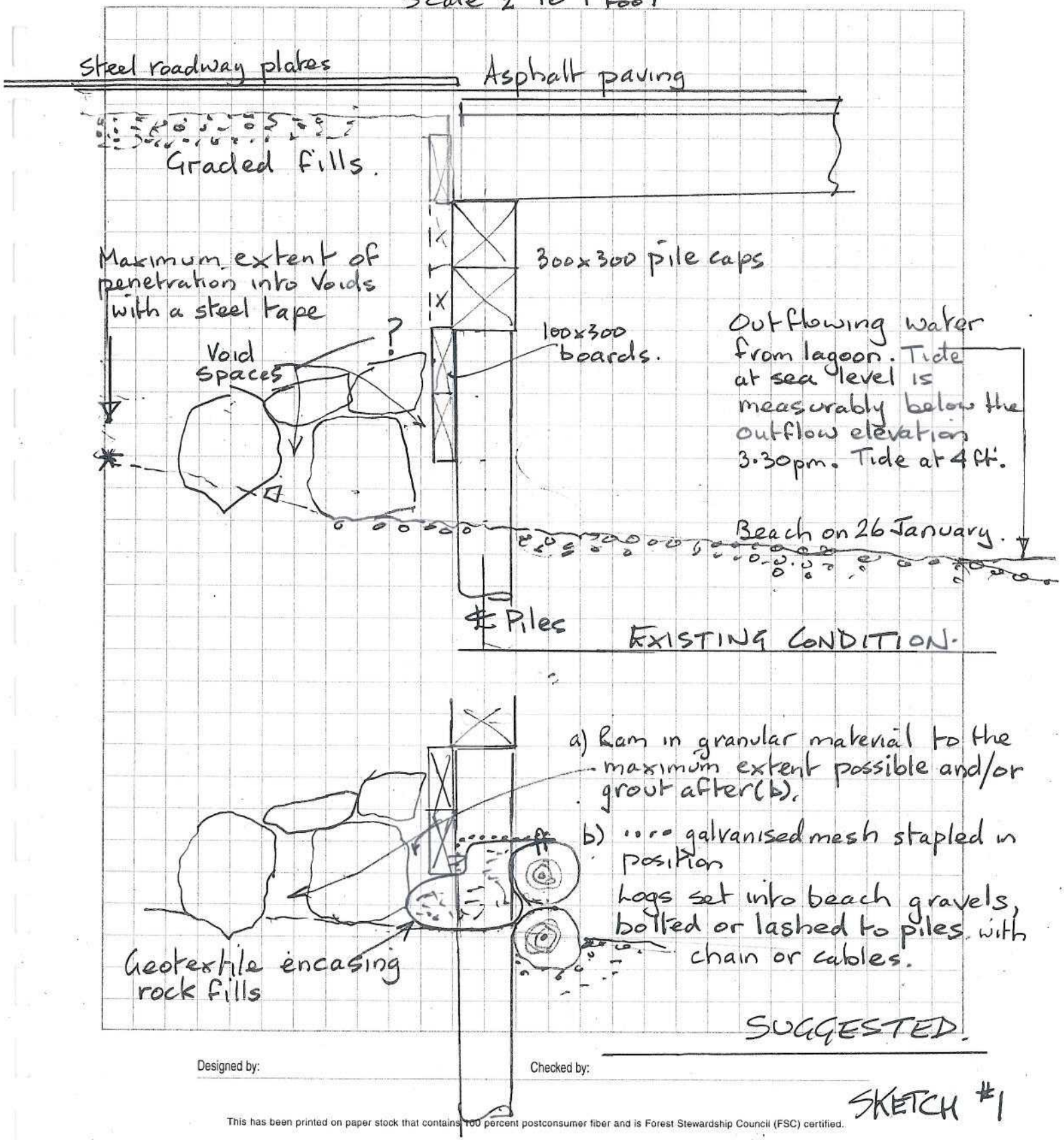
Stantec

JAN 2010.

ESQUIMALT LAGOON BRIDGE

ABUTMENT EROSION PROTECTION

Scale ½" to 1 FOOT



Designed by:

Checked by:

SKETCH #1

Capital Regional District Map

Legend

- Highways
- Major Roads
- Roads
- Major Lakes
- Lakes and Rivers
- CRD Boundary

0 22 44 66 88 m.

Scale: 1:1,908

Created: January 20, 2010

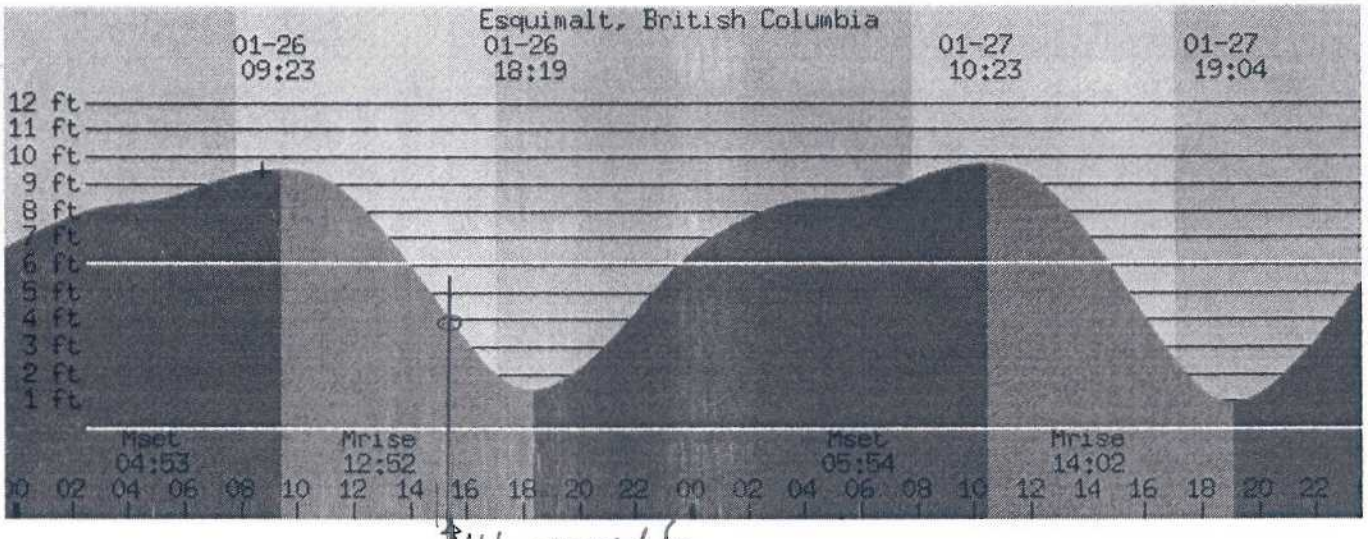
WWW Tide and Current Predictor

Pick a different site | Frequently Asked Questions

Web interface by Dean Pentcheff, calculations and graphics by David Flater's XTide Program

Esquimalt, British Columbia

26 January 2010 - 27 January 2010



Alt accessable.

If present, horizontal lines mark mean sea level and datum (usually mean lower low water). Colors under the curve indicate rising and falling tide (not ebb and flood currents).

Make Prediction Using Options

Prediction Options

Select a different site

Select display type

- ○ Tabular List (quickest)
- ○ Text Plot (Plot Type: ◉ Horizontal ○ Vertical) (more plot options below)
- ◉ Graphic Plot: size 640 by 240 pixels (more plot options below)