Ivanhoe Crossing - Background

Shire of Wyndham East Kimberley, 16 May 2016

Introduction

This paper is intended to provide background information relating to Ivanhoe Crossing and the issues surrounding whether or not to open the crossing to traffic. There have been enquiries about other aspects of the crossing and these matters have also been addressed in this paper.

Background

Ivanhoe Crossing is situated on vacant Crown land and the Shire has legal advice that the road would be considered to be a road dedicated at common law meaning that the Shire has the same responsibilities toward the crossing as if it were a formally dedicated road.

The crossing consists of a curved mass concrete causeway approximately 540 m long and 5.3 m wide. The crossing includes 114 circular conduits of approximately 580 mm diameter in three groups of 104, 4 and 6 which allow water to flow from the upstream side to the downstream side. Prior to commencement of the recent project to re-open the crossing to traffic, under normal flow conditions the flow of water across the crossing was estimated by Shire staff to be approximately 450 mm deep with an estimated flow velocity of just under 1 m/s.

As a result of Council's decision in June 2014 **"That Council supports reopening of the Ivanhoe Crossing"** and Council's inclusion of a budget allocation for "*Ivanhoe Crossing – Reconstruct*" in the 2014/15 budget, the Shire prepared the crossing to be re-opened.

The preparations included a structural assessment of the crossing which was completed previously in 2013 by consulting engineers BG&E, the repair of some minor damage to the crossing, the opening of some culvert pipes (that were previously closed) in order to lower the water flow to a safe level, installation of boom gates across the road and the erection of additional signage.

At the commencement of the project approximately 50% of the conduits were already partially or completely blocked, either by steel plates or riverbed rock. The result of the culverts being blocked was that the flow over the crossing was too deep to safely open the road. Approximately 28 steel plates were removed and rock was removed from in front of the conduit inlets of about a further 20 conduits. The two groups of, 4 conduits in the middle of the crossing and 6 conduits towards the eastern side of the crossing were blocked and have not been cleared. At the normal summer river flow rate, the flow depth over the crossing with the culverts open is close to maximum allowable flow depth and velocity (discussed later) to allow use by traffic.

It should be noted that these conduits are simply a series of culverts. Culverts can be found across in Australia.

The waters at the crossing contain crocodiles and entering the water or swimming is discouraged and signage has been erected to this effect.

The Crossing

The maximum allowable design flow depth to allow the crossing to open for use by traffic is 300 mm in accordance with *Austroads Guide to Road Design Part 5B: Drainage – Open Channel, Culverts and Floodways. Austroads 2013*.

The operational decision regarding a safe depth of flow at the crossing is made by reference to available safety and research information. In this case including but not limited to the guidelines mentioned above and to;

- Guide to Road Design
- T D Shand, R J Cox, M J Blacka and G P Smith, *Australian Rainfall and Runoff, Revision Project 10, Appropriate Safety Criteria for Vehicles – Literature Review, Stage 2 Report.* February 2011 National Committee on Water Engineering,
- Dr J Affum, G Giummarra, H Cheung, (2015) *Austroads Research report AP-R481-15 Safety Provisions for Floodways Over Roads*, March 2015.

The maximum allowable flow depth and velocity to allow the crossing to open for use by traffic is a safety matter. It Is not possible to increase this maximum allowable flow depth as this would compromise the safety of the public and place the Shire in a situation where it would be liable for any loss or injury that might occur through use of the crossing at flow levels deeper than 300 mm.

The flow across the crossing with the culverts blocked under normal summer low flow of 54 m^3/s has been calculated to be 440 mm deep at 0.8 m/s which is supported and confirmed by the measurements taken prior to the works. At a higher summer flow of 69 m^3/s the flow was calculated to be 480 mm deep at 0.9 m/s

Following the recent works and with most of the culvers partially or completely open with a flow rate at the crossing at the higher summer flow of 69 m^3/s, a series of measurements were taken at various locations across the crossing. The results were remarkably uniform across the main part of the crossing with the flow 300 mm deep at 0.4 m/s which as mentioned above is the maximum allowable (safe) flow depth to enable the crossing to open for use by traffic

In its current configuration with most of the culverts open, it is expected that the crossing would be open to traffic for 7 to 9 months of the year.

With the culvers blocked the flow depth over the crossing has been calculated to be between 440 mm and 480 mm for the normal dry weather flow which is significantly above the established safe maximum of 300 mm. To ensure safety of the public it is unlikely that the Shire could open the crossing at any time of the year.

Load limit

The imposition of a 15 tonne load limit on the crossing follows a Council decision of 24 June 2014. The limit was recommended by Main Roads in an email of 14 April 2014. It seems that the limit was initiated by the existence of the previous 15 tonne limit. Given that the limit is in place and the age of the structure, the Shire is not in a position to recommend raising the limit without specialist advice. It is expected that Main Roads will also not recommend raising the load limit without specialist advice.

An unbudgeted estimate of $15,000 has been provided to re-inspect the crossing and a to undertake a finite element multi-span arch bridge analysis of the crossing. The inspection could be undertaken when the Water Corporation next lowers the level of Lake Kununurra which is expected to be in February 2017 with a report possibly available in about May 2017.

Main Roads Western Australia Structural Report (by BG&E)

Main Roads Western Australia commissioned a structural report on the crossing by BG&E. BG&E completed their report in November 2013, there were four recommendations of the report;

1. That the feasibility to lower the water level further in order to carry out more comprehensive inspection be investigated.
2. That the crossing be inspected on a regular basis and after major flood events or after very wet wet seasons.
3. That the missing and damaged marker posts are either replaced or repaired.
4. The a load limit be placed on the crossing to prevent the use of the causeway by heavy trucks.

All of these recommendations have been implemented.

Making the Culverts Safe for People in the Water

Large saltwater crocodiles are known to inhabit the area around Ivanhoe crossing. Signage has been erected by the Department of Parks and Wildlife to warn that the waters at the crossing contain crocodiles and cleaning fish or camping near the water, approaching the water, swimming or entering the water is discouraged.

Measurements of the flow taken after the works were completed and subsequent calculations show that under the normal dry season flows with the culverts open, approximately 1/3 of the water flows over the crossing and 2/3 of the water flows through the culverts.

It has been suggested on a number of occasions that grates, perforated material or large rock could be placed in front of the culverts to allow water to flow through the culverts to make the culverts safe for people who may be in the water. It is possible to provide such a grate effect to the culverts but the maximum depth - velocity product where there is potential for entrapment must not exceed 0.4 m^2 /s. this gives a maximum allowable flow velocity to avoid entrapment at Ivanhoe Crossing of 0.3 m/s. It follows that a total maximum flow through all of the culverts at the crossing is about 6.7 m^3/s which means an increase of about 29.3 m^3/s to the flow going over the crossing equating to a total flow of about 47.5 m^3/s over the crossing giving a calculated depth of about 420mm. It can be seen from the preceding analysis that it is not possible to make the culverts safe and have the crossing safe for traffic at normal dry season flows.

If enough water is permitted to flow through rocks, a grate or perforated material to maintain a trafficable flow depth over the crossing, the rocks, grate or perforated material would create an entrapment hazard.

The options are to leave the culverts open which will allow the crossing to be open to traffic during the dry season or block the culverts to remove the entrapment and drowning hazard for people who may be in the water but note that the crossing will be closed for most of the year.

Further comment regarding risk to people in the water is provided by Mr Julian Martin, Principal Engineer, Water Technology and appended to this fact sheet.

Risk

Advice has been sought from the Shire's insurer regarding the risk implications associated with Ivanhoe Crossing and the treatment of the culverts. The advice is;

…. it is important that in deciding on the appropriate risk treatment for the location, the Shire turns its minds to the risks at hand and considers if their decision is consistent with what another reasonable local government in its position would have done. Ultimately, the Shire's decision regarding suitable risk treatment options will be measured by whether the Shire has acted reasonably in response to the risks. We would therefore suggest that the decision making process is able to demonstrate some rigour by considering the following principles:

- *The magnitude of the risk/s. That is the seriousness or consequence of the risk/s.*
- *The probability of harm. The likelihood of injury or damage occurring.*
- *The burden on the Shire. That is the difficulty, expense and inconvenience involved in implementing and maintaining the risk treatment/s.*
- *The allocation of the Shire's resources and any conflicting responsibilities or competing priorities.*
- *The social utility of the activity that creates the risk of harm and/or damage. What effect the proposed risk treatments will have on the community.*

Risk is a complicated and difficult concept to manage. The advice is essentially for the Shire to recognise the risk and take reasonable measures to mitigate these risks.

The Shire and the Department of Parks and Wild life have provided appropriate signage warning of the risks at the crossing. The signage is both written and symbolic to aid in understanding. Images of the signs are appended to this report.

Liability

The Shire could minimise its liability with regard to the crossing by blocking the culverts, closing the crossing, blocking the access road, erecting appropriate signage and removing the crossing from its asset register. These actions would only minimise the Shire's liability with respect to the crossing. As the Shire has been responsible for the crossing for a significant period of time and undertaken significant work on the crossing it will bear some responsibility with respect to it while it exists. It would be possible for the Shire to remove all liability regarding the crossing be removing it and reinstating the river bed.

Further Work Required

Should the decision be taken to place perforated material or large rock in front of the culverts to allow water to flow through the culverts to make the culverts safe for people who may be in the water. This could be achieved using imported rock at an estimated cost of about $21,000.

Should the decision be taken to close the culverts, rock from the river bed could be dragged against the upstream side of the crossing using an excavator. This solution will result in smaller rock falling or being washed into the culverts and permanently blocking them which will be extremely difficult and expensive to remove should it be required in the future.

Alternatively the culverts could be closed by placing steel plates against the culverts and then dragging rock from the river bed against them. This solution will make very little difference to the flow depth at the crossing compared to the previous two options but will remove the potential problem of rock making its way into the conduits. This solution cannot

be implemented until Water Corp lower river levels which is expected to next occur in February 2017.

Department of Parks and Wildlife signage currently installed at Ivanhoe Crossing.

Shire of Wyndham East Kimberley signage currently installed at Ivanhoe Crossing.

Independent comment regarding risk to people in the water at Ivanhoe Crossing provided by Mr Julian Martin, Principal Engineer, Water Technology

The entry and exit areas of any culvert crossing can be a very turbulent area, subject to high hydraulic forces. These hydraulic forces can vary depending upon the flow rates and conditions occurring at the crossing at any point in time. To account for the hydraulic forces many culvert crossings incorporate rock armouring on the upstream and downstream side to prevent erosion. We believe that the incorporation of any rock, grate or perforated material create an additional hazard to swimmers due to the significant velocities and pressures involved. Furthermore, like the culverts themselves, any rock, grate or perforated material structure will be prone to trapping debris and/or sediment that may further add to the risk.

Additionally, it does seem unusual to have to consider the safety of swimmers in the river. We are not aware of any drainage/road design guidelines in Australia which refer to the safety of swimmers in culvert design. If that was a typical assumed condition it would present a risk to any culvert design.

We think that reasonable measures to minimise the risk to swimmers would be to block the culverts completely which obviously defeats the point of having them there and reverts the crossing to a causeway (and therefore impassable during certain flow conditions/times of the year). In that case the risk to swimmers would still remain significant given the velocities and turbulence across the causeway. A large clear span structure would be the only other alternative and obviously not an option in this instance.

In terms of practical management of the risk to swimmers the only other options could be an exclusion zone marked with buoys etc. (which given swimmers aren't meant to be in there is probably not an option) or some additional wording added to the warning sign. An extra line specifically mentioning the risk the culverts pose to swimmers could be included.

Julian Martin
Principal Engineer
WATER TECHNOLOGY