Deterioration of Prestressed Concrete Bridge Beams in New Zealand

S M Bruce, Opus International Consultants Ltd.

Sheldon is the manager of the Asset Management Group at Central Laboratories, Opus International Consultants in Wellington, New Zealand.

Sheldon has 23 years experience in the concrete technology area with specialisation in the assessment and repair of concrete structures both in Australia and New Zealand. Structures assessed include bridges, high-rise buildings, reservoirs, chimneys, utility poles, dams, pipelines and tunnels. He is also active in concrete durability research.

Contact Details: Phone 644 5870607
Fax 644 5870604
Email Sheldon.Bruce@opus.co.nz

P S McCarten, Opus International Consultants Ltd.

Peter is a Chartered Professional Engineer and Group Technical Leader for Opus International Consultants in Napier, New Zealand.

Peter has almost 30 years experience in a broad range of civil engineering projects. Recently Peter has specialised in bridge asset management as Transit New Zealand Regional Bridge Consultant for Gisborne and Hawkes Bay and with sojourns to Canada, Malaysia and Sri Lanka.
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S M Bruce, Research Manager (Asset Management), Opus International Consultants Ltd, Central Laboratories
P S McCarten, Group Technical Leader, Opus International Consultants Ltd, Napier

SYNOPSIS

A routine detailed inspection of the Hamanatua Bridge in Gisborne, New Zealand identified significant deterioration to three of the prestressed concrete I-beams. Corrosion of prestressing strands had caused concrete spalling along the bottom flange of the beams. The deterioration of the prestressed beams on Hamanatua Bridge raised the concern that there were other bridges on the New Zealand State Highway network, of similar age and design, where there was a risk of prestressing steel corrosion occurring. This paper describes an investigation that was carried out to determine the cause of deterioration on Hamanatua Bridge and to assess the current condition and risk of prestressing steel corrosion on other similar bridges. The results of the investigation showed that the majority of bridges in the B1 (coastal perimeter) and A2 (inland) exposure zones are in good condition and measured chloride ion and carbonation levels indicate that the future risk of deterioration due to reinforcement corrosion is low despite concrete cover depths not meeting current durability requirements. Of the bridges located in the B2 (coastal frontage) exposure zone only Hamanatua Bridge is affected by spalling due to prestressing steel corrosion but other bridges in the B2 zone show a similar risk of corrosion due to chloride ion contamination and spalling due to prestressing steel corrosion can be expected to develop on these structures in the future. The concrete covers provided on bridges in the B2 exposure zone do not meet current durability requirements and have proved to be insufficient to protect the prestressing and reinforcing steel from corrosion due to chloride ion ingress. Maintenance intervention will be required to achieve a 100 year service life for these structures. Recommendations include assessment of the impact of prestressing strand corrosion on Hamanatua Bridge to enable appropriate remedial and preventative strategies to be developed and further investigation of pre-1973 precast prestressed I-beam bridges within 1km of the coast throughout New Zealand with a view to considering proactive maintenance options such as applying appropriate protective coating to the highest risk structures to extend their service lives.

1 INTRODUCTION

Hamanatua Bridge is a 3 span bridge constructed in 1966 with prestressed concrete I-beams. It is located within 200m of an open surf beach on State Highway 35 in Gisborne, New Zealand. A routine detailed inspection of the structure in 2004 identified significant deterioration in one of the I-beams which was not evident when inspected in 2002. Corrosion of prestressing strands had caused concrete spalling along the bottom flange of the beam. Further investigation revealed that two other beams were affected by spalling to a lesser degree.
This was believed to be one of the first cases reported in New Zealand of corroding prestressing steel on a State Highway bridge of standard design and there was concern that in this design the stirrup reinforcing did not enclose the prestressing steel and offer an initial indicator of corrosion. It raised the concern that there may be other bridges on the New Zealand State Highway network, of similar age and design, where there was a risk of prestressing steel corrosion occurring. As a result an investigation was carried out to:

- Determine the cause of deterioration on Hamanatua Bridge.
- Assess the current condition and risk of corrosion of both prestressing and convention reinforcing steel on other bridges of similar age and design in a range of exposure environments.
- Assess the variability in materials and workmanship practice for this type of bridge beam.
- Develop recommendations for the future management of these structures to assist New Zealand bridge owners and managers to optimise their remaining life.

2 DESIGN AND DISTRIBUTION OF PRESTRESSED I-BEAM BRIDGES

Prestressed I-beam bridges were first constructed in New Zealand in the late 1950s. The initial prestressed design was based on that prepared by the Ministry of Works with an H20-S16-44 design loading which was further revised with the introduction of the H20-S16-T16 loading in 1961. An example of the later design for a nominal 50 foot span is shown in Figure 1. The design was used, with a number of modifications and improvements, through to the early 1970s. The earliest versions included 0.2 inch diameter pretensioned high tensile wire but this was later replaced with ¾ inch diameter stress relieved strand. The beams were designed with a 28 day concrete compressive strength of 38 MPa (5,500lbs/in²) and minimum cover depths to reinforcing stirrups of 25mm (1 inch). In addition, the earlier beam design specified 29mm (1 ⅛ inch) minimum cover to the prestressing strand.

The Transit New Zealand Bridge Descriptive Inventory was interrogated to determine the number and distribution of these prestressed I-beam bridges. Using a search criterion of “pre-1973 precast pretensioned I-beam bridges” 117 bridges of this type were identified, distributed throughout the country. Seventy three of these bridges are in the North Island of which 46 are within 10km of the coast and 44 bridges of these bridges are in the South Island of which 16 are within 10km of the coast.

3 METHODOLOGY

3.1 Selection of Bridge Sample

Twenty nine bridges, or 25% of the 117 bridges of interest, were selected for assessment. A map showing the location of the selected bridges is shown in Figure 2. Details of the bridges are summarised in Table 1. These structures were selected on the following basis:
• All in the central North Island, and in general proximity to the Hamanatua Bridge.
• In several different regions to ensure beams from a range of precast concrete yards was sampled.
• In a range of exposure classifications as defined by NZS3101: 2006. The sample included sixteen bridges in an inland environment, five bridges in the coastal perimeter (B1) and eight in the coastal frontage (B2). The bridges in the coastal perimeter are all 500m or less from open surf beaches affected at times by onshore winds.

The selected bridges range in age between 35 and 48 years and they included examples reinforced with both high tensile wire and prestressing strand.

The bridges were subjected to three different levels of assessment as detailed in Table 1. Bridges in a range of different locations and exposure zones were selected for each assessment type. A Cursory Assessment consisted of a detailed visual assessment only (see 3.3 below) and took approximately one hour to complete. A Detailed Assessment consisted of a detailed visual inspection plus determination of volume of permeable voids, compressive strength, cover depth, chloride ion contamination and carbonation (see 3.4 to 3.8 below) on one or two representative beams. This assessment took approximately 4 hours to complete. A Comprehensive Assessment included assessment of up to six beams in the bridge but was otherwise the same as a Detailed Assessment. This assessment took eight to twelve hours to complete.

3.2 Inspection Nomenclature

Hamanatua Bridge is a three span structure that was labelled Abutment A to Abutment D from north to south. For all other structures spans were identified by compass bearings based on the general orientation of the road carriageway. Beams were labelled upstream, inner and downstream.

3.3 Visual Inspection

The beams were visually inspected from ground level by naked eye and, where appropriate, with binoculars. On most bridges, inspection of all beams was possible although the width of the river channel on some bridges prevented full inspection of beams in the central spans. The inspection concentrated on identifying defects such as cracking and spalling due to prestressing or reinforcing steel corrosion, exposed prestressing or reinforcing steel and poor concrete compaction that are likely to influence the durability of the beams. Defects and features of interest were photographed.

3.4 Volume of Permeable Voids

Two concrete cores, nominally 54mm in diameter, were removed from the web of each beam. The nature and quality of concrete in the cores was described then the volume of permeable voids (VPV) measured. Testing was in accordance with AS1012.21: 1997 except that measurements were made on whole cores rather than slices and drying was carried out at 60 degrees Celsius. This approach allowed
compressive strength to be measured on the cores at the completion of the VPV testing.

An important influence on the durability of prestressed or reinforced concrete is the ingress of moisture. Water is required to initiate reinforcement corrosion and also acts as the carrier for aggressive agents such as chloride ions. The amount of moisture that can enter the concrete is a function of the VPV so is a useful durability indicator. The quality and likely durability of the concrete in these bridges was assessed by comparison with limits proposed by Andrews-Phaedonos (1997) for the acceptability of VPV results based on durability classification factors.

3.5 Compressive Strength

The compressive strength of the concrete cores was measured after 7 days dry conditioning. Testing was in accordance with NZS3112: 1986 except that the core diameter/aggregate ratio was just under three, rather than four or greater as required by NZS3112. A relatively small core diameter was considered to be acceptable for this work as the results were only required to provide an indication of strength. All concretes had the same maximum aggregate size so any effect of this deviation from the standard will be consistent for all samples.

3.6 Depth of Cover Concrete

The depth of cover concrete was determined using a digital electromagnetic covermeter. Cover was measured over reinforcing stirrups in the web and soffit of the lower flange of each of twenty beams. Covermeter readings were calibrated against actual cover depths at locations where the reinforcing steel was exposed by drilling.

3.7 Chloride Ion Contamination

Drilled powdered samples were collected to determine chloride ion contamination levels. A surface sample was removed to give an indication of the chlorides available at the concrete surface then samples were removed at 20mm increments to a depth of 60mm. The samples were then ground and analysed by X-ray fluorescence and the chloride ion content expressed as a percentage of the dry weight of concrete.

The corrosion of reinforcing steel in chloride contaminated concrete is a complex process and the occurrence of corrosion depends on several factors, (e.g. availability of water and oxygen, concrete permeability) other than the chloride content of the concrete. Practically, however, the use of a chloride threshold to indicate the likelihood of reinforcement corrosion provides a reasonable estimate of corrosion risk. The UK Concrete Society (1984) suggests there is some risk of corrosion when chloride ion levels are over 0.05% by weight of concrete, and a high risk of corrosion at levels exceeding 0.15%. These thresholds were used to assess the corrosion risk on these bridges.
3.8 Carbonation Depth

The carbonation depth of the concrete was assessed using a phenolphthalein indicator at all holes drilled. Carbonation was also measured on the concrete cores removed from the beams.

4 RESULTS

4.1 Visual Inspection

The principal defect affecting beams on Hamanatua Bridge is corrosion of the prestressing steel in the side face of the bottom flange. The worst affected area is at the north end of the upstream beam in Span BC where two prestressing strands are exposed and corroding over a 2.5m length (Figure 3). Cracking extends from this area through to the mid span of the beam. In the worst affected area, cover to the prestressing steel at the side of the beam flange exceeds 30mm and is virtually the same as the cover to reinforcing stirrups in the soffit of the flange. Although both the prestressing steel and the stirrup are corroding, spalling has occurred preferentially over the strands due to the higher corrosion expansion forces exerted by the closely spaced strands in this area. Spalling cracks also affect the bottom flange of one inner beam in each of Spans AB and BC. Each of these areas are currently less than 500mm long and prestressing steel is currently not exposed but they will eventually develop into more significant spalls.

No other bridges were detected where spalling due to prestressing steel corrosion was currently occurring. Although Transit Bridge Inspection records for Kereu Bridge indicate prestressing strands were exposed and corroding in some spans only corrosion of conventional reinforcing steel was observed in this investigation.

Eight bridges are affected by corrosion of the conventional reinforcing steel:

- On five bridges, minor spalling has occurred in the bottom flange of some beams due to poor placement of individual reinforcing stirrups. Stirrups have corroded due to lack of cover in the soffit of the beam flanges and to lack of cover to the cut ends of the stirrups in the side of the flanges. Cover depths are as low as 5mm in some instances. Spalls are generally isolated with only one or two affecting each bridge and are of no significant durability concern.

- The beams on three bridges are affected by widespread spalling in the bottom flanges of the beams due to low cover to the stirrups. All of these bridges are in a coastal exposure zone. Lack of cover in these beams is as a direct result of poor quality control at the time of construction and has implications for the long term durability of prestressing steel adjacent to the stirrups. These bridges are characterised by numerous nails and tie wires corroding in the soffits of the beams and are likely to have been supplied from the same precast yard. Many of the spalls have been repaired with a cement-based mortar and most have subsequently failed. Repairs are currently ongoing.

Apart from the reinforcement corrosion issues described above the general impression of the precast beams in the bridges inspected is that they represent good
Concrete Bridge Beam Deterioration. Minor surface defects, primarily bugholes and areas of grout loss, affect most beams but in many cases were bagrubbed at the time of construction. Shallow areas of poorly compacted concrete were also detected on a number of bridges. A more significant example of poor compaction was detected on Sandys Bridge where a third to half the length of two beams were affected to a depth of up to 20mm. This poses some durability risk although the inland location of this bridge means this risk is relatively minor.

4.2 As-Built Concrete Properties

Concrete used in the precast beams was generally well proportioned and well compacted and in all cases contained approximately a 20mm maximum aggregate size. The coarse aggregate were rounded greywacke in the Gisborne and East Cape areas, crushed volcanic aggregate in the Bay of Plenty and crushed greywacke aggregate at Kawhia (Oparau Bridge) on the west coast.

The compressive strength of the concrete ranges from 40MPa to 81.5MPa and in all cases apart from one exceeds 50MPa. The 40MPa strength result was measured on one beam on Kereu Bridge and it is unlikely this beam would have met the 28 day specified strength of 38MPa. All other concretes are likely to have met this 28 day strength requirement.

The VPV results range from 7.8 to 10.7 which correlate with a Durability Classification Indicator of “Excellent” when assessed in accordance with Andrews-Phaedonos (1997). This indicates that for all the concretes assessed the void structure in the concrete is likely to enhance rather than detract from the overall durability performance. No correlation between VPV and compressive strength was observed.

4.3 Depth of Cover Concrete

Concrete cover depths measured on the prestressed beams are presented in Table 1. Average cover depths range from 27mm to 48mm but are commonly 31mm to 33mm. Minimum cover depths range from 23mm to 14mm.

Although the average depths of concrete cover meet the specified minimum of 25mm, covers to a number of individual reinforcing bars do not. If the 25mm cover requirement is interpreted as an absolute minimum then it can be concluded that the concrete covers in these beams do not meet that requirement.

NZS3101: 2006 allows for the design of concrete structures for design lives of either 50 or 100 years and defines minimum concrete cover depths for durability based on environmental exposure and specified compressive strength. Transit New Zealand requires a design life of 100 years for its bridge structures. Using the current durability design approach for a design life of 100 years and assuming a specified concrete compressive strength of 40MPa, the cover depths required for these prestressed I-beams would be as follows:

<table>
<thead>
<tr>
<th>Zone</th>
<th>Minimum Cover Depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>A2 (Inland)</td>
<td>35mm</td>
</tr>
<tr>
<td>B1 (Coastal Perimeter)</td>
<td>40mm</td>
</tr>
<tr>
<td>B2 (Coastal Frontage)</td>
<td>50mm</td>
</tr>
</tbody>
</table>
The specified cover of 25mm is clearly deficient when compared to these requirements. The measured concrete covers do not conform with these requirements.

4.4 Reinforcement Corrosion Risk

The current and future risk of reinforcement corrosion on these bridges is defined by the depth of both chloride ion contamination and carbonation relative to the depth of concrete cover.

With one exception the current and future risk of reinforcement corrosion on bridges in the A2 and B1 exposure zones is low. Apart from at the surface, chloride contamination levels are less than the 0.05% threshold that indicates some corrosion risk and the depth of carbonation is minimal (i.e. 1mm to 5mm). The exception to this is Waikohu No.3 Bridge, situated some 32km inland, where the chloride ion contamination levels are uniformly 0.04% to 0.05% to a depth of 60mm. Similarly high levels of chloride ions were measured at 60mm depth on the Hawai Bridge which is beyond the influence of atmospheric contamination on this structure. It is likely the beams in both of these bridges contain chlorides added to the fresh concrete, probably in the form of a set-accelerating admixture. Concrete in both bridges contain a volcanic coarse aggregate, are similar in strength and appearance and were probably supplied from the same precast yard. No deterioration is currently occurring on either of these bridges as a result of this contamination.

Chloride ion contamination levels on Hamanatua Bridge show a high level of available chlorides at the surface and some risk of reinforcement corrosion (based on the 0.05% threshold) at depths of between 25mm and 29mm (see Figure 4). Concrete cover depths in these beams are as low as 21mm so it can be assumed that chloride ion contamination is the principal cause of prestressing steel corrosion. There is a high risk of further prestressing steel corrosion developing as chloride contamination continues.

Carbonation in the beams on Hamanatua Bridge is a maximum of 15mm. The ongoing carbonation rate can be estimated using the relationship:

\[ X = k \cdot t^{1/2} \]

where \( X \) is the position of the carbonation front after time \( t \), and \( k \) is a constant dependant on the porosity of the concrete, the relative humidity and carbon dioxide content of the environment, and the amount of reactable calcium hydroxide in the concrete. Using this relationship the total time for the carbonation front to reach a depth of 21mm (i.e. the minimum depth of cover) is 78 years or a further 38 years. This indicates there is currently a low risk of carbonation-induced reinforcement corrosion but some risk of corrosion within the foreseeable life of the bridge.

The chloride contamination profiles for bridges in the B2 exposure zone are presented in Figure 5. These results show that for two of these bridges the chloride ion contamination levels are similar to those measured on Hamanatua Bridge with reinforcement up to a depth of 31mm being at some risk of corrosion (based on the
0.05% threshold). Some conventional reinforcing steel corrosion is already occurring on these bridges where covers are particularly low. The chloride contamination levels indicate that the current and future risk of corrosion to both prestressing and conventional reinforcing steel is high. Carbonation depths on these bridges are a maximum of 1mm so pose no risk for reinforcement corrosion, now or in the foreseeable future.

Further analysis of the chloride contamination results is still to be completed.

5 CONCLUSIONS

Prestressed I-beam bridges located in a range of exposure environments and constructed from the late 1950’s through to the early 1970’s were assessed. In general, the quality of construction in the beams was good with areas of poor compaction at the base of the beams and poor placement of reinforcing stirrups being the most significant visible workmanship issues. The compressive strength of the concrete used in the beams generally meets the requirements of the original construction specification and measurements of the volume of permeable voids indicate good durability performance is likely.

Average concrete cover depths meet the 25mm minimum concrete cover specified but minimum concrete cover depths do not. The specified depth of concrete cover is deficient with respect to the current durability design requirements defined in NZS3101: 2006, particularly in the coastal exposure zones.

The majority of bridges in the B1 (coastal perimeter) and A2 (inland) exposure zones are in good condition and unaffected by reinforcement corrosion. Measured chloride ion and carbonation levels indicate that the future risk of deterioration due to reinforcement corrosion is low despite concrete cover depths not meeting current durability requirements. Some risk of reinforcement corrosion was identified on one bridge in the A2 exposure zone due to chlorides added to the fresh concrete but deterioration is not currently occurring.

Of the bridges located in the B2 (coastal frontage) exposure zone only Hamanatua Bridge is affected by spalling due to prestressing steel corrosion. Three other bridges are affected by relatively widespread corrosion of conventional reinforcing stirrups due to low cover depths and this corrosion has implications for the long term durability of the adjacent prestressing steel. Deterioration to the Hamanatua Bridge is the most advanced of the bridges inspected but other bridges in the B2 zone show a similar risk of corrosion due to chloride ion contamination and spalling due to prestressing steel corrosion can be expected to develop on these structures in the future. There is also a risk of carbonation-induced corrosion developing on Hamanatua Bridge within about 40 years.

The bridges inspected are between 35 and 48 years old and the results of this investigation indicate that there is a current and future risk of prestressing and conventional reinforcing steel corrosion for bridges in the B2 exposure zone. The concrete covers are less than current durability requirements and have proved to be insufficient to protect the reinforcing steel from corrosion due to chloride ion ingress. Maintenance intervention will be required to achieve a 100 year service life.
6 RECOMMENDATIONS

- Investigate the impact of prestressing strand corrosion on Hamanatua Bridge to enable appropriate remedial and preventative strategies to be developed.
- Carry out detailed assessments of all pre-1973 precast prestressed I-beam bridges in New Zealand located within 1km of the coast. Measure concrete cover depths and the level of chloride ion contamination to define the current and future risk of reinforcement corrosion.
- On bridges where a high risk of reinforcement corrosion is identified consider proactive maintenance options, such as the application of a suitable protective coating system, to inhibit the ingress of further atmospheric contaminants into the concrete thereby extending the service life of these structures.

REFERENCES


ACKNOWLEDGEMENTS

Funding for this research project was provided by Land Transport New Zealand.
Figure 1: Prestressed concrete I-beam design for a nominal 50 foot span.

Figure 3: Prestressing strand corrosion on Hamanatua Bridge.
Figure 2: Location of bridges selected for assessment.
Figure 4: Chloride content of concrete versus depth from surface for Hamanatua Bridge

Figure 5: Chloride content of concrete versus depth for bridges in the B2 exposure zone.
Table 1: General Bridge Details

<table>
<thead>
<tr>
<th>Bridge Name</th>
<th>Date of Construction</th>
<th>Distance from coast</th>
<th>NZS 3101 Exposure Zone</th>
<th>Type of Assessment</th>
<th>Concrete Cover (mm)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Tapuata Stream</td>
<td>1968</td>
<td>45.0 km</td>
<td>A2</td>
<td>Cursory</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Pakuratahi Stream</td>
<td>1962</td>
<td>250 m to open surf beach</td>
<td>B2</td>
<td>Cursory</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Poroporo</td>
<td>1969</td>
<td>6.0 km</td>
<td>B2</td>
<td>Cursory</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Mangaiwi</td>
<td>1963</td>
<td>7.2 km</td>
<td>A2</td>
<td>Cursory</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Mangahauini No. 1</td>
<td>1966</td>
<td>100 m to open surf beach</td>
<td>B2</td>
<td>Detailed</td>
<td>27</td>
<td>34 18</td>
</tr>
<tr>
<td>Hamanatua</td>
<td>1966</td>
<td>200 m to open surf beach</td>
<td>B2</td>
<td>Comprehensive</td>
<td>33</td>
<td>44 21</td>
</tr>
<tr>
<td>Mangakuri</td>
<td>1962</td>
<td>4.3 km</td>
<td>B1</td>
<td>Detailed</td>
<td>48</td>
<td>90 23</td>
</tr>
<tr>
<td>Aro Aro</td>
<td>1967</td>
<td>14.0 km</td>
<td>A2</td>
<td>Cursory</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Omoko</td>
<td>1967</td>
<td>14.6 km</td>
<td>A2</td>
<td>Cursory</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Owhiritoa</td>
<td>1967</td>
<td>20.2 km</td>
<td>A2</td>
<td>Cursory</td>
<td>-</td>
<td>-</td>
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<td>Omaukora</td>
<td>1967</td>
<td>31.3 km</td>
<td>A2</td>
<td>Cursory</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Gibsons</td>
<td>1967</td>
<td>35.7 km</td>
<td>A2</td>
<td>Cursory</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Sandys</td>
<td>1968</td>
<td>38.7 km</td>
<td>A2</td>
<td>Cursory</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Waikohu No. 1</td>
<td>1960</td>
<td>49.9 km</td>
<td>A2</td>
<td>Cursory</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Waihuka No. 1</td>
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<td>43.7 km</td>
<td>A2</td>
<td>Cursory</td>
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<td>-</td>
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<tr>
<td>Waihuka No. 3</td>
<td>1971</td>
<td>36.0 km</td>
<td>A2</td>
<td>Cursory</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Waihuka No. 3</td>
<td>1970</td>
<td>32.0 km</td>
<td>A2</td>
<td>Detailed</td>
<td>33</td>
<td>42 24</td>
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<td>Waiaua River</td>
<td>1962</td>
<td>270 m to open surf beach</td>
<td>B2</td>
<td>Cursory</td>
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<td>-</td>
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<td>Hawai River</td>
<td>1969</td>
<td>100 m to open surf beach</td>
<td>B2</td>
<td>Detailed</td>
<td>31</td>
<td>47 14</td>
</tr>
<tr>
<td>Otara</td>
<td>1961</td>
<td>1.4 km to open surf beach</td>
<td>B1</td>
<td>Cursory</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Kereu</td>
<td>1964</td>
<td>460 m to open surf beach</td>
<td>B2</td>
<td>Comprehensive</td>
<td>33</td>
<td>48 14</td>
</tr>
<tr>
<td>Hauone Stream</td>
<td>1962</td>
<td>170 m to open surf beach</td>
<td>B2</td>
<td>Cursory</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Tahawai River</td>
<td>1961</td>
<td>280 m to sheltered harbour</td>
<td>B1</td>
<td>Cursory</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Te Rereatukahia Stream</td>
<td>1968</td>
<td>890 m to sheltered harbour</td>
<td>B1</td>
<td>Cursory</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Waitoa River</td>
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<td>24.8 km</td>
<td>A2</td>
<td>Cursory</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Oparau</td>
<td>1971</td>
<td>340 m to sheltered harbour</td>
<td>B1</td>
<td>Detailed</td>
<td>32</td>
<td>38 23</td>
</tr>
<tr>
<td>Waipa</td>
<td>1964</td>
<td>28.3 km</td>
<td>A2</td>
<td>Cursory</td>
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</tr>
<tr>
<td>Taumarunui Rail Overbridge</td>
<td>1964</td>
<td>59.5 km</td>
<td>A2</td>
<td>Cursory</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Owhango Rail Overbridge</td>
<td>1958</td>
<td>72.4 km</td>
<td>A2</td>
<td>Cursory</td>
<td>-</td>
<td>-</td>
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