7 July 2021

Our ref: E309583

Russell Fox

47 Cole Street, P.O. Box 126, Sorell, TAS, 7172

Dear Russell,

**Blue Lagoon preliminary pipe sizing concept**

A preliminary model study of Blue Lagoon has been undertaken to estimate the required pipe dimensions to alleviate the risk of flooding. In particular the risk of inundation of the properties on Kannah Street which had the potential to create health risks when their on-site waste water systems are flooded. The aim of the culvert is to keep water levels below 2.5 m AHD which is when the water almost spills into the drain north of the lagoon (which starts at 2.6 m AHD).

A 1D TUFLOW model has been used to model the storage volume of Blue Lagoon and the proposed culvert from Blue Lagoon to the ocean. The culvert has been assumed to be 81.4m long.

The hydrology has been carried out in accordance with AR&R 2019 guidelines by considering an ensemble of 10 temporal patterns for each Intensity-Frequency-Duration (IFD) design rainfall depth provided by Bureau of Meteorology (BoM) and selecting the median flood depth. The impact of climate change is included.

The model assumptions are detailed below:

- All of the rainfall excess on the catchment is immediately transported to the lagoon; that flow rate into the lagoon = (rainfall intensity minus losses) x catchment area, and outflow is calculated dynamically by the TUFLOW culvert hydraulics along with the water balance to give the pond level changing over time
- No allowance in the water balance has been made for the infiltration of ponded water into the groundwater system at Blue Lagoon (that is, it's assumed the base of the pond is sealed)
- An initial loss of 29 mm and a continuing loss of 3.7 mm/hour have been applied to the design rainfall as per AR&R data hub (accessed 25/06/2021) for this location (suitable for rural catchments).
- The storage volume has been calculated based on the survey data (pers. comms. Sam Lane, 13/06/2021) which has a minimum level of 1.7 m AHD, and LiDAR from Geoscience Australia beyond the survey extents
- Climate change factor of an 18% increase in rainfall as guided by Sorell Council (pers. comms. Paul Markey 24/06/2021)

The modelled scenarios are:

- 450 mm and 600 mm internal pipe diameter (larger or multiple pipes were not considered due to the limited construction budget for this project)

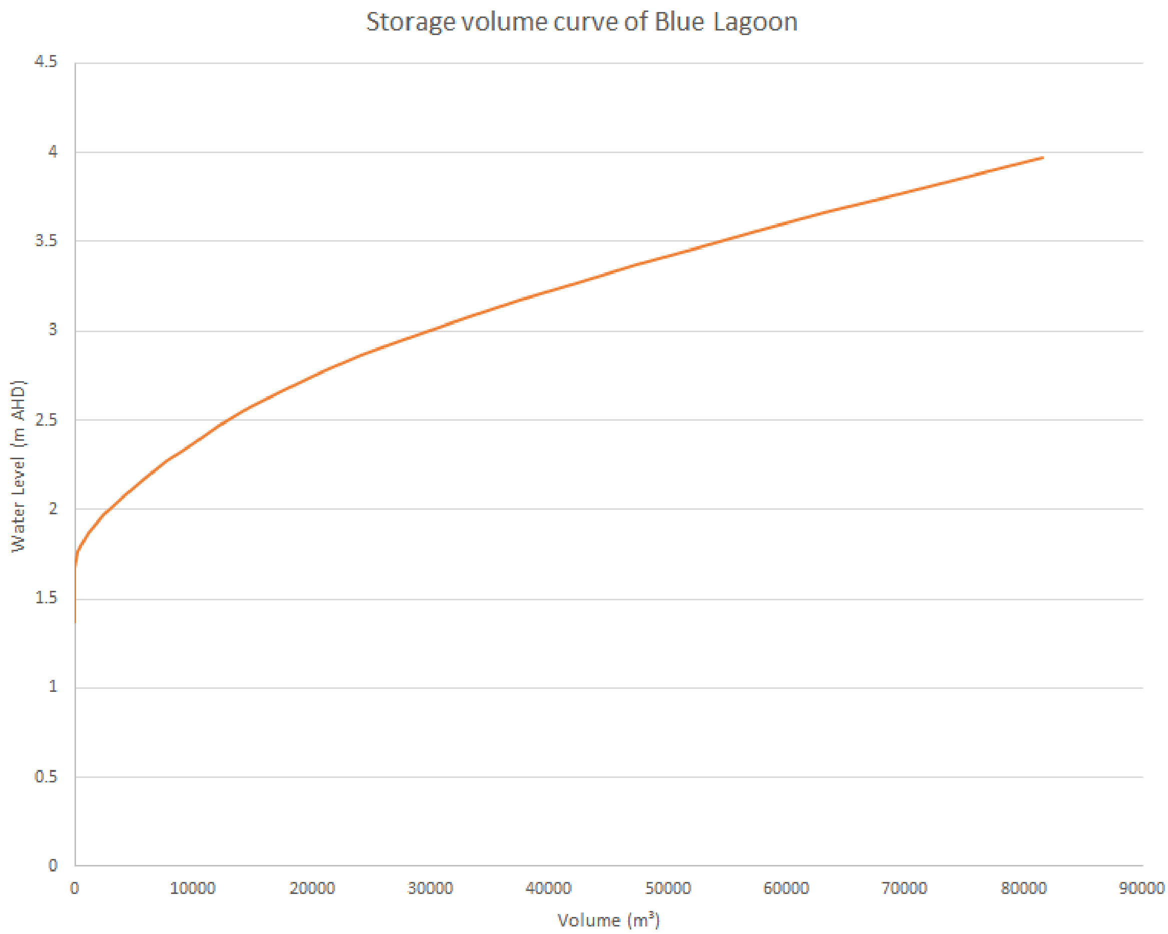
- Tail water level conditions as highest astronomical tide (HAT) of 0.86 m AHD and HAT with sea level rise (SLR) with a tail water level of 1.86 m AHD
- Two sets of upstream and downstream culvert inverts of 1.75 m AHD and 1.40 m AHD respectively, and 1.40 m AHD and 1.20 m AHD respectively
- It is assumed that the culverts are 50% blocked (combination of a grill and debris)

The following design storm annual exceedance probabilities (AEP) have been modelled:

- 1% AEP
- 2% AEP
- 5% AEP
- 10% AEP
- 20% AEP
- 50% AEP
- 63.2% AEP

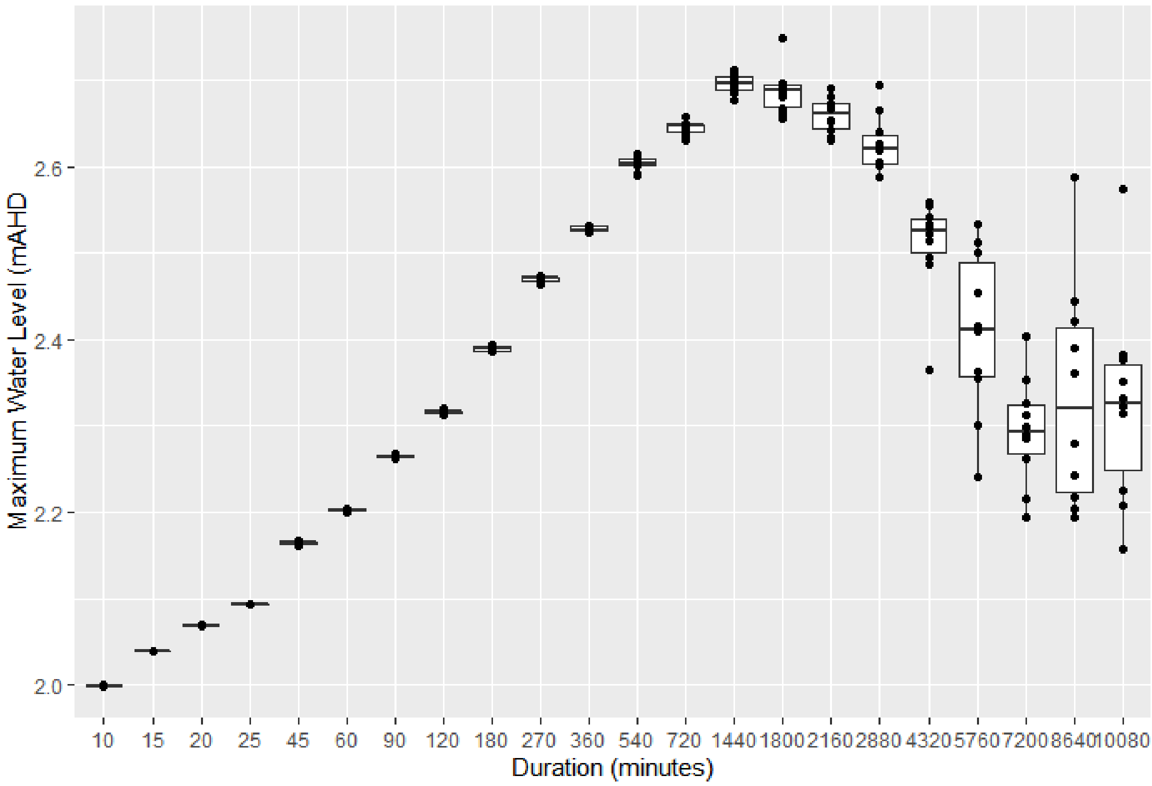
The 50% AEP IFD corresponds to a 1.44 average recurrence interval (ARI) IFD, and the 20% AEP IFD corresponds to a 4.48 ARI IFD.

The storage volume curve adopted for Blue Lagoon is shown below:

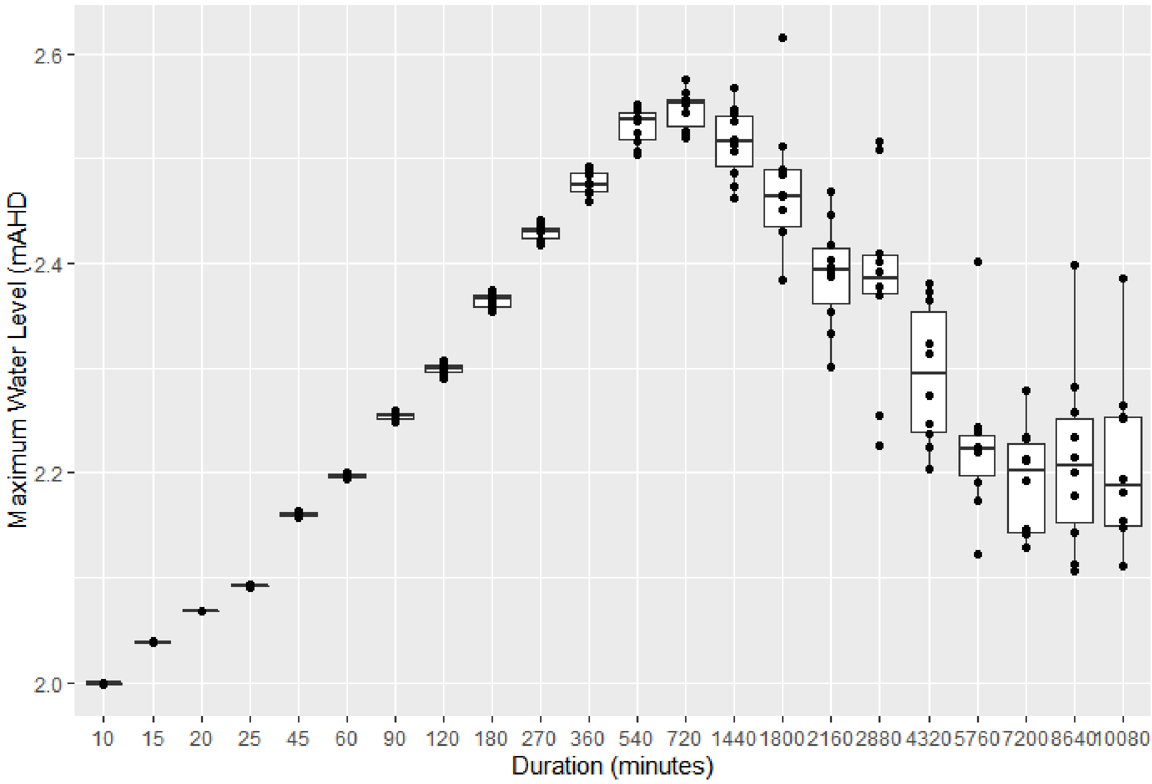


The results are shown below in a box plot style showing the spread of the 10 temporal patterns modelled for the water level at the inlet of the culvert. As the storage volume curve only goes to 4 m AHD, any water levels above this are not being modelled correctly. Only the most frequent AEPs are shown because the modelled water level exceeds the storage volume curve.

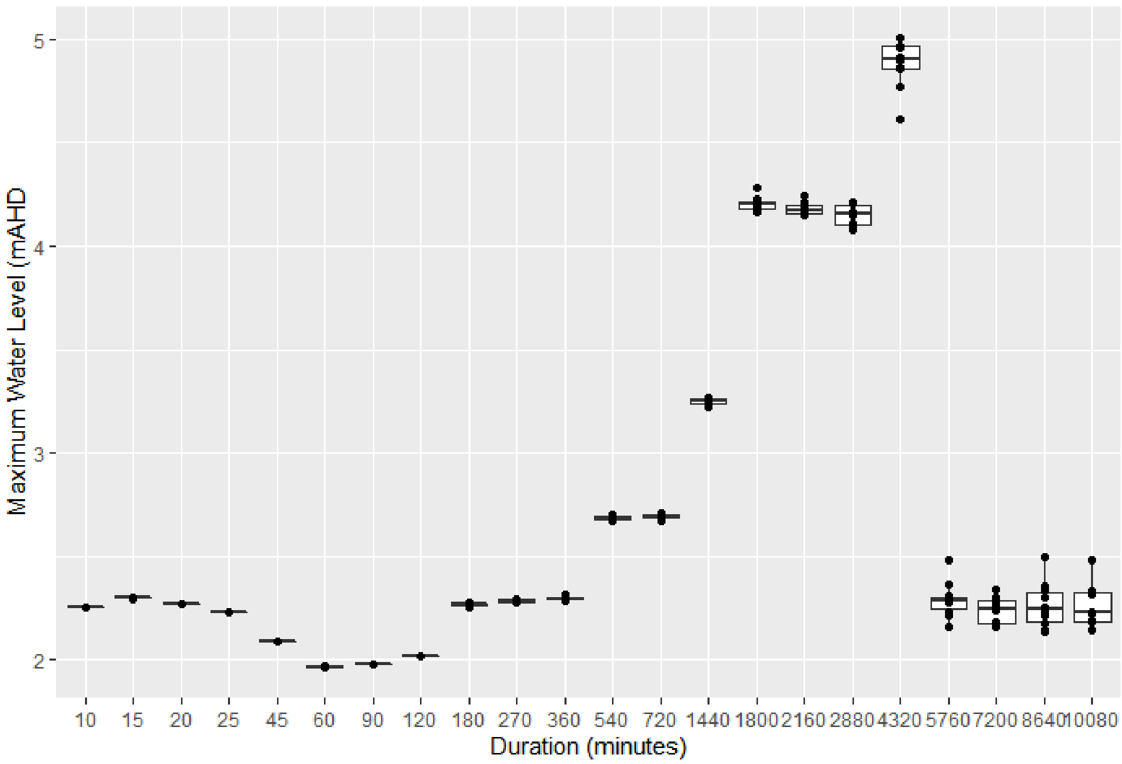
**1.75m AHD inlet invert, 450mm culvert, 63.2% AEP event with HAT**



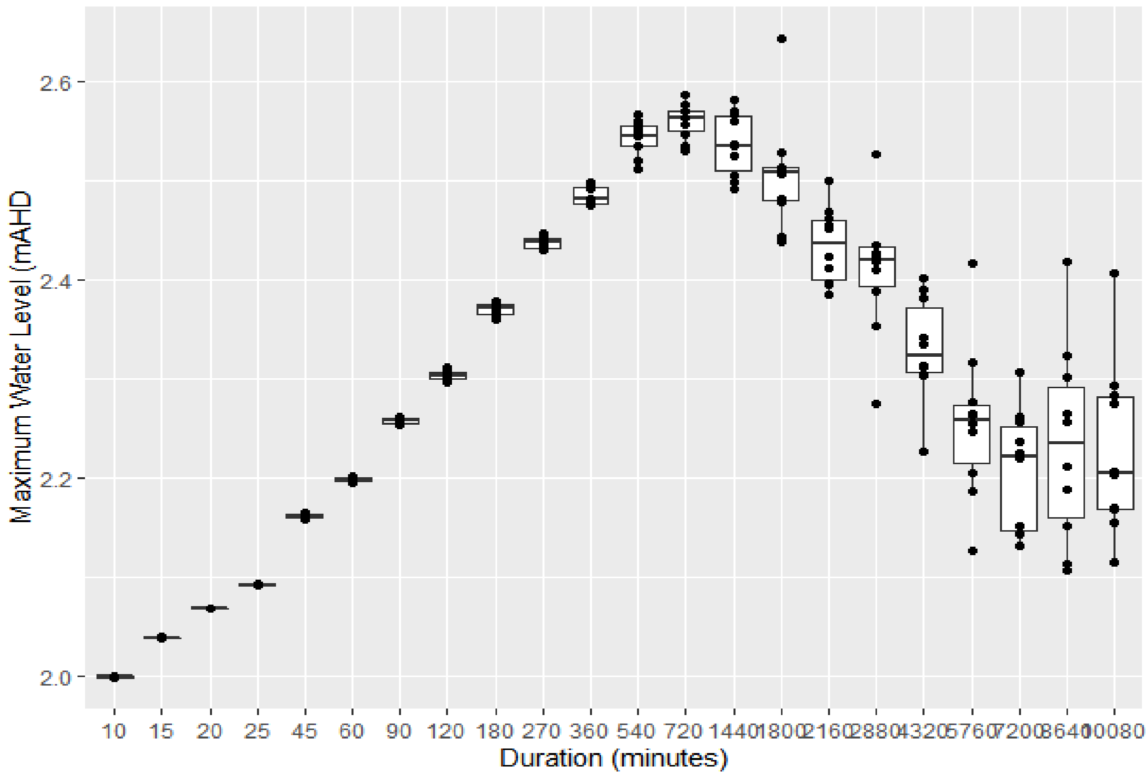
**1.75 m AHD inlet invert, 600 mm culvert, 63.2% AEP event with HAT**



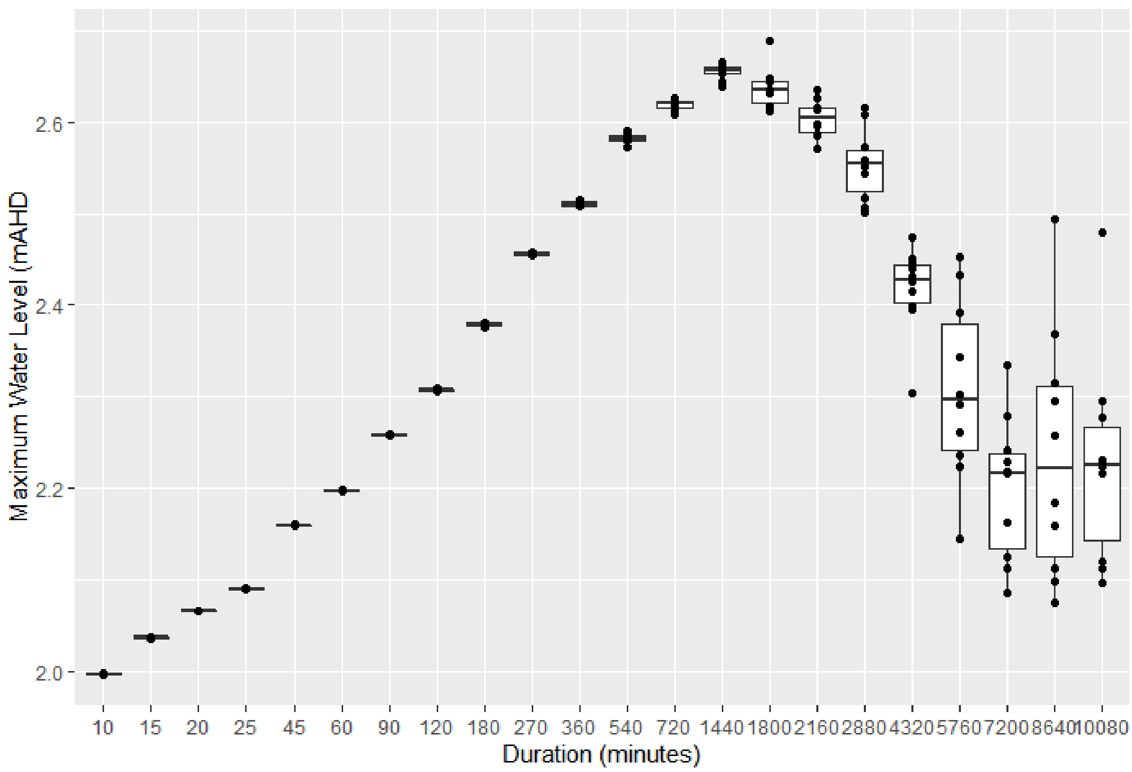

**1.75 m AHD inlet invert, 600 mm culvert, 50% AEP event with HAT**



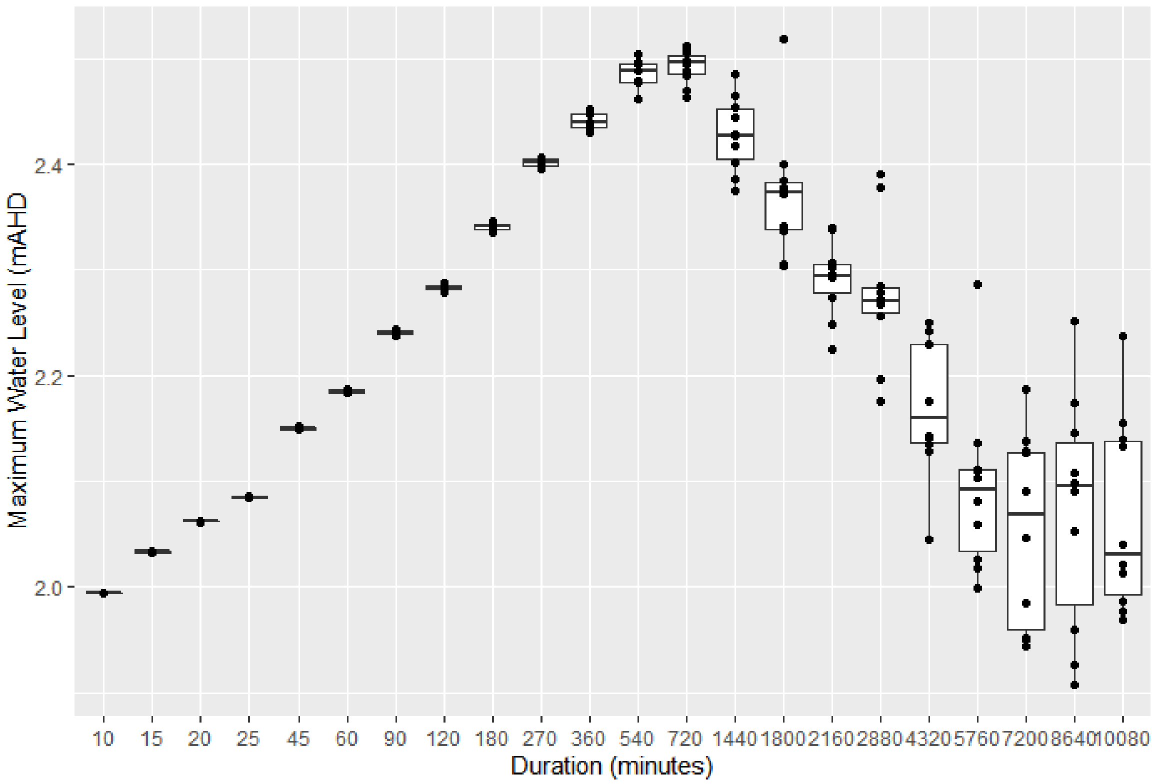
**1.75 m AHD inlet invert, 600mm culvert, 63.2% AEP with HAT+SLR**



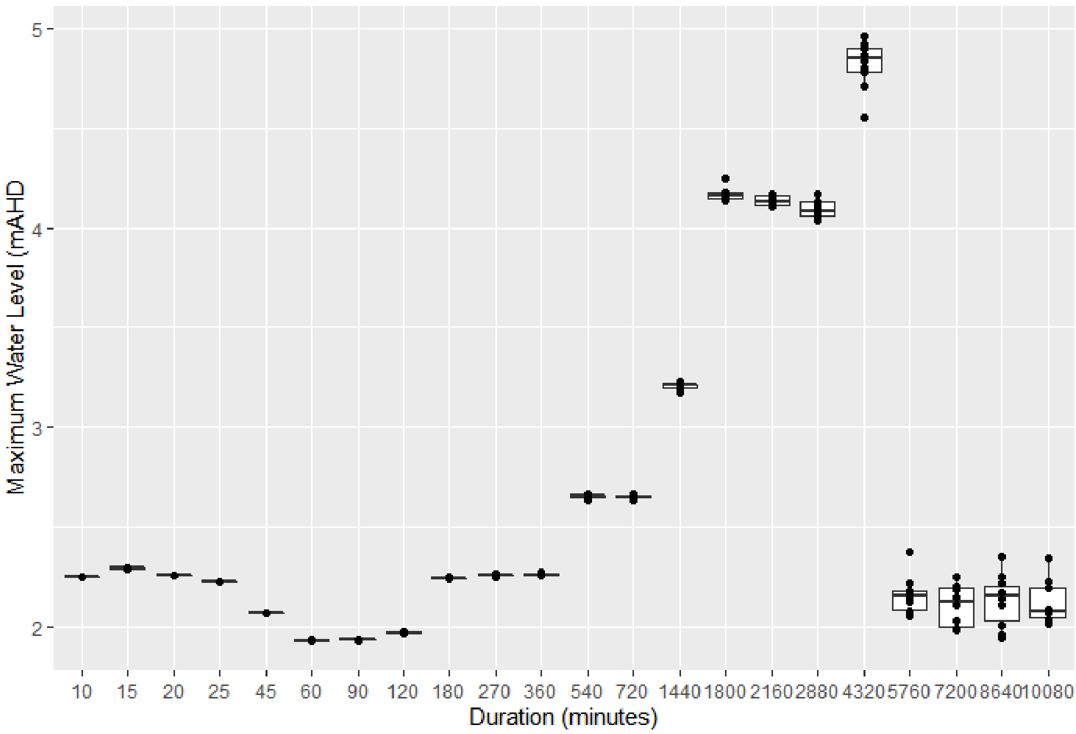

**1.4 m AHD inlet invert, 450 mm culvert, 63.2% AEP with HAT**



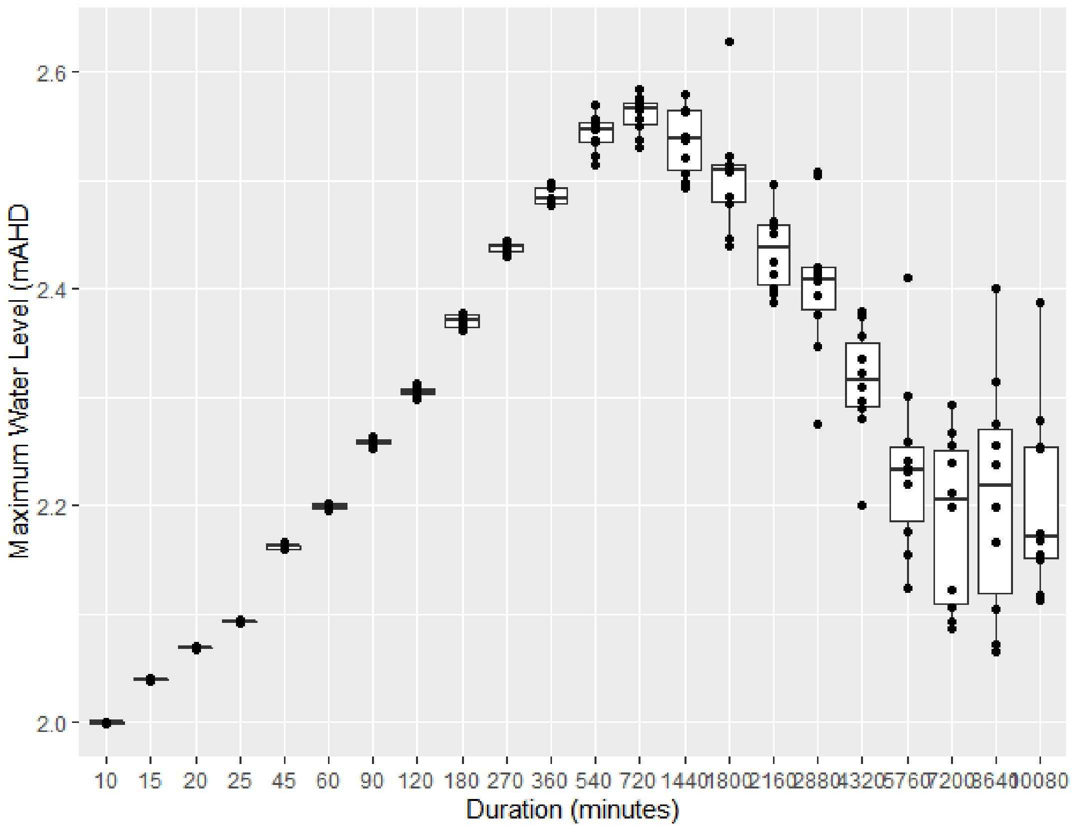
**1.4 m AHD inlet invert, 600 mm culvert, 63.2% AEP with HAT**




**1.4 m AHD inlet invert, 600 mm culvert, 50% AEP with HAT**



**1.4 m AHD inlet invert, 600 mm culvert, 63.2% AEP with HAT+SLR**




As shown above, the critical duration varies between 12 hours for the 63.2% AEP event to 72 hours for the 50% AEP event. The only scenario in which water levels are kept below 2.5 m AHD is with a 600 mm diameter pipe with an inlet invert of 1.4 m AHD and outlet invert of 1.2 m AHD with HAT for a 63.2% AEP event. Comparing the sensitivity of other events to this scenario indicates:

- A 1 m rise in tail water level raises the water level in the lagoon by ~0.06 m indicating that the culvert is inlet controlled
- The 50% AEP event is not contained within the scope of this model and has water levels in the lagoon above 4 m AHD
- Using a 450 mm culvert raises water levels by ~0.15 m
- Changing the inlet to 1.75 m AHD and outlet to 1.4 m AHD raises the water level in the lagoon by ~0.05 m. A lower outlet will mean larger excavations required into the beach.

Limitations of the model include:

- Applying the rural losses for the hydrological model which does not account for urban parts of the catchments (although with these longer duration events the impact will be small)
- Missing infiltration of the lagoon which is likely significant given that the area has sandy soil and is in close proximity to the ocean. This would allow more water to leave the lagoon and decrease water levels

- Missing groundwater flow into the lagoon which would affect the timing of the event and peak of the hydrograph. By assuming all of the water is readily available at the lagoon from the storm is a conservative estimate
- By applying losses to the rain water is removing this water from the catchment flows, which is unlikely to occur completely in the longer duration events. It is likely that the continuing losses would become groundwater which would end up at the lagoon therefore this is under-estimating volumes in the lagoon

Of these limitations the lack of groundwater flow from the pond is the one most likely to have caused the unexpectantly low level of service.

Groundwater flow is complex and to be quantified would require soil profiling, field monitoring of pond levels and rainfall over an expended period (ideally more than a year), potentially ground water piezometers installed in other areas, and then calculations performed. Prior to this more involved level of assessment, some preliminary calculations with a flow net and Darcy's equations could be conducted assuming a range of soil permeabilities.

It is recommended that to keep the pond levels below a target of 2.5 m AHD with 63.2% AEP

- Detailed design of the outlet pipe proceeds with an **internal diameter of 600 mm and no rougher than a Manning's n of 0.013, inverts 1.4 m AHD inlet and 1.2 m AHD outlet**, and an inlet grill to reduce the chance of blockage within the pipe and reduce the quantity of litter escaping to the beach
- The outlet of the pipe be free flowing, or designed to allow any build up of sand to be flushed out of the way, or Council to clear the exit of the pipe prior to pond reaching the outflow pipe
- Given the apparent relatively low level of service assuming no ground infiltration from the pond, council
    - should maintain readiness to excavate a. open trench to the beach for draining the pond as they have done before if the pond gets above the target level, unless
    - further groundwater field work and modelling is undertaken to provide confidence that there is a significant infiltration of groundwater, that when included in the water balance modelling would increase the reliability of the mitigation works to much lower AEPs

Yours sincerely

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