JOHNSON STREET BRIDGE

CONDITION REPORT

PREPARED FOR

CITY OF VICTORIA

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**APPENDICES**

- Inspection Notes
- Levelton Engineering Report
- Erection Drawings Numbers 1 and 3 for reference purposes
- Ultrasonic test results
- Photos
1.0 **TERMS OF REFERENCE**

The investigation is required to include a structural evaluation and protective coating assessment on the highway bridge and approach spans as follows:

**Structural Evaluation**

1. An assessment of the level of corrosion in members resulting in reduced structural capacity. This is to include a program of ultrasonic measurement.
2. Give a load rating for the bridge.
3. Investigate the condition of the counterweight.
4. Record significant levels of corrosion on marked up copies of the erection drawings.
5. Prepare recommendations on maintenance and repairs.
6. Give budget cost estimates and prioritization of the maintenance/repair work.

**Paint System Evaluation**

1. An assessment of the paint system including degree of active rusting, degree of paint breakdown, thickness and adhesion of existing paints.
2. An evaluation of current maintenance practices and practical life of the paint system.
3. Options and recommendations, including budget cost estimates to include, at a minimum, continued or upgraded maintenance and new coating systems.

2.0 **METHODOLOGY**

2.1 **Prime Consultant (Graeme & Murray Consultants Ltd.)**

1. The previous full inspection of the road bridge was undertaken by Graeme & Murray Consultants Ltd. in 1978 when a record of the level of corrosion for every member was made. Following this inspection a major restoration of both road and rail bridges was undertaken with many members being replaced, particularly on the railway bridge deck. The bridges were then painted the present blue by overcoating the previous black.

Files and drawings of this 1978 investigation were retrieved from archives in order to repeat a similar methodology and to compare the results.

2. The field investigation was carried out by a team of two staff members. The below deck steel and concrete was inspected from existing platforms and gantries, from the flanges of the east approach girders and by climbing the girders and bracing members where necessary. The upper portion of the bascule bridge was inspected from existing platforms and by climbing over the individual members. The main difficulty was the east approach span which does not have
a below deck gantry, however by climbing on to the bacing tees close to the
abutments a close up inspection of the upper beams was possible. Those close
to the abutments appeared to be representative of the general condition.

It was found that the ultrasonic investigation was of limited value. The
equipment was bulky and not easily moved into difficult places, however
measurements were taken at similar locations to those taken in 1978. The results
although very accurate are specific to a pinpoint location whereas visually it is
easily seen that conditions vary greatly in short distances. By far the most useful
tool is a small pick to remove the surface rust or laminations and then make a
visual assessment.

Much of the conditions have been photographed and "representative" photographs
have been chosen to illustrate the commentary.

3. The actual field notes are included in Appendix I to the report and give the level
of corrosion in a tabular manner referenced to the member designation given on
the erection drawings. To better describe the detailed observations summary
statements are made which correspond to specific recommendations for repair.

4. An analysis of certain affected elements was made where necessary in order to
prepare recommendations for repairs.

5. During the investigation it became obvious that severe corrosion of members
directly supporting the concrete deck would result in some form of load
restriction being required. This load restriction would have to be maintained
until replacement of the concrete deck and steel members below was undertaken.
Over time the load limit will have to be progressively reviewed and reduced as
corrosion continues.

6. The construction cost and prioritization has been made for the items of work
recommended.

7. The investigation did not include the electrical system and machinery, nor the
concrete piers and abutments.

2.2 Subconsultants (Levelton Engineering Ltd.)

A painting assessment has been made by Levelton Engineering Ltd. and their report is
included as Appendix 2. This has included the following:

1. History of the painting on the Johnson Street Bridge.

2. Research and discussion of environmental restrictions.

3. Recent developments in paint technology for bridges.

4. Discussion of cleaning and preparation options.

5. Discussion of total removal and repainting versus overcoating the existing paint.
6. Comparative cost estimates of different repainting options. No overall cost of implementing these was prepared as a policy discussion is required on future maintenance programs and or bridge replacement.

3.0 SUMMARY OBSERVATIONS

3.1 West Approach Span

1. The roadway surface is covered with a thin layer of asphalt. It has been worn through to the concrete deck slab over a small area at the east end. The longitudinal construction joints of the slab are reflected in the asphalt surface, mostly noticeably at the east end. The sidewalk surface on the south side and the curb on the north side are concrete which is in reasonable condition.

2. Dirt from the roadway penetrates the deck joints and deposits on the horizontal surfaces of angle bracing and beam flanges accelerating corrosion of these elements. (photo 1)

3. Water and chloride ingress into the structural concrete deck, particularly at construction joints is corroding the slab reinforcement and spalling the concrete in large sections from the soffit. (photo 2) Corrosion occurs extensively at the top flange of the upper transverse steel beams. (photo 3) The situation is typical throughout the west span. It must be emphasized that the construction joints are not solely the cause of corrosion. The members are exposed to airborne salt from proximity to the ocean.

4. Water and chloride ingress into the structural concrete deck occurs at the guardrail posts. The detail and problem is the same on both the north and south sides. Corrosion of the steel at the connection of the posts to the transverse steel beams is causing concrete spalling from the structural concrete deck. (photos 4 & 5) The problem is general, at most of the guardrail posts.

5. The west ends of the main girders above the baseplate have severe corrosion. (photo 6) A comparison to a photograph of the '78 Report indicates how much the situation has deteriorated in 20 years.

6. There is some minor seepage through the fixed construction joint over the west abutment at the south end. This may be to blame for the main girder corrosion at the ends.

7. Immediately below the concrete deck accumulation of the rusted metal (oxides) on the top flanges of the transverse beams have lifted the concrete resulting in additional stresses within the structural concrete deck and leaving parts of it unsupported. (photo 7)

8. The main girders, (with the exception of the ends over the bearing plates), the main transverse beams and stringers are only minimally or superficially corroded, i.e. the severe corrosion is confined to the upper transverse steel beams.
9. A more stringent program of preventive maintenance is required with regular removal of debris and dirt removal followed by paint touch-up.

3.2 East Approach Span

1. The driving surface is the structural concrete deck and there is no asphalt. There are longitudinal construction joints which are filled with bitumen. The sidewalk surface on the south side and the curb on the north side are concrete which is in reasonable condition.

2. As is the case with the west span the construction joints in the concrete slab are causing serious corrosion problems in the structural steel in the area below. (top flange of the upper transverse beams). The bituminous seal to the joints appears to be ineffective. (photos 8 and 9).

3. The deck beam adjacent to the joint in the deck at the west end is in a particularly serious condition because of its inaccessibility which makes it impossible to clean or paint. (photo 10).

4. The guard rail post detail explained and depicted for the west span is similar for this span also.

5. All four bearing locations have varying degrees of corrosion to the bearing stiffeners and at all locations there is at least one stiffener which is corroded through entirely where it connects to the baseplate. (photos 11 and 12) The south east anchor bolt at the east end is severely reduced in cross section.

6. Accumulation of the rusted metal (oxides) on the top flanges of the transverse beams have lifted the structural slab so that it is poorly supported at certain locations. (photos 13 and 14) and any exceptional wheel load could easily cause cracking of the slab.

7. There is serious corrosion in the angle bracing between the main girders at some locations. (photo 15)

8. The absence of an inspection gantry limits inspection (and maintenance) to areas close to the abutments.

9. The main girders, (with the exception of the ends over the bearing plates), the main transverse beams and stringers are only minimally or superficially corroded, i.e. the severe corrosion is confined to the upper transverse steel beams.

10. A more stringent program of preventive maintenance is required with regular removal of debris and dirt removal followed by paint touch-up.

3.3 Bascule Span

1. The driving surface is a riveted steel grid deck which was installed in 1966 and which replaced an original wood deck. It is in acceptable condition although rivets occasionally fail and it is the practice of the City to repair this by welding.
We would expect this welding to lead to local failures from fatigue stresses. The sidewalk is transverse wood boards on sleepers over three longitudinally spanning steel channels. The wood deck is in acceptable condition. The concrete curbs to the roadway have some minor spalling.

2. The steel deck is supported on transverse steel beams. These were also part of the retrofit when the steel deck was installed and do not date from the original construction. These transverse steel beams are still in good condition although considerable debris from the road has accumulated on them. (photo 16) The flanges are cleaned by washing but are difficult to clean adequately for painting.

3. The longitudinal stringers have light corrosion only.

4. The main transverse floor beams are constructed as built up riveted plate girders. There is a large buildup of debris from the roadway on the bottom flange which causes it to be constantly damp. Rivets which connect the plates and angles are seriously corroded at their heads. (photos 17 and 18).

5. Structural tees provide bracing between the main transverse floor beams and the bascule truss bottom chord. The connection is made through a large horizontal steel gusset plate. The gusset has been subjected to serious corrosion. The rivets connecting the tee were replaced with bolts in the '79 repairs. The gusset has thinned to an unacceptable degree. (photo 19).

6. The bottom chord of the bascule truss is comprised of longitudinal angles and side plates, linked by lattice flat bars. The bottom chord is only lightly corroded except for the locations where the floor beams and vertical truss members connect. Locally here the horizontal legs of the angles are thinned by heavy corrosion. The loss is estimated to be about 12% of the member. (photos 20 and 21).

7. One of the channels supporting the sidewalk has an unacceptable loss of section. (photo 22).

8. The double angle members of the cantilever brackets are thinned locally at the gusset connector plates. (photo 23).

9. Corrosion of the upper structure occurs more predominantly in the lighter members which are present for bracing and to ensure stability of the main bascule truss. The main truss members are only lightly corroded although photo 38 indicates one seriously deteriorated member.

3.4 Counterweight Span

1. The driving surface is a concrete slab which is of relatively recent construction and is presumed to have been constructed in 1966 as part of the work which removed the old wood deck. This concrete structure is in good condition. The sidewalk is timber similar to the bascule span except that the support structure extends for the operators hut. There is heavy corrosion of the channel sections in this area which have been strengthened in a rudimentary fashion. In two of the three channels the strengthening is ineffective. (photo 24).
2. Steel beams and stringers which support the concrete slab are in relatively better condition in the counterweight span than the other spans except for some local areas of moderate corrosion.

3. The lattice trusses, designated 11-16, 14-16, and 16-18 on both sides of the bridge are constructed of built up plates and angles and lacing flat bars. The legs of the angles are corroded at the lacing connections and flat bars themselves have corroded so that the end distance of the rivets (at some locations replacement with bolts and plates has been done) is too small. Horizontal projecting legs of the angles have considerable loss of section. Member 16-20 is a double 15 inch channel. Lattice flat bars join the two channels together. Where this member connects to the gusset, water has infiltrated into the joint and the web of the channel has corroded with the accumulated oxides distorting the large gusset plate connection. This is one of the most extensive areas of corrosion on the bridge. (photos 25, 26, 27 and 28).

4. At the bases of the main column members all anchor bolts are moderately corroded around their perimeter. These bolts are 2 1/4 inches in diameter and have lost up to 1/4 inches in some areas. The anchor bolts project about 2 feet 6 inches above the baseplate and have a stiffener on each side. In some locations this stiffener has rotted out completely just above the baseplate. (photo 29).

5. Corrosion of the upper structure occurs more predominantly in the lighter members which are present for bracing and stability of the main counterweight support frame. The main frame members are only lightly corroded except for the portal frame following.

6. A deep box truss about 13 feet in depth forms a portal between the two main towers. The box is comprised of a horizontal truss of two sets of double angles, lacing bars and gussets top and bottom as well as similar side members. All the angles of the horizontal truss are seriously corroded through the leg which is horizontal. (photos 30 and 31).

7. The heavy steel sections which are embedded into the concrete counterweights are corroded at the concrete interface. These locations were an area of concern during the '78 investigation and the concrete was chipped out and caulked with a sealant. Some careful probing with a pick was done for the current work. It is felt that there is no significant increase in corrosion at this location. The caulking has deteriorated in places. (photos 32, 33, 34 and 35).

8. The perimeter frames of the four counterweight cavities in the top are in poor condition and do not prevent water ingress. (photo 36).

9. There is a large concrete spall in the side of the N.W. cavity. (photo 37). Although water obviously enters the mass concrete which is cast around some very heavy steel sections there are no rust stains on the bottom and sides (where the water exits through cracks) which might indicate corrosion of these sections.

10. The toothed operating strut has some minor corroded locations.
11. One of the timber buffers is detached and missing.

4.0 RECOMMENDATIONS

4.1 West Approach Span

Two options are discussed and estimated for the West Approach Span. These are:

1. A cut and repair solution or
2. A partial replacement solution.

1. In the cut and repair solution the following is recommended

   1. Repair the construction joint in the concrete deck at the west end (fixed joint). Remove and reinstall the asphalt surface.

   2. Cut out sand blast and repair the spalls in the concrete deck soffit with a latex modified portland cement or polymer concrete shotcrete.

   3. Cut out the spalled sections of concrete and repair the lower portion of the guardrail posts to sound material (sandblasting if necessary) and paint. Reconstruct the guardrail connection and do a patch repair with a latex modified portland cement or polymer concrete.

   4. A new detail is recommended to be constructed at the west end of the main girders to compensate for the loss in section at the stiffeners, girder ends and anchor bolts.

   5. Clean and install a new protective coating system in accordance with the recommendations of Levelton Engineering Ltd.

   6. Place a load restriction on the bridge due to the corrosion and loss of capacity of the upper transverse beams. Pack the gap between the transverse beams and underside of concrete deck with epoxy mortar.

2. In the partial replacement solution the following is recommended.

   1. The main longitudinal girders, transverse girders and secondary longitudinal girders would be retained. These would be cleaned and a new protective coating installed in accordance with the recommendations of Levelton Engineering Ltd.

   2. The guardrails would be taken off, cleaned to bare metal, the lower part cut off and replaced, a new protective coating applied.
3. The structural concrete deck and upper transverse beams would be removed and discarded in two operations. To keep one lane of the bridge open a temporary precast concrete barrier would be constructed in the centre lane which would be moved to the newly poured section after it was constructed. The remaining section could then be constructed and the barrier removed.

4. Items in the cut and repair solution outside of the above scope would also be required.

4.2 East Approach Span

The two options discussed for the west approach span are equally applicable for this span.

1. A cut and repair solution or

2. A partial replacement solution.

In the cut and repair solution the following is recommended:

1. Some form of surface treatment to restrict water and chloride ingress into and through the concrete deck is recommended. A membrane and asphalt layer or a bonded concrete topping overlay is recommended. The asphalt option appears in the cost estimate section.

2. Cut out, sandblast and repair the spalls in the concrete deck soffit with a latex modified portland cement or polymer concrete shotcrete.

3. Cut out the spalled sections of concrete and repair the lower portion of the guardrail posts to sound material (sandblasting if necessary) and paint. Reconstruct the guardrail connection and do a patch repair with a latex modified portland cement or polymer concrete.

4. Replace the upper transverse beam adjacent to the joint at the west end. It would be necessary to cut the concrete deck to install this from above.

5. Drill and core through the existing baseplate and concrete abutment to install two new anchor bolts at the east end. Anchor bolts would be set in epoxy at a location close to the existing and would then supplement the originals.

6. Cut out the rotted portions of the main girder bearing stiffeners and weld in new material.

7. Clean and install a new protective coating system in accordance with the recommendations of Levelton Engineering Ltd.

8. Place a load restriction on the bridge due to the corrosion and loss of capacity of the upper transverse beams.

The partial replacement solution is identical to that for the west approach span.
4.3 Bascule Span

1. Although all the transverse plate girders, where badly corroded rivet heads are reported, are in similar condition which might require the replacement of some one thousand rivets it is recommended that only one floor beam be repaired to start with. The difficulty of punching out the rivets will be an indication of how well they are performing, in holding the section's together. This information would be useful for the database for other evaluations of the bridge.

2. The large horizontal gusset plate which connects the bracing tees between the main floor beams and the bottom chord of the bascule truss needs replacing.

3. The span was originally designed for 45 ton street cars or Coopers E50 railway loading. Using a lesser load of a vehicle of 17,500 kilograms G.V.W. as per the load restriction recommended the bottom chord is adequate. However, the thinning is local and repairable by cutting out and welding in new material. It is therefore recommended to cut out the thinned horizontal leg of the 4x4 angles at the floor beam connections and replace it.

4. One channel which supports the sidewalk needs to be replaced.

5. The lowest angle of four which comprises the box truss bracing element needs to be replaced at S12, L35, L52.

6. The bottom angle of the lattice truss at S1, and S2 needs to be replaced.

7. Clean and install a new protective coating system in accordance with the recommendations of Levelton Engineering Ltd.

4.4 Counterweight Span

1. Replace angles and flat bar lattices in members 11-16, 14-16, and 16-18. Member 16-20 is a channel box beam which requires repairing as below: as these members are part of the main truss, and are permanently loaded replacement would be required to be sequential and follow engineering procedure which would need to be evaluated.

The scope of work is briefly as follows:

North Side
11-16 Only 1 lattice requires replacement.
14-16 Replace all 4 angles and all the lattices.
16-18 This member does not need to be repaired.
16-20 Remove the channel for cleaning the interface to the large gusset. Straighten the gusset plate. Cut out one local section which has thinned and weld in a piece of new material.
Replace the channel.

South Side
11-16 Most of the lattices have already been replaced
14-16 Replace all 4 angles and all the lattices.
16-18 Replace all 4 angles and all the lattices.
16-20 Repare channel as per north side.

2. Cut out and replace the anchor bolt stiffeners as follows:
   N-E not required
   S-E Replace all on north face
   N-W Replace all
   S-W Replace on north face

3. The lowest angle of four which comprises a box truss bracing element needs to be replaced at L51 and 15-17 north.

4. Replace all horizontal angles (8) in the deep box truss portal which braces the two main towers. Inclined member L52 also needs to be replaced.

5. All the interface locations of steel and concrete counterweight need to be cleaned, in some cases of large accumulations of organic material. The cleaning could be done with high pressure water. Replace caulking where deteriorated, at locations where water could pond chip out and replace the concrete with a polymer concrete grout mix.

6. Replace the frames and covers of the four counterweight covers in the top. The bolted wooden cover on the north side which was dismantled for our inspection also needs to be replaced.

7. Reconstruct the timber buffer on the tracking beam.

8. Clean and install a new protective coating system in accordance with the recommendations of Levelton Engineering Ltd.

4.5 Load Restrictions

1. The cantilevered beams which have a corroded top flange have been checked and are still adequate for 100 pounds per square foot which is normal pedestrian loading. They would not be adequate if a large vehicle were to ride up and over the curb.

2. The sidewalk brackets are adequate for normal pedestrian loading.

3. Truss members of the bascule span are adequate except for the members 11-16, 14-16, and 16-18 and the large portal truss which need repair. The bascule bottom chord has a loss in section which effectively increases the stress in it from 15.6 to 17.8 kips per square inch. The ’78 report based on limited tests of the steelwork advises that more recent codes would give the structural steel an allowable strength of 20 kips per square inch. It could therefore be adequate, however because of the localised thinning a repair is recommended as above.

4. The concrete deck of the east and west approach spans are supported by transverse beams all with badly corroded top flanges. The condition of these flanges reduces their structural capacity. A load restriction of 17,500kg G.V.W is deemed advisable for this condition. This load is equivalent to that of a transit bus. Any heavy vehicle should be prohibited and directed to use the Point Ellice Bridge.
### 4.6 Construction Cost and Prioritization

**Option 1 - The cut and repair solution**

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**Option 2 - The partial replacement solution**

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**Clean and paint - not estimated**

**Engineering fees not estimated**

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**New Steel Inspection** Gantry under east fixed sponds and Replace Existing corroded rails on centre span

**Graeme & Murray Engineering Consultants Ltd**
5.0 EXECUTIVE SUMMARY

1. This report covers deterioration of the steelwork from rust over the past 20 years with the base line record being that of the 1978 report prepared by Graeme & Murray Consultants Ltd. That report was the basis for the major restoration work - which included much steelwork replacement (especially on the railway bridge) and the repainting of the bridge to the current blue colour. This present report is confined solely to deterioration of the roadway bridge superstructure steelwork. No work was undertaken on the concrete and electrical or mechanical systems.

2. The investigation work included a detailed inspection of most of the steelwork although access to certain areas was difficult. In particular the condition of the steelwork beams under the concrete deck of the east fixed spans had to be viewed from the sides as no access platform has been installed under this span to date.

Recommendations. Installation of this inspection gantry is recommended and this then would also be of use for maintenance work.

3. There are many areas where regular maintenance (i.e. cleaning and rust prevention) has not taken place. As a result corrosion has developed to such a stage where

a. A load restriction be imposed on traffic using the highway bridge. This is based on corrosion in the members immediately below the concrete deck and in the bottom of the bascule main trusses.

Recommendation. A load restriction limiting highway vehicles to 17500kg GVW be imposed. This limit will permit transit vehicles but nothing with heavier axles. (Axle limit 12000kg.)

b. Corrosion of numerous smaller members has occurred to such an extent that repairs are not worthwhile. These include such typical items as angle bracing members, gusset, counterweight match frames.

Recommendation. Severely corroded smaller members be replaced rather than repairs attempted.

4. The Concrete Decks Slabs and Transverse Steel Beams underneath both side spans are deteriorating and a serious maintenance problem. Water leaks through joints in the deck causing corrosion of the top flanges of the beams below (which are more than 50% gone) and in areas of the concrete reinforcement. Two options are presented for remedial work - either a short term patch and repair option or a more permanent deck and steel beam replacement solution.

5. Bascule and counterweight sections are generally in reasonable condition above the deck but are more deteriorated below where dirt and moisture can collect and where areas are relatively accessible for cleaning or painting. A few lighter steel sections are in need of replacement. Serious rusting is occurring in the areas at the base of the main towers, attacking both stiffeners and anchor bolts, and along lines of rivet heads of the main trussed frames and repairs are required.

Recommendation. Thorough cleaning is required, followed by repairs and repainting.
6. The Johnson Street Bridge is now nearly 80 years old which probably exceeds the life of most steel bridges in North America.

The exposure to air borne salt, the many locations which are virtually impossible to access for painting or cleaning and the areas where dirt can accumulate are all impediments to a long life. Rust prevention maintenance must be improved if the life of this bridge is to be extended for another 20 to 30 years. If this regular maintenance is neglected either the load capacity of the bridge will have to be progressively reduced - until it is eventually closed or a very expensive structural upgrade will be needed.

7. Budgets

Steelworks

We have estimated as best we can the cost of undertaking various repair operations. This has been done without consulting the steelwork trade. A more detailed cost estimating study should be undertaken once the City have reviewed their options.

8. Cost estimates for repairs to steelwork and concrete decks range between $372,000 and $804,000.

9. Painting

The Levelton report gives comparative costs for different processes. These have not been extended to areas of steelwork. Ramsay Painting Ltd., prior to this report indicated for the City Engineers budget use that $1.0m would be appropriate.

Recommendations. A separate cost study be done to evaluate options probably based on a maintenance program.

Report prepared by:

D.J. Tansley, P.Eng.

and

A.J. Rushforth, P.Eng.
### City Of Victoria
#### Johnson Street Bridge
#### Inspection Notes
#### WEST APPROACH SPAN

Note: Underside of span is accessible by gantry for the full width and length.

<table>
<thead>
<tr>
<th>Description</th>
<th>Reference Number</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deck Beams</td>
<td>B9 (P 1 to P5)</td>
<td>Heavy corrosion on upper flange at south end extending up to 3m north of Girder. 30 to 50% loss. Heavy corrosion on upper flange also at north end extending 0.5m south of girder. 30 to 50% loss. Moderate corrosion on top flange between Girders at construction joints in concrete deck. 20 to 40% loss. Noted concrete deck is not supported on Deck Beams at some locations under sidewalks, 15mm gaps. Also noted areas of concrete deck spalling with exposed rebar protruding.</td>
</tr>
<tr>
<td>Deck Beams</td>
<td>B10 (P1 to P5)</td>
<td>Similar to B9 except corrosion worse at north and south ends as handrail posts pass through the concrete deck and are attached to the Deck Beam allowing water seepage. 50 to 75% loss of top flange section and 50 to 75% loss of handrail post connection. Severe concrete spalling also noted in these areas.</td>
</tr>
<tr>
<td>Deck Beam</td>
<td>B12 (P1)</td>
<td>As beam is located adjacent to deck joint, there is heavy corrosion in entire section over the full length. 25 to 50% loss. Surface corrosion.</td>
</tr>
<tr>
<td>Floor Beam</td>
<td>FB 1 (P5)</td>
<td>Light corrosion in top and bottom flange at construction joints in concrete deck. 5% loss. Otherwise surface rust only. Surface corrosion.</td>
</tr>
<tr>
<td>Floor Beam</td>
<td>FB 2 (P5/4)</td>
<td>Light corrosion in top and bottom flange at construction joints in concrete deck. 5% loss. Otherwise surface rust only. Light corrosion in top and bottom flange at construction joints in concrete deck. 5% loss. Otherwise surface rust only.</td>
</tr>
<tr>
<td>Floor Beam</td>
<td>FB 3 (P4/3)</td>
<td>Light corrosion in top and bottom flange at construction joints in concrete deck. 5% loss. Otherwise surface rust only. Light corrosion in top and bottom flange at construction joints in concrete deck. 5% loss. Otherwise surface rust only.</td>
</tr>
<tr>
<td>Floor Beam</td>
<td>FB 3X (P2/3)</td>
<td>Light corrosion in top and bottom flange at construction joints in concrete deck. 5% loss. Otherwise surface rust only. Light corrosion in top and bottom flange at construction joints in concrete deck. 5% loss. Otherwise surface rust only.</td>
</tr>
<tr>
<td>Floor Beam</td>
<td>FB 2 (P2/1)</td>
<td>Light corrosion in top and bottom flange at construction joints in concrete deck. 5% loss. Otherwise surface rust only. Light corrosion in top and bottom flange at construction joints in concrete deck. 5% loss. Otherwise surface rust only.</td>
</tr>
<tr>
<td>Cross Brace Angles</td>
<td>L2L &amp; L2R (P5)</td>
<td>Light to moderate corrosion on angle at construction joints in concrete deck. 10 to 20% loss. Gusset plate at FB 2 has moderate corrosion, 15% loss. Surface corrosion.</td>
</tr>
<tr>
<td>Cross Brace Angles</td>
<td>L1L &amp; L1R (P4)</td>
<td>Light to moderate corrosion on angle at construction joints in concrete deck. 10 to 20% loss. Gusset plate at FB 2 has moderate corrosion, 15% loss. Surface corrosion.</td>
</tr>
<tr>
<td>Cross Brace Angles</td>
<td>L3, L4 &amp; L5 (P3)</td>
<td>Light to moderate corrosion on angle at construction joints in concrete deck. 10 to 20% loss. Gusset plate at FB 2 has moderate corrosion, 15% loss. Surface corrosion.</td>
</tr>
<tr>
<td>Cross Brace Angles</td>
<td>L1L &amp; L1R (P2)</td>
<td>Light to moderate corrosion on angle at construction joints in concrete deck. 10 to 20% loss. Gusset plate at FB 2 has moderate corrosion, 15% loss. Surface corrosion.</td>
</tr>
<tr>
<td>Stringers</td>
<td>S3 to S7, S13 (P1 to P5)</td>
<td>Mostly light surface corrosion on tops of flanges. P7 has slightly heavier areas of corrosion.</td>
</tr>
<tr>
<td>Girder</td>
<td>G1 (P1 to P5)</td>
<td>Spots of surface corrosion over entire length. Rivet heads have deteriorated in some locations. Vertical embedded plate at West end has 75% loss of section.</td>
</tr>
<tr>
<td>Girder</td>
<td>G2 (P1 to P5)</td>
<td>Spots of surface corrosion over entire length. Moderate rust in top of bottom flange at 6m from West bearing. 5-10% loss. Top flange rivet heads have deteriorated in some locations. Heavy corrosion areas at West bearing. 75-100% loss in bottom 300mm of flange including vertical stiffeners. Bottom flange also corroded this area. Moderate corrosion in anchor bolts. 10 to 20% loss. Vertical embedded plate at girder ends has 75% loss of section. East bearing similar except moderate loss of section. These areas susceptible to soil debris buildup.</td>
</tr>
<tr>
<td>North-West Bearing</td>
<td>West end of G1</td>
<td>Light corrosion at bearing stiffeners. Slightly heavier on South face but does not require remedial work. Anchor bolts (North face) have heavy corrosion. Remedial work may be required. Bearing area susceptible to soil buildup.</td>
</tr>
<tr>
<td>South-West Bearing</td>
<td>West end of G2</td>
<td>Light corrosion at bearing stiffeners. Slightly heavier on South face but does not require remedial work. Horizontal angle over bearing plate has moderate corrosion on North face. Bearing area susceptible to soil buildup. Moderate corrosion in Anchor bolts. 4&quot; Corrosion hole has formed in web at very end of Girder.</td>
</tr>
<tr>
<td>North-East Bearing</td>
<td>East end of G1</td>
<td>No corrosion on South face. Light corrosion on North face. Heavy corrosion in Anchor bolts. May require remedial work.</td>
</tr>
<tr>
<td>North-West Bearing</td>
<td>East end of G2</td>
<td>North face - 50% loss in Westmost stiffener at base. Light corrosion on Anchor bolts. Horizontal angle over bearing plate has moderate corrosion. South face - Light areas of surface corrosion.</td>
</tr>
</tbody>
</table>

Reference number in brackets (P##) refers to panel location. See reference drawings for identifications of panels.
**City Of Victoria**  
**Johnson Street Bridge**  
**Inspection Notes**  
**EAST APPROACH SPAN**

Note: Underside of span only accessible from Girders. No gantry is in place.

<table>
<thead>
<tr>
<th>Description</th>
<th>Reference Number</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deck Beams</td>
<td>B15 &amp; B16 (P1 to PB)</td>
<td>As beam is located adjacent to deck joint, there is heavy corrosion in entire section over the full length. 25% to 50% loss. Support members (B1 to B5) also moderately corroded at support point to Deck Beams.</td>
</tr>
<tr>
<td>Deck Beams</td>
<td>B17 to BS7 (P1 to PB)</td>
<td>Moderate to heavy corrosion on upper flange over entire length of section. 10% to 50% loss. Corrosion more significant at north and south ends at handrail post connection (every 3rd beam). 50% to 75% loss of top flange section and 50% to 75% loss of handrail post connection. Noted numerous areas of concrete spalling and exposed rebar, particularly at handrail posts. Moderate to heavy corrosion also noted in bottom flanges at construction joints in concrete deck. Significant staining and dirt buildup/fungal growth in these areas.</td>
</tr>
<tr>
<td>Deck Beam</td>
<td>BS8 (P1)</td>
<td>Appears to be a newly installed beam. Prime painted.</td>
</tr>
<tr>
<td>Floor Beam</td>
<td>FB5 (P8)</td>
<td>Moderate corrosion on top flange. As beam is adjacent to deck joint, area is susceptible to dirt/debris buildup. Light to moderate corrosion patches on remaining section.</td>
</tr>
<tr>
<td>Floor Beams</td>
<td>FB6 to FB11 (P1 to PB)</td>
<td>Moderate corrosion on top and bottom flange at construction joints in concrete deck. Significant staining and dirt buildup/fungal growth in these areas. Area not accessible for ultra sound testing.</td>
</tr>
<tr>
<td>Cross Brace Angles</td>
<td>L7 (P8)</td>
<td>Heavy corrosion near to connection to gusset plate on Girder G4. 150 x 50mm hole has corroded through. Otherwise moderate corrosion at construction joints in deck. Dirt buildup on bottom flange of angle in these areas. Angle requires replacement.</td>
</tr>
<tr>
<td>Cross Brace Angles</td>
<td>L6L, L6R, L7 (P1 to PB)</td>
<td>Surface rust patches. Moderate corrosion at construction joints in deck. Dirt buildup on bottom flange of angle in these areas. Gusset plates have light rust typical.</td>
</tr>
<tr>
<td>Stringers</td>
<td>S10R, S10L, S2X, S2 (P1 to PB)</td>
<td>Light to moderate corrosion in the top flange over the entire length. In areas where parallel running concrete deck construction joints are directly over beams, the corrosion is heavier with corrosion also occurring in top of bottom flange. These areas also have dirt buildup/fungal growth on top and bottom flange. Panel 7 appears to be the most corroded. Areas not accessible for ultrasonic testing.</td>
</tr>
<tr>
<td>Stringers</td>
<td>S12R, S12L, S1, S8, S11, S9, S12R (P1 to PB)</td>
<td>Areas of light corrosion.</td>
</tr>
<tr>
<td>Girder</td>
<td>G3 (P1 to P8)</td>
<td>Spots of surface corrosion over entire length. Moderate corrosion areas at West bearing location. 10-25% loss in bottom 100mm of flange including vertical stiffeners. Rivet heads in this area also corroded. Heavy corrosion areas at East bearing location. 50% to 75% loss in bottom 150mm of flange including vertical stiffeners. Rivet heads also corroded. Moderate corrosion in anchor bolts. 25% to 40% loss. East bearing susceptible to soil/debris buildup.</td>
</tr>
</tbody>
</table>
| Girder           | G4 (P1 to P8)    | Spots of surface corrosion over entire length. 
Appears to be double bearing assembly. Possibly added to original. South face - Light corrosion on stiffeners. Diagonal brace has been replaced. Moderate surface corrosion around the bearing plates. Does not require remedial work. North face - 100% loss in section in Eastmost stiffener. Requires remedial work. Moderate corrosion in remaining 2 stiffeners. 40% loss in anchor bolts. Horizontal angle over bearing plate has moderate corrosion. Lower bearing assembly has corroded top surface of lower plate. (separate layer?) Lower fingers on bottom plate have moderate corrosion on North side. |
| North-East Bearing | East end of G3 | Appears to be double bearing assembly. Possibly added to original. South face - stiffener necked at bearing end. Horizontal angle over bearing plate sounds hollow between stiffeners. Light corrosion anchor bolts. North face - Eastmost stiffener corroded 100% at bottom. Remaining 2 stiffeners OK. Surface corrosion around the bearing plates. |
| South-East Bearing | East end of G4 | Appears to be double bearing assembly. Possibly added to original. South face - stiffener necked at bearing end. Horizontal angle over bearing plate sounds hollow between stiffeners. Light corrosion anchor bolts. North face - Eastmost stiffener corroded 100% at bottom. Remaining 2 stiffeners OK. Surface corrosion around the bearing plates. |
| North-West Bearing | West end of G3 | 100% loss in Eastmost Stiffener at base on North side of Girder. 1/8" loss in centre Stiffener at base. Light corrosion in Westmost Stiffener. 60% loss in Anchor bolts. |
| South-West Bearing | West end of G4 | Light corrosion on stiffeners. Light corrosion in Anchor bolts. |

Reference number in brackets (P#) refers to panel location. See reference drawings for identification of panels.
# City Of Victoria

**Johnson Street Bridge**

**Inspection Notes**

**COUNTERWEIGHT SPAN**

Note: Underside of span only accessible from Girders/Concrete Portal. No gantry is in place.

<table>
<thead>
<tr>
<th>Description</th>
<th>Reference Number</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stringers</td>
<td>S series (P1 to P2)</td>
<td>Spots of surface corrosion. Top flanges on north and south most beams have moderately corroded edges.</td>
</tr>
<tr>
<td>Cross Braces</td>
<td>L17, L19, L20 (P1 to P2)</td>
<td>Not original members. Newer &quot;I&quot; sections have been installed. Light surface rust.</td>
</tr>
<tr>
<td>Floor Beam</td>
<td>FB1(P2)</td>
<td>Heavy corrosion on top flange of cantilevered Stringers on West side of Floor Beam. 20 to 50% loss. Lighter corrosion on bottom flange also in these areas. Dirt buildup and staining in these areas. Otherwise light surface patches over entire length of member.</td>
</tr>
<tr>
<td>Floor Beam</td>
<td>FB3 (P1/2)</td>
<td>Moderate to heavy corrosion areas at Cross Brace connection gussets. 100mm diameter holes have formed in gusset at north side. 30% loss in bottom flange of Floor Beam at south side Cross Brace connection.</td>
</tr>
<tr>
<td>Floor Beam</td>
<td>FB2 (P1)</td>
<td>Moderate corrosion at each end. Rivet heads deteriorated also in these areas.</td>
</tr>
<tr>
<td>Lattice Truss Member <em>south side</em></td>
<td>16-18 (P1)</td>
<td>Heavy corrosion areas. Loss in lattices - 50 to 70%. Some lattices appear not to be original members. Top and bottom angles connecting lattices are heavily corroded. Up to 90% loss of section. Edge distance to lattice connection rivet/bolt minimal. Light corrosion patches on channel members. Horizontal gusset plates at ends have moderate to heavy corrosion. Rivet heads deteriorated in these areas. Vertical gusset plates have light corrosion patches. Inside face of both interior and exterior channels has 20-30% loss in section. A gap has formed which allows water to seep in which caused the corrosion.</td>
</tr>
<tr>
<td>Lattice Truss Member <em>south side</em></td>
<td>16-20A (P1)</td>
<td>Similar to member 16-18.</td>
</tr>
<tr>
<td>Lattice Truss Member <em>south side</em></td>
<td>14-16 (P2)</td>
<td>Horizontal leg of middle angle has 50% loss in section. Lattices appear to have been replaced in middle area. Lower lattices have 50% average loss in section. Horizontal leg of lower angle has 50% loss of section.</td>
</tr>
<tr>
<td>Lattice Truss Member <em>south side</em></td>
<td>11-16 (P2)</td>
<td>Gusset plate at node 11 has corrosion hole. Top lattices have been replaced at node 11 end. Otherwise OK.</td>
</tr>
<tr>
<td>Lattice Truss Member <em>north side</em></td>
<td>16-18 (P1)</td>
<td>Heavy corrosion areas. Loss in lattices - 50 to 70%. Some lattices appear not to be original members. Top and bottom angles connecting lattices are heavily corroded. Up to 90% loss of section. Edge distance to lattice connection rivet/bolt minimal. Light corrosion patches on channel members with heavier corrosion on inside on channels at ends. Horizontal gusset plates have moderate corrosion with some rivet head deterioration. Vertical gusset plates have light corrosion patches.</td>
</tr>
<tr>
<td>Lattice Truss Member <em>north side</em></td>
<td>16-20A (P1)</td>
<td>Light corrosion typical in all members. New plate has been installed to replace lattices at node 16. Bottom flanges necked at bolted cover plate. 70% loss in section.</td>
</tr>
<tr>
<td>Lattice Truss Member <em>north side</em></td>
<td>14-16 (P2)</td>
<td>All lattices heavily corroded in areas. Up to 90% loss of section. All require replacement. Heavy corrosion also in connecting angles as per south side.</td>
</tr>
<tr>
<td>Lattice Truss Member <em>north side</em></td>
<td>11-16 (P2)</td>
<td>1 lattices requires replacement. Otherwise surface corrosion only.</td>
</tr>
<tr>
<td>North-East Bearing</td>
<td></td>
<td>South Face - 1/8&quot; loss in 2 1/2&quot; diam. Eastmost Anchor bolt. West Anchor bolt has surface corrosion only. Moderate corrosion in stiffeners. North Face - 1/4&quot; loss in both 2 1/2&quot; diam. Anchor bolts. Light corrosion in stiffeners.</td>
</tr>
<tr>
<td>South-East Bearing</td>
<td></td>
<td>North Face - 3/16&quot; loss in 2 1/2&quot; diam. Anchor bolts. All stiffeners require strengthening this face. South Face - 1/8&quot; loss in both 2 1/2&quot; diam. Anchor bolts. Light corrosion in stiffeners.</td>
</tr>
<tr>
<td>North-West Bearing</td>
<td></td>
<td>North Face - East stiffeners around Anchor bolts require strengthening. 1/8&quot; loss in Eastmost Anchor bolt. West stiffener and Anchor bolt OK. South Face - 50% loss in stiffeners at base. Requires strengthening. Anchors bolts have 1/8&quot; loss typ.</td>
</tr>
<tr>
<td>South-West Bearing</td>
<td></td>
<td>North Face - Similar to North Girdor South face. South Face - Light corrosion in stiffeners. 3/16&quot; loss in Anchor bolts.</td>
</tr>
</tbody>
</table>

Reference number in brackets (P#) refers to panel location. See reference drawings for identifications of panels.
### City of Victoria
### Johnson Street Bridge
### Inspection Notes
### BASCULE SPAN - BELOW DECK

Note: Underside of span is accessible by gantry for the full width and length.

<table>
<thead>
<tr>
<th>Description</th>
<th>Reference Number</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deck Beams</td>
<td>(not referenced)</td>
<td>Channel sections running perpendicular to bridge span located directly under the deck. Light corrosion spots only.</td>
</tr>
<tr>
<td>Stringers (north &amp; south)</td>
<td>S16, S17, S20 (P1 to P6)</td>
<td>Concrete curbs are supported off these girders. Light to moderate corrosion or top flange, 5 to 10% loss. Otherwise surface patches only. Spalling of concrete curb in areas.</td>
</tr>
<tr>
<td>Stringers</td>
<td>S10, S15, S26 (P1)</td>
<td>Light top flange corrosion. Otherwise surface corrosion patches.</td>
</tr>
<tr>
<td>Stringers</td>
<td>S6, S7, S25 (P2)</td>
<td>Light top flange corrosion. Otherwise surface corrosion patches.</td>
</tr>
<tr>
<td>Stringers</td>
<td>S6, S7, S25 (P3)</td>
<td>Light top flange corrosion. Light corrosion at connection to Floor Beam FB5 (west).</td>
</tr>
<tr>
<td>Stringers</td>
<td>S6, S7, S25 (P4)</td>
<td>Light top flange corrosion. Otherwise surface corrosion patches.</td>
</tr>
<tr>
<td>Cross Brace</td>
<td>L14, L15, L16 (P1)</td>
<td>Surface rust patches over length of section. Light to moderate rust on center gusset.</td>
</tr>
<tr>
<td>Cross Brace</td>
<td>L14, L15, L16 (P2)</td>
<td>Surface rust patches over length of section.</td>
</tr>
<tr>
<td>Cross Brace</td>
<td>L14, L15, L16 (P3)</td>
<td>Surface rust patches over length of section. Moderate rust on center gusset.</td>
</tr>
<tr>
<td>Cross Brace</td>
<td>L14, L15, L16 (P4)</td>
<td>Surface rust patches over length of section.</td>
</tr>
<tr>
<td>Cross Brace</td>
<td>L14, L15, L16 (P5)</td>
<td>Surface rust patches over length of section.</td>
</tr>
<tr>
<td>Cross Brace</td>
<td>L14, L15, L16 (P6)</td>
<td>Surface rust patches over length of section.</td>
</tr>
<tr>
<td>Floor Beam</td>
<td>FB5 (P1)</td>
<td>Light to moderate corrosion on bottom flange on west side. Heavy at cross brace angle gussets. Heavy deterioration of rivet heads along entire length. Susceptible to soil/debris buildup on bottom flange. Corroded braces on East side of beam have moderate corrosion on top flange.</td>
</tr>
<tr>
<td>Floor Beam</td>
<td>FB8 (P1/2)</td>
<td>Light to moderate corrosion on bottom flange on west side. Heavy at cross brace angle gussets. Heavy deterioration of rivet heads at cross brace angle gusset and periodically along west side on bottom flange. Debris buildup on bottom flange.</td>
</tr>
<tr>
<td>Floor Beam</td>
<td>FB6 (P2/3)</td>
<td>Light to moderate corrosion on bottom flange on west side. Heavy at cross brace angle gusset. Heavy deterioration of rivet heads at cross brace angle gusset and periodically along west side on bottom flange. Debris buildup on bottom flange.</td>
</tr>
<tr>
<td>Floor Beam</td>
<td>FB6 (P3/4)</td>
<td>Light to moderate corrosion on bottom flange on west side. Heavy at cross brace angle gussets. Heavy deterioration of rivet heads at cross brace angle gussets and periodically along west side on bottom flange. Debris buildup on bottom flange.</td>
</tr>
<tr>
<td>Floor Beam</td>
<td>FB6 (P4/5)</td>
<td>Moderate corrosion on bottom flange on west side. Heavy at cross brace angle gussets. Heavy deterioration of rivet heads also on west side on bottom flange. Debris buildup on bottom flange.</td>
</tr>
<tr>
<td>Floor Beam</td>
<td>FB7 (P5/6)</td>
<td>Light to moderate corrosion on bottom flange on west side. Heavy at cross brace angle gussets. Heavy deterioration of rivet heads at cross brace angle gussets and periodically along west side on bottom flange. Debris buildup on bottom flange.</td>
</tr>
<tr>
<td>Lattice Truss Member (north and south)</td>
<td>0-12 (P1 to P6)</td>
<td>Heavy corrosion areas at connection to floor beams typical. Lattice members are lightly corroded. Top and bottom angles connecting lattices are heavily corroded in areas. Light corrosion patches on channel members with heavy corrosion at connections to floor beams. Horizontal gusset plates at ends have moderate to heavy corrosion. Rivet heads have deteriorated in these areas. Vertical gusset plates have light corrosion patches.</td>
</tr>
<tr>
<td>Sidewalk Stringers</td>
<td>S29 to S37 (P1 to P6)</td>
<td>Light to moderate rust over entire length of member. 50% loss of top flange at mid span in Panel No. 4.</td>
</tr>
<tr>
<td>Sidewalk Supports</td>
<td>B1 to B4, B8, B9, B11 (P1 to P6)</td>
<td>Light to moderate rust mainly on double top angles. Support B1 has 70% gone in Eastmost of double top angle. 10% in adjacent.</td>
</tr>
<tr>
<td>Operator's Shed</td>
<td></td>
<td>Support channels under operator's shed have areas of moderate to heavy corrosion. Appears new short lengths of angle have been welded to flanges and webs at areas of heavy corrosion to support wood decking in these areas. Channels S301X and S30R have areas of 100% loss in top flange. Channel S38 has areas of 50% loss in top flange but remedial strengthening with angle has been undertaken - no extra strengthening required in this channel.</td>
</tr>
</tbody>
</table>

Reference number in brackets ( P#) refers to panel location. See reference drawings for identification of panels.
<table>
<thead>
<tr>
<th>Description</th>
<th>Reference Number</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>15-17 (north)</td>
<td>50% loss of material at center gusset.</td>
<td></td>
</tr>
<tr>
<td>17-19 (north)</td>
<td>Areas of surface corrosion.</td>
<td></td>
</tr>
<tr>
<td>15'-19' (north)</td>
<td>Areas of surface corrosion.</td>
<td></td>
</tr>
<tr>
<td>17'-15' (north)</td>
<td>Areas of surface corrosion.</td>
<td></td>
</tr>
<tr>
<td>15'-19' (south)</td>
<td>Areas of 1/8&quot; loss of section.</td>
<td></td>
</tr>
<tr>
<td>15-17 (south)</td>
<td>Areas of 1/8&quot; loss of section.</td>
<td></td>
</tr>
<tr>
<td>17-19 (south)</td>
<td>Areas of 1/8&quot; loss of section.</td>
<td></td>
</tr>
<tr>
<td>15'-19' (south)</td>
<td>Areas of 1/8&quot; loss of section.</td>
<td></td>
</tr>
<tr>
<td>17'-15' (south)</td>
<td>Areas of 1/8&quot; loss of section.</td>
<td></td>
</tr>
<tr>
<td>14-19 (south)</td>
<td>1/8&quot; loss in areas in flanges of channels at top hinge location. Angles holding interior plate have 1/8&quot; loss in areas. Also noted wooden &quot;bumper&quot; blocks on South side are not in place at North side locations.</td>
<td></td>
</tr>
</tbody>
</table>

Reference number in brackets (P#) refers to panel location. See reference drawings for identifications of panels.
February 10, 1998
File: 297-1465

Graeme & Murray Consultants Ltd.
1137 Yates Street
Victoria, B.C.
V8V 3N1

Attention: Mr. Andrew Rushforth, P.Eng.

Dear Sirs:

RE: Johnson Street Bridge Painting

Please find enclosed a disk copy and paper copy of our portion of the report for the bridge.

If you have any questions, please contact me. I will be in Victoria next week for the NACE conference and could meet with you and the City, if need be.

Yours sincerely,

LEVELTON ENGINEERING LTD.

[Signature]

M.J. Magee, P.Eng.

Direct Line: 207-5107

Attachment:
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City of Victoria  
Johnson Street Bascule Bridge and Side Spans  
Maintenance Painting

1.0 HISTORY OF JOHNSON STREET BRIDGE PAINTING

The Johnson Street bridge was constructed in 1922 and painted with a black linseed oil type of paint. This was a commonly used type of paint for bridges in the early 20th century, particularly riveted steel railway bridges.

The system consisted of a red lead linseed oil primer topcoated with one or more linseed oil-graphite topcoats. Surface preparation was usually minimal. Abrasive blast cleaning was not employed, hence mill scale was allowed to remain on the steel. The system was usually brush-applied and would thoroughly wet the steel surface. The ability of the primer to wet the surface, improved the adhesion of the paint to the minimally prepared surface. The addition of red lead in the primer, offered some corrosion resistance to the steel. The graphite in the topcoat improved the water resistance of the paint, with its flake structure protecting the linseed oil from weathering.

Maintenance painting was performed on the bridge to maintain the paint after 1922, however it tended to be non-uniform in nature with easily accessible areas receiving the most attention. Locations of difficult access were not maintained resulting in extensive corrosion.

The bridge was repainted with the existing blue-coloured alkyd paint system in 1979 as part of an overall maintenance program that involved steelwork repairs.

In areas where the existing black linseed oil paint were intact, records indicate that the existing paint was power washed to remove loose rust, dirt, grease and other debris and then overcoated by both brush and spray, with the alkyd system. The coating system consisted of the following:

- Alkyd red oxide zinc chromate or basic lead silico chromate primer.
- Two, alkyd marine enamel topcoats.

Areas of bare steel were either power tool cleaned to SSPC-SP3 or Commercially sandblasted to SSPC-SP6 after the power washing. These areas were then spot-primed with one coat of the aforementioned primer followed by the two alkyd topcoats.

Metallizing was used on some of the cross beams and girders below the deck. The steel was sandblasted to a Near-White finish SSPC-SP10 prior to metallizing with zinc and applying a vinyl sealer.

Since 1979, the City of Victoria has used their own crews to maintain the paint on the bridge. This has consisted of degreasing existing steel with a water soluble cleaner, rinsing, then power tool cleaning steel to an SSPC-SP3 finish in accessible locations where the paint has deteriorated, followed by the application of a slow drying, red oxide alkyd primer and two marine enamel alkyd topcoats. Debris and wash water are collected by vacuum adapters on power tools and contained by tarps.

New steel that has been added to the bridge by the City is degreased with a water based degreaser then power tool cleaned to an SSPC-SP11 finish. The steel is then solvent cleaned and an epoxy coating system is applied.
2.0 PRESENT DAY ENVIRONMENTAL RESTRICTIONS

In the last twenty years, bridge painting has changed dramatically in North America and elsewhere in the world. The primary reason is more stringent environmental regulations. As recent as ten years ago, contractors were still sandblasting bridge steel with little or no containment for the waste sand and paint debris. Tarps were deployed on the bridges but really they served little purpose other than giving the appearance that the waste material was being retained.

Since that time, the regulations in the Province of British Columbia have become much more stringent partially because of the public awareness generated by the cleanup of the contaminated soils on the Expo 86 lands. Bridge painting that was once a primary source of income for many painting contractors, has all but ended in the province. The Ministry of Transportation and Highways (MOTH) has not tendered any major bridge painting contracts for at least five years, primarily because of the environmental regulations and the resultant increase in cost to clean and paint a bridge.

To clean and paint any bridge in the province including the Johnson Street bridge, one must abide by the following regulations:

- Federal Government Fisheries Act - Sections 35 and 36 of the Act govern any activities involving fish or fish habitat. Section 35 states that no person shall carry on any work that could result in the harmful alteration, disruption or destruction of fish habitat. Section 36 refers to the deposit of deleterious substances in water frequented by fish and states that no person shall deposit such substance in the water. The local Department of Fisheries and Oceans (DFO) office must be contacted prior to any work on bridges.

- Federal Government Fisheries and Oceans Technical Report No.1692 - this report was published in 1991 and is entitled "Guidelines for the Protection of Fish and Fish Habitat During Bridge Maintenance Operations in British Columbia". It details the legislation, bridge painting technology, impact on fish and their habitat, the process for submitting bridge painting proposals and mitigative strategies for protecting fish habitat during paint operations. However, the DFO stated that the guidelines are out of date and will be updated in the near future because of the changes in technology that have taken place since 1991.

- Province of B.C. Ministry of Environment, Lands and Parks - Section 7 of the Water Act provides a set of standards for parties who wish to undertake works in and about a stream. The regulations are designed to protect the land, vegetation, natural environment and flow of water within or adjacent to the stream channel. A notification form must be filed with the regional office of BC Environment before the proposed work will take place. Section 7 activities that are regulated include the repair of bridge superstructures.

- Workers' Compensation Board of B.C. - new Occupational Health and Safety Regulations come into effect on April 15 of this year. The new regulations have been updated for lead and are detailed in Sections 6.59 to 6.69 of Part 6. These sections deal with control measures, health monitoring and protection and the training of workers. In addition, Section 20.2 requires that a notice of project be filed at least 24 hours before starting a project that involves significant disturbance of lead-containing coatings on structures. The notice must include amongst other items, detailed written work procedures which will be used to minimize the risk to workers who might be exposed to the lead in the paint.
The regulations will force the City to implement procedures to deal with the lead paint when ever bridge maintenance work impacts on the paint. This could range from routine maintenance painting by City workers to cleaning and painting or steelwork repairs by a contractor. The procedures will have to address the protection of the environment, the workers and the public. To meet the regulations, the City will have to utilize technological advancements in materials and equipment developed for bridge painting and the safe removal of lead-based paints.

3.0 TECHNOLOGICAL DEVELOPMENTS IN BRIDGE PAINTING

3.1 ENCLOSURES FOR BRIDGES

In the last ten years, different materials have been developed to enclose bridges to prevent the escape of fugitive emissions such as wash water, paint debris, rust, lead dust and paint overspray.

The type of containment constructed for a bridge is dependent on the complexity of the bridge structure, the surrounding environment, the type of paint on the bridge and the nature of the cleaning and painting operations. The Steel Structures Painting Council (SSPC) Guide 61 details different levels of containment ranging from Class 1 which provides the highest level of emissions control to Class 4 which provides a minimal level of control of emissions. For example, a Class 1 enclosure would be used where the contractor or City crews are removing the lead paint by open, sandblasting techniques. Class 4 containment would be used if the City was hand tool cleaning and brush or roller painting small areas of the steelwork for maintenance purposes.

The most stringent of enclosures must be under negative pressure to ensure that no emissions escape into the environment. An air flow system is constructed to draw air from the outside, into the enclosure. The air is then circulated through the enclosure and exhausted through a high efficiency HEPA filter, to trap the lead dust generated by the cleaning operations, very similar to enclosures built to remove asbestos from buildings.

Attached to the containment work area are decontamination facilities for equipment and personnel. These usually consist of a room(s) where the workers, equipment and materials can be decontaminated using vacuuming equipment equipped with HEPA filters for the removal of dust and debris from the workers’ clothes. The rooms are normally separated by air locks which may consist of two or three overlapping tarps that allow air to flow from the clean side to the dirty side and prevents dust from entering the clean side.

Once the workers exit the decontamination facility, they must enter a facility (usually a nearby trailer) to clean up. If they are merely taking a break for lunch, this would involve washing their hands and other exposed skin. If they are leaving the site, they are required to shower prior to changing into their street clothes. All waste water from the site would have to be filtered prior to being discharged into the sewer.

Several companies in the United States manufacture tarps designed for abrasive blast cleaning and painting operations. For example, Indian Valley Industries of Johnson City, New York and Detroit Tarpaulin of Romulus, Michigan are just a few companies who make a wide range of products for this purpose.

More recently, structures have been enclosed by shrinkwrap systems that consist of plastic sheets that are installed onto scaffolding or cables and heat shrunk in place to form a seamless enclosure. Numerous companies manufacture the shrinkwrap containment including Hipp Plastic Wrap of San Diego, California and Eagle Industries of New Orleans, Louisiana. Locally, Shrink
Tech Systems of Langley and Integral Shrink Film Inc. of Surrey, distribute and install shrinkwrap systems in B.C. Levelton Engineering has experience using these systems on steel water tanks during the removal of lead-based paint. They seem to work quite well.

The Johnson Street bridge will be difficult to enclose because of the fact that it is raised to allow marine traffic to pass through the waterway. If the marine traffic could be rerouted to eliminate or reduce the number of openings, the shrinkwrap would probably work quite well on the bridge superstructure and substructure.

3.2 Cleaning of Bridge

1. Power Washing

Twenty years ago, power washing was used to clean the bridge. The waste water was simply allowed to fall into the waterway. This is no longer possible because of the current environmental regulations. If water was used to wash the bridge, the waste including any paint chips, would have to be retained in an enclosure and disposed of as per the environmental regulations. The water would have to be filtered through a commercially available waste water filtration system and tested to ensure that it met the regulations prior to disposal. Eagle Industries and others manufacture equipment to filter waste water. Locally, Hazmasters Environmental Controls Inc. in Burnaby, distribute filtration systems.

2. Salt Contamination

The use of road salt is not permitted on roads within 250 meters of the bridge however vehicles are likely to carry the salt onto the deck as they drive over the bridge. The salt will be washed down onto areas of the steel below the deck, by rain water. If the salt is not periodically removed, it will accelerate the corrosion of the structural steel particularly at bearings, expansion joints and steel subject to runoff or splash from the vehicles.

In addition, the salt must be either removed or neutralized prior to repainting the steel in these areas. If the salt is not removed, the paint will blister and fail prematurely. Chlor*Rid International Inc. of Arizona, manufacturers a liquid chemical known as Chlor*Rid that has proven to be effective in reducing the level of chlorides and sulfates on steel in marine and industrial environments. Levelton has experience using it to remove chlorides from industrial sites such as potash shiploaders in North Vancouver. The Chlor*Rid was used during the power washing stage prior to abrasive blast cleaning. Tests showed that the Chlor*Rid significantly reduced the chloride concentration on the steel.

Chlor*Rid is added to water in a dilution ratio of 50 to 100:1. It is not rinsed from the surface prior to tool or blast cleaning. The surface is allowed to dry. During this process, the organic chemistry of the Chlor*Rid bonds to the salts thereby allowing it to be removed by conventional abrasive blast cleaning procedures.

It is biodegradable and contains no volatile organic compounds. Tests have shown that it is compatible with epoxies, moisture-cured urethanes, siloxane and other protective coatings. It does not have detrimental effects on the adhesion of these coatings to the steel.

3. Total Removal of Paint

The City of Victoria has the option of totally removing the paint from the Johnson Street bridge. This would rid the City of having to deal with the problem of the lead paint in the future.
It could involve one of the following methodologies for removal of the paint:

- Enclosure of the bridge either totally at one time or in sections and the removal of the paint by dry abrasive blast cleaning. Blast cleaning could be performed by either conventional open blasting or by vacuum blast equipment. Vacuum blast equipment has its advantages. It will minimize the debris generated; reduce the level of containment required to ensure no debris enters the water; and minimize the protection for personnel that WCB would require. Two approaches are as follows:
  - E.Raltt Painters of Richmond, have a recyclable blast system mounted on a truck that uses steel grit and shot to remove the paint and to prepare the steel. The material is vacuumed up after open blasting and the abrasive is recycled and used again. The lead paint and the steel blast abrasive fines are removed during the recycling process and stored in drums for disposal. This method has two advantages. It reduces the amount of debris that requires disposal and the steel shot will be effective in removing any mill scale on the steel. Steel shot is more effective than silica sand or slag grits in removing mill scale. Unfortunately, the method does not reduce the level of containment or the personal protection required by workers.
  - LTC Americas manufacture vacuum shrouded blast equipment that greatly reduces the level of containment required for lead paint removal. The debris is trapped and vacuumed between the blast nozzle and the steel surface. Fugitive emissions are almost completely eliminated. This procedure also reduces the volume of debris generated because the aluminum oxide abrasive is recycled and it reduces the degree of personal protection required by workers. The primary disadvantage of this equipment is that the production rate is slower than open abrasive blasting and the aluminum oxide will not efficiently remove mill scale. Hazmasters Environmental Controls distribute the equipment locally.

- Instead of using dry blasting techniques, the bridge could be enclosed and the steel cleaned using wet abrasive blasting. Restoration Environmental Contractors Ltd. of Gormley, Ontario, have a system known as Torbo for the removal of lead paint and other hazardous materials. It eliminates 95% of the dust generated by normal blasting by providing a water mist with the sand. Typically, only 68 to 82 litres of water are used per hour. This means that there is no free water to clean up or treat. The water is absorbed by the blast debris. The Torbo system also reduces the level of containment required, since this operation is virtually dust free.

- High pressure water blasting (greater than 10,000 psi) could be used to strip the paint from the bridge however there are disadvantages with this approach. It involves larger quantities of water that would have to be filtered and treated and a water tight enclosure would be needed. Secondly, the water will remove the paint but will not remove any mill scale on the steel, unless the pressure is increased. Increasing the pressure forces the contractor to reduce the water flow rate which consequently reduces the production rate. Thirdly, the water will not abrade the steel to provide an anchor pattern which is necessary to provide proper adhesion for the protective coatings.

- Sections of the bridge could be enclosed and the paint could be removed using chemical strippers such as Peel Away, a product that is a paste that is brushed or sprayed onto the paint then covered with a laminated cloth. The solvents in the paste dissolve the paint. The paint and paste adhere to the cloth. When the cloth is removed, the bulk of the paint is removed. The steel surface is then washed and could then be cleaned by conventional
methods to prepare the steel for the new coating materials. This method would reduce the level of containment required, personal protection requirements and the amount of waste generated. However the procedure is slower than blast cleaning and it would not remove mill scale nor would it properly prepare the steel for recoating. This method is really only suitable for removing limited amounts of lead paint. The product is available from Peel Away Canada, who are based in Montreal.

.4 Disposal of Lead Contaminated Waste

Disposal of the lead contaminated waste can be a problem because landfills no longer accept the material if it is classified as a hazardous waste. The options are the following:

- Reduce the amount of debris generated by using recyclable abrasives that can be used more than once to clean the steel. These include steel shot, steel grit and aluminum oxide. This doesn't really eliminate the problem but it does greatly reduce the volume of waste generated. The volume of waste could be contained in a limited number of drums which could then be transported to a facility such as Cominco and used in their manufacturing process.

- Specify an abrasive that can be recycled and used in another manufacturing process. For example, Target Products of Burnaby has a program where the waste is trucked to either Holnam Cement in Seattle where it is used in concrete or Cominco in Trail, where it is used in their manufacturing process. The location depends on the lead content in the waste material. Waste abrasive containing less than 5 ppm lead can be sent to Holnam Cement. Waste sand containing more than 5 ppm lead must be sent to Cominco.

- OCL Industrial Materials Ltd. in Surrey offer a similar type of waste recycling program. Lafarge Cement in Richmond will accept either lead contaminated waste silica sand or copper slag grit from OCL. Cominco will also accept OCL silica sand contaminated with higher levels of lead. OCL also has arrangements with a concrete block manufacturer in Victoria where it is used in the feed stock for the blocks, if the spent abrasive is designated as a non-special waste. The last option that they offer is to ship special lead contaminated waste to an industrial landfill in Alberta or Oregon.

- Add a chemical to the abrasive prior to blasting, that renders the lead non-hazardous. LEADX is a product manufactured by Proactive Environmental Research and Development Inc. of Houston, Texas. Another product is Blastox, that has been used in conjunction with the Torbo cleaning system by Restoration Environmental Contractors. Blastox renders the waste non-hazardous. It is distributed by OCL Industrial Materials.

In recent years, the approach that has received the greatest acceptance by industry in British Columbia and by Environment Canada, are the life-cycle management services. Target's program has been nominated for a 1997 Minister's Environmental Award.

.5 Maintenance of Existing Paint

Instead of removing all of the paint, the City has the option of leaving it on the bridge and simply addressing those areas where the paint has failed and the steel is corroding. Generally, the paint on the bridge superstructure appears to be in good condition, with only a need to touch-up limited areas where the paint has failed. The worst paint failure and corrosion is on the bridge substructure.
Being this is the case, there appears to be no sound reason to remove the paint on the bridge that is in good condition. It would be a very expensive exercise to totally remove all paint. It makes more sense to spot repair the existing paint above the deck and perform more extensive repairs in conjunction with steelwork repairs below the deck.

Spot cleaning could be achieved with vacuum shrouded cleaning equipment using either the LTC Americas abrasive blast equipment (previously noted) or Desco Manufacturing Co. Inc. vacuum assisted power tools. The power tools consist of needle scalers, roto-peen scaling tools, mini sanders and grinders and angle sanders. The tools are connected to HEPA vacuums that filter the air removing 99.97% of all ultra-fine particulates. These tools would greatly minimize the containment required by regulations. In addition, they would remove the lead paint, rust and mill scale, preparing the surface to an acceptable SSPC-SP3 finish.

Alternatively, the steel could be spot repaired using the chemical paint strippers previously noted, to remove the lead paint, followed by surface preparation by conventional power or hand tools. However a higher level of containment would be required to trap the wash water that is used to rinse the surface, after the chemical strippers are removed.

Vacuum assisted power tools are apparently already being used by the City crews who are responsible for maintaining the Johnson Street bridge. These tools or the vacuum blast equipment could also be utilized by painting contractors who may be involved with steelwork repairs.

3.3 PROTECTIVE COATINGS

A review of published literature from the U.S. and information from MOTH in the province has revealed the following:

1 Overcoating

Overcoating the existing paint to encapsulate it, has gained in popularity in the last ten years because of the high costs associated with totally removing lead-based paints. However it is not new because this is exactly the approach that has been taken by the City in maintaining the paint on the Johnson Street bridge since it was built. In 1979, the original linseed oil paint system was overcoated with an alkyd system and has been maintained with an alkyd system since that time.

The danger with continuing to overcoat the Johnson Street bridge is that eventually the entire paint system could lose its adhesion to the steel. The problem is that the steel was never properly cleaned by abrasive blast cleaning prior to the application of the linseed oil paint. The linseed oil paint was perfect for the marginally cleaned steel surface which undoubtedly included mill scale. It was slow drying, highly penetrating, soft and flexible with high elongation and virtually no internal strain. Premature failures are very rare with this type of paint.

Unfortunately, such paints cure by oxidation and over the years in the presence of oxygen and UV light, they undergo a change in structure and can become mechanically unstable. They become more brittle, with a reduction in elongation and a significant increase in internal strain. The mechanical integrity of the paint depends on the adhesive strength of each layer of paint to each other and to the steel, and the cohesive strength of each layer remaining greater than the cumulative stresses that act on it. When the stresses exceed the strength of the paint, failure usually occurs between the primer (the oldest layer of paint) and the steel substrate because of the lack of a mechanical bond between the smooth steel and the primer.
Overcoating the existing linseed oil/alkyd paint system will produce additional stress on the paint during the curing period of the overcoat. The stresses are transferred throughout the composite paint film, increasing the stress on the old linseed oil primer. Combined with external stresses such as vibration, impact and stresses created by changes in temperature and humidity, the paint could lose bond if the cumulative stresses exceed the combined strength of the film.

Since 1979, the paint industry has evolved and developed higher technology coatings that are specifically designed for overcoating to minimize the stress on the underlying paints. However it should be stated that prior to the full scale application of any overcoat coating system to the bridge, test patches should be applied and allowed to weather for at least one full year to ensure that there is a change in season to stress the overcoat test patches.

Materials that have gained in popularity in recent years for overcoating applications on bridges are the following:

- Moisture-cured Urethanes - The moisture-cured urethanes have been in use in Europe for over 20 years and were introduced to North America approximately ten years ago. They can be applied over a wide range of surfaces and weather conditions. They require moisture to cure and therefore are not effected by high humidity like most other high performance coatings. They are also tolerant of low temperatures and can be applied over marginally prepared steel. This combination of characteristics has increased their use on bridges, where weather can be inclement or sections of the bridge are inaccessible and can not be cleaned properly. Many of these products contain micaceous iron oxide (MIO) that improves the cohesive strength of the coating, improves the moisture, weather and UV resistance and imparts other desirable characteristics such as reduction of the internal stresses in the coating. Manufacturers of these types of coatings include Wasser High-Tech Coatings, Xymax Coatings Inc. (Camcoat Industries (B.C.) Ltd.) and Aquarius Coatings Inc (ICI Devoe Coatings).

- Epoxy Penetrating Sealers - low viscosity epoxies were developed approximately ten years ago to overcoat existing coatings and minimally prepare rusty surfaces. The key to their success is their ability to wet, penetrate, seal and bond existing paints and rust and to provide a suitable surface for topcoats. In addition, they are usually solvent free and are 100% solids therefore when they cure, they induce minimal stresses on the old paints. The epoxy sealers are used as the primer in combination with suitable topcoats in an overcoat system. They are never used without topcoats. Manufacturers of the penetrating epoxy sealers include ICI Devoe Coatings and Carboline Co.

Other generic coating types that are being used to overcoat bridges include alkyds, aluminum pigmented primers and topcoats such as epoxies or urethanes, calcium sulfonate waxes and waterborne coatings. Some of these are not new and have been used in industry for years, however they are included in this discussion because many bridge test programs and maintenance programs in the United States have included them in recent years. Some of the materials have proven to be as good as the moisture-cured urethanes and the epoxy sealers. A discussion of each follows:

- Alkyds - MOTH in British Columbia has numerous overcoat systems including an alkyd system. It consists of a three-coat system for use on intact alkyd paint in a moderate environment such as bridge steel above the deck not subject to splash or abrasion damage. The primer is General Paint 06-160. The topcoats are alkyds, formulated to CGSB 1-GP-59M. The system is not intended for more severe applications below the deck such as bearings and expansion joints.
Other sources such as the Journal of Protective Coatings & Linings report successful applications where alkyls were used. In Kentucky, a slow drying red oxide primer and alkyd topcoat were applied in 1995 to a 40 year old bridge\(^1\). The steel was pressure washed only with no tool cleaning. Corroded areas were then spot primed by brush with the primer, followed by a spray-applied alkyd topcoat to the entire bridge. Two years later, the paint is in very good condition. The only rusting noted was found at the bearings. Although the Department of Highways (DOH) were satisfied with the system, they are upgrading the surface preparation to include mechanical cleaning and higher pressure water blasting.

The Federal Highway Administration (FHWA) in the United States undertook a study to identify environmentally acceptable bridge coatings suitable for minimally prepared surfaces\(^2\). The study tested a number of coating systems on four bridges that represented different environments including a marine environment in Louisiana. The test patches were prepared by pressure washing and power tool cleaning to an SSPC-SP3 finish. The three-coat alkyd outperformed all other coating systems except for a three-coat moisture-cured urethane system and a three-coat epoxy system (with a penetrating sealer) after a two year test period.

- **Aluminum Flake-Filled Coatings** - Clive Hare of Coating System Design Inc. recommends the use of coatings using aluminum flake pigments\(^3\). The aluminum flake helps dissipate internal stresses, it reflects UV and heat thereby minimizes stress cycling and it reduces moisture penetration. In addition, the aluminum flakes, slow the evaporation of the solvent during curing thereby allowing the coating to stay wet longer and penetrate into rusty areas or cracks in the paint and improve the adhesion. The aforementioned FHWA study on bridge coatings tested a three-coat epoxy system that included an aluminum pigmented epoxy mastic as a mid-coat. This system rated second highest in the test. Only the three-coat moisture-cured urethane scored slightly higher.

- **Calcium Sulfonate Coatings** - Calcium sulfonate coatings are long oil alkyd coatings that contain crystalline calcium sulfonate. They can be applied in a single coat to a thickness of 300 microns. Their main advantage is that they are single component, surface and application tolerant products with a low surface tension. This means that they are well suited for overcoating existing alkyd paint systems on bridges. Their primary disadvantage is that they are soft and are not suitable for areas subject to abrasion or public access. In the FHWA test program, the calcium sulfonate was ranked behind the moisture-cured urethanes (two and three coat systems), three-coat epoxy and the two- and three-coat alkyls.

The MOTH currently has it as one of their accepted systems for overcoating. Bridgecoat Inc. of Quebec manufactures a penetrating sealer and a topcoat that are calcium sulfonate based products, approved by MOTH.

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Water-Borne Coatings - The B.C. MOTH is still developing a coating system for waterborne coatings. When developed, it would be designed for field overcoating existing alkyd systems that are largely intact with some paint breakdown, that could be repaired by tool cleaning. One product that has been specified by MOTH is ICI Glidden's Rustmaster 5571/5572/5573 three-coat system.

The aforementioned FHWA study on bridge coatings, tested several two- and three-coat water-borne acrylic coating systems however the systems rated near the bottom of the test program. The coatings exhibited early rust breakdown when applied to bare metal and rust and one of the systems disbonded on all bridges in northern climates, after only one winter. There would appear to be problems with the water-borne coatings. We would not recommend their use on the Johnson Street bridge, until further advancements are made in water-borne coating technology.

We believe that overcoating has its applications however it also can be fraught with problems if the incorrect material or too much material is applied to the existing paint thereby exceeding the stress limit of the paint and causing the original linseed oil primer to lose bond to the steel. In addition, overcoating should not be used in severe exposure areas of the bridge particularly areas subjected to frequent wetting/drying cycles, road salt, splash zones on trusses, bearings, expansion joints and guard rail posts. These areas should be treated differently. A greater degree of corrosion protection is required in these areas.

.2 Complete Recoat

The B.C. MOTH specifies a higher degree of corrosion protection for the severely corrosive locations on a bridge. They have three basic systems that they use:

- New Steel - SSPC-SP10 blast with an inorganic zinc primer, an epoxy stripe coat on edges and welds, a full epoxy mid-coat and a polyurethane topcoat. The total thickness is 200 to 300 microns.

- Existing Steel:
  - White-Metal SSPC-SP5 blast with zinc or zinc:aluminum(85:15) alloy metallizing sealed with a solvent thinned epoxy sealer; then topcoated with a full coat of epoxy and a full coat of polyurethane to a total thickness of 325 to 505 microns.
  - SSPC-SP5 blast with zinc or zinc:aluminum(85:15) alloy metallizing sealed with a vinyl seal coat; then topcoated with a midcoat of a high build vinyl and a topcoat of vinyl. The total thickness is 405 to 590 microns. This system is intended for use only where an epoxy or polyurethane can not be sprayed because of adjacent buildings and traffic.

These systems are intended for use in the highly corrosive areas of the bridge near bearings, expansion joints, at fence posts and other areas exposed to de-icing salts.

For steel handrails, the MOTH prefers to use one or a combination of the following systems:

- Thermoplastic powder coatings that are flame sprayed in the field or shop applied by fluidized bed dipping, where rail sections can be removed. The steel is first cleaned to an SSPC-SP10 finish. These thermoplastic coatings are designed for high abrasion environments.
Hot dip galvanizing is used on railings that can be removed and sent to the galvanizing plant. This system provides a long life combined with low maintenance.

Steel cleaned to an SSPC-SP5 finish, then metallized with zinc or the zinc:aluminum alloy is used in the field where fence posts that can not be removed.

Overcoating systems are not recommended in these highly corrosive areas. It is more desirable to start over rather than try to spot repair and topcoat areas where the paint has failed. The steel must be thoroughly cleaned by solvent cleaning to remove any grease and oil, followed by the application of the chemical salt remover (Chlor-Rid) and abrasive blast cleaning to at least a Near-White metal, SSPC-SP10 finish. If metallizing is used, the steel must be cleaned to a White metal, SSPC-SP5 finish. Once this is achieved, it is desirable to coat the steel with a coating system at least 400 microns thick, consisting of either a galvanized, metallized or zinc rich primer coat and organic topcoats.

If the primer coats are galvanizing or metallizing, special provisions are necessary prior to applying midcoats. Galvanizing should be abraded by abrasive sweep blasting to roughen the smooth galvanized finish to provide a mechanical bond for the midcoat. Metallizing must be sealed with a sealer such as a penetrating 100% solids epoxy or with a solvent thinned epoxy primer prior to the application of the midcoat.

Literature in recent years, seems to favour the use of a reinforced midcoat on top of the primer, to reduce moisture transmission through the coating. Coatings containing aluminum flake or micaceous iron oxide would be suitable for this application. The topcoat should be a coating with excellent weathering and UV resistance characteristics and is aesthetically acceptable. Urethanes and acrylics normally are used as topcoats for these reasons.

For moderate exposure situations, such as steel above the bridge deck that is only subjected to normal weathering or steel below the deck that is not be subjected to de-icing salts and may or may not be exposed to the weather, the MOTH uses the following systems:

- Abrasive blast clean to an SSPC-SP6 finish followed by the application of an organic zinc primer, a stripe coat of epoxy to welds and edges, a full midcoat of high build epoxy and a topcoat of polyurethane to a total thickness of 230 to 355 microns.

- Same as above except vinyls are substituted for the epoxy and the polyurethane. The total thickness is 265 to 390 microns.

- Same abrasive blast finish as above, followed by the application of a calcium sulfonate penetrating sealer, an optional stripe coat of a calcium sulfonate topcoat to welds and edges and a full topcoat of a high build calcium sulfonate coating. The total thickness is 235 to 265 microns. This system is intended for steel that is not subject to abrasion or public access, since it is soft.

- Same abrasive blast finish as above, followed by the application of a moisture-cured zinc rich urethane primer, a stripe coat and full midcoat of a moisture-cured MIO filled moisture-cured urethane and a topcoat of a UV resistant, moisture-cured urethane to a total thickness of 205 to 280 microns.

The last two coating systems are intended for unique situations where environmental conditions (low temperature and high humidity) limit the use of the other coating systems.
4.0 ESTIMATE OF COSTS

The estimated costs to totally recoat the Johnson Street bridge are as follows:

<table>
<thead>
<tr>
<th>Degree of Cleaning &amp; Coating of Bridge</th>
<th>Severity of Exposure to Corrosion</th>
<th>Estimated Cost of Containment ($ per Sq. Meter)</th>
<th>Estimated Cost of Cleaning ($ per Sq. Meter)</th>
<th>Estimated Cost of Coating Application ($ per Sq. Meter)</th>
<th>Estimated Total Costs ($ per Sq. Meter)</th>
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<td>Complete paint removal &amp; recoat</td>
<td>Light to Moderate</td>
<td>88.00</td>
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<td>35.00</td>
<td>110.00</td>
<td>233.00</td>
</tr>
<tr>
<td>Overcoat</td>
<td>Light to Moderate</td>
<td>68.00</td>
<td>7.00</td>
<td>10.00</td>
<td>83.00</td>
</tr>
</tbody>
</table>

These costs are based on and assume the following:

- The costs were calculated from guidelines published by the Journal of Protective Coatings & Linings. The 1997 guidelines, entitled "Updated Protective Coating Costs, Products and Service Life" were written by Brevoort, McLampy and Shields and are updated every two years. They are generated from costs obtained from manufacturers, suppliers, contractors and fabricators. The guide has been in existence for almost 20 years and has proven to be practical in selecting and approximating the costs of coating projects.

- The light to moderate exposure includes the steel above and below the deck that is in good condition with little corrosion. As previously noted, this steel is not in the highly corrosive areas and is not subject to de-icing salts. The severe exposure includes steel that is subjected to de-icing salts and is in a highly corrosive area.

- The highest level of environmental containment as detailed previously in this report, has been assumed for projects involving the complete removal of all paint on the bridge and recoating the steel. This will probably be the largest portion of the cost to clean and paint the Johnson Street bridge. For overcoating applications, a lesser degree of containment will probably be required for pressure washing the bridge, in zones of light to moderate exposure.

- The complete removal of the existing paint and recoating in the light to moderate exposure areas assumes that the bridge will be cleaned by blast cleaning to an SSPC SP6 finish followed by the application of an organic zinc primer/epoxy midcoat/urethane topcoat.

- The complete removal of the existing paint and rust and recoating in the area of severe exposure is applicable to both bridge overcoat projects and to projects involving the complete removal of the paint. It assumes that the steel in these areas will be pressure washed with the Chlor-Rid cleaner to remove any salts on the steel; followed by a SSPC-SP5 blast and metallizing and the application of an epoxy seal coat, epoxy midcoat and a polyurethane topcoat.

- Overcoating the existing paint in the light to moderate exposure areas, includes pressure washing and power tool cleaning to prepare the steel, followed by spot priming and spot midcoating the steel in locations of paint failure, then complete topcoating with an alkyd