

Victoria Street Bridge (Cambridge) Condition Assessment Report

Prepared for Waipa District Council

Prepared by Beca Limited

10 August 2020



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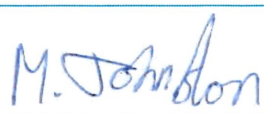
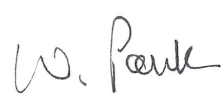
Appendices

- Appendix A – NZTA S6 Principal Inspection Report
- Appendix B – Rope Access Inspection Report By Lumen
- Appendix C – Under-Bridge Element Nomenclature
- Appendix D – Deck Slab GPR Scanning Results

Revision History

Revision N°	Prepared By	Description	Date
1	Cheng Liu	Issued for client review	04/06/2020
2	Mike Johnston	Revised following Waipa DC Comments	10/08/2020

Document Acceptance

Action	Name	Signed	Date
Prepared by	Cheng Liu		10/08/2020
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Executive Summary

Victoria Street (RP 969) Bridge is a four span steel structure over the Waikato River. The bridge was designed and constructed in 1905 and opened to public in 1907. The bridge is 141m long, comprising an 88m long main arch span with steel girder approach spans on either side.

Waipa District Council (Council) commissioned Beca to investigate the condition and potential vulnerabilities of the Victoria Street Bridge in Cambridge as part of an assessment of the future life expectancy of the structure.

The scope of this report consists of a condition summary of bridge elements inspected by rope access and on foot, including the protective coating system for steel elements under the bridge and recommendations on future maintenance.

The original deck of the bridge was timber and there was no footpath on the bridge. During upgrades to the bridge, the old timber deck was replaced with a 95mm thick concrete deck and a 1.5m FRP footpath has been added to each side of the bridge. The steel elements under the bridge were last painted in 1999.

Elements below the deck level were inspected by Lumen Ltd between the 9th to the 16th of March 2020. The inspection of the bridge was completed by means of a rope access and fall arrest system. Elements above the deck level were inspected by Beca staff on 11 March 2020.

While the majority of the structure appears to be in good condition, there are two areas of structural concern:

- The first is that there is significant corrosion to elements around the arch pins with some corrosion present on the pins themselves. Major works were carried out on the pins in 1999 however it is not known if the elements which are currently showing deterioration were made redundant by these works. As the pins are critical components this requires further investigation.
- The second element of concern is the concrete deck slab. The GPR scanning revealed locations with potential defects that may include vertical cracking, horizontal planar cracking, spalled and bony concrete. The scans also indicated that the deck thickness may be less than that used in the current assessment. Further investigations of the condition of the concrete slab is recommended.

Most coated surfaces are stable and intact. However, corrosion is present on the structure which is in keeping with a structure which was last painted 21 years ago and where access for short term patch repairs is limited. The coating is in need of remediation. An NPV analysis was carried out to determine the most economical painting option over the life cycle of the bridge. This identified Option 2, patch repairs of corroded areas followed by a new topcoat over the whole structure, as the most cost efficient with a cost estimate of \$2.1M (for repainting only). This estimate, provided by Lumen, is not to be used for budgeting purposes and it is recommended that a contractor's quotation is sought to provide better certainty on out-turn cost.

Recommendations

The following recommendations have resulted from the 2020 principal inspection and coating inspection:

- Repaint the structure. – Patch repair corroded areas and apply a new topcoat over the whole structure. While the access is in place, carry out repairs to elements with severe section loss and replace defective rivets, bolts and the defective cross bracing tie connections (note this will require some design prior to RFP).
- Deck investigations – Carry out intrusive investigations into the deck issues identified by the GPR scan.
- PIN investigations – Carry out a detailed desktop review of the pinned connections. Carry out ultrasound investigations of the pins when access is in place for the painting works.
- Testing of the coating system is recommended prior to the tendering of the repainting works.

In addition to the above, routine maintenance items are identified in Appendix A.

1 Introduction and Scope

Waipa District Council (Council) wish to review the condition and potential vulnerabilities of the Victoria Street Bridge in Cambridge as part of an assessment of the future life expectancy of the structure.

A staged approach has been adopted as detailed in the Offer of Service, summarised below:

Stage 1: Desktop Review

Stage 1 consisted of:

- A desktop study to provide an overview of potential structural and geotechnical vulnerabilities of the structure.
- A high-level review of the previous structure and associated live load assessment.
- A review of the available geotechnical information.
- A geotechnical inspection of the bridge and surrounding slopes.
- Confirmation of assessment parameters for any future ground analysis.
- Identify potential risks to the public.

The report for Stage 1 was issued to Council on 14 August 2018. Refer to “Victoria Bridge (Cambridge) - Resilience Review Report”.

Stage 2:

The structural scope is as follows:

- A Principle Inspection of the structure using Roped Access.
- Arrange a painting inspection to assess the condition of the existing paint and recommendations to be made if recoating is required.
- Undertake a visual inspection and core testing of the concrete deck to confirm the condition of the deck panels.
- Provide commentary on the cost and risks involved in maintaining the structure in the next 10-30 year period.

The geotechnical scope (not covered in this report) is summarised as follows:

- Undertake a geotechnical investigation interpret the findings and develop a representative ground model for assessment.
- Complete geotechnical stability and liquefaction assessments of the river bank.
- Review the potential for internal erosion to occur within materials supporting the bridge foundations and other risk factors, including storm water infrastructure and discharge locations near the bridge.
- Assess the geotechnical capacity of existing bridge foundations, including consideration of any reduced confinement as a result of slope instability or erosion since the bridge was constructed.
- Assess scour risk by inspecting the river banks for signs of active scour and inspect the local soils for susceptibility to scour.

This report summarises the findings from the structural scope of **Stage 2**.

2 Bridge Background Information

Victoria Street (RP 969) Bridge is a four span steel structure over the Waikato River. The bridge was designed and constructed in 1905 and opened to public in 1907. The bridge is 141m long, comprising an 88m long main arch span with steel girder approach spans on either side. The Leamington approach span is 19.8m while the Cambridge approach consists of two spans (19.8m and 12.8m). The main span is founded on the steep river banks. The two end spans are supported on mass concrete abutments.

The original deck of the bridge was timber and there was no footpath on the bridge. During upgrades to the bridge, the old timber deck was replaced with a 95mm thick concrete deck and a 1.5m FRP footpath has been added to each side of the bridge.

The steel elements under the bridge were last painted in 1999.

The bridge currently has a weight restriction of 3 tonnes gross, a height restriction of 3m and a width restriction of 2.1m for each lane.

For further details refer to the Stage 1 Resilience Review Report.

3 Inspection Procedure

3.1 Inspection by Rope Access

Elements below the deck level were inspected by Lumen Ltd between the 9th to the 16th of March 2020. The inspection of the bridge was completed by means of a rope access and fall arrest system. A total of 16 descents were completed during the inspection timeframe, 13 on the upstream (east) side and 3 on the downstream (west) side. A proportion of all element types were inspected within touching distance with other similar elements inspected visually from further away. While the majority of elements were inspected, a small number of elements were not accessed (for example the concrete soffit which is covered by asbestos panels and the internal faces of steel element inspected from a distance).

Dry film thickness readings of the protective coating system were recorded using an ELCOMETER 456 Coating Thickness Gauge. A series of images were also taken to supplement the inspection findings.

Due to the large number of steel elements under the bridge, a nomenclature system has been provided for identification of each element. To provide consistency, we have developed upon the 1976 remedial drawing's nomenclature system as provided in Appendix C. Note that multiple different naming systems have been used in the historic documents depending on the type of works being carried out, the original drawings had the most comprehensive naming system.

3.2 Inspection on Foot

Elements above the deck level were inspected by Beca staff on 11 March 2020. Both bridge abutments were inspected from ground level.

4 Inspection Observations

A standard NZTA S6 Principal Inspection Form is included in Appendix A. Due to the complexity of the structure is not appropriate to use the standard template as a standalone document. For this reason, a detailed breakdown of the condition of steelwork elements is included in Appendix C. Representative photographs have been included in both Appendix A and the main body of this report, many more photographs and including those taken by drone and from the roped access are available in separate files.

4.1 Elements Inspected by Rope Access

This section of the report is a summary of the structural defects identified within the steelwork from the photographs provided by the roped access team.

The protective coating system has varying levels of deterioration across the structure including general surface corrosion and localised areas of heavy pitting and crevice corrosion distributed across the structure. Section 6 of this report discusses the condition of the paintwork and associated corrosion defects.

Except for the pins (refer 4.1.7), the structural integrity of all elements is generally in good condition. In a few locations section loss has been observed that may be a cause for further investigation.

Specific defects of note are discussed below.

4.1.1 Lacing bars

Numerous elements on the structure are formed of C channels tied with lacing bars. Bent laced plates and crevice corrosion were observed throughout the structure with some rivets and bolts having moderate corrosion.

A known issue on the structure is that the lacing bars within the top chords of the arch have deflected. These were identified in 2014 during the footpath widening works and were last reviewed through a 2016 special inspection. The deflections were not measured during this inspection, it is intended that these will be remeasured as part of the painting works.

4.1.2 X Brace Connections

One of the vertical cross bracing rod ties showed signs of significant section loss, all of these tie locations should be checked when full access to the structure is provided for the painting, defective connections should be replaced.



Figure 4-1 Corrosion at bracing connection at UT4.



Figure 4-1 - Rod tie at UT4 showing signs of significant corrosion, requires replacement.

4.1.3 Transoms

The structural integrity of these elements is generally in good condition, while the protective coating system is showing moderate signs of deterioration. General corrosion and some crevice corrosion were observed around laced plate ends. Minor crevice corrosion was observed at some stringer and transom connections.

Specific Defects of note are shown below. Due to the location at the support no structural maintenance is proposed for the section loss on UT07-DT07 other than corrosion remediation.



Figure 4-3 - Widespread corrosion spots were observed on transom UT09-DT09.



Figure 4-4 - Nut missing on transom at T10.



Figure 4-5 - Corrosion to lacing of Transom UT01-DT01



Figure 4-6 - Section loss to bottom flange of Transom UT07-DT07

4.1.4 Bottom Chord Laced Column Connection Points

The structural integrity of these elements is generally in good condition, while the protective coating system is showing early to moderate signs of deterioration.

Fungal growth, dirt entrapment and minor isolated spot corrosion are common throughout.

Specific Defects of note are shown below, the corrosion in these locations should be remediated during the painting works, in some cases this may require new plates to be added where section loss has formed. This is to be agreed with the engineer on site. At one of the nodes a bent plate was observed, this should be investigated by an engineer when access is provided as part of the painting works.



Figure 4-7 - Full penetration corrosion at UB11



Figure 4-8 - Plate is bent with corrosion present on underside at UT6/DT6.



Figure 4-9 Full penetration corrosion at UB03



Figure 4-10 - Deep corrosion at UB08

4.1.5 Bottom Arch Spans

The structural integrity of these elements is generally in good condition, while the protective coating system is showing moderate signs of deterioration. Fungal growth and crevice corrosion were observed. There is also some localised coating failures.

Specific Defects of note are shown below:



Figure 4-11 - Crevice corrosion in arch chords along top flange to web joint UB09-UB10.



Figure 4-12 - Steel crack in arch chord UB05-UB06, likely historic, monitor.

4.1.6 Stringers

The structural integrity of these elements is generally in good condition, while the protective coating system is showing moderate signs of deterioration. A specific defect of note is shown below:



Figure 4-13 - Web may be deformed investigate during painting at T10.

4.1.7 Pins and Pivots

There are six pins on the structure, these are critical elements that must be treated with extreme care as there are no alternative load paths in the event of their failure. All six pins are showing signs of metal loss with the two centre pins more affected. A combination of pitting and crevice corrosion is prevalent on the welded joint where the side and top panels of the steel arch meet. Previous attempts of a maintenance applied joint sealant at this connection point is failing and the added occurrence of fungal growth has accelerated this due to dirt entrapment and prolonged wetness of the area. Corrosion is present on the arch pins themselves at the ground level pins.

The structural integrity of these elements requires further investigation. Several components showed section loss and a breakdown of the protective coating system with moderate to severe corrosion. Other elements were in significantly better condition. Following the first issue of this report, Waipa DC have advised that the strengthening works carried out in 1999 included significant work to the pins and may have made redundant the elements that are seriously deteriorated. Records of the 1999 works state *"The detailed strengthening is intended to improve the bearing situation and provide some assurance that should the Original bearing surfaces eventually corrode completely away that the loads can still be transferred across the pin without catastrophic failure occurring."* The level of the assurance mentioned above is not quite clear. It is not known if the strengthening of the pins made the corroded areas redundant or if the strengthened pins still rely on some capacity from these elements. It is recommended that the designer (Tony Mans of BBO) is approached for comment and for any information they may have on file. Regardless of the outcome of these inquiries, further investigation is recommended including a detailed review prior to works commencing on site, inspection of the pins by a structural engineer, and ultrasound testing of the elements once the scaffolding is in place.



Figure 4-14 - Pitting and crevice corrosion at central pin



Figure 4-15 - Evidence of significant metal loss at central pins



Figure 4-16- Corrosion in steelwork around central pins.



Figure 4-17 - Vegetation build-up at ground level Pins

4.1.8 Deck

The concrete deck soffit was generally not visible during the inspection as it is mostly covered by asbestos panels. Loose, broken and missing asbestos panels were observed on all the bays. Where the concrete was visible beneath the footpath exposed reinforcement and honeycombing in the deck was observed. Spalling was present in the soffit between beams. Refer to Section 5 for the GPR scan investigation of the deck.



Figure 4-18 - Honeycombing and exposed reinforcement in deck



Figure 4-19 - Horizontal cracking in concrete. May be longitudinal shear issue at UP Span 1-2.

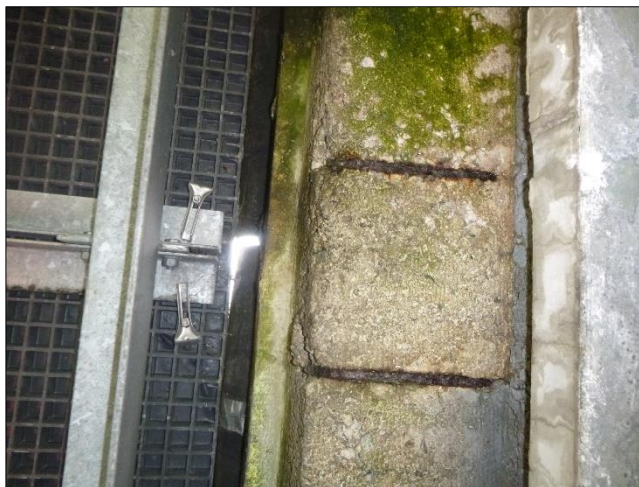


Figure 4-20 - Exposed reinforcement adjacent to footpath at UP Span 4-5.



Figure 4-21 - Spalls adjacent to expansion joints at UP Span 6-7 T2-3.



Figure 4-22 Loose, broken and missing asbestos panels observed on all bays at UP Span 5-6 T2-3.



Figure 4-23 – Void in kerb allowing water to drain onto steelwork at Span DE.

4.2 Elements Inspected on Foot

The elements inspected on foot are generally in good condition with only minor defects. Refer to the Principal Inspection Report in Appendix A for the recommended remedial work and estimated costs on these elements. A brief outline of the defects is shown below.

- Minor moss growth and loss of protective coating were observed throughout the footpath handrail over the bridge which is leading to corrosion. A patch of overgrown vegetation is protruding onto the footpath at the downstream side near the Cambridge end.
- The approach handrails show minor loss of coating on the upstream side near the Cambridge approach. However, these rails appear to be galvanised beneath this coating.
- Fine transverse cracks were observed on the surfacing at multiple locations. Worse towards the Cambridge end. These may correspond to the cracks in the deck slab identified in Section 5 of this report. Suggest further investigation during deck coring to determine whether the surfacing cracks align with those identified in the GRP scan.
- Some drainage holes on the downstream kerb are blocked by dirt.
- A transverse crack along deck joint at Abutment A was observed. Some debris inside expansion joints.
- Loose concrete was observed on face of Abutment B at ends of Stringers 2 and 4.
- A small shallow void was observed on the approach A downstream wing wall with vegetation growing out of the void.

5 Concrete Deck Slab Investigations

A GPR scan was carried out for the concrete deck slab by GPR Imaging Solutions Pty Ltd. The scans were taken from a moving vehicle and comprised 10 continuous longitudinal sections spaced across the width of the carriageway. The nature of scanning from a moving vehicle reduces the accuracy of the results. The aim of the scan was to identify concrete defects such as voids, large cracks, concentrated areas of aggregate and honeycombing to help target future intrusive concrete investigations. The scanning was also to investigate the deck thickness, transverse reinforcement spacing and concrete cover.

The main findings from the investigation are presented below, Appendix D contains the data from the GPR scanning and the interpretive report from the specialist sub-contractor.

5.1 Concrete Deck Thickness

The average concrete deck thickness obtained from the scan was 98mm, compared to the design deck thickness of 95mm (3.75") according to the as-built drawings. The proportion of the deck that is less than the design thickness is 35%.

The 5th and 95th percentiles of the deck thickness scan data are 83mm and 117mm respectively, meaning that 90% of the data is within this range. The measured 5th percentile value is 12% less than the design value. The data is mapped in the figure below showing that the areas of low deck thickness are concentrated in discrete regions. The latest evaluation of the deck slab capacity (BBO-1996) used the 1964 design details. It follows that, for the regions of low deck thickness, the existing calculation is likely unconservative posing a punching risk.

A new assessment may be appropriate. It can be seen in the maps below that the critical area of low deck thickness is in Span 01-02. A reasonable approach to analysis may be to take the average thickness under a patch equivalent to the size of patch used for a punching failure check. As an initial approximation an average of the deck thickness beneath a circa 1m square located at chainage 33.5 is 70mm. Confirmation of cover and deck thickness in Span 01-02 is recommended as part of the intrusive investigations.

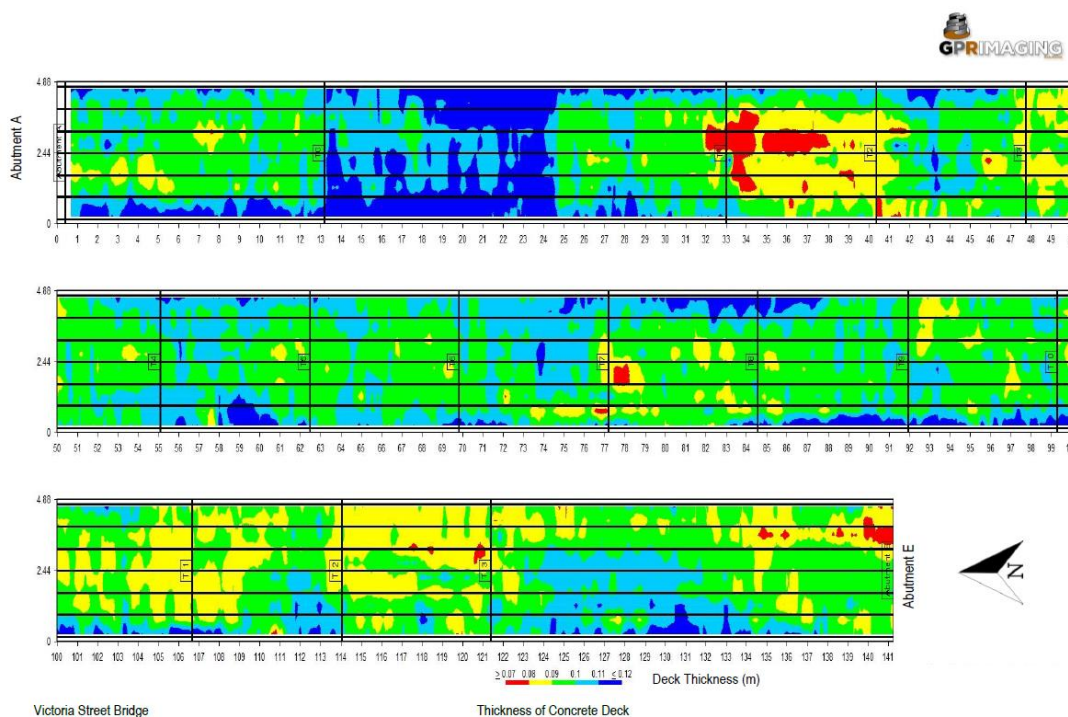


Figure 5-1 Deck thickness mapping

5.2 Transverse Reinforcement Layout

The 1964 re-decking drawings show a single layer of transverse reinforcement that is 3/8 inches (9.5mm) in diameter at 9 inch (228mm) centres placed mid height in the deck. This equates to a design cover of 43mm. Two longitudinal bars of the same diameter are also shown in each bay beneath the transverse reinforcement. Note longitudinal bar locations cannot be determined from the longitudinal GPR scans.

The spacing between the transverse reinforcement detected by the GPR scanning was measured with a mean of 230mm and 95th percentile of 255 (a 10% increase in spacing). There were two cases identified where a reinforcing bar seemed to be missing as per the table below. If these cases are omitted from the data set then the maximum spacing is 300mm. Were a new assessment to be carried out due to the low deck thicknesses the increased spacing should be incorporated.

Missing Transverse Bars	
Chainage (Approx.)	Description
13.5	Over T0
24.7	T0-T1 midspan

The image below shows the location on the missing bar at Ch.13.5 it can be seen that a vertical crack has developed directly over the location of the missing bar, this is also the case at Ch. 24.5. Both cracks are across the full width of the deck and the crack at Ch13.5 is larger.

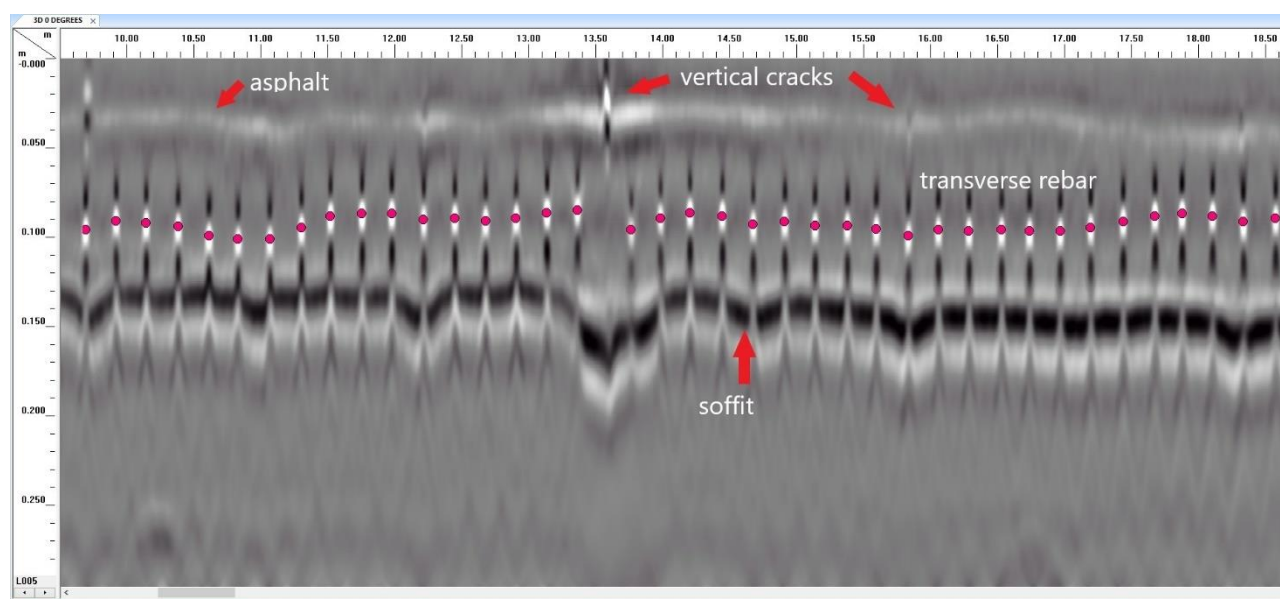


Figure 5-2 - Missing bar at Chainage 13.5

The cover to the transverse reinforcement detected by the GPR scanning was measured with a mean of 46mm and 5th percentile of 30mm (a 30% decrease in cover). Due to the generally high consistency of cover it is considered that a small number of localised breakouts to check on corrosion of reinforcing would be enough. Less than 0.5% of bars have a cover less than 20mm with a single bar at 1mm cover.

5.3 Concrete Deck Defects

A number of defects within the deck were detected by the GPR scanning. These show up as reflections within the concrete deck on the scan images.

The table below summarises the three main categories of the defects.

Defect Category	Effect on Structure
Horizontal planar cracking	Affects structural integrity
Vertical cracking	Affects structural integrity
Spalling and bony concrete	Results in loss of concrete section and structural capacity

Figures 5-3 below shows a map of concrete defects. An example of vertical cracking is circled in green. An example of an area of overall poor concrete condition (bony concrete) is circled in black and an example of a localised concrete issue is circled in orange.

It can be seen that there are areas of poor-quality concrete towards each kerb. There are many defects spanning across the deck that may be indicators of full width vertical cracking. This is of particular concern as if these are full depth cracks then the distribution of load longitudinally through the slab may be reduced. Investigations into several of these cracks are recommended to determine their depth and width.

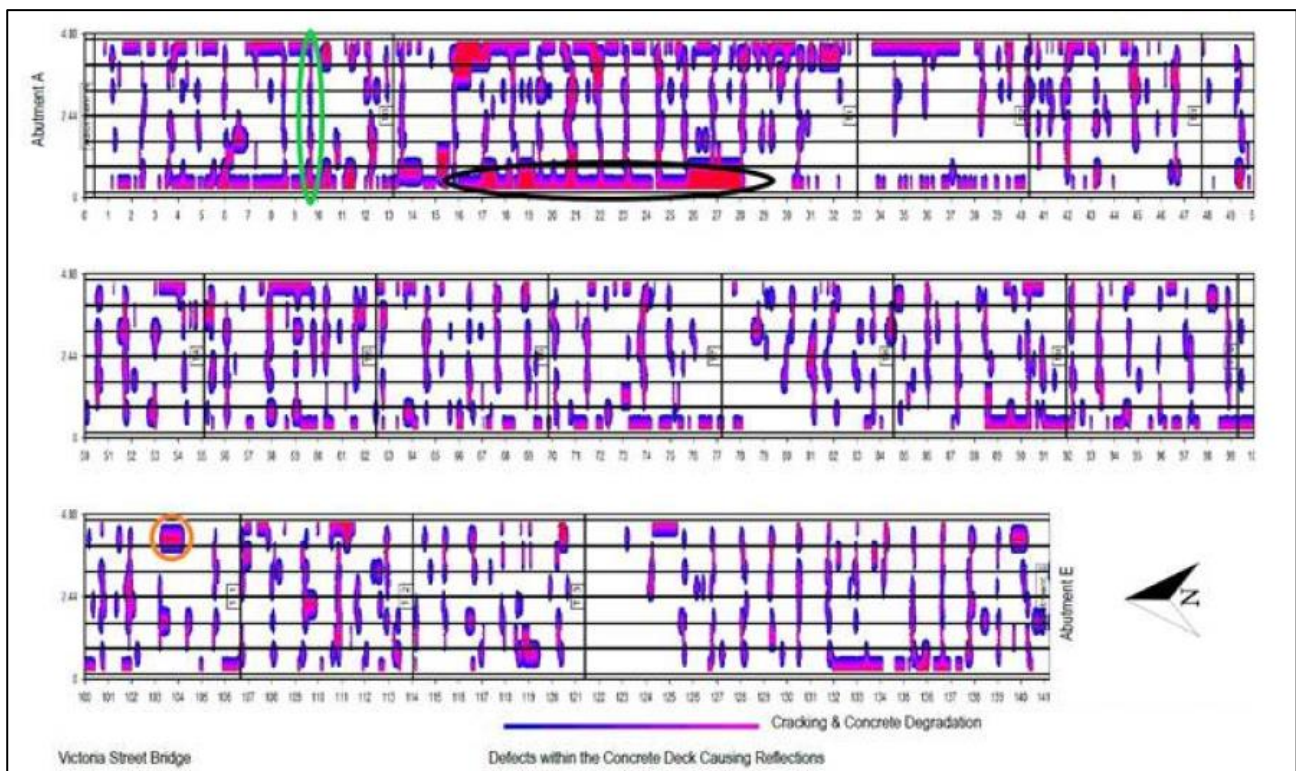


Figure 5-3 GPR scan image showing possible locations of defects causing reflections

Figure 5-4 below identifies areas of potential spalling to the soffit. The vehicle mounted scanner is a good screening tool for identifying areas of concern however a more accurate handheld device should be used prior to carrying out exploratory cores on these locations. One possibility is that the permanent formwork has fallen away from the soffit which the scanner may have identified as spalling, the investigations should identify if this is the case.

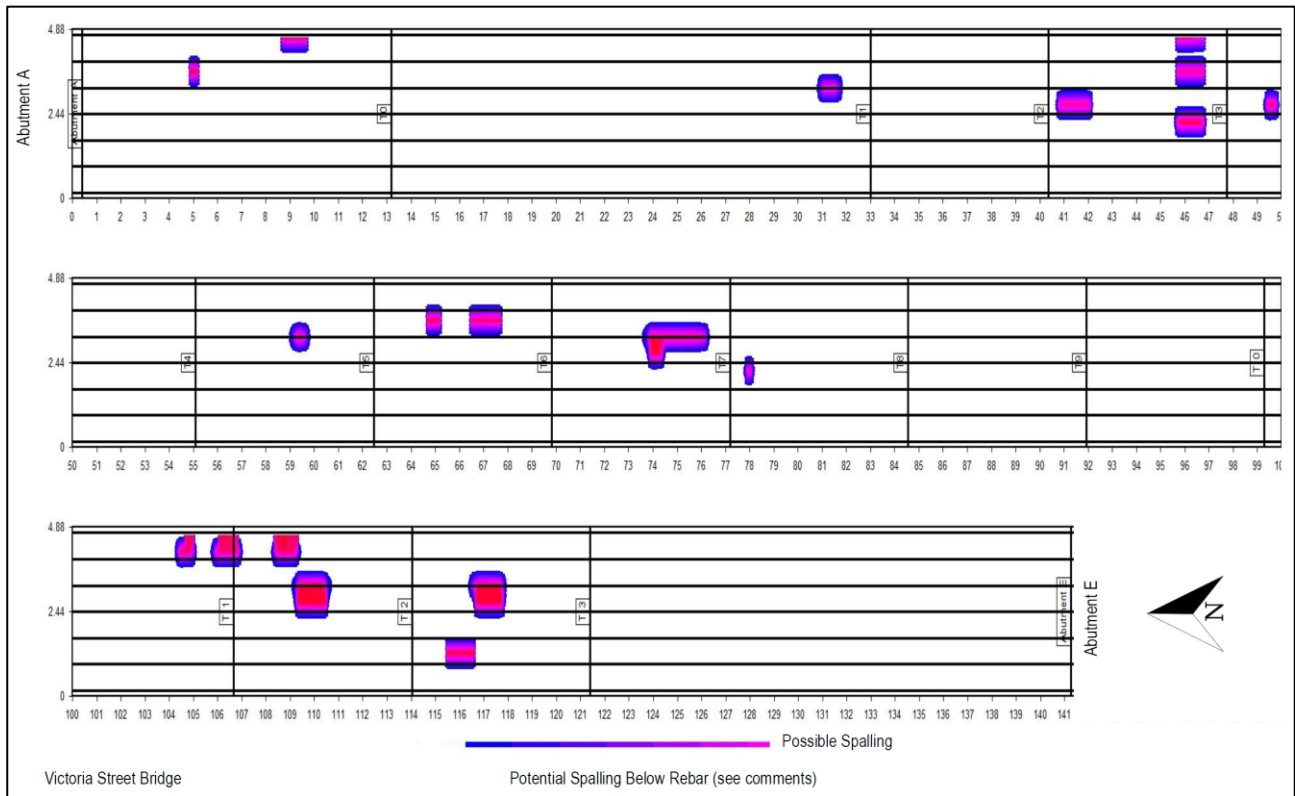


Figure 5-4 GPR scan image showing locations with potential spalling below rebar

Previous investigations carried out in the mid-90s identified that full depth cracking was present and that the concrete was “soft” and broke away under water-blasting. A waterproofing membrane was installed to prevent water from travelling through the cracks and falling on the steelwork beneath.

5.4 Asbestos Panels

The asbestos panels on the underside of the concrete deck were generally in good condition. However, there are numerous locations distributed over the entire length of the structure where the panels are found to be loose, broken or missing. Transverse cracking is also observed and this may correspond with the deck cracking discussed above. Due to their location at significant height, these do not pose a health concern to the public.

When managing asbestos, the general approach taken for bridge structures is that asbestos in good condition poses no risk unless they are disturbed and they are therefore generally left in place. However, as the panels are broken in various locations, in this case there is a risk of exposure to fibres for any works in close proximity to the soffit. This includes during the cleaning and painting of superstructure elements. We recommend that the risks posed by asbestos on the bridge are considered carefully prior to the painting works.

5.5 Recommendations for Investigations

The GPR results have identified several areas for further investigation. The recommended investigations are as follows:

Scanning of a sample group of potentially defective areas using more accurate, handheld GPR equipment. As part of this work a test panel is to be identified on the structure and cracking carefully recorded. This is to be used in the future as a way of monitoring the rate of deterioration by re-scanning the test panel at the next Principal Inspection.

Use of ultrasound to understand the crack widths and depths for a sample group of the identified cracking.

Breakout of the top cover in areas where cracking is observed near bars – this will be to observe if the reinforcement is corroding. Care will need to be taken in this process not to damage surrounding areas of the deck, using methods such as water blasting

Cores of the deck slab for the following (following discussions with council and internal discussions we have reduced the amount of cores noted by items with a strikethrough):

- Core of a cracked location to visually inspect the crack interface and get an idea of interlock across the crack (include in descriptions).
- Cores of the areas identified as poor-quality concrete to observe the condition/friability.
- Cores of areas identified as sound concrete. (as a benchmark/comparison)

GPR scanning should be undertaken in every core location to avoid reinforcement. The waterproofing layer that is present beneath the asphalt shall be reinstated for each core. It is proposed that a bridge closure is used to allow access for investigations. Note that with the narrow lanes on the bridge compliance with TM codes for safe working distances may be difficult to achieve if the contractor tries to carry out the works under a lane closure alone. Beca staff are to be on site during the investigations. Protective measures for asbestos shall be implemented prior to carrying out intrusive deck investigations.

6 Paint Inspection

As part of the condition assessment, the specialist subconsultant Lumen was engaged to provide a painting inspection. This included assessing the condition of the current coating system including the extent and degree of corrosion as well as identifying options for remediation. The full report can be found in Appendix B, a summary can be found below.

6.1 Existing Coating System

According to archive contract documentation, the current coating system consists of a single pack modified alkyd zinc phosphate primer, "High Build Rust Barrier" and Isotal Ferrox Enamel (alkyd) as the final applied coat, this system was applied in 1999. The previous system was an existing red lead and micaceous iron oxide alkyd system, applied in 1978. During the inspection the average thickness was measured as circa 700µm. No formal "Red Lead" detection testing was carried out, but evidence of this primer was observed in areas where previous damage has exposed the coating system. From the 1999 contract documents it is understood that the red lead paint system was removed in areas exhibiting corrosion but retained and painted over in other areas. Overall the existing coating system is generally in fair to good condition and considered to be stable. Testing of the coating system is recommended prior to the tendering of the repainting works.

6.2 Corrosion

The highest level of coating failure, pitting or crevice corrosion was located predominantly in areas not rain washed, and which has significant contaminant build up, mostly caused by bird excreta, debris, or fungal growth. Sites included are the arched section panels, laced columns, lateral braces, transoms, and tension stiffeners. The underside of the bridge arches has widespread corrosion and the connection ends of the laced plates are showing consistent signs of crevice corrosion, some degree of metal loss and coating degradation. The internal faces of the arches are showing signs coating breakdown. All laced columns had signs of corrosion on the internal faces, consisting of pitting, general and spot corrosion. The connection point of the vertical and diagonal laced columns and the bottom arch are also affected due to dirt entrapment and prolonged wetness.

The worst affected elements under the bridge are the pinned connections points. All are showing signs of metal loss, with the two centre pins being in the worst condition. Pitting and crevice corrosion were observed on the welded joint where the side and top panels of the steel arch meet.

Estimation of the total surface corrosion (visible surfaces) present is VIS2, Rust Grade 4G - 10.0% Rusted.



Figure 6-1 General corrosion and loss of paint



Figure 6-2 Crevice corrosion on edges of elements

6.3 Mechanical Damage and Coating Delamination

There are multiple areas where mechanical damage of the coatings has occurred, mostly around sharp edges and on plates of the laced columns. Coating delamination is occurring on localised parts of the bridge.

6.4 Fungal Growth and Bird Excretion

Fungal growth was observed on both the upstream and downstream faces of the bridge. Bird excretion is widespread on the bridge including many bird nests despite the presence of bird spikes. Both have negative effects on the coating systems and increase rates of corrosion.



Figure 6-3 - Example of Fungal Growth



Figure 6-4 - Example of birds nesting.

7 Protective Coating Repair Options

7.1 Options Considered

The three options were identified in the Lumen report to maintain the protective coating system on the steel elements. These options are listed below along with estimated costs provided by Lumen.

Option 1 – Patch Repairs Only

Based on the rope access inspection, this option involves spot repair for approximately 22% of the total steel area, accounting for any coating disturbance and overlapping that occurs during the primary wash. The rest of the existing coating on the entire structure is to remain. The suggested coating system is a zinc/vinyl type based product.

Estimated cost: \$1.8M

Option 2 – Full topcoat with patch repair (25 year with normal maintenance)

This option involves carrying out the secondary preparation, spot priming and spot undercoat to 22% of the total steel area identical to Option 1. However, the final topcoat is to be applied to the entire steel area rather than spot repairs only. The suggested coating system is a zinc/vinyl type based product.

Estimated cost: \$2.1M

Option 3 – Full blast and repaint (between 25 - 40 year with normal maintenance)

This option involves carrying out the secondary preparation, priming, undercoating and top coating to the entire steel area. The suggested coating system is an epoxy zinc/epoxy/polyurethane type-based product. Note that while systems for new structures are now specified at 40 years to first maintenance it is unlikely that the coating manufacturer is willing to provide a 40 year guarantee due to this being an existing structure. A lower 30 year return period has therefore been used.

Estimated cost: \$3.8M

The costs are estimates provided by the painting inspector based on their recent experience. All three options involve the installation of access scaffolding, containment, disposal, sealing of asbestos, and a primary wash of all steel elements under the bridge. The estimated costs have not included for any maintenance works such as structural repairs and installation of bird deterrents that may also be required. It is anticipated such work would be carried out at the same time using the same access. Also excluded are consenting costs, heating costs, traffic management, project management and quality assurance costs. No contingencies have been applied to the values.

7.2 Economic Evaluation of Options

A Net Present Value (NPV) analysis has been carried out to compare the three paint repair options to determine the most cost-effective option throughout the long term life cycle of the bridge. The timeframe used in the analysis is 60 years, which is the same as the option with the longest maintenance interval (Option 3). Only the cost of repainting has been included with no other maintenance costs incorporated.

Discount rates of 0%, 3%, 4% and 6% have been used.

The NPV cost for each option using each discount rate is presented in the table below.

% Discount	NPV Costs (\$m)		
	Option 1 Spot repair	Option 2 Full top coat with patch repair - 25 Year	Option 3 Full blast and repaint - 30 Year
Undiscounted	\$ 8.90	\$ 6.22	\$ 7.62
3%	\$ 5.86	\$ 3.54	\$ 5.38
4%	\$ 5.23	\$ 3.14	\$ 4.99
6%	\$ 4.31	\$ 2.67	\$ 4.48

It can be seen from the above table that:

Option 1 has highest cost estimate regardless of the discount rate throughout its life cycle. This is due to a high frequency of spot repairs estimated to be required at 8 year intervals. The costs associated with scaffolding, containment, disposal and asbestos treatment will be incurred during every repair.

Option 2 appears to have the lowest cost estimate with 3%, 4% or 6% discount rates. However, there is a risk of cost overrun due to possibility of discovering more areas that require paint repair than initially planned for once the underside of the bridge is accessed and cleaning has been undertaken. In this case the cost benefits of Option 2 over Option 3 may be negated.

Option 3 shows a higher cost estimate than Option 2 with 3%, 4% or 6% discount rates. In line with the discussion in the Section 7.1 a 30 year design return period has been used. Savings will be made on the general items such as access costs. There is no risk of cost overrun as the plan is to repaint the entire bridge.

The selection from the above options will be influenced by Council's ease of funding and cost risk appetite. Option 2 is identified as the most cost-efficient option however this involves taking on a higher cost risk due to the potential for a larger amount of steelwork requiring repair than the 22% estimate currently allowed. In addition this cost risk may be incurred with more regularity due to the lower expected lifespan (25 years vs 30 years).

Based on the output of the NPV we recommend that Option 2 be taken forward. However, we consider the likelihood of the cost risk to be not insubstantial and recommend that this is reflected in the contract terms.

None of the cost estimates stated in this report should be taken for budgeting purposes, it is recommended that a contractor's quotation is sought to provide better budgeting certainty.

8 Conclusions and Recommendations

While the majority of the structure appears to be in good condition, there are two areas of structural concern:

- The first is that there is significant corrosion to elements around the arch pins with some corrosion present on the pins themselves. Major works were carried out on the pins in 1999 however it is not known if the elements which are currently showing deterioration were made redundant by these works. As the pins are critical components this requires further investigation.
- The second element of concern is the concrete deck slab. The GPR scanning revealed locations with potential defects that may include vertical cracking, horizontal planar cracking, spalled and bony concrete. The scans also indicated that the deck thickness may be less than that used in the current assessment. Further investigations of the condition of the concrete slab is recommended.

Most coated surfaces are stable and intact. However, corrosion is present on the structure which is in keeping with a structure which was last painted 21 years ago and where access for short term patch repairs is limited. The coating is in need of remediation.

Three options to repair the coating system on the steel elements under the bridge have been considered, ranging from spot repairs only to full blast and repaint. The initial cost of each option was assessed and ranged from 1.8 million to 3.8 million. An NPV analysis was carried out to determine the most economical painting option over the life cycle of the bridge. This identified Option 2, patch repairs of corroded areas followed by a new topcoat over the whole structure, as the most cost efficient with a cost estimate of \$2.1M.

Recommendations

The following recommendations have resulted from the 2020 principal inspection and coating inspection:

- Repaint the structure. – Patch repair corroded areas and apply a new topcoat over the whole structure. While the access is in place, carry out repairs to elements with severe section loss and replace defective rivets, bolts and the defective cross bracing tie connections (note this will require some design prior to RFP).
- Deck investigations – Carry out intrusive investigations into the deck issues identified by the GPR scan.
- PIN investigations – Carry out a detailed desktop review of the pinned connections. Carry out ultrasound investigations of the pins when access is in place for the painting works.
- Testing of the coating system is recommended prior to the tendering of the repainting works.

In addition to the above, routine maintenance items are identified in Appendix A.



Appendix A – NZTA S6 Principal Inspection Report

		Bridge Name: Victoria Bridge (Cambridge)		Road name: Victoria Street		RP: 969		Bridge ID: 969	
Bridge Type: Concrete deck slab on steel truss arch and beams		Inspection type:				Principal			
Marking Code 0 = Not inspected 1 = Satisfactory 2 = Monitor next inspection R = Routine maintenance S = Structural maintenance N = Not applicable		Deck width (m):		4.88		Longitude:		175.281946	
		Total Bridge Length (m):		140		Latitude:		-37.786936	
		Span lengths (m):		1/12.8, 1/19.81, 1/88.39, 1/19.81					
Inspector Cheng Liu		Next Inspection Type				General			
Date 11/03/2020		Next Inspection Date				11/03/2022			
Element			Mark	Brief description of defect and comments					
Set	No	Description							
Superstructure elements	1	Primary load carrying element	S	The arched section panels, laced columns and lateral braces show the highest level of coating failure, with either surface, pitting or crevice corrosion was located predominantly in areas not rain washed, and which has significant contaminant build up, mostly caused by bird excreta, debris, or fungal growth. The underside of the bridge arches has widespread corrosion and the connection ends of the laced plates are showing consistent signs of crevice corrosion, some degree of metal loss and coating degradation. The internal faces of the arches are showing signs coating breakdown due to widespread general corrosion. All inspected laced columns had signs of corrosion on the internal faces which consists of a combination of pitting, general and spot corrosion. All six major connection points or "pins" are showing signs of metal loss with the two centre pins more affected (around positioning plates of pins).					
	2	Transverse beams (Secondary element)	2	The structural integrity is in good condition, while the protective coating system is showing moderate signs of deterioration. General corrosion and some crevice corrosion were observed around laced plate ends. Minor crevice corrosion was observed at some stringer and transom connections. Widespread corrosion spots were observed on element "UT09-DT09".					
	3	Other (incl. deck) (Secondary element)	S	The concrete deck soffit is mostly covered by asbestos panels and therefore not visible for inspection. There are numerous damaged and missing asbestos panels in all the bays. GPR has identified issues with deck that require further investigation.					
	4	Half joints	N						
	5	Seismic linkages/holding down bolts	1						
	6	Parapet beam or cantilever	2	The deck cantilever is generally in good condition. However a portion of it on both upstream and downstream was not visible to inspect being covered by service utilities.					
	7	Cross bracing	S	General corrosion and some crevice corrosion around stringers, transom connections and laced plate ends. A heavily corroded tie rod is present. Location is at DB1 downstream side.					
Load-bearing structure	8	Foundations	1						
	9	Abutments	2	Loose concrete on face of Abutment B at ends of Stringers 2 and 4.					
	10	Head wall	1						
	11	Pier/column	R	Corrosion and vegetation growth around all piers causing increased corrosion.					
	12	Cross-head/capping beam	1						
	13	Bearings	1						
	14	Bearing plinth/shelf	2	Vegetation growth on upstream side of Abutment B bearing shelf.					
Durability elements	15	Superstructure drainage	R	Some drainage holes on downstream kerb blocked by dirt.					
	16	Substructure drainage	2	Water leakage marks on front face of Abutment A.					
	17	Movement/expansion joints	S	Crack to surfacing above Abutment A. Some debris in and around expansion joint.					
	18	Painting: superstructure elements	S	All forms of corrosion are present throughout the structure including crevice and pitting corrosion. While the condition of the coating ranges from fair to good condition, a repaint is now required to prevent further steelwork breakdown. Refer to the "Victoria Bridge (Cambridge) Condition Assessment Report" 2020 for a detailed outline of the condition of the protective coating system.					
	19	Painting: substructure elements	2	Graffiti on Abutments and Piers that are accessible by foot by the public.					
	20	Painting: barriers/guardrails	R	Moss growth and loss of protective coating on footpath handrail.					
Safety elements	21	Access/walkways/gantries	1						
	22	Guardrail/handrail/safety fences	R	Overgrown vegetation at footpath handrail. Downstream at L/10 from Cambridge end.					
	23	Carriageway surfacing	2	Transverse cracking on surfacing at multiple locations. Worse towards the Cambridge end. Investigate location of cracks and compare to GPR scanning images during deck investigation.					
	24	Footway/verge/footbridge surfacing	1						
Waterway elements	25	Invert/river bed	0	Could not access due to steep banks and dense vegetation.					
	26	Aprons	N						
	27	River bed upstream	0	Could not access due to steep banks and dense vegetation.					
	28	River bed downstream	0	Could not access due to steep banks and dense vegetation.					
	29	Scour	2	Erosion at base of upstream side of Abutment A caused by stormwater runoff.					
	30	River banks	0	Could not inspect, both sides of river banks are covered in dense vegetation. A geotechnical review of the gorge slopes at the structure is currently being undertaken.					
Finishing elements	31	Revetment/batter slope paving	N						
	32	Wing walls	R	Small shallow void on Approach A downstream wing wall with vegetation growing out of the void.					

		Bridge Name: Victoria Bridge (Cambridge)		Road name: Victoria Street	RP: 969	Bridge ID: 969
Retaining element	33	Retaining walls	N			
	34	Embankments	1			
Other	35	Approach rails/barriers/walls	2	Minor loss of coating on approach barriers.		
	36	Approach adequacy	1			
	37	Signs	1			
	38	Lighting	1			
	39	Services	1			
	40	Appearance	1			

		Bridge Name: Victoria Bridge (Cambridge)	Road name: Victoria Street	RP: 969	Bridge ID: 969
Comments and recommendations for maintenance/repairs					
Item no	Element no.	Suggested remedial work	Priority (H/M/L)	Estimated Cost	
1	1	Investigate pins and repair steelwork across whole structure where required. To be undertaken from repainting scaffold.	High	\$50,000	
2	3	Investigate defects in concrete deck. To be undertaken from repainting scaffold.	High	\$20,000	
3	7	Replace tie rod connection. To be undertaken from repainting scaffold.	High	\$1,000	
4	11	Remove vegetation	Medium	\$5,000	
5	15	Clean blocked drainage holes. Repair hole in kerb during repainting work.	Medium	\$5,000	
6	17	Install asphaltic plug expansion joint. Clean debris from expansion joints.	Medium	\$15,000	
7	18	Repaint structure in line with recommendations.	High	\$2,200,000	
8	20	Clean and spot repair handrails.	Low	\$10,000	
9	22	Trim back vegetation.	Low	\$500	
10	32	Remove vegetation and fill void with concrete	Medium	\$500	
				Total cost	\$2,307,000

Remedial work recommended in last inspection has been completed: N/A

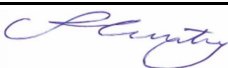
Database changes required:

Comments & recommendations relating to future management

Structure is due for a repaint, this will involve significant access costs which should be utilised to fix all known defects regardless of severity. Please refer to associated report for more detailed breakdown of defects of the structure. For future Principle Inspections, rope access is required by specialist coatings inspectors. For details of the full scope refer to the "Victoria Bridge (Cambridge) Condition Assessment Report" 2020. Costs above are rough order cost estimates, and exclude access with the exception of the repainting.

Overall Condition and Remaining Useful Life:

	Overall Condition Score	Remaining Useful Life	Condition Marking Code	
Edge Protection:	1	20	0	Not Inspected
Superstructure:	2	20	1	Good
Substructure:	1	20	2	Average
Overall:	2	20	3	Poor

Inspected by:	Cheng Liu	Signature:		Date:	11/03/2020
Reviewed by:	Michael Johnston	Signature:		Date:	11/05/2020
Approved by:	Gareth Guirry	Signature:		Date:	15/05/2020

	Bridge Name: Victoria Bridge (Cambridge)	Road name: Victoria Street	RP: 969	Bridge ID: 969
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View Along Carriageway (increasing direction)



View Along Carriageway (decreasing direction)

	Bridge Name: Victoria Bridge (Cambridge)	Road name: Victoria Street	RP: 969	Bridge ID: 969
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LHS Elevation



RHS Elevation

	Bridge Name: Victoria Bridge (Cambridge)	Road name: Victoria Street	RP: 969	Bridge ID: 969
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Underside



Approach Rails / Barriers / Walls (Element 35): Minor loss of coating on approach barriers. Downstream of Cambridge approach.

	Bridge Name: Victoria Bridge (Cambridge)	Road name: Victoria Street	RP: 969	Bridge ID: 969
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Painting: Barriers / Guardrails (Element 20): Loss of coating on footpath handrail. Upstream at L/5 from Cambridge end.



Painting: Barriers / Guardrails (Element 20): Moss growth on footpath handrail posts. Worst over the land spans.

	Bridge Name: Victoria Bridge (Cambridge)	Road name: Victoria Street	RP: 969	Bridge ID: 969
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Painting: Barriers / Guardrails (Element 20): Loss of coating on footpath handrail. Upstream at L/5 from Leamington end.



Painting: Barriers / Guardrails (Element 20): Loss of coating on traffic barrier. Upstream at L/4 from Cambridge end.

	Bridge Name: Victoria Bridge (Cambridge)	Road name: Victoria Street	RP: 969	Bridge ID: 969
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Painting: Barriers / Guardrails (Element 20): Loss of coating on traffic barrier. Downstream at L/6 from Cambridge end.



Painting: Barriers / Guardrails (Element 20): Loss of coating on top of footpath horizontal capping rail. Downstream at L/10 from Cambridge end.

	Bridge Name: Victoria Bridge (Cambridge)	Road name: Victoria Street	RP: 969	Bridge ID: 969
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Guardrail / Handrail / Safety Fences (Element 22): Overgrown vegetation at footpath handrail. Downstream at L/10 from Cambridge end.



Carriageway Surfacing (Element 23): Transverse cracking on surfacing at 2m from Abutment A.

	Bridge Name: Victoria Bridge (Cambridge)	Road name: Victoria Street	RP: 969	Bridge ID: 969
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Carriageway Surfacing (Element 23): Transverse cracking on surfacing at 5m from Abutment A.



Carriageway Surfacing (Element 23): Transverse cracking on surfacing at 2m from Abutment A.

	Bridge Name: Victoria Bridge (Cambridge)	Road name: Victoria Street	RP: 969	Bridge ID: 969
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Carriageway Surfacing (Element 23): Transverse cracking on surfacing at 12m from Abutment A.



Carriageway Surfacing (Element 23): Transverse cracking on surfacing at 30m from Abutment B.

	Bridge Name: Victoria Bridge (Cambridge)	Road name: Victoria Street	RP: 969	Bridge ID: 969
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Superstructure Drainage (Element 15): Clear drain hole on kerb.



Superstructure Drainage (Element 15): Blocked drain hole on kerb.

	Bridge Name: Victoria Bridge (Cambridge)	Road name: Victoria Street	RP: 969	Bridge ID: 969
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Superstructure Drainage (Element 15): Void in kerb allowing water to drain onto steelwork at Span DE.

	Bridge Name: Victoria Bridge (Cambridge)	Road name: Victoria Street	RP: 969	Bridge ID: 969
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Movement / Expansion Joints (Element 17): Crack to surfacing above Abutment A.



Movement / Expansion Joints (Element 17): Some debris in and around expansion joint.

	Bridge Name: Victoria Bridge (Cambridge)	Road name: Victoria Street	RP: 969	Bridge ID: 969
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Abutments (Element 9): Loose concrete on face of Abutment B at ends of Stringer 2.



Abutments (Element 9): Loose concrete on face of Abutment B at ends of Stringer 4.

	Bridge Name: Victoria Bridge (Cambridge)	Road name: Victoria Street	RP: 969	Bridge ID: 969
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Wing Wall (Element 32): Small shallow void on Approach A downstream wing wall with vegetation growing out of the void.

	Bridge Name: Victoria Bridge (Cambridge)	Road name: Victoria Street	RP: 969	Bridge ID: 969
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Primary Load Carrying Element (Element 1) : Spots of corrosion on vertical laced columns at UT05.

	Bridge Name: Victoria Bridge (Cambridge)	Road name: Victoria Street	RP: 969	Bridge ID: 969
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Primary Load Carrying Element (Element 1) : Fungal growth on diagonal laced columns at UT11-UB10.

	Bridge Name: Victoria Bridge (Cambridge)	Road name: Victoria Street	RP: 969	Bridge ID: 969
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Primary Load Carrying Element (Element 1) : Fungal growth on arch bottom chord at UB07-UB08.



Primary Load Carrying Element (Element 1) : Steel beams on land spans generally in good condition. View from D/S side looking towards Cambridge end.

	Bridge Name: Victoria Bridge (Cambridge)	Road name: Victoria Street	RP: 969	Bridge ID: 969
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Primary Load Carrying Element (Element 1) : Crevice corrosion, metal loss and coating failure at U/S Centre pin.



Primary Load Carrying Element (Element 1) : Crevice corrosion, metal loss and coating failure at D/S Centre pin.

	Bridge Name: Victoria Bridge (Cambridge)	Road name: Victoria Street	RP: 969	Bridge ID: 969
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Primary Load Carrying Element (Element 1) : Element UB06-DN06 showing signs of delamination corrosion and loss of protective coating.

	Bridge Name: Victoria Bridge (Cambridge)	Road name: Victoria Street	RP: 969	Bridge ID: 969
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Secondary Elements - Transverse Beams (Element 2): Widespread corrosion spots were observed on element "UT09-DT09".

	Bridge Name: Victoria Bridge (Cambridge)	Road name: Victoria Street	RP: 969	Bridge ID: 969
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Secondary Elements - Other Including Deck (Element 3): Underside of deck covered by asbestos panels, except where asbestos panels are broken.

	Bridge Name: Victoria Bridge (Cambridge)	Road name: Victoria Street	RP: 969	Bridge ID: 969
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Parapet Beam or Cantilever (Element 6): The deck cantilever is generally in good condition. However a portion of it was not visible to inspect being covered by service utilities.

	Bridge Name: Victoria Bridge (Cambridge)	Road name: Victoria Street	RP: 969	Bridge ID: 969
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Cross bracing / diaphragms (Element 7): Corroded tie rod connection at UP T4.

	Bridge Name: Victoria Bridge (Cambridge)	Road name: Victoria Street	RP: 969	Bridge ID: 969
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Pier / Column (Element 11): Corrosion on base plate of upstream side of Column Pier B.



Pier / Column (Element 11): Corrosion on base plate of upstream side of Column Pier B.

	Bridge Name: Victoria Bridge (Cambridge)	Road name: Victoria Street	RP: 969	Bridge ID: 969
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Bearing Plinth / Shelf (Element 14): Vegetation growth on upstream side of Abutment B bearing shelf.

	Bridge Name: Victoria Bridge (Cambridge)	Road name: Victoria Street	RP: 969	Bridge ID: 969
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Substructure Drainage (Element 16): Water leakage marks on front face of Abutment A.



Substructure Drainage (Element 16): Water leakage marks on front face of Abutment A.

	Bridge Name: Victoria Bridge (Cambridge)	Road name: Victoria Street	RP: 969	Bridge ID: 969
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Painting: Superstructure Elements (Element 18): The general condition of the entire coating system is considered stable. View from U/S side.

	Bridge Name: Victoria Bridge (Cambridge)	Road name: Victoria Street	RP: 969	Bridge ID: 969
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Painting: Substructure Elements (Element 19): Graffiti on Abutment A and wing walls.



Painting: Substructure Elements (Element 19): Graffiti on A side of Pier B.

	Bridge Name: Victoria Bridge (Cambridge)	Road name: Victoria Street	RP: 969	Bridge ID: 969
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Invert / River Bed (Element 25): Could not access due to steep banks and dense vegetation.



Scour (Element 29): Erosion at base of upstream side of Abutment A caused by stormwater runoff.

B

Appendix B – Rope Access Inspection Report By Lumen

VICTORIA BRIDGE – CAMBRIDGE



CONDITION ASSESSMENT REPORT

20 APRIL 2020

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REVISION HISTORY

REVISION	DATE	DESCRIPTION	PREPARED BY	REVIEWED BY	APPROVED BY
V1	20 April 2020	Draft for review	M van Rooyen	M Boardman	
V2		Revision 1			
		Revision 2			
		Issue 1			

INTRODUCTION

This document consists of a condition assessment of the coating and corrosion condition of the Victoria Bridge in Cambridge, New Zealand.

The purpose of the assessment was to record the maximum amount of information on the following issues:

- *Extent and degree of corrosion to steelwork.*
- *Wear to or loss of member section size.*
- *Condition of connections (welds, bolts, rivets).*
- *Assess the current coating system and the possible breakdown thereof.*

LOCATION

The Victoria Bridge spans the Waikato River in Cambridge, linking the suburb of Leamington and Cambridge town.

HISTORICAL DATA

The steel arch bridge was designed by the eminent American engineer John Alexander Low Waddell of Kansas City. The bridge stands 38.4 metres (m) above ordinary river level with a three pinned and braced arch of 88.4 m with side girder spans of 19.8 m and 12.8 m.

INSPECTION COMMENTARY

An inspection of the bridge coating and corrosion condition was carried between 9th to the 16th of March by Martin Van Rooyen from Lumen (NACE CIP3 / IRATA L1), Siva Pierard (IRATA L3) and Luke Lennox (IRATA L3). The inspection of the bridge was completed by means of a Rope Access and Fall Arrest System overseen by S Pierard, L Lennox and S McIntosh. Multiple areas of the bridge underside were viewed by different rope access and fall arrest techniques. A total of 16 drops were completed during the inspection timeframe, 13 on the upstream (north) side and 3 on the downstream (south) side. Both bridge abutments were inspected from ground level.

Dry film thickness readings of the coating were recorded using an ELCOMETER 456 Coating Thickness Gauge (Appendix A)

A series of images were also taken to supplement the inspection findings (Appendix B).

Additional images were taken with a UAV (Drone) on both upstream and downstream elevations.

CONDITION SUMMARY

PROTECTIVE COATINGS

The current coating system consists of a single pack modified alkyd zinc phosphate primer, “High Build Rust Barrier” and Isotal Ferrox Enamel (alkyd) as the final applied coat, this system was applied in 1999 over an existing red lead and micaceous iron oxide alkyd system, applied in 1978.

The condition of the coating ranges from “fair” to “good” with minimal localised areas of unsound coatings. The general condition of the entire coating system is considered stable.

FUNGAL GROWTH

Fungal growth is visible on both the upstream and downstream faces and are predominantly on the bottom arch external faces as well as the diagonal lace plate columns.

BIRD EXCRETION

Bird excretion is everywhere on the bridge. All transoms, stringers, lateral bracings, tension stiffeners have either bird nests or excretion visible on them. Anecdotally, any build-up of pigeon droppings will corrode steel due to the high levels of ammonia and salts. The Inspection team did not go too close to the mounds of excreta as it is a known health hazard. This is a serious issue and will need addressing.

MECHANICAL DAMAGE AND COATING DELAMINATION

There are multiple areas where mechanical damage of the coatings has occurred, mostly around sharp edges and on plates of the laced columns. Coating delamination is occurring on localised parts of the bridge, mostly on and around the steel transoms, some spliced connection ends of vertical cross braces and on previous replaced horizontal cross bracing between the bottom arch sections.

A range of dry film thickness readings were taken using an Electro-Magnetic DFT Gauge. The overall thickness of the current coatings was high with an average thickness of approximately 700µ (Details of the readings are presented in Appendix A).

No formal “Red Lead” detection testing was carried out, but evidence of this primer was in areas where previous mechanical and impact damaged has exposed various layers of the overall applied coating system. It is understood that the original coating system would have been an alkyd micaceous iron oxide (Ferrodor type) with the ubiquitous red lead primer.

ASBESTOS PANELS

The underside of the deck where it meets with the steel stringer beams have numerous damaged and missing asbestos tile panels. This is consistent with all the bays.

CORROSION ISSUES

The highest level of coating failure, with either surface, pitting or crevice corrosion was located predominantly in areas not rain washed, and which has significant contaminant build up, mostly caused by bird excreta, debris, or fungal growth. Sites included are the arched section panels, laced columns, lateral braces, transoms, and tension stiffeners.

The underside of the bridge arches have widespread corrosion and the connection ends of the laced plates are showing consistent signs of crevice corrosion, some degree of metal loss and coating degradation.

The internal faces of the arches are also showing signs coating breakdown due to widespread general corrosion. All inspected laced columns had signs of corrosion on the internal faces which consists of a combination of pitting, general and spot corrosion. The connection point of the vertical and diagonal laced columns and the bottom arch are also affected, this due to insufficient drainage of the area as well as the combination of dirt entrapment and prolonged wetness.

All six major connection points or “pins” are showing signs of metal loss with the two centre pins more affected (around positioning plates of pins) . A combination of pitting and crevice corrosion is prevalent on the welded joint where the side and top panels of the steel arch meet. Previous attempts of a maintenance applied joint sealant at this connection point is failing and the added occurrence of fungal growth has accelerated this due to dirt entrapment and prolonged wetness of the area.

Estimation of the total surface corrosion (visible surfaces) present is VIS2, Rust Grade 4G - 10.0% Rusted.

ESTIMATED COST

OPT 1	Patch repairs only								
	Element	Area	Rate	Type	Total				
	Access scaffold			L/S	\$ 650,000				
	Containment			L/S	\$ 120,000				
	Disposal			L/S	\$ 50,000				
	Seal Asbestos	600	120	m2 rate	\$ 72,000				
	Primary wash	6280	50	m2 rate	\$ 314,000				
	Structural repairs	0	0	0	\$ -				
	Secondary Prep	1381.6	250	m2 rate	\$ 345,400	Spot repair is based on a total of 22% and accounts for overlapping			
	Spot Prime	1381.6	50	m2 rate	\$ 69,080	Spot repair of 22%			
	Spot Undercoat	1381.6	55	m2 rate	\$ 75,988	Spot repair of 22%			
	Spot Topcoat	1381.6	60	m2 rate	\$ 82,896				
					\$ 1,779,364				
NOTE*	Based on SSPC VIS 2 rating of 10% plus overlapping = approx 22%								
	Will end up with more exposed corrosion and/or coating delamination during washing due to coating disturbance (impossible to measure)								
	Depending on how much coating is disturbed during the primary wash, the next intervention for either repair work or patch work could be anything between 4-8yrs								
	Consider that a 21 year old coating will still remain for at least 75% of the entire structure								
	Suggested coating system = ZINC/VINYL/VINYL								

OPT 2	Full topcoat with patch repair and prep (25 year with normal maintenance)								
	Element	Area	Rate	Type	Total				
	Access scaffold			L/S	\$ 650,000				
	Containment			L/S	\$ 120,000				
	Disposal			L/S	\$ 50,000				
	Seal Asbestos	600	120	m2 rate	\$ 72,000				
	Primary wash	6280	50	m2 rate	\$ 314,000				
	Structural Repairs	0	0	0	\$ -				
	Secondary Prep	1381.6	250	m2 rate	\$ 345,400	Spot repair of 22% accounting for overlaps			
	Spot Prime	1381.6	50	m2 rate	\$ 69,080	Spot repair of 22%			
	Spot Undercoat	1381.6	55	m2 rate	\$ 75,988	Spot repair of 22%			
	Full Topcoat	6280	60	m2 rate	\$ 376,800				
					\$ 2,073,268				
NOTE*	Based on SSPC VIS 2 rating of 10% plus overlapping = approx 22%								
	Suggested coating system = ZINC/VINYL/VINYL								

OPT 3	Full blast and repaint to achieve 40 years unlikely to get guarantee								
	Element	Area	Rate	Type	Total				
	Access scaffold			L/S	\$ 650,000				
	Containment			L/S	\$ 120,000				
	Disposal			L/S	\$ 50,000				
	Seal Asbestos	600	120	m2 rate	\$ 72,000				
	Primary wash	6280	50	m2 rate	\$ 314,000				
	Structural Repairs	0	0	0	\$ -				
	Secondary Prep	6280	250	m2 rate	\$ 1,570,000	100% for a 25-40 years design life			
	Full primer application	6280	50	m2 rate	\$ 314,000				
	Full Undercoat application	6280	55	m2 rate	\$ 345,400				
	Full Topcoat application	6280	60	m2 rate	\$ 376,800				
					\$ 3,812,200				
NOTE*	Suggested coating system = EPOXY ZINC/EPOXY/POLYURETHANE								

EXCLUSIONS

The following elements are not included in the costing: -

- The selection and fitting of bird deterrents
- Resource consents, permits or any other council fees
- New Member replacement or any structural bracing
- Replacement of any missing or deteriorated rivets
- Heating and or dehumidification to the work area
- Project management & Compliance Inspections (3rd Party)
- Contingencies

CONCLUSIONS

Overall, the structure appears to be in reasonable condition with most coated surfaces, stable and intact. Corrosion sites and areas where the coating is breaking down and failing, can be attributed to the lack of timely maintenance intervention. A lack of preventative measures regarding bird deterrents has not helped. With the optimum cleaning, preparation and recoat system, the structure's protective coating system should give a minimum of a twenty-five-year life to the next maintenance intervention.

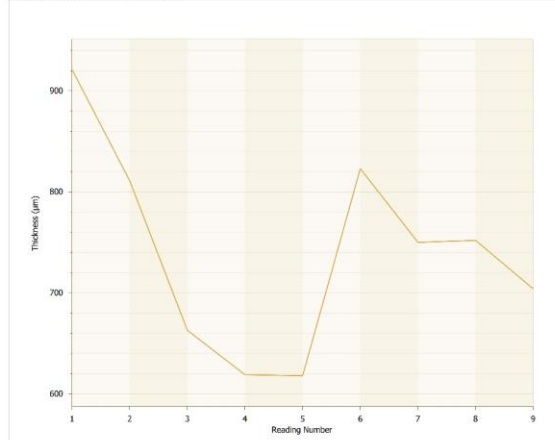
APPENDIX A – DRY FILM THICKNESS READINGS

Inspection Report - Dry Film Thickness

Victoria Bridge-Cambridge\
VB AB CAM



Individuals / Run Chart



Project

Name: Victoria Bridge-Cambridge

Gauge

Type: Elcometer 456/4
Serial #: SG24071

Probe

Type: FNF1U
Serial #: SA13144

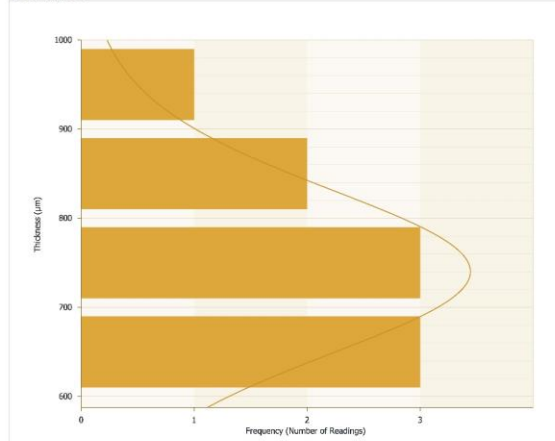
Calibration

Calibration Method: Two Point Auto Calibration
Type: F1
Date: 2/26/2020 10:36 AM
Thick Foil: 1503.0
Thin Foil: 48.7

Batch

Type: Thickness
Name in Gauge: VBABA
User ID: VB AB CAM
Created Date: 3/17/2020 10:58:05 AM
Updated Date: 3/17/2020 10:58:05 AM
First Reading Date: 3/17/2020 10:59:24 AM
Last Reading Date: 3/17/2020 11:00:08 AM

Histogram



Statistics

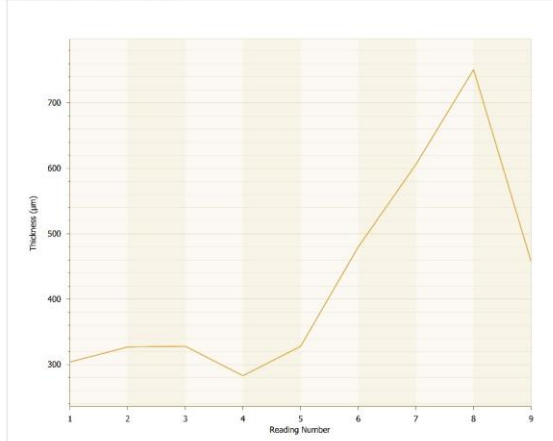
# Readings	9
Mean	740.11 µm
Maximum	921.0 µm
Minimum	618.0 µm
Standard Deviation (σ)	101.05 µm
Mean + 3 σ	1043.25 µm
Mean - 3 σ	436.97 µm
Coefficient of Variation	13.7%

Inspection Report - Dry Film Thickness

Victoria Bridge-Cambridge\
VB AB LEAM



Individuals / Run Chart



Project

Name	Victoria Bridge-Cambridge
------	---------------------------

Gauge

Type	Elcometer 456/4
Serial #	SG24071

Probe

Type	FNFIU
Serial #	SA13144

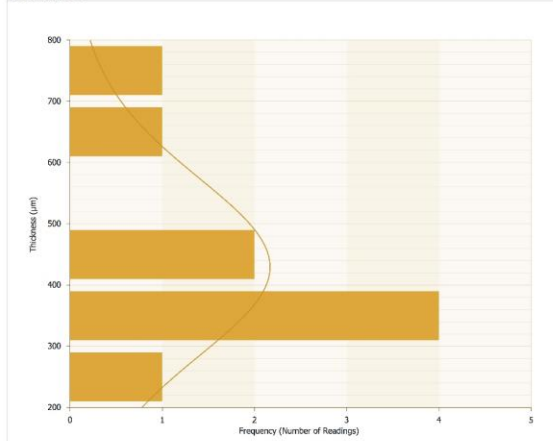
Calibration

Calibration Method	Two Point Auto Calibration
Type	F1
Date	2/26/2020 10:36 AM
Thick Foil	1503.0
Thin Foil	48.7

Batch

Type	Thickness
Name in Gauge	VBABL
User ID	VB AB LEAM
Created Date	3/17/2020 11:51:46 AM
Updated Date	3/17/2020 11:51:46 AM
First Reading Date	3/17/2020 11:52:17 AM
Last Reading Date	3/17/2020 11:53:04 AM

Histogram



Statistics

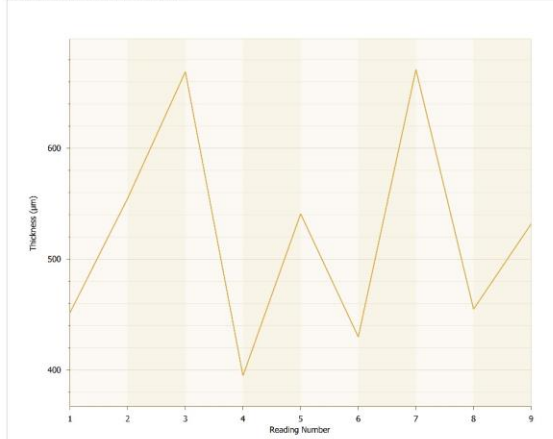
# Readings	9
Mean	429.33 µm
Maximum	751.0 µm
Minimum	283.0 µm
Standard Deviation (σ)	160.52 µm
Mean + 3 σ	910.91 µm
Mean - 3 σ	-52.24 µm
Coefficient of Variation	37.4%

Inspection Report - Dry Film Thickness

Victoria Bridge-Cambridge\
VB T5 DS



Individuals / Run Chart



Project

Name Victoria Bridge-Cambridge

Gauge

Type Elcometer 456/4
Serial # SG24071

Probe

Type FNF1U
Serial # SA13144

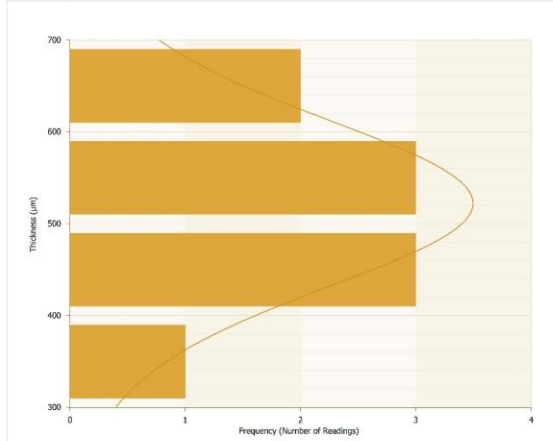
Calibration

Calibration Method Two Point Auto Calibration
Type F1
Date 2/26/2020 10:36 AM
Thick Foil 1503.0
Thin Foil 48.7

Batch

Type Thickness
Name in Gauge VB5DS
User ID VB T5 DS
Created Date 3/16/2020 2:25:47 PM
Updated Date 3/16/2020 2:25:47 PM
First Reading Date 3/16/2020 2:26:32 PM
Last Reading Date 3/16/2020 2:28:12 PM

Histogram



Statistics

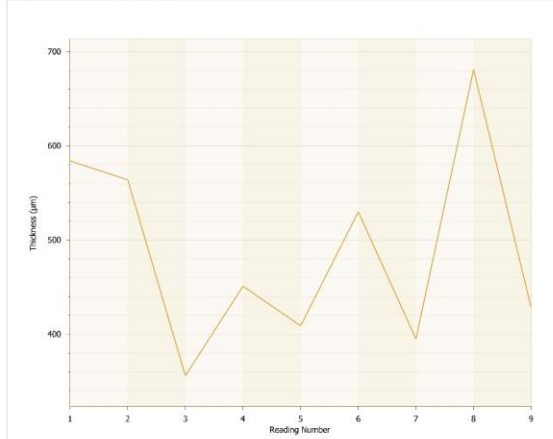
# Readings	9
Mean	522.22 µm
Maximum	671.0 µm
Minimum	395.0 µm
Standard Deviation (σ)	99.59 µm
Mean + 3 σ	820.99 µm
Mean - 3 σ	223.46 µm
Coefficient of Variation	19.1%

Inspection Report - Dry Film Thickness

Victoria Bridge-Cambridge\
VB T7 DS



Individuals / Run Chart



Project

Name	Victoria Bridge-Cambridge
------	---------------------------

Gauge

Type	Elcometer 456/4
Serial #	SG24071

Probe

Type	FNFIU
Serial #	SA13144

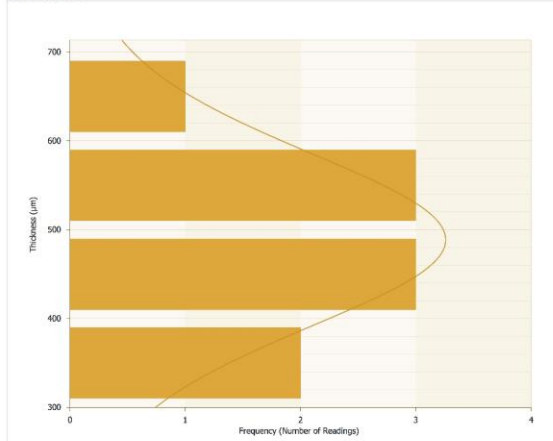
Calibration

Calibration Method	Two Point Auto Calibration
Type	F1
Date	2/26/2020 10:36 AM
Thick Foil	1503.0
Thin Foil	48.7

Batch

Type	Thickness
Name in Gauge	VB7DS
User ID	VB T7 DS
Created Date	3/16/2020 11:02:05 AM
Updated Date	3/16/2020 11:02:05 AM
First Reading Date	3/16/2020 11:02:44 AM
Last Reading Date	3/16/2020 11:03:34 AM

Histogram



Statistics

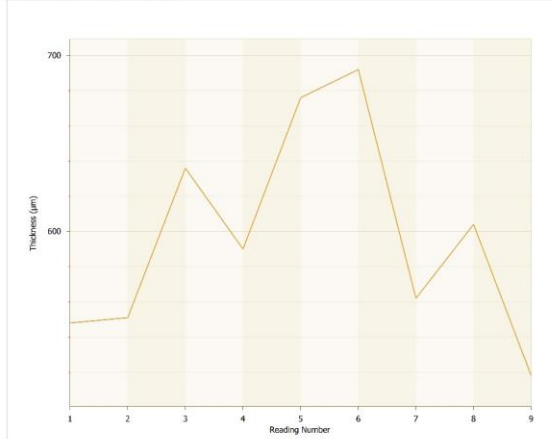
# Readings	9
Mean	488.67 µm
Maximum	681.0 µm
Minimum	356.0 µm
Standard Deviation (σ)	106.82 µm
Mean + 3 σ	809.13 µm
Mean - 3 σ	168.21 µm
Coefficient of Variation	21.9%

Inspection Report - Dry Film Thickness

Victoria Bridge-Cambridge\
VB T12 UP



Individuals / Run Chart



Project

Name Victoria Bridge-Cambridge

Gauge

Type Elcometer 456/4
Serial # SG24071

Probe

Type FNF1U
Serial # SA13144

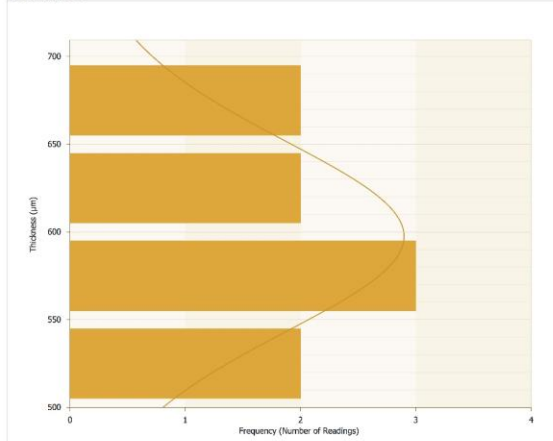
Calibration

Calibration Method Two Point Auto Calibration
Type F1
Date 2/26/2020 10:36 AM
Thick Foil 1503.0
Thin Foil 48.7

Batch

Type Thickness
Name in Gauge VB12UP
User ID VB T12 UP
Created Date 3/13/2020 9:53:23 AM
Updated Date 3/13/2020 9:53:23 AM
First Reading Date 3/13/2020 9:53:35 AM
Last Reading Date 3/13/2020 9:54:11 AM

Histogram



Statistics

# Readings	9
Mean	597.44 µm
Maximum	692.0 µm
Minimum	518.0 µm
Standard Deviation (σ)	60.07 µm
Mean + 3 σ	777.65 µm
Mean - 3 σ	417.24 µm
Coefficient of Variation	10.1%

APPENDIX B– IMAGES



MECHANICAL DAMAGE EXPOSING RED LEAD COATING



CORROSION ON INTERNAL FACE OF VERTICAL LACED COLUMN CAUSING COATING DELAMINATION



METAL LOSS DUE TO CREVICE CORROSION ON SPLICED SECTION OF LACED COLUMN



CREVICE CORROSION OF LACE PLATE ON COLUMN



SURFACE CORROSION SCATTERED ON TRANSOM



SURFACE CORROSION SCATTERED ON SHARP EDGES AND FLANGE UNDERSIDE OF TRANSOM



PITTING CORROSION ON INTERNAL FACE OF VERTICAL COLUMN



PITTING CORROSION WHERE JOINT SEAL HAS FAILED.



FUNGAL GROWTH WITH CORROSION VISIBLE AT RIVET ENDS



FUNGAL GROWTH ON INTERNAL FACES OF LACED COLUMN



GENERAL CORROSION ON UDESIDE FACE OF BOTTOM ARCH



GENERAL CORROSION ON UDESIDE FACE OF BOTTOM ARCH



SURFACE CORROSION ON DIAGONAL CROSS BRACING



SURFACE CORROSION AT CONNECTION NODE OF DIAGONAL CROSS BRACING



COATING DELAMINATION



COATING DELAMINATION



METAL LOSS AT TENSION STIFFENER CONNECTION END



GENERAL COROSION WITH METAL LOSS AT TENSION STIFFENER CONEECTION



CENTRE PIN - UPSTREAM



CENTRE PIN - UPSTREAM



CENTRE PIN - DOWNSTREAM



CENTRE PIN - DOWNSTREAM



GENERAL CORROSION AT VERTICAL COLUMN AND ARCH CONNECTION



GENERAL CORROSION AT VERTICAL COLUMN AND ARCH CONNECTION



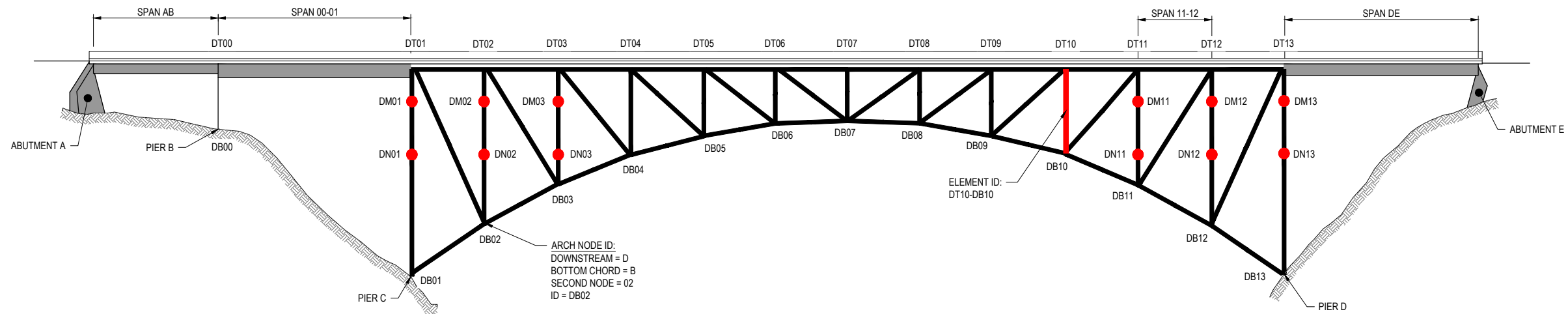
GENERAL CORROSION WITH COATING DELAMINATION AT TRANSOM AND STRINGER CONNECTION



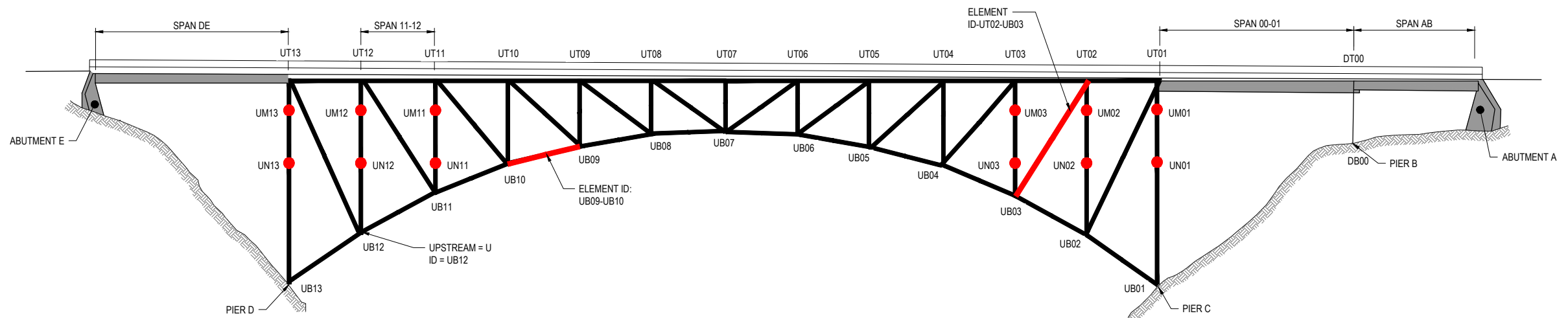
CROSS BRACE AND TRANSOM CONNECTION

C

Appendix C – Under-Bridge Element Nomenclature



DOWNSTREAM ELEVATION
SCALE : 1:250



UPSTREAM ELEVATION
SCALE : 1:250

A	ISSUED FOR INFORMATION	AG	MJ						
No.	Revision	By	Chk	Appd	Date				

Drawing Originator:
Beca

Original Scale (A1) AS SHOWN	Design				Approved For Construction*
Reduced Scale (A3) HALF SHOWN	Drawn	A. GARCIA	APRIL '20		Date
	Desig Verifier				
	Dwg Check	P. NOBLE	APRIL '20		
	*Refer to Revision 1 for Original Signature				

Client:
Waipa DISTRICT COUNCIL

Project:
VICTORIA BRIDGE (CAMBRIDGE)

Title:
NOMENCLATURE SHEET 1 OF 2

FOR INFORMATION NOT FOR CONSTRUCTION

Discipline	STRUCTURAL ENGINEERING
Drawing No.	5640849-SE-051
Rev.	A



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D

Appendix D – Deck Slab GPR Scanning Results

From: Jason Brewerton <jason.brewerton@gprimaging.com.au>

Sent: Thursday, 2 April 2020 12:29 p.m.

To: Michael Johnston <Michael.Johnston@beca.com>

Cc: Mereia Tavuki <Mereia.Tavuki@beca.com>

Subject: GPR Results Victoria Bridge, Cambridge

Hi Michael,

Please find the GPR results for Victoria Bridge which are available to download here:

<https://1drv.ms/u/s!AozhKlIPdtbMhDjeyATCW8RNtFzL?e=Td9Siw>

For your information, the north expansion joint is assumed to be directly above T1 and has been set as chainage 33. The centreline of the bridge was set at 2.44m for the Y direction, 0m in the invert of the northbound lane kicker and 4.88m in the southbound lane kicker (see fig 1). We collected data at 0.25m, 0.65m, 1.22m, 1.75m, 2.15m, 2.73m, 3.13m, 3.66m, 4.23m & 4.63m. As 1.75m and 3.13m were catching the edge of the concrete plinth for stringers 3 & 5, we also collected data at 1.9m and 2.98m to determine the thickness of the concrete deck in the right wheel path.

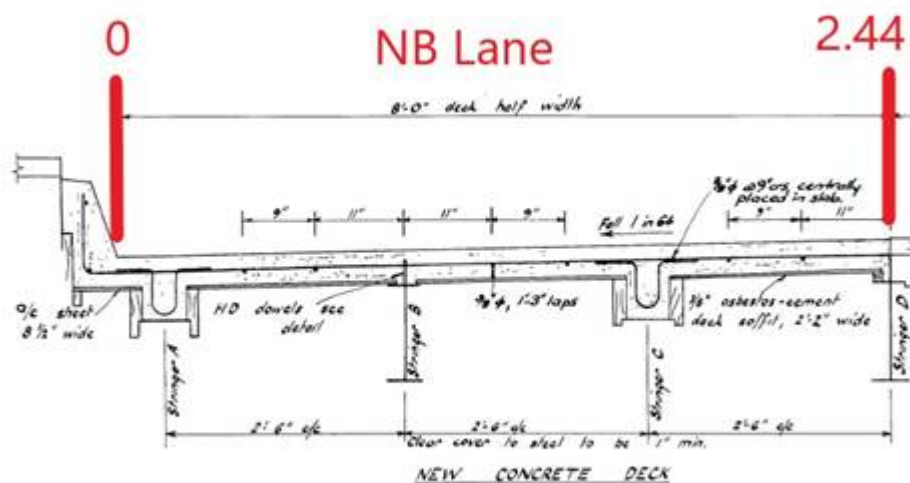


Fig 1: Location of Y measurements

The average spacing of the transverse bars is 230mm with an average cover of 45mm (although the cover does vary considerably). There are two transverse bars missing for the full width of the deck at CH13.6m CH 24.5m, both in span T0-T1 (see fig 2). There is a vertical full width crack in both these locations, however the crack at CH13.6m appears larger and can be clearly seen in the data on the underside as well.

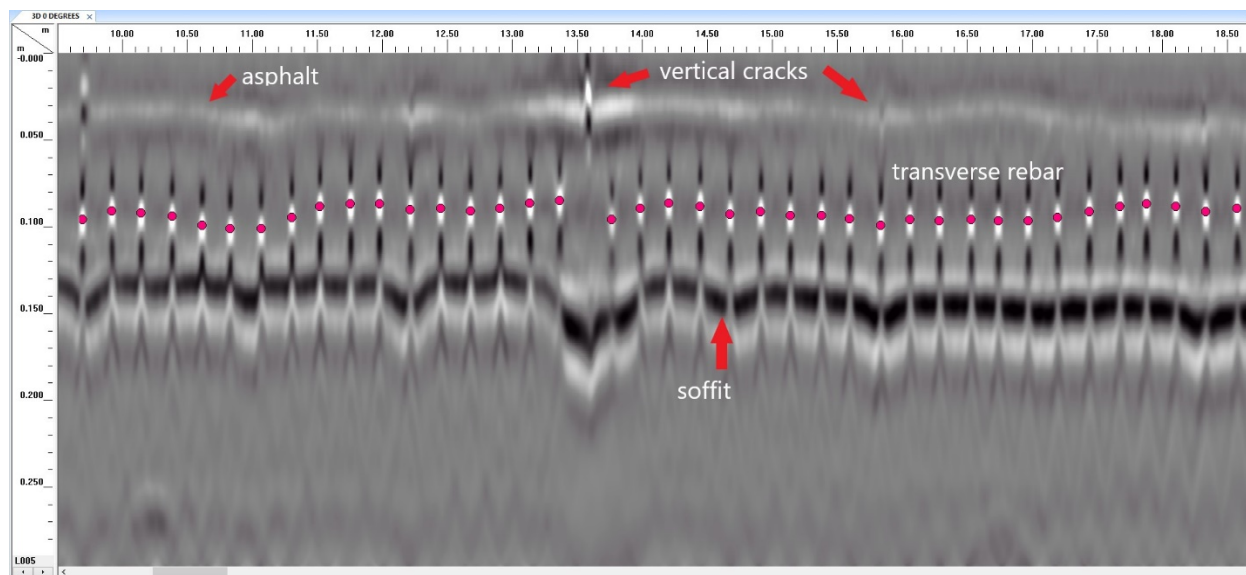


Fig 2: Northbound Inner Edge, Y=2.15m showing crack at 13.6m.

GPR does not normally detect vertical cracking, however in this instance (from the settings and post processing used), we were able to clearly see vertical cracking in the data. Overall, there are a number of different reflections observed which relate to various issues in the concrete. The overall condition of the concrete deck appears most deteriorated between stringers 1 & 2 and stringers 6 & 7 for deck spans abutment A – T0 and T0-T1. Reflections don't occur within a homogeneous concrete so this is a strong indication of deterioration. Please be aware as we are scanning through the asphalt, the condition of the asphalt will also effect the results.

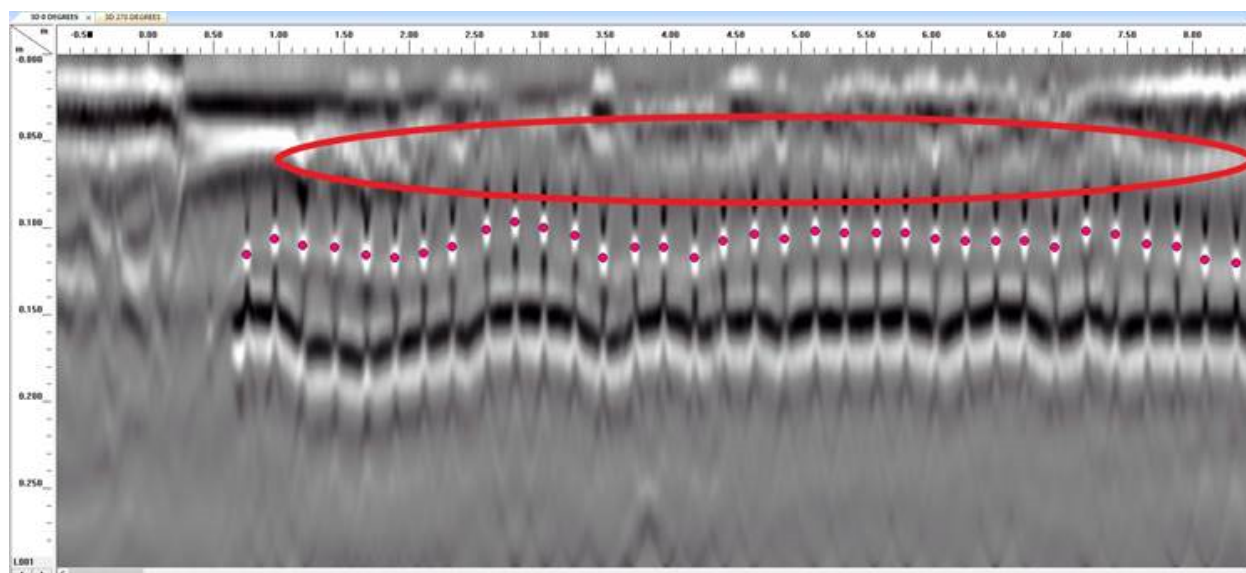


Fig 3: Northbound Outer Edge, Y=0.25m showing reflections within the concrete.

There is consistent vertical cracking across the length of the concrete deck which can be seen in the file “Map Concrete Defects”. This file shows the locations of the vertical cracking as well as locations related to other concrete issues (see fig 4).

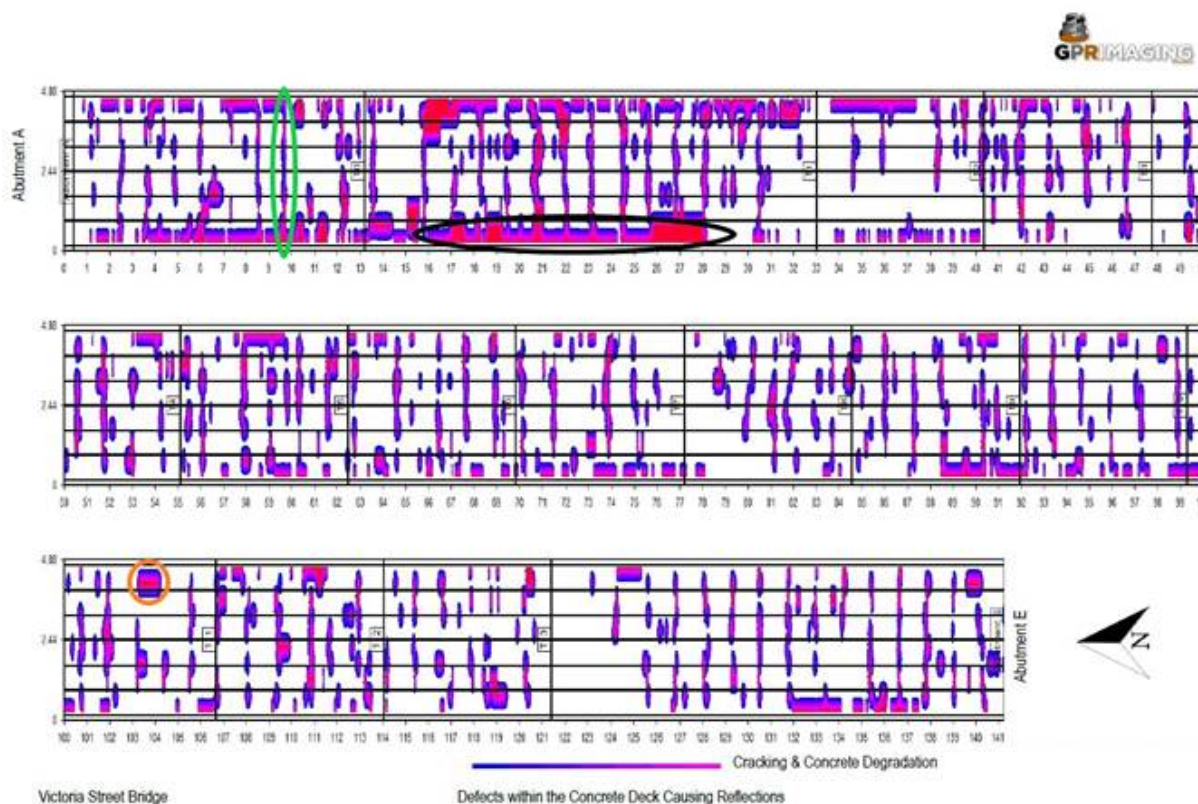


Fig 4: An example of vertical cracking is circled in green. An example of an area of overall poor concrete condition is circled in black and an example of a localised concrete issue is circled in orange. Further comments are included in the excel spreadsheet.

The file “Map of Concrete Condition Above Transverse Rebar” is based on wave scatter above the rebar. Please be aware, the span T1-T2 showing as less deteriorated, is significantly influenced by the compromised cover in this area (only 20-30mm in places), so we would consider the condition of the concrete is similar to elsewhere rather than less deteriorated as shown.

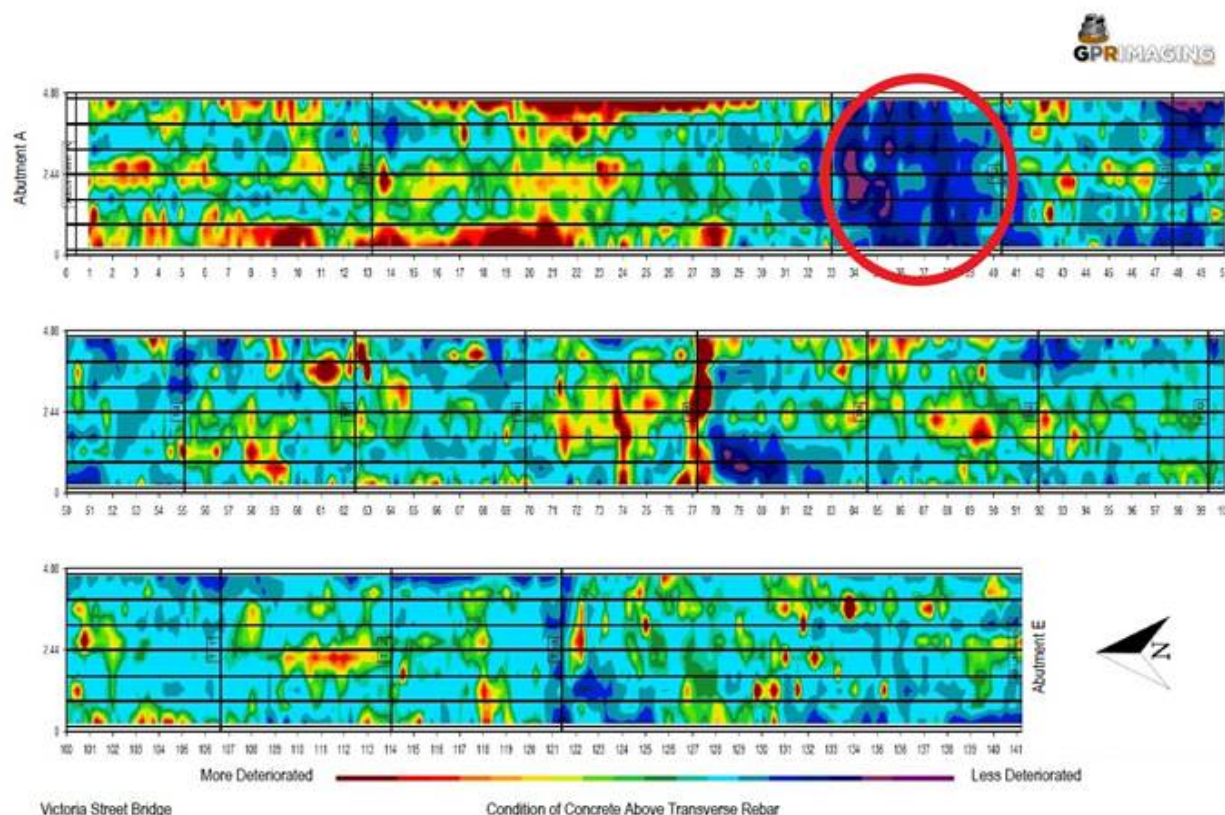


Fig 5: Showing the span T1-T2 referred to above.

With regards to potential spalling locations, longitudinal bars can obscure these underneath the rebar. It is difficult when collecting data from a vehicle to avoid these bars so we would prefer to rescan these potential locations by hand to confirm this (perhaps on the day of the coring). There are some isolated areas where the reflection at the soffit of the deck look like steel rather than air. It is possible the vehicle has deviated slightly and we are just catching the edge of a stringer, but apart from this, do you know of any areas that have a steel plate fixed to the soffit? (see the comments in the excel file Concrete Defects)? If it is not these reasons, there is a high possibility this is either a repaired epoxy area or a potential horizontal planar crack. Our high resolution 2.7GHz hand antenna will give us a better picture of this.

There are also what is interpreted to be surface patch repairs in various locations (though these could also be an area of concrete that is very bony). An example of what these look like (including possible spalling) is shown below. If one of these locations is cored, it will confirm what they are for the length of the deck.

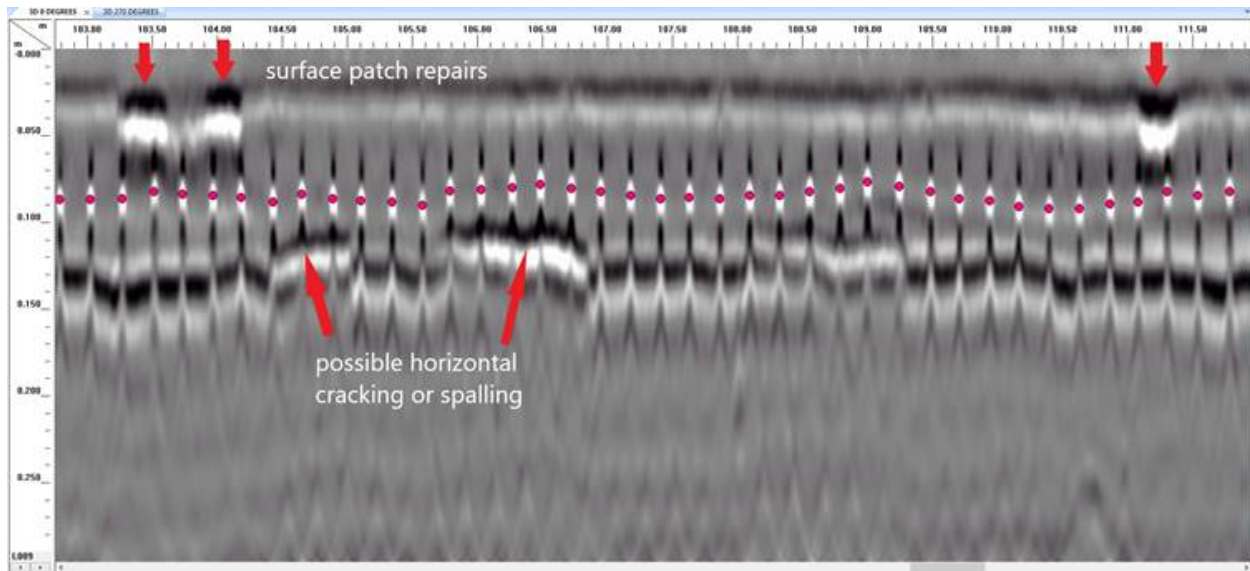


Fig 6: Southbound LWP, Y=4.23m showing surface patches and possible horizontal cracking.

Please be aware for the most accurate asphalt depth readings we would prefer to measure the asphalt with our horn antenna (which is accurate to 2-3mm), however due to COVID19 restrictions this was not possible. Also, the asphalt /concrete reflection between T13 and Abutment E was different compared to the rest of the deck. This could be either because the asphalt mix is different in this section, or the surface of the concrete is bonier compared to other areas. It would be good to verify this when coring.

If you have any questions on the results please do not hesitate to contact me.

Kind regards

Jason Brewerton – Managing Director

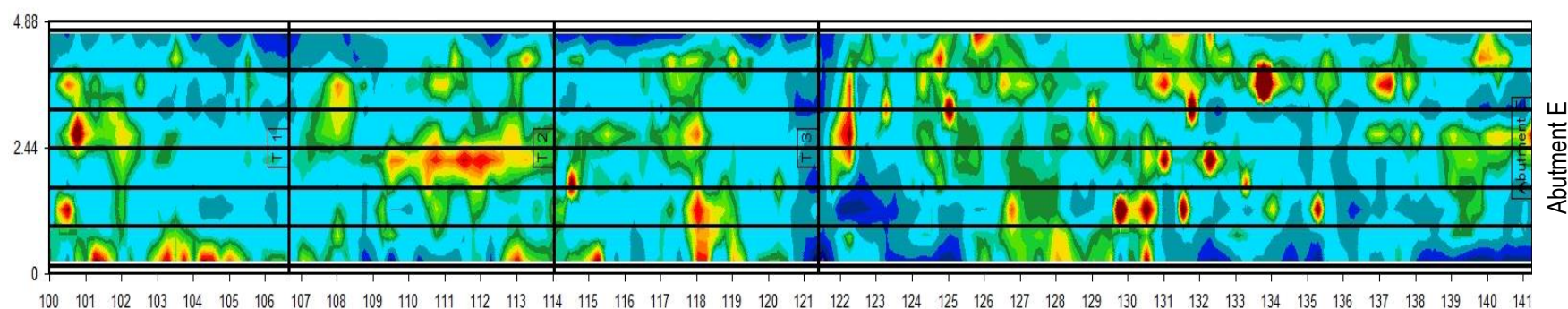
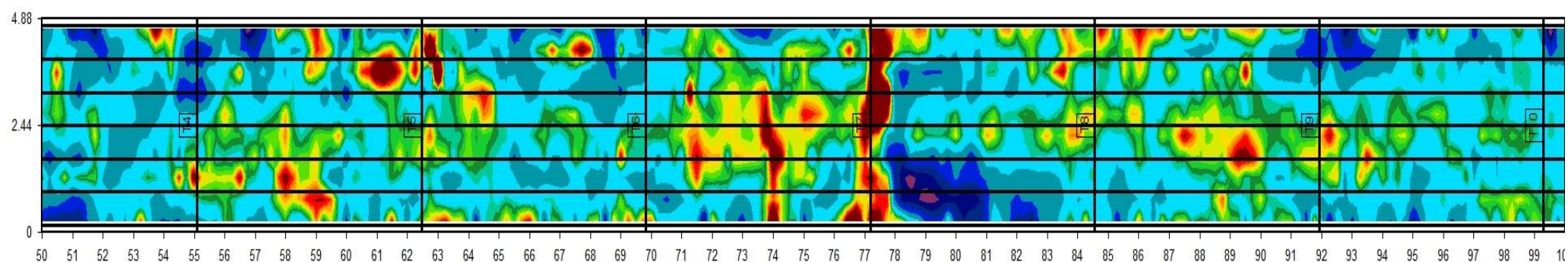
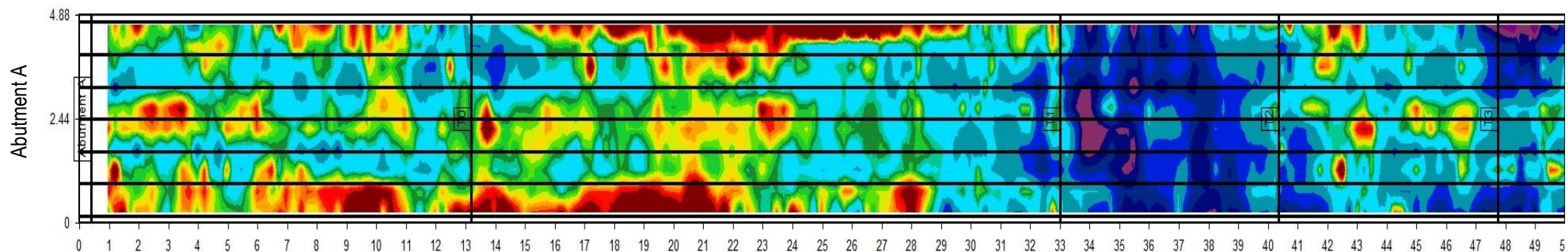
GPR Imaging Solutions

Australia | T: +61 3 9010 6054 | M: +61 439 566 502

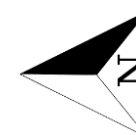
New Zealand | T: +64 7 570 3092 | M: +64 221 038 765

www.gprimaging.com.au | E: jason.brewerton@gprimaging.com.au



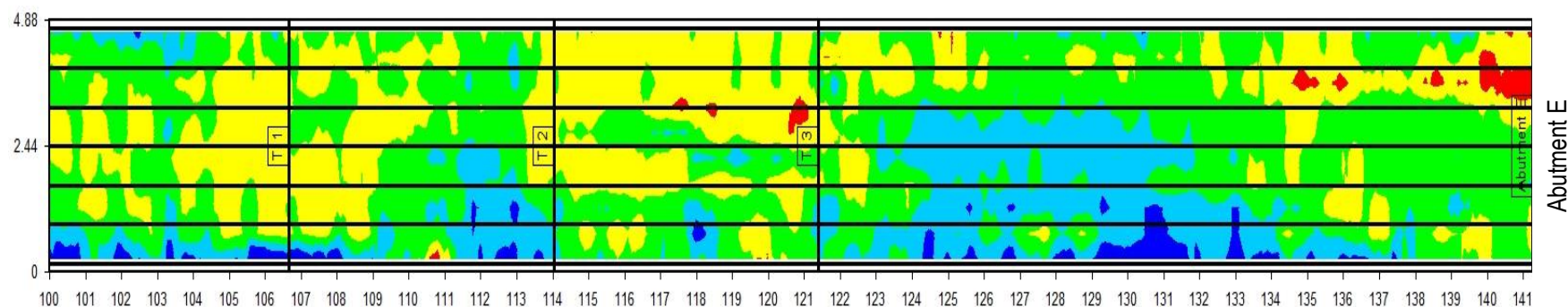
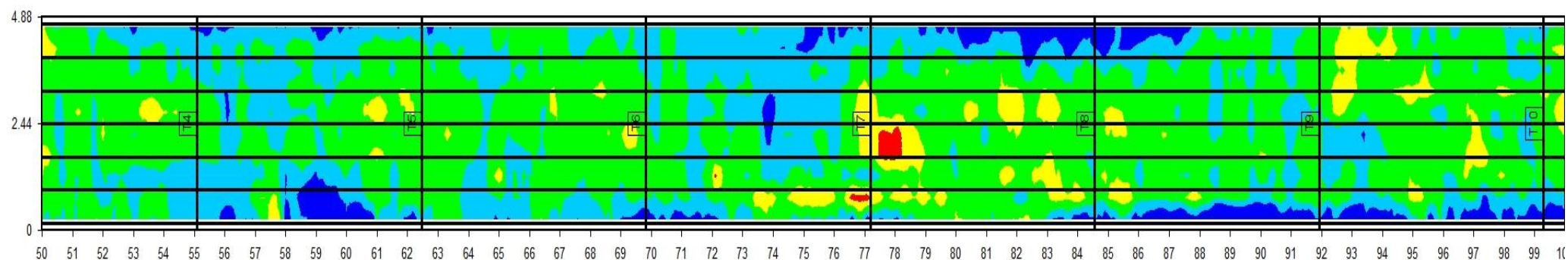
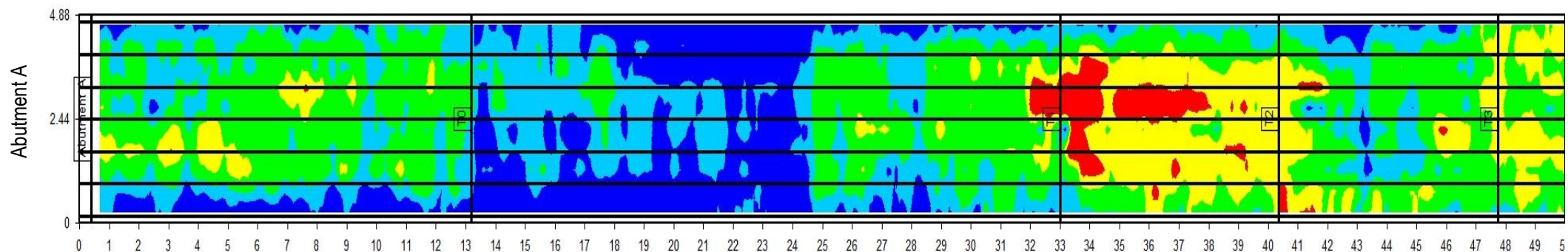


More Deteriorated  Less Deteriorated



Victoria Street Bridge

Condition of Concrete Above Transverse Rebar

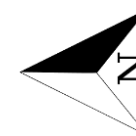


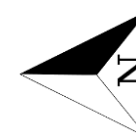
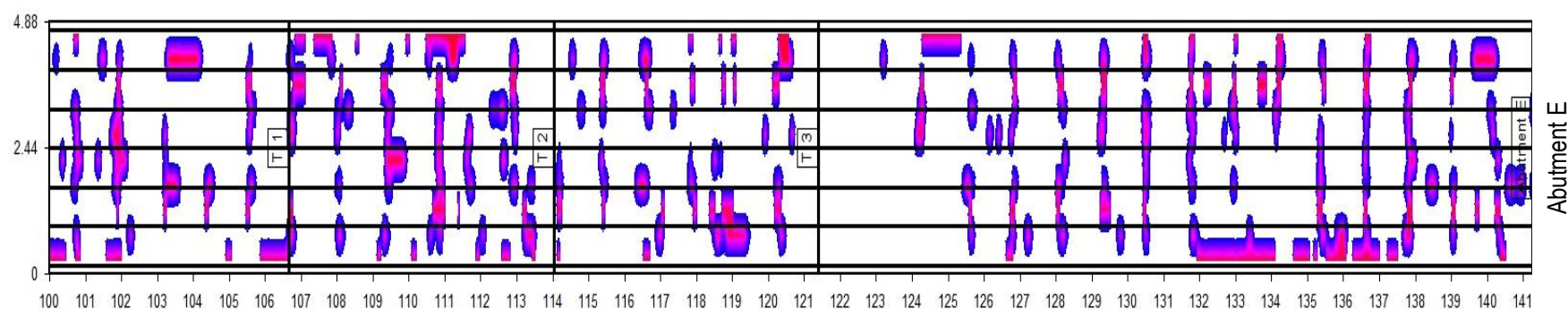
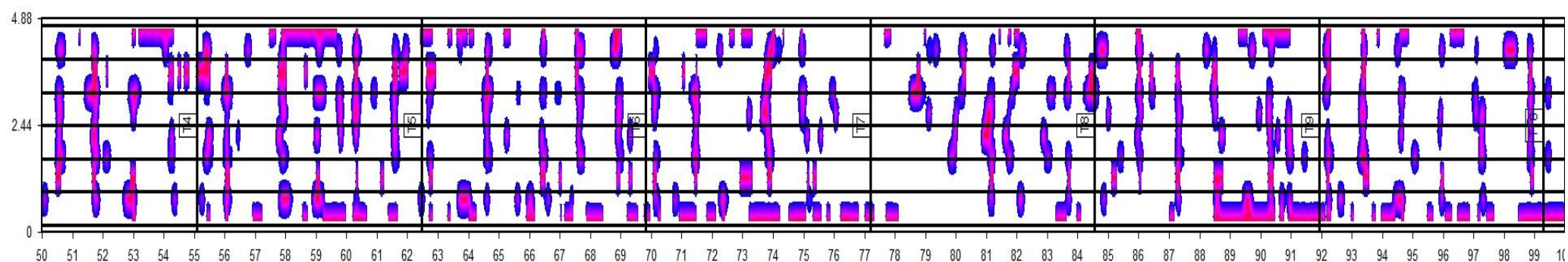
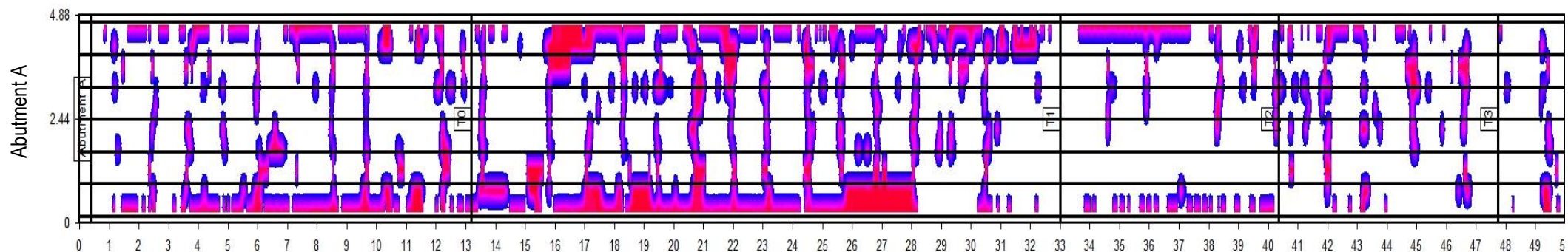
Deck Thickness (m)

Thickness of Concrete Deck

Victoria Street Bridge

Thickness of Concrete Deck

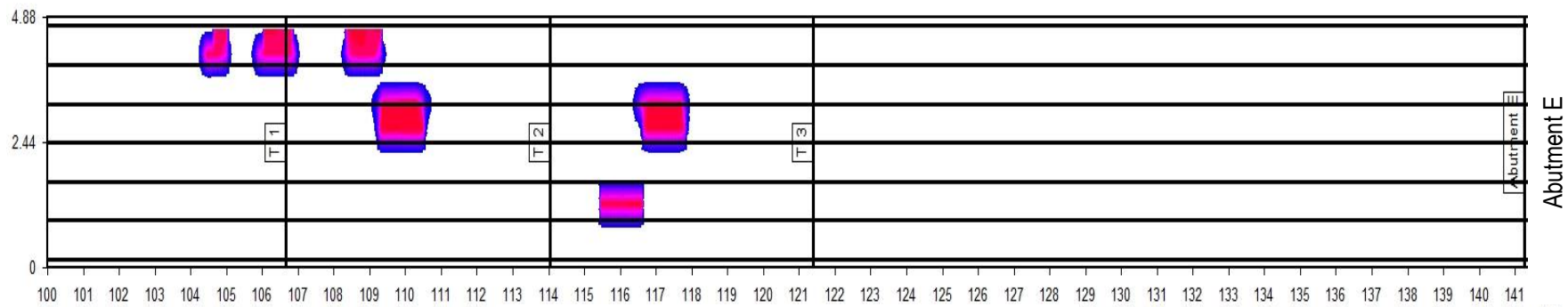
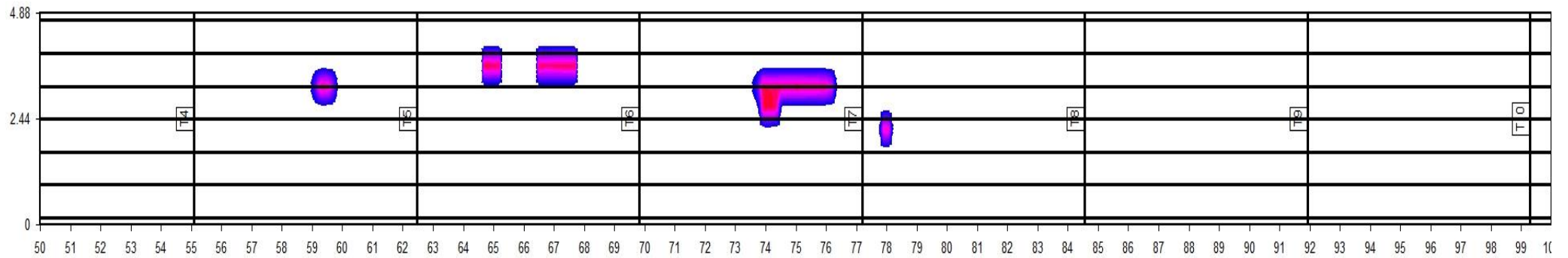
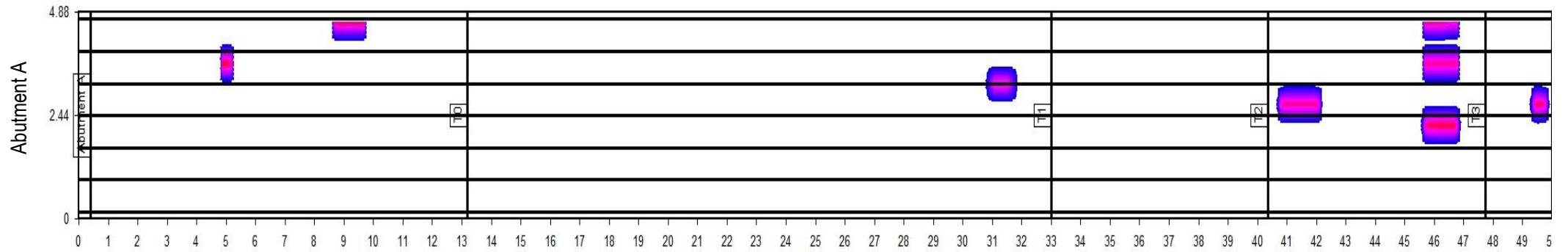




Cracking & Concrete Degradation

Victoria Street Bridge

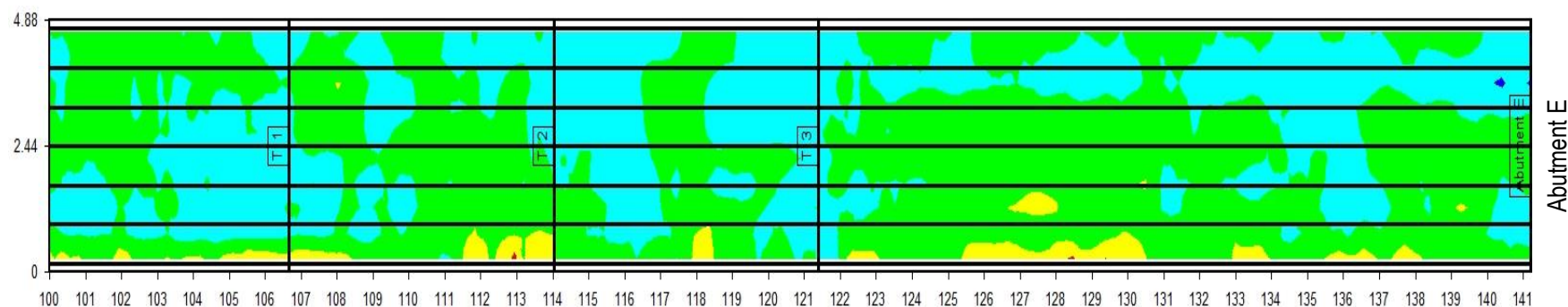
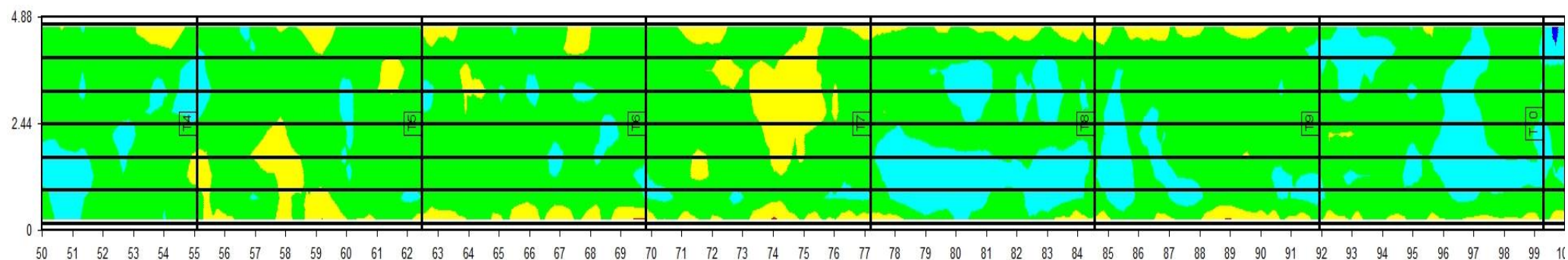
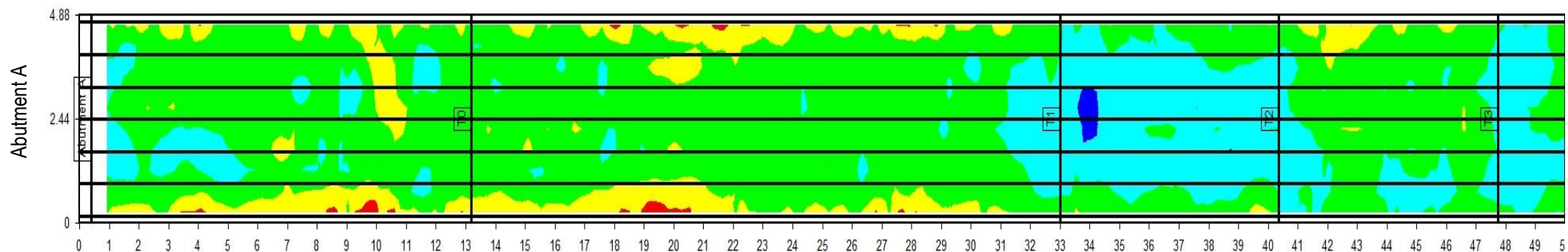
Defects within the Concrete Deck Causing Reflections



Possible Spalling

Victoria Street Bridge

Potential Spalling Below Rebar (see comments)

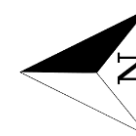


0 0.02 0.04 0.06 0.08 0.1

Cover to Transverse Rebar (m)

Victoria Street Bridge

Concrete Cover of Transverse Reinforcing Steel



Abutment E