Stormwater Management Report

Lot 104 DP 751388, James Creek Road

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1. Introduction

1.1 Background

GeoLINK has been engaged by MPD Investments to prepare a stormwater management strategy for a proposed residential subdivision at Lot 104 DP 751388 James Creek Road, James Creek. This report summarises the stormwater management strategy for the proposed development and should be read in conjunction with the Statement of Environmental Effects and the associated design drawings.

1.2 Site Description

From a stormwater management perspective, the key features of the site are:

- The site is rectangular and has an area of approximately 33.5 ha.
- The site has been historically cleared and modified for agriculture, sugar cane production and cattle grazing.
- Vegetation at the site comprises improved pasture dominated by Kikuyu.
- The crest of a small hill is located slightly to the north-west of the centre of the site. From this crest, the land falls away in all directions.
- The slopes on the site are typically in the range of 3% to 10%.
- The highest level on the site is approximately 21 mAHD and the lowest level is approximately 4 mAHD.
- There are no permanent water bodies or watercourses located on the site.

1.3 Proposed Development

The design drawings provide details of the proposed development. The proposal is for subdivision of the site resulting in approximately 290 residential lots and associated infrastructure (e.g., roads, services). At the time of writing, the subdivision is proposed to occur in five stages, however it is noted that the number of stages, the number of lots in each stage and the sequence of staging will be influenced by the market at the time of development and possibly by the provision of services.

2. Design Criteria

Design criteria for stormwater management are specified in the *Clarence Valley Council Residential Zones Development Control Plan 2011 – Part H – Sustainable Water Controls* (Amendment No 7, in force 29 July 2022).

2.1 Stormwater Peak Flow Attenuation

Table H1 of the DCP states that post-development peak flows are not to exceed pre-development peak flows specified within Council policy and design standards. It is understood that the relevant standard is the *Handbook of Stormwater Drainage Design*, which forms part of the *Northern Rivers Local Government Development Design Manual*. Accordingly, the stormwater peak flow attenuation target is to ensure that the peak flow from the proposed development does not exceed the existing peak flow from the site for the 5, 10-, 20-, 50- and 100-year average recurrence interval (ARI) events, for storm durations from five minutes to three hours.

2.2 Stormwater Treatment

Table H2 of the DCP lists the requirements for stormwater treatment, which are reproduced below as **Table 2.1**.

Table 2.1 DCP Stormwater Treatment Targets

Water Quality Parameter	Default Target
Gross Pollutants	90% of average annual load retained
Total Phosphorus (TP)	60% of average annual load retained
Total Nitrogen (TN)	45% of average annual load retained
Total Suspended Solids (TSS)	85% of average annual load retained

2.3 Stormwater Runoff Volumes and Frequency of Runoff

Table H1 of the DCP states the following requirement regarding stormwater runoff volumes and the frequency of stormwater runoff:

Stormwater runoff volumes and frequency reduced or maintained to the pre development through application of Harvesting, Retention, Infiltration and Detention as appropriate.

It is understood that the above requirement is rarely, if ever, enforced because it is almost impossible to implement a residential development on a previously undeveloped (i.e., 100% pervious) site without increasing the volume and altering the frequency of stormwater runoff discharging from the site. This is discussed further in **Section 3.2.3**.

3. Stormwater Management Strategy

3.1 Overview

3.1.1 Catchments and Discharge Locations

The existing topography of the site results in four stormwater catchments in the pre-development situation. The logical design response to the grading of the site is to continue managing stormwater in four catchments.

An objective of the proposed development is to ensure no change to the stormwater runoff from the north-west Catchment 1. As such, the proposal is to retain this catchment as 100% pervious and ensure the post-development catchment area is the same as the pre-development catchment area. The Catchment 1 boundaries will be slightly realigned, but the catchment area will be unchanged.

The post-development discharge locations for the other three catchments will be at the same locations as the pre-development situation.

The stormwater catchment areas are presented in **Table 3.1**. Some of the post-development catchments will be different to the pre-development catchments because the post-development catchment boundaries will be dictated by the road and lot layouts. Refer to drawings 3204/C160 and 3204/C161 for the stormwater layout and catchment boundaries.

Table 3.1 Stormwater Catchment Areas

Catchment	Pre-development area (ha)	Post-development area (ha)
1 (north-west)	4.98	4.98
2 (north-east)	11.37	10.84
3 (south-east)	13.64	13.63
4 (south-west)	3.48	4.02
Total	**33.47**	**33.47**

3.1.2 Stormwater Management

Stormwater management will be provided using the following infrastructure:

- Rainwater tanks on each residential allotment.
- Standard underground pit and pipe drainage system to collect and convey stormwater.
- Three bioretention basins (one for each of the developed catchments).

Each dwelling will require a rainwater tank to meet the requirements of the NSW Building Sustainability Index (BASIX). It has been assumed that the average rainwater tank size will be 4.5 kL and the tank will be connected to appropriate indoor uses and outdoor taps. The rainwater tanks contribute to achieving stormwater management targets through the capture and reuse of roofwater runoff.

A bioretention basin will be located in a drainage reserve adjacent to the outlet of Catchments 2, 3 and 4. Each basin will perform the dual function of providing peak flow attenuation and treatment of stormwater to meet the design criteria. There will also be some infiltration of stormwater through the base of the basins into the underlying soils, thereby reducing the volume and frequency of surface runoff from the site. A maintenance plan for the bioretention basins is provided in **Appendix D**.

During regular, smaller rainfall events (e.g., less than one year ARI storm events), the focus is on the treatment of stormwater to protect downstream aquatic ecosystems. Most of the stormwater will temporarily pond on the surface of the basin and infiltrate down through the filter media (sandy loam soil) to be collected in the slotted under-drainage pipes. Some of the stormwater that infiltrates down to the base of the basin will continue to infiltrate into the underlying soils rather than being collected in the under-drainage pipes. More information regarding the stormwater treatment processes is provided in **Section 3.2.2**.

During infrequent, larger rainfall events (e.g., five-year ARI storm events and larger), the focus is on the reduction of peak outflows to prevent detrimental impacts on downstream drainage systems, infrastructure, properties, and waterways. The function of the basin is to temporarily fill with stormwater, thereby buffering the flow and slowing the release of water from the developed catchment. In these larger rainfall events, stormwater will fill the basin to a greater depth (maximum depth approximately 1.1 m) and there will be controlled/ throttled outflow via low flow pipe outlets and a high flow weir. Once the rainfall ceases, the depth of water in the basin will drop to 200 mm within minutes. Assuming there is no additional rainfall and subsequent inflow to the basin, the remaining 200 mm of water will drain via infiltration within several hours.

3.1.2.1 Consideration of Alternative Stormwater Management Options

Bioretention basins are an effective method of providing peak flow attenuation and treatment of stormwater and are widely utilised throughout Australia. Prior to the selection of end-of-line bioretention basins as the preferred approach, the following stormwater treatment options were considered:

Roadside Swales/ Bioretention Swales: The longitudinal grades of the roads will generally be too steep for swales to be suitable. There would also need to be individual driveway crossings over the swales (i.e., culverts) and this would increase the ongoing road reserve maintenance requirements.

- Distributed Bioretention Basins/ Pods: As for the swales, the significant longitudinal road grades mean that it would be challenging to incorporate a large number of smaller bioretention basins (or pods) throughout the road network. Also, it would typically be more onerous and costly for Council to maintain a large number of smaller basins, rather than a small number of larger basins.
- Constructed Stormwater Wetlands: The significant surface gradients, particularly along the western site boundary, are not well suited to stormwater wetlands. Wetlands also typically require a larger footprint than bioretention basins to achieve the same level of stormwater treatment.

In general, it is difficult and impractical to incorporate stormwater peak flow attenuation into the stormwater treatment options listed above. As such, there would typically need to be additional end-of-line stormwater infrastructure (i.e. stormwater detention basins) to provide peak flow attenuation. Once again, this would increase the number of assets that need to be maintained by Council.

3.1.3 Stormwater Discharge Characteristics

The north-east Basin 2 and the south-east Basin 3 will discharge into the James Creek Road reserve, while the south-west Basin 4 will discharge into the Austons Lane road reserve. There is considerable flexibility regarding the configuration of the discharge from these basins. For example, the outflow from the basin can be configured to discharge at a single point, or a level spreader can be incorporated so that the flow is dispersed across a greater width. The preferred discharge configuration for these three basins will be discussed and agreed with Council during the detailed design. In each case, appropriate scour protection will be provided at the outlet. At this stage of concept design, preliminary outlet configurations have been presented on the design drawings 3204/C162 to 3204/C164. For Basins 2 and 4, swales will be constructed to connect the basin spillway to the ultimate discharge location.

The stormwater discharge from the north-west Catchment 1 will be unchanged because the catchment will remain as 100% pervious and the catchment area will be the same. The Catchment 1 boundaries will be slightly realigned, but the landform within the majority of the catchment will be unchanged.

3.2 Modelling

The development of the site will result in an increase in the impervious area in Catchments 2 to 4, which will lead to increases in the peak flow of stormwater emanating from these internal catchments. To ensure that the proposed stormwater system meets the peak flow attenuation targets for stormwater that discharges from the site, hydrologic and hydraulic calculations have been undertaken using a model developed with the DRAINS software.

The proposed land use changes and associated increase in impervious areas will also result in higher loads of water-borne contaminants being generated from the internal catchments. Compliance with the stormwater quality targets will, by default, require the vast majority of stormwater runoff from within the site to flow through treatment devices (such as bioretention basins) before discharging from the site. This will ensure the hydraulic 'disconnection' of runoff from impervious surfaces, thus significantly attenuating the impact of frequent flows on the ecological health of downstream waterways.
A conceptual stormwater treatment model was developed using the MUSIC software and this model was used to ensure that the stormwater system meets the stormwater quality targets. The MUSIC model incorporates rainwater tanks for each residential lot and the bioretention basins.

The MUSIC model was also used to simulate long-term water balances for the pre-development and post-development scenarios. These water balance simulations provide calculations of the average annual volumes of:

- Stormwater generated within the site.
- Rainwater reused by households.
- Evapotranspiration from the bioretention basins.
- Infiltration into the underlying soils from the bioretention basins.
- Stormwater runoff discharged from the site (for both pre-development and post-development).

The DRAINS and MUSIC models include appropriate input parameters (i.e. roof area, car parking area) to represent the proposed childcare centre, commercial centre and medium density lots. As such, Bioretention Basins 2 and 3 have been designed to provide stormwater peak flow attenuation and treatment for the fully developed Catchments 2 and 3.

3.2.1 Stormwater Peak Flow Attenuation

The DRAINS model was used to design the basins from a stormwater peak flow attenuation perspective. The function of the basins is to temporarily fill with stormwater, thereby buffering the flow and slowing the release of water from the developed catchment. So, even though the peak flows <u>into</u> the basins will be higher than the pre-development peak flows, the peak flows <u>out of</u> the basins will be reduced to below the pre-development peak flows by this buffering effect.

The schematic and results from the DRAINS model are presented in Appendix A. The basin geometries used in the DRAINS model are presented in **Table 3.2** to **Table 3.4**. The actual basin geometries, as designed and constructed, do not need to exactly match the geometries listed in the tables. However, the surface area of the base of the basin (i.e., at depth = 0 m) and the storage volume at the maximum water depth must be at least as large as the numbers listed in the tables.

Table 3.2 Basin 2 (NE catchment) Geometry

Depth of Water (m)	Surface Area of Basin (m²)	Storage Volume of Basin (m³)
0	1,478	-
1.10	2,506	2,180

Table 3.3 Basin 3 (SE catchment) Geometry

Depth of Water (m)	Surface Area of Basin (m²)	Storage Volume of Basin (m³)
0	2,287	-
1.10	3,610	3,231

Table 3.4 Basin 4 (SW catchment) Geometry

Depth of Water (m)	Surface Area of Basin (m²)	Storage Volume of Basin (m³)
0	777	-
1.10	1,424	1,199

Outflow from the basins will be controlled via low flow pipe outlets and a high flow weir. The outlet configurations utilised in the DRAINS model are listed below. Any changes to these outlet configurations during the detailed design phase would need to be validated with further modelling.

The outlet configuration for Basin 2 (NE catchment) is as follows:

- 4 x 525 mm diameter pipes (length = 18 m; slope = 8%).
- Weir with a crest level 850 mm above the floor of the basin and a crest length of 12.0 m.

The outlet configuration for Basin 3 (SE catchment) is as follows:

- 6 x 450 mm diameter pipes (length = 15 m; slope = 3%).
- Weir with a crest level 800 mm above the floor of the basin and a crest length of 11.5 m.

The outlet configuration for Basin 4 (SW catchment) is as follows:

- 4 x 300 mm diameter pipes (length = 20 m; slope = 6%).
- Weir with a crest level 900 mm above the floor of the basin and a crest length of 5.2 m.

The upstream invert level of the basin outlet pipes will be set at a level that is 200 mm higher than the base of the basin (i.e., water ponds to a depth of 200 mm within the basin before flowing out of the pipes). This provides the extended detention depth for the basins and ensures that a substantial proportion of the stormwater captured in the basin infiltrates down through the basin's filter media soil layer. This is critical for the stormwater treatment function of the basin.

3.2.1.1 Results

The peak flows for the pre-development and post-development situations are presented in the following tables. It is evident from the results that the basins provide the required level of stormwater peak flow attenuation for all relevant design storm events. In fact, the peak flow attenuation significantly exceeds Council's requirements, with the post-development peak flows being at least 10% lower than the pre-development peak flows for all design storm events.

Table 3.5 Peak Flows and Water Depth – Basin 2 (NE)

Design Storm Event (ARI)	Peak Flows (m^3/s) Pre-Development	Post-Development	Post-Dev Peak Flow as % of Pre-Dev Peak Flow	Peak Water Depth in Basin (m)
5 yr	1.56	1.38	88%	-
10 yr	2.43	1.89	78%	-
20 yr	2.94	2.47	84%	-
50 yr	3.89	3.41	88%	-
100 yr	4.39	3.94	90%	1.08

Table 3.6 Peak Flows and Water Depth – Basin 3 (SE)

Design Storm Event (ARI)	Peak Flows (m^3/s) Pre-Development	Post-Development	Post-Dev Peak Flow as % of Pre-Dev Peak Flow	Peak Water Depth in Basin (m)
5 yr	1.79	1.56	87%	-
10 yr	2.81	2.27	81%	-
20 yr	3.42	2.94	86%	-
50 yr	4.59	3.96	86%	-
100 yr	5.19	4.61	89%	1.07

Table 3.7 Peak Flows and Water Depth – Basin 4 (SW)

Design Storm Event (ARI)	Peak Flows (m^3/s) Pre-Development	Post-Development	Post-Dev Peak Flow as % of Pre-Dev Peak Flow	Peak Water Depth in Basin (m)
5 yr	0.50	0.43	86%	-
10 yr	0.77	0.51	66%	-
20 yr	0.92	0.61	66%	-
50 yr	1.23	0.98	80%	-
100 yr	1.40	1.23	88%	1.08

3.2.1.2 Capacity of Downstream Infrastructure

The DRAINS model has been extended downstream of the property boundary to assess the capacity of existing downstream infrastructure. There are two locations along the James Creek Rd site frontage where existing cross-drainage culverts convey stormwater runoff underneath James Creek Rd. There is a small box culvert towards the north of the site and a single 750 mm diameter pipe just north of the intersection with Austons Ln. The proposed design conveys stormwater flows from the bioretention basins to these existing outlet locations.

To comply with the *Handbook of Stormwater Drainage Design*, these culverts should be sized to have capacity for the 20yr ARI flow in the existing situation (i.e. pre-development). The DRAINS model analysis indicates that the culverts do not have this capacity.

To convey the 20yr ARI flow, the culverts need to be upsized to:

- Northern culvert: 1800 mm (w) x 600 mm (h) box culvert, or equivalent (e.g. 3 x 600 mm x 600 mm or 2 x 900 mm x 600 mm). This culvert needs to be a box culvert because there is limited cover.
- Southern culvert: 3 x 750 mm diameter pipes.

These culverts are under-sized and should be upgraded as per the above. This upgrade should occur regardless of whether the proposed development proceeds because the culverts are under-sized for the existing situation. As per **Section** Error! Reference source not found., the post-development peak flows are significantly lower than the pre-development peak flows, so the proposed development will not worsen the situation regarding these under-sized culverts.

The DRAINS modelling results presented in **Appendix A** incorporate the upgraded culvert sizes listed above.

3.2.2 Stormwater Treatment

In each bioretention basin, stormwater runoff will be retained within an extended detention depth (200 mm) and then infiltrate down through the filter layer (sandy loam soil). Most of the excess water that drains to the bottom of the filter layer will be collected in slotted under-drainage pipes and conveyed to the discharge location. Some infiltrated water will continue to infiltrate down into the underlying soils rather than being collected in the under-drainage pipes. The surface of the bioretention basin will be densely planted with locally occurring native ground cover species.

Treatment of the stormwater occurs both on the surface of the bioretention system and within the filter layer. When storm inflows cause temporary ponding on the surface of the system, pollutants are removed from the stormwater through sedimentation and particulate adhesion onto the stems and leaves of the vegetation. The agitation of the surface layer of the soil caused by movement of the vegetation and the root systems prevents the accreted sediments clogging the filter layer. As stormwater percolates through the filter layer, fine particulates and some soluble pollutants are removed through processes such as adhesion onto the surface of the soil particles, biological transformation of pollutants by biofilms growing on the surface of the soil particles, and biomass uptake of nutrients and metals through the root systems of the vegetation.

The MUSIC model was used to quantify the pollutant removal provided by the bioretention basins and rainwater tanks.

3.2.2.1 Model Inputs

The MUSIC model was developed based on the guidance provided in the *NSW MUSIC Modelling Guidelines* (BMT WBM, August 2015) and the *MUSIC Modelling Guidelines* (Consultation Draft) (Healthy Land and Water, 2018). The model simulates a five year period using historical rainfall data from 1972 to 1976. This is the time period specified by Council to be used in MUSIC model simulations. This five year period has rainfall characteristics representative of the long-term rainfall record and also includes the 1974 extreme rainfall and flood event.

Other key model inputs are listed below:

- Surface types:
  - Roof area assumed to be 300 m² per standard residential lot and 200 m² per small residential lot (<450 m² lot area).
  - Driveway area assumed to be 30 m² per residential lot.
  - Road, car parking and footpath areas measured and calculated from subdivision design.
- Rainwater tanks:
  - Daily indoor demand (0.173 kL/ day for 3 people per dwelling) from Table 6-1 of the *NSW MUSIC Modelling Guidelines.*
  - Annual outdoor demand (55 kL/ yr) from Table 6-1 of the *NSW MUSIC Modelling Guidelines.*
  - Roof area that flows to rainwater tank assumed to be 80% of total roof area.
- Soil characteristics:
  - Silty clay parameters from Table 5-5 of the *NSW MUSIC Modelling Guidelines*, based on the geotechnical assessment by Regional Geotechnical Solutions reporting silty clay, with some sandy clay.
  - Infiltration rate of soils beneath bioretention basins and infiltration trench assumed to be 10 mm/ hr, based on silty clay and sandy clay at the relevant depths.

3.2.2.2 Results

The MUSIC modelling results are summarised in **Table 3.8**, with the model schematic and results presented in **Appendix B**. The MUSIC-link report is presented in **Appendix C**. The results indicate that the predicted pollutant load reductions meet the targets by a comfortable margin, with the modelled load reductions being significantly higher than the target load reductions for all parameters.

Table 3.8 Stormwater Pollutant Load Reductions

Pollutant	Post-Development Load – without treatment (kg/ yr)	Post-Development Load – with treatment (kg/ yr)	Modelled Load Reduction (%)	Target Load Reduction (%)
Total suspended solids	34,000	3,950	88	85
Total phosphorus	66.7	24.2	64	60
Total nitrogen	481	202	58	45
Gross pollutants	4,410	0	100	90

To provide additional assurance regarding the adequacy of the proposed stormwater treatment, an additional check has been undertaken against the pre-development scenario. For the pre-development scenario, two different land uses were tested. The first is an ‘agricultural’ land use, which is representative of sugar cane production or intensive cattle grazing. The second is a ‘rural’ land use, which is representative of a rural residential area and is more conservative because it predicts lower pollutant loads for the pre-development situation.

The results of the comparison are presented in the table below and indicate that the post-development pollutant loads will be substantially less than the pre-development pollutant loads, regardless of the assumed pre-development land use.

Table 3.9 Stormwater Pollutant Load Comparison to Pre-Development

Pollutant	Pre-Development Load – agriculture (kg/ yr)	Pre-Development Load – rural (kg/ yr)	Post-Development Load – with treatment (kg/ yr)	Is Post-Development less than Pre-Development ?
Total suspended solids	21,700	13,700	3,950	Yes
Total phosphorus	91.1	30.1	24.2	Yes
Total nitrogen	425	263	202	Yes
Gross pollutants	0	0	0	Equal

Two input parameters are listed as ‘failing parameters’ in the MUSIC-link report in **Appendix C**. These input parameters are listed in the following table, along with the source of the adopted value. The values that have been used are considered to be appropriate because they are taken from the *NSW MUSIC Modelling Guidelines*. Also, the impervious area is stated as 100.3% in the Project Details section on the first page of the MUSIC-link report. It is unclear why this value has been generated by the MUSIC-link report, because this does not match the overall impervious percentage of the post-development scenario, which is 50% (for the developed Catchments 2, 3 and 4).

Table 3.10 Source of Parameters reported as ‘Failing’ in MUSIC Model

Parameter	Value	Source of Value
Road surface type – Impervious Area Rainfall Threshold (mm/ day)	1.5	*NSW MUSIC Modelling Guidelines, Table 5-4*
Roof surface type – Impervious Area Rainfall Threshold (mm/ day)	0.3	*NSW MUSIC Modelling Guidelines, Table 5-4*

3.2.3 Stormwater Runoff Volumes and Frequency of Runoff

As noted in **Section 2.3**, Table H1 of the DCP states the following requirement with regard to stormwater runoff volumes and the frequency of stormwater runoff:

Stormwater runoff volumes and frequency reduced or maintained to the pre development through application of Harvesting, Retention, Infiltration and Detention as appropriate.

The DCP does not provide guidance as to how compliance with the above clause should be demonstrated. For example, should the pre-development and post-development runoff volumes be compared for a range of individual design storm events (e.g., 5, 10, 20, 50 and 100 year ARI events), similar to the peak flow attenuation assessment, or should the runoff volumes be checked over longer time periods (e.g., months, years) that incorporate multiple, varied rain events? Similarly, should the frequency of runoff be assessed for every event that causes discharge from the site, or only events that are above, below, or in between certain thresholds?

If the intention of the DCP is that the post-development stormwater runoff volume cannot exceed the pre-development stormwater runoff volume in any individual design storm event, or for any multi-event time period assessed using representative historical climate data, then it is suggested that this cannot be practically achieved for a residential development that is proposed on the previously undeveloped James Creek site.

A residential development incorporates a range of impervious surfaces, including roofs, roads and footpaths. For a previously undeveloped site, this increases the percentage of impervious area on the site from 0% to approximately 50%. This results in more stormwater runoff being generated when it rains. If the intention is to reduce the volume of stormwater runoff down to pre-development levels, options include:

- Capture, storage and reuse of roof water using rainwater tanks.
- Capture, storage and infiltration of stormwater into the underlying soils.
- Capture, storage and reuse of stormwater at a subdivision scale.

The first two of these measures are included in the development proposal. But they are not sufficient to reduce stormwater runoff volumes to pre-development levels for all individual design storm events and all multi-event time periods.

Therefore, a subdivision-scale stormwater harvesting scheme would be required if full compliance with the DCP clause was required. Such a scheme would need to be designed and justified based on exhaustive water balance modelling of a comprehensive range of individual storms and multi-event periods. It is highly likely that the stormwater would need to be treated to potable water standard so that it could be used for purposes that aren't already supplied by rainwater tanks. Also, large storage reservoirs would be required to store the stormwater that is captured and treated during rainfall events, so that it can be used over the subsequent weeks or months. The capital and operating costs of such a stormwater harvesting scheme would be very high. As such, this is not considered to be a reasonable and feasible option for this residential subdivision.

Given the above, full compliance with the DCP clause is considered to be unreasonable. Instead, the adopted approach has been to identify the specific issues or potential impacts that could be caused by changes to stormwater runoff volumes or frequencies and address those specific issues. These specific issues are discussed in the following sections.

3.2.3.1 Impacts on Stormwater Conveyance Infrastructure

With regard to stormwater conveyance or 'drainage' infrastructure located downstream of the site (e.g., culverts, channels, drains), it is suggested that increases in runoff volumes or frequencies would have a negligible impact. The key constraint for this infrastructure is the flow rate (m^3/s), not the volume (m^3) or frequency. For example, it is the flow rate that determines whether channel banks are overtopped, and it is the flow rate, and associated velocity, that primarily influences channel erosion and scour processes. The purpose of the stormwater peak flow attenuation requirements and measures (refer to **Section 3.2.1**) is to manage potential impacts associated with flow rates.

3.2.3.2 Frequent Flow Impacts on Downstream Waterways

Increases in the frequency of stormwater runoff to natural waterways can have detrimental impacts on in-stream ecosystems. When comparing a pre-development 0% impervious catchment to a post-development catchment, a difference is that smaller rainfall events (e.g., 5 mm of rain) will not typically generate stormwater runoff in the pre-development situation because all of the rain will infiltrate into the ground, but similar rainfall events will generate stormwater runoff in the post-development situation due to impervious surfaces.

The general best-practice approach to managing the potential impact of increased frequency of runoff is to provide a stormwater management system that provides a method to capture the relatively small volume of stormwater generated from these smaller rainfall events and prevent it from being discharged as a pulse of surface water runoff to downstream waterways. The rainwater tanks and bioretention basins that are proposed as part of the development are best-practice methods of managing the potential impacts of frequent flows.

3.2.3.3 Long-term Water Balances

The long-term water balances extracted from the MUSIC model simulation are presented in the following tables. It is noted that the 'rainfall onto catchment' values differ between the post-development and pre-development scenarios because the post-development and pre-development catchment areas are different, as per **Table 3.1**.

The MUSIC model simulation indicates that the average annual surface water discharge across the site boundary will be higher in the post-development situation compared to the pre-development situation. This increase in the average annual stormwater volume is not expected to have a significant detrimental impact on downstream waterways or properties. These catchments discharge into designated watercourses or channels. As discussed in **Section** Error! Reference source not found. above, the key constraint for watercourses and channels is the flow rate (m^3/s), not the volume (m^3) or frequency of runoff. Stormwater peak flow attenuation measures are proposed (refer to **Section 3.2.1**) to manage potential impacts associated with flow rates.

Table 3.11 Catchment 2 Water Balance

Water Balance Item	Post-Development Scenario	Pre-Development Scenario
Rainfall onto catchment	**125.4 ML/ yr**	**131.6 ML/ yr**
Evapotranspiration from vegetated/ pervious surfaces within catchment	- 50.5 ML/ yr	- 83.7 ML/ yr
Water stored in soil	- 0.2 ML/ yr	- 0.5 ML/ yr
Stormwater generated within residential development	**= 74.7 ML/ yr**	
Collection and reuse of roofwater via rainwater tanks	- 7.5 ML/ yr	
Evapotranspiration losses from bioretention basin	- 3.3 ML/ yr	
Infiltration into underlying soils from base and sides of bioretention basin	- 8.5 ML/ yr	
Surface water discharge from site	**= 55.4 ML/ yr**	**= 47.4 ML/ yr**
% change from pre-development scenario	*+ 17%*	

Table 3.12 Catchment 3 Water Balance

Water Balance Item	Post-Development Scenario	Pre-Development Scenario
Rainfall onto catchment	**157.8 ML/ yr**	**158.0 ML/ yr**
Evapotranspiration from vegetated/ pervious surfaces within catchment	- 49.8 ML/ yr	- 100.5 ML/ yr
Water stored in soil	- 0.2 ML/ yr	- 0.6 ML/ yr
Stormwater generated within residential development	**= 107.8 ML/ yr**	
Collection and reuse of roofwater via rainwater tanks	- 11.7 ML/ yr	
Evapotranspiration losses from bioretention basin	- 5.2 ML/ yr	
Infiltration into underlying soils from base and sides of bioretention basin	- 13.9 ML/ yr	
Surface water discharge from site	**= 77.0 ML/ yr**	**= 56.9 ML/ yr**
% change from pre-development scenario	*+ 35%*	

Table 3.13 Catchment 4 Water Balance

Water Balance Item	Post-Development Scenario	Pre-Development Scenario
Rainfall onto catchment	**46.6 ML/ yr**	**40.3 ML/ yr**
Evapotranspiration from vegetated/ pervious surfaces within catchment	- 15.3 ML/ yr	- 25.6 ML/ yr
Water stored in soil	- 0.1 ML/ yr	- 0.2 ML/ yr
Stormwater generated within residential development	**= 31.2 ML/ yr**	
Collection and reuse of roofwater via rainwater tanks	- 3.6 ML/ yr	
Evapotranspiration losses from bioretention basin	- 1.7 ML/ yr	
Infiltration into underlying soils from base and sides of bioretention basin	- 4.3 ML/ yr	
Surface water discharge from site	**= 21.6 ML/ yr**	**= 14.5 ML/ yr**
% change from pre-development scenario	*+ 49%*	

References

BMT WBM, (2015). *NSW MUSIC Modelling Guidelines.* Prepared for Greater Sydney Local Land Services.

Clarence Valley Council, (2011). *Clarence Valley Council Residential Zones Development Control Plan 2011.*

Healthy Land and Water, (2018). *MUSIC Modelling Guidelines (Consultation Draft).* Healthy Land and Water Limited, Brisbane, Queensland.

Water by Design, (2010). *MUSIC Modelling Guidelines (Version 1.0).* SEQ Healthy Waterways Partnership.

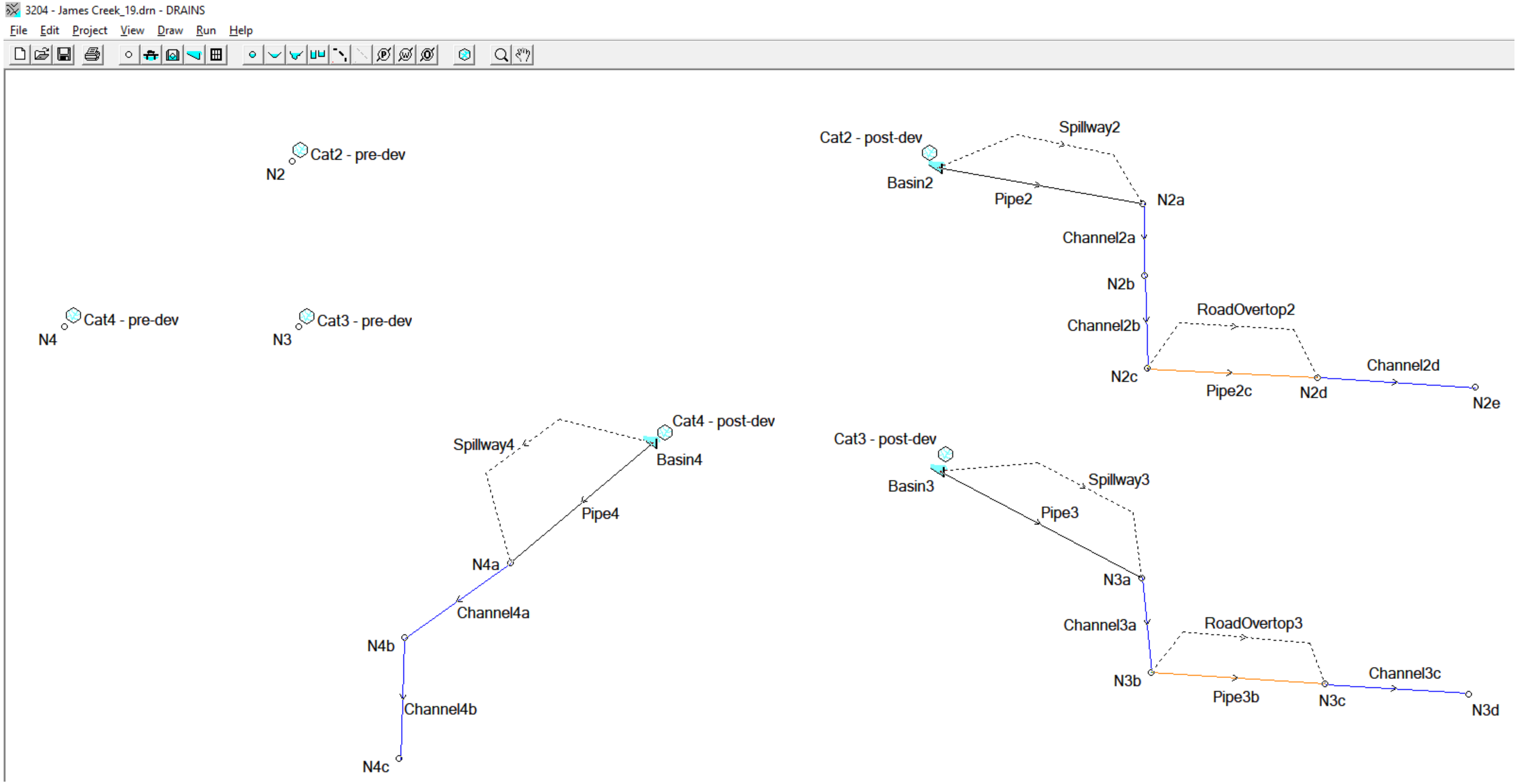
Copyright and Usage

Appendix A

DRAINS Model Schematic and Results

Schematic of Model Layout

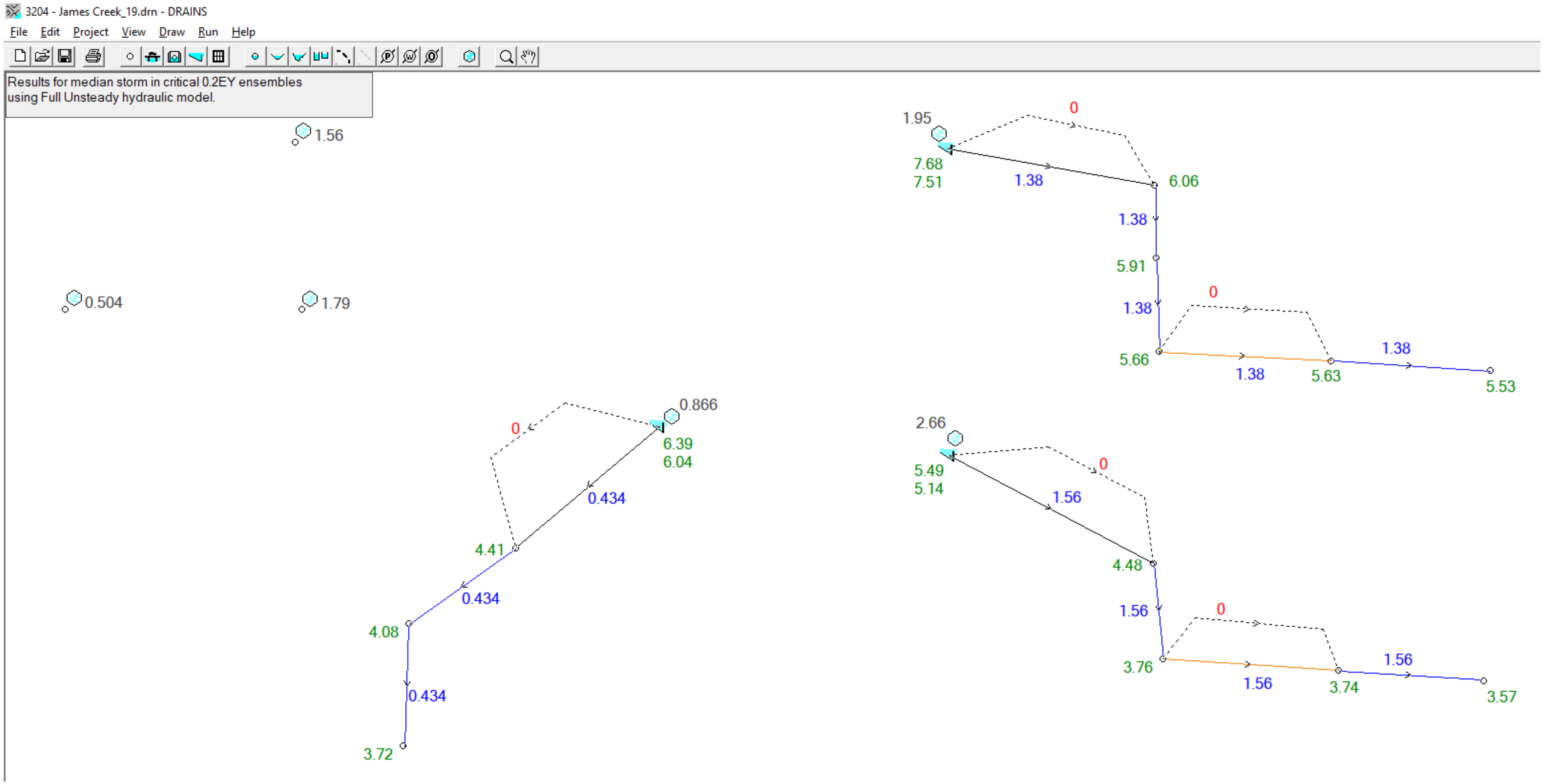
Notes: 1. Pre-development at top-left and post-development at right.



Results – 5yr ARI (0.2EY)

Notes: 1. Pre-development at top-left and post-development at right.

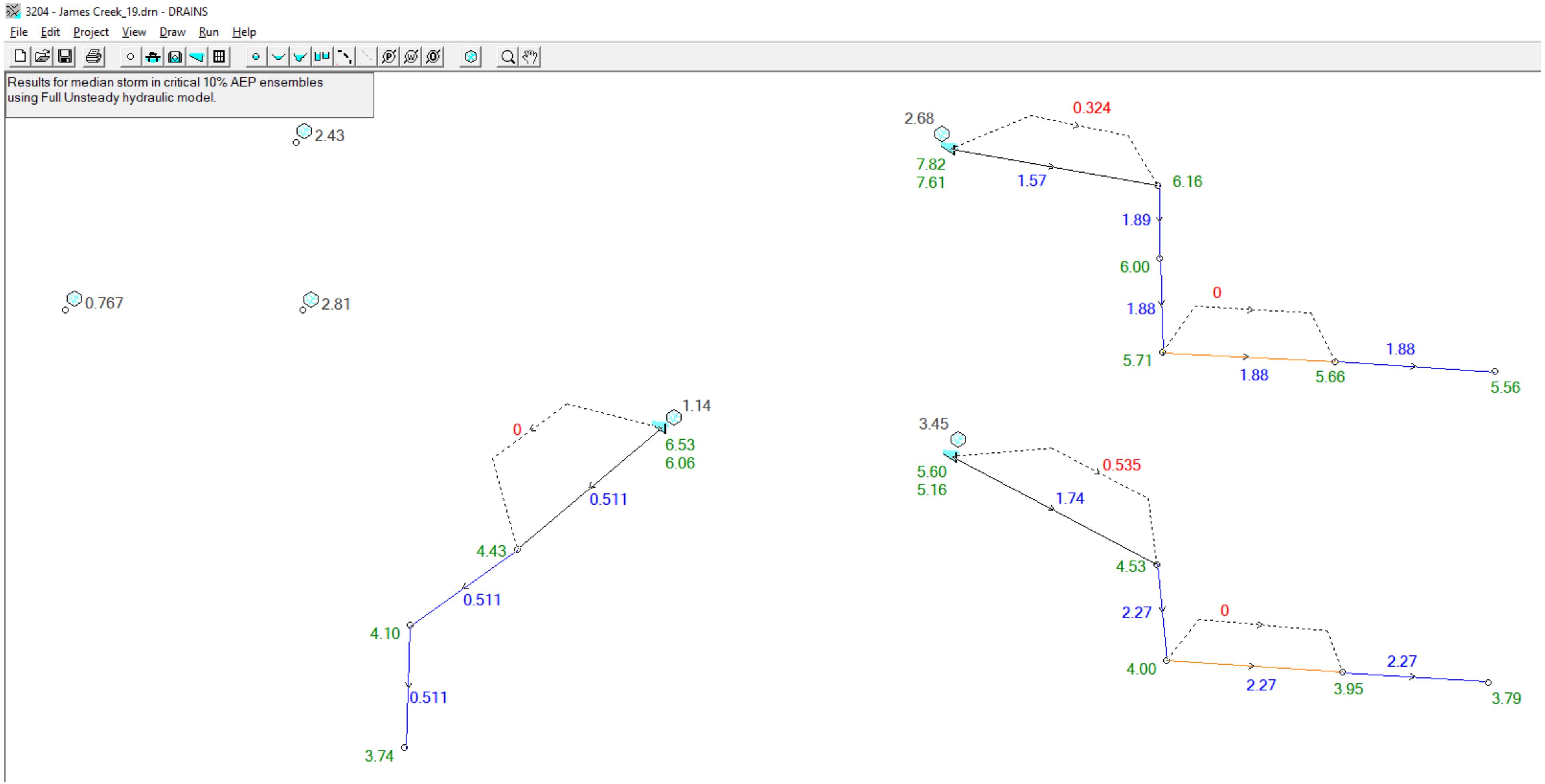
2. Black numbers are catchment inflows; blue numbers are peak flow rates in pipes/ channels; red numbers are peak flow rates in weirs; green numbers are peak water levels.



Results – 10yr ARI (10% AEP)

Notes: 1. Pre-development at top-left and post-development at right.

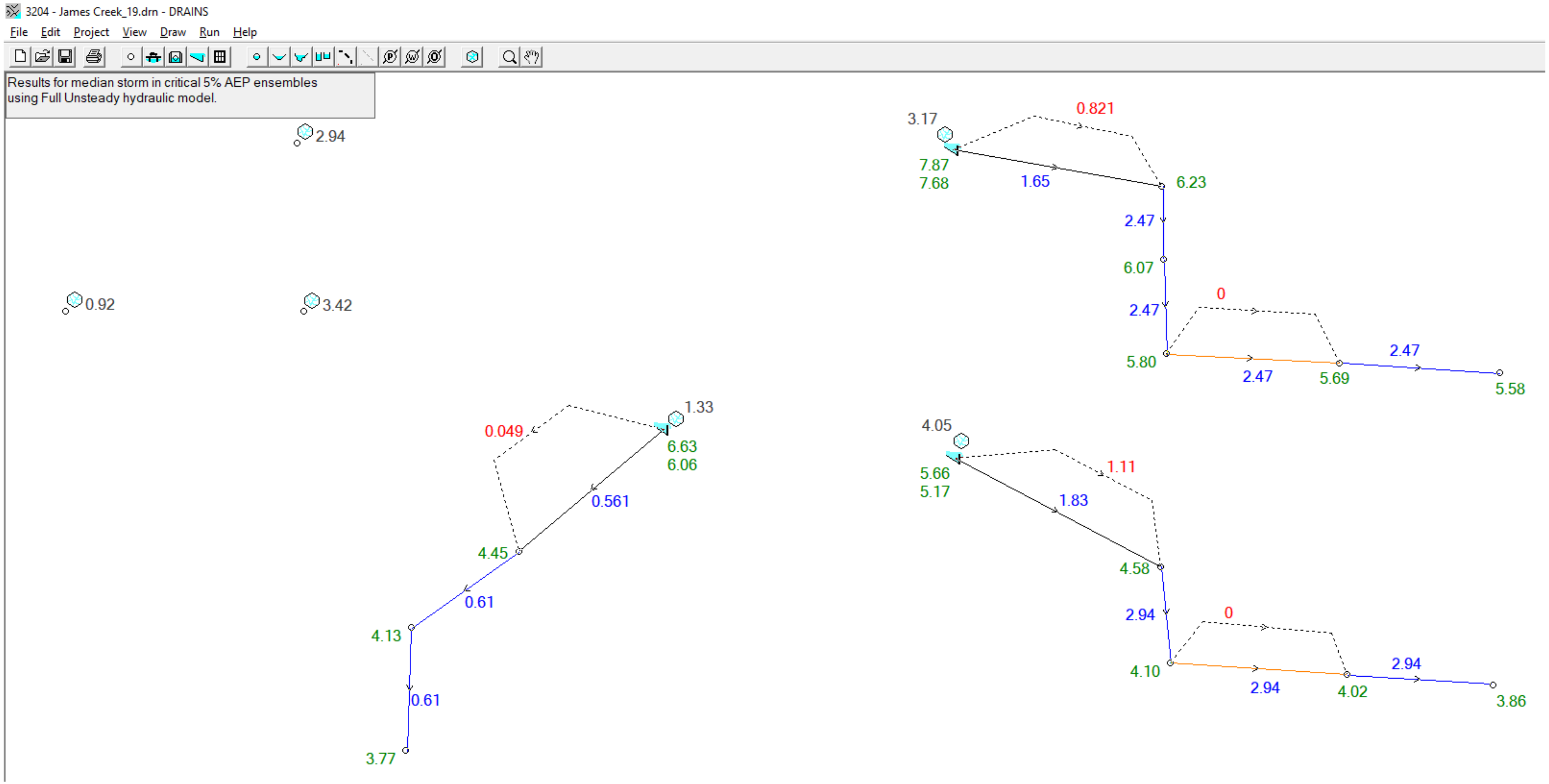
2. Black numbers are catchment inflows; blue numbers are peak flow rates in pipes/ channels; red numbers are peak flow rates in weirs; green numbers are peak water levels.



Results – 20yr ARI (5% AEP)

Notes: 1. Pre-development at top-left and post-development at right.

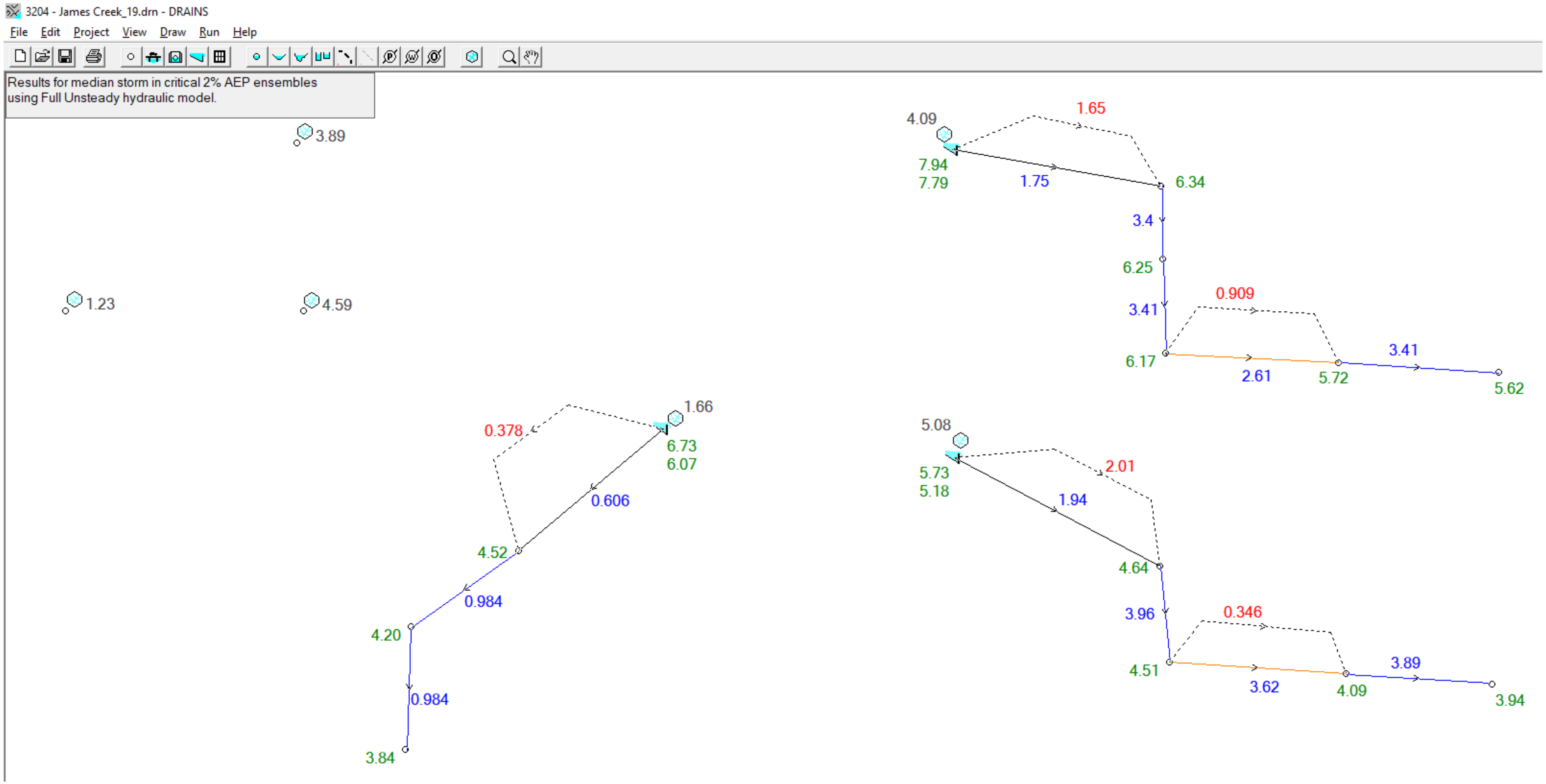
2. Black numbers are catchment inflows; blue numbers are peak flow rates in pipes/ channels; red numbers are peak flow rates in weirs; green numbers are peak water levels.



Results – 50yr ARI (2% AEP)

Notes: 1. Pre-development at top-left and post-development at right.

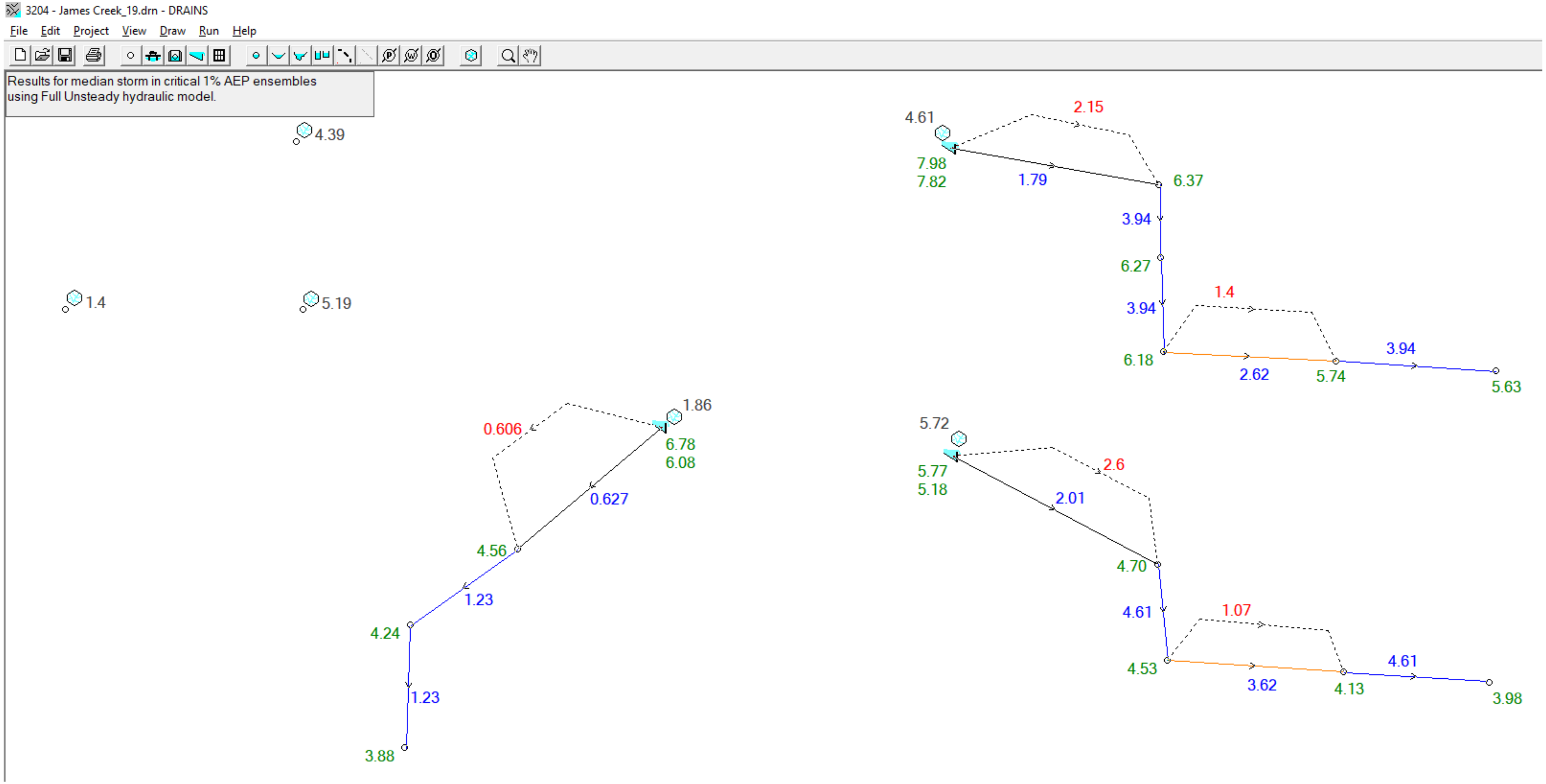
2. Black numbers are catchment inflows; blue numbers are peak flow rates in pipes/ channels; red numbers are peak flow rates in weirs; green numbers are peak water levels.



Results – 100yr ARI (1% AEP)

Notes: 1. Pre-development at top-left and post-development at right.

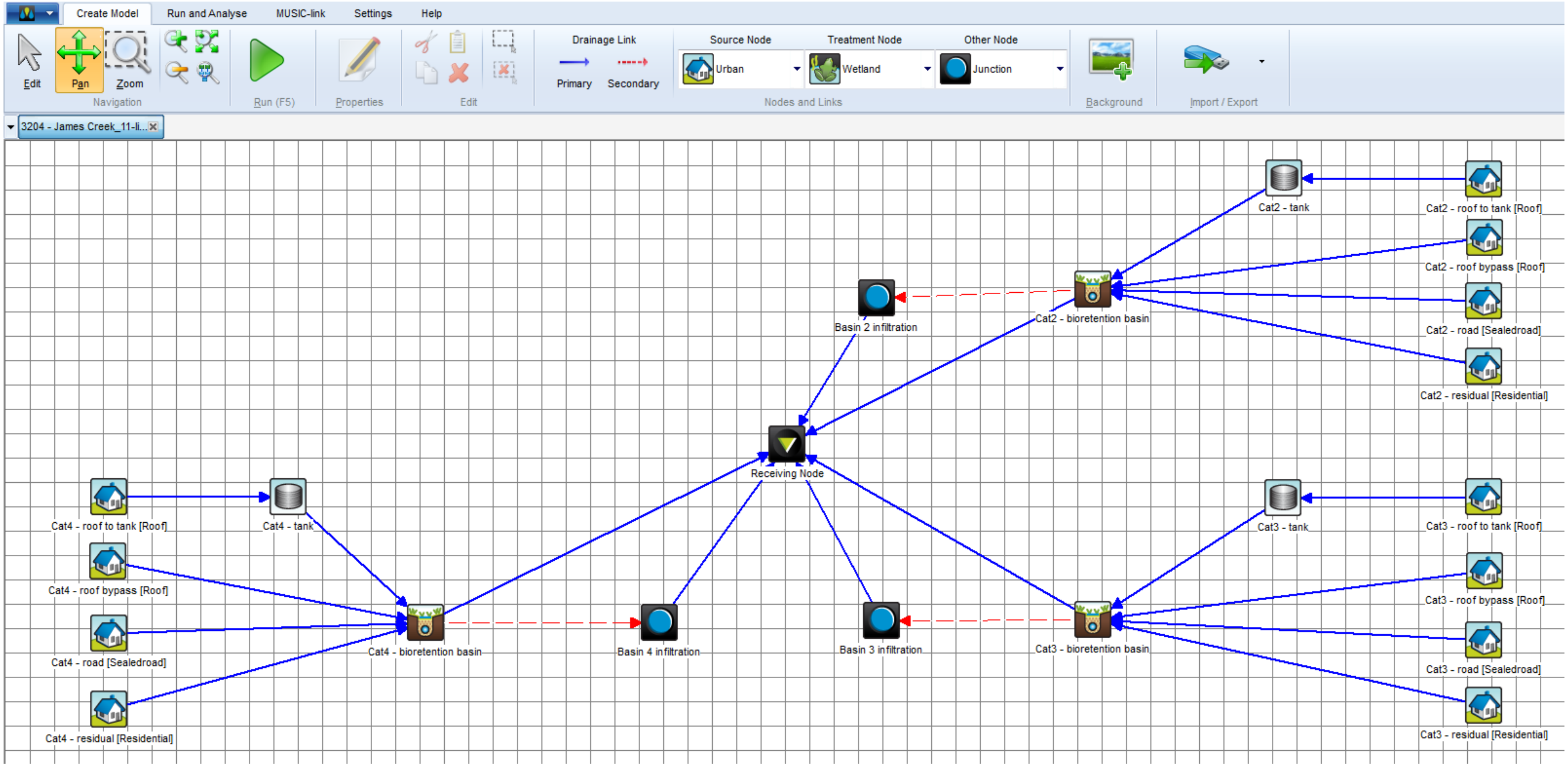
2. Black numbers are catchment inflows; blue numbers are peak flow rates in pipes/ channels; red numbers are peak flow rates in weirs; green numbers are peak water levels.



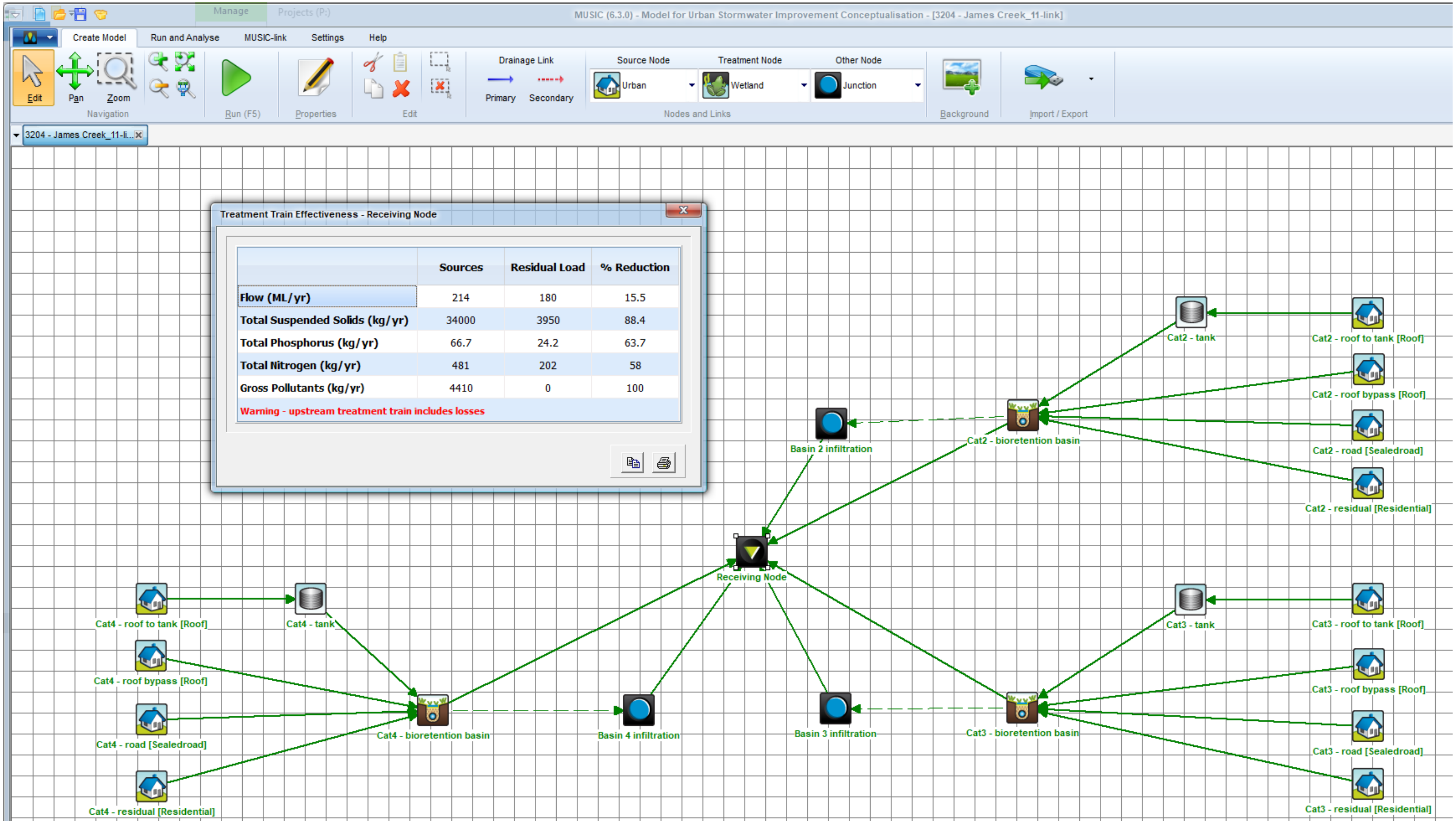
Appendix B

MUSIC Model Schematic and Results

Schematic


Create Model
Run and Analyse
MUSIC-link
Settings
Help
Edit
Pan
Zoom
Navigation
Run (F5)
Properties
Edit
Drainage Link
Primary
Secondary
Source Node
Urban
Treatment Node
Wetland
Other Node
Junction
Nodes and Links
Background
Import / Export
3204 - James Creek_11-li...
Cat2 - tank
Cat2 - roof to tank [Roof]
Cat2 - roof bypass [Roof]
Basin 2 infiltration
Cat2 - bioretention basin
Cat2 - road [Sealedroad]
Cat2 - residual [Residential]
Receiving Node
Cat4 - roof to tank [Roof]
Cat4 - tank
Cat3 - tank
Cat3 - roof to tank [Roof]
Cat4 - roof bypass [Roof]
Cat3 - roof bypass [Roof]
Cat4 - bioretention basin
Basin 4 infiltration
Basin 3 infiltration
Cat3 - bioretention basin
Cat4 - road [Sealedroad]
Cat3 - road [Sealedroad]
Cat4 - residual [Residential]
Cat3 - residual [Residential]

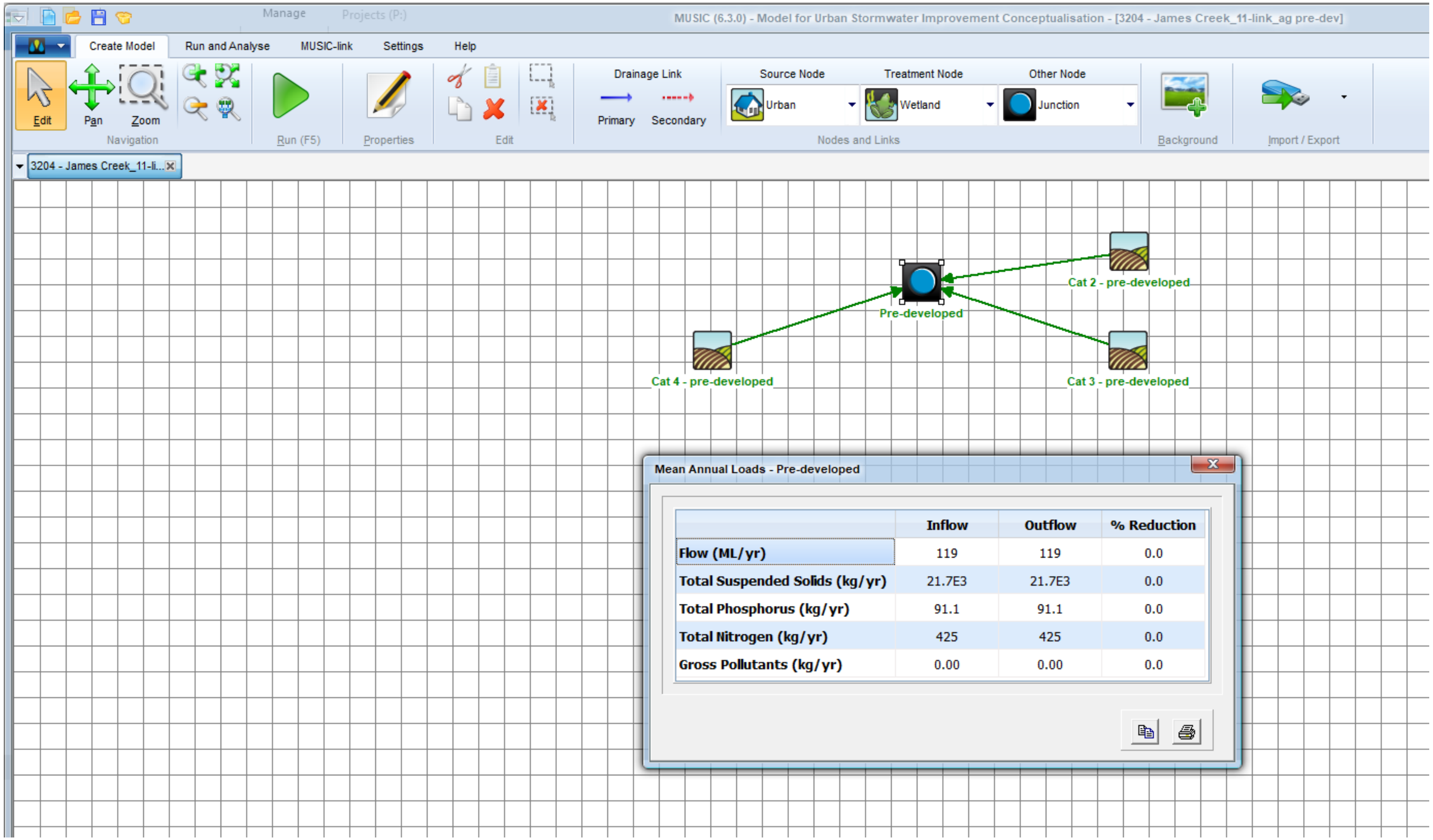
Results – Post-Development



	Sources	Residual Load	% Reduction
Flow (ML/yr)	214	180	15.5
Total Suspended Solids (kg/yr)	34000	3950	88.4
Total Phosphorus (kg/yr)	66.7	24.2	63.7
Total Nitrogen (kg/yr)	481	202	58
Gross Pollutants (kg/yr)	4410	0	100

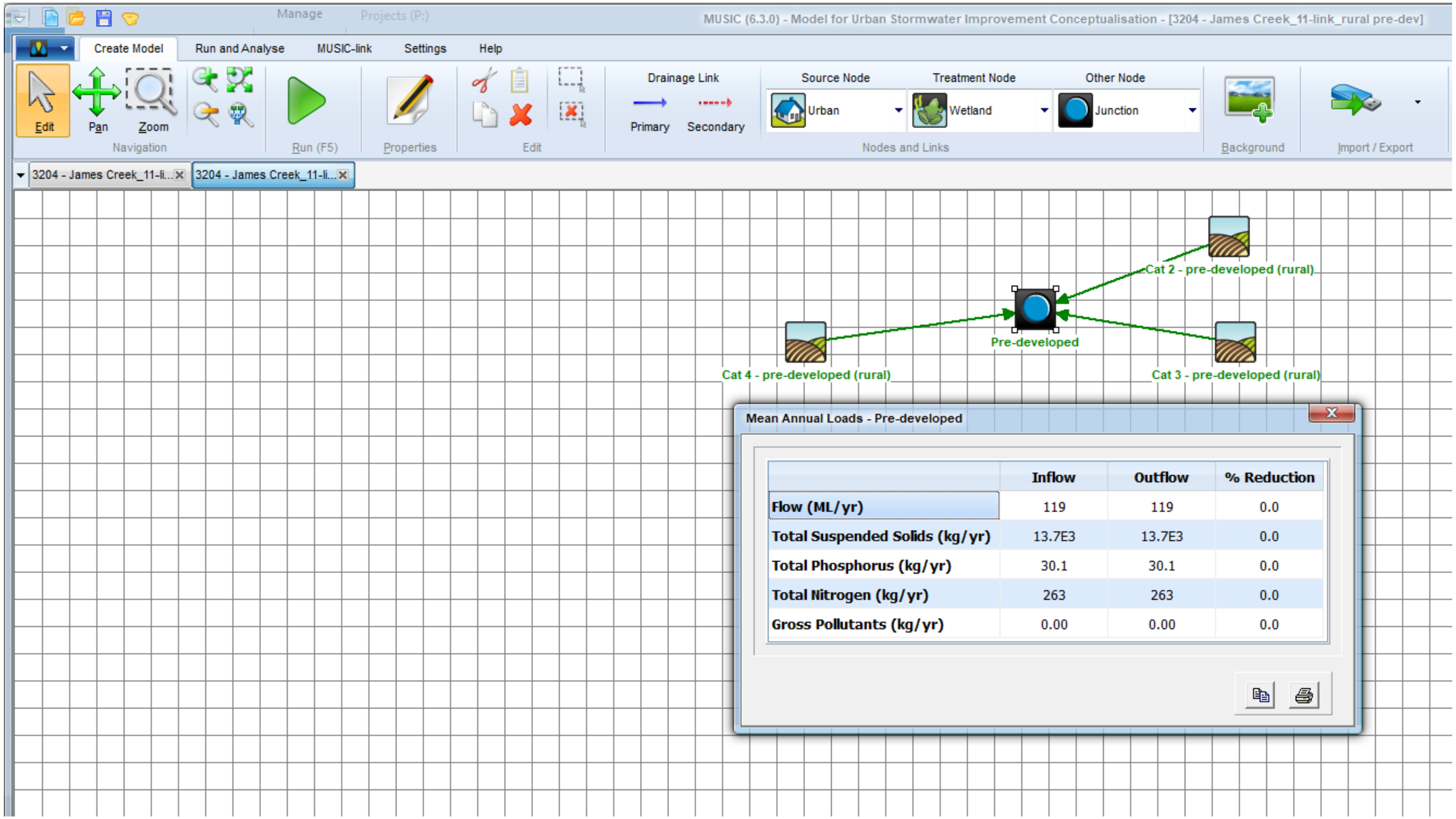
Warning - upstream treatment train includes losses

Results – Pre-Development (agricultural)



	Inflow	Outflow	% Reduction
Flow (ML/yr)	119	119	0.0
Total Suspended Solids (kg/yr)	21.7E3	21.7E3	0.0
Total Phosphorus (kg/yr)	91.1	91.1	0.0
Total Nitrogen (kg/yr)	425	425	0.0
Gross Pollutants (kg/yr)	0.00	0.00	0.0

Results – Pre-Development (rural)



	Inflow	Outflow	% Reduction
Flow (ML/yr)	119	119	0.0
Total Suspended Solids (kg/yr)	13.7E3	13.7E3	0.0
Total Phosphorus (kg/yr)	30.1	30.1	0.0
Total Nitrogen (kg/yr)	263	263	0.0
Gross Pollutants (kg/yr)	0.00	0.00	0.0

Appendix C

MUSIC-link Report

CLARENCE VALLEY COUNCIL

MUSIC-*link* Report

Project Details		Company Details	
Project:	Lot 104 DP 751388, James Ck Road	**Company:**	GeoLINK
Report Export Date:	15/11/2023	**Contact:**	Duncan Thomson
Catchment Name:	3204 - James Creek_11-link	**Address:**	Level 1, 64 Ballina St, Lennox Head
Catchment Area:	28.489ha	**Phone:**	02-6687-7666
Impervious Area*:	100.3%	**Email:**	duncan@geolink.net.au
Rainfall Station:	58076 GRAFTON		
Modelling Time-step:	6 Minutes		
Modelling Period:	1/01/1972 - 31/12/1976 11:54:00 PM		
Mean Annual Rainfall:	1160mm		
Evapotranspiration:	1327mm		
MUSIC Version:	6.3.0		
MUSIC-link data Version:	6.34		
Study Area:	North		
Scenario:	CVC Development		

* takes into account area from all source nodes that link to the chosen reporting node, excluding Import Data Nodes

Treatment Train Effectiveness		Treatment Nodes		Source Nodes	
Node: Receiving Node	**Reduction**	**Node Type**	**Number**	**Node Type**	**Number**
Flow	15.5%	Rain Water Tank Node	3	Urban Source Node	12
TSS	88.4%	Bio Retention Node	3		
TP	63.7%				
TN	58%				
GP	100%				

Comments

Refer to Stormwater Management Report for justification of failing parameters.

Passing Parameters

Node Type	Node Name	Parameter	Min	Max	Actual
Bio	Cat2 - bioretention basin	Exfiltration Rate (mm/hr)	None	None	10
Bio	Cat2 - bioretention basin	Extended detention depth (m)	None	None	0.2
Bio	Cat2 - bioretention basin	Filter depth (m)	None	None	0.5
Bio	Cat2 - bioretention basin	Hi-flow bypass rate (cum/sec)	None	None	100
Bio	Cat2 - bioretention basin	Orthophosphate Content in Filter (mg/kg)	50	50	50
Bio	Cat2 - bioretention basin	PET Scaling Factor	2.1	2.1	2.1
Bio	Cat2 - bioretention basin	Saturated Hydraulic Conductivity (mm/hr)	100	100	100
Bio	Cat2 - bioretention basin	Total Nitrogen Content in Filter (mg/kg)	800	800	800
Bio	Cat3 - bioretention basin	Exfiltration Rate (mm/hr)	None	None	10
Bio	Cat3 - bioretention basin	Extended detention depth (m)	None	None	0.2
Bio	Cat3 - bioretention basin	Filter depth (m)	None	None	0.5
Bio	Cat3 - bioretention basin	Hi-flow bypass rate (cum/sec)	None	None	100
Bio	Cat3 - bioretention basin	Orthophosphate Content in Filter (mg/kg)	50	50	50
Bio	Cat3 - bioretention basin	PET Scaling Factor	2.1	2.1	2.1
Bio	Cat3 - bioretention basin	Saturated Hydraulic Conductivity (mm/hr)	100	100	100
Bio	Cat3 - bioretention basin	Total Nitrogen Content in Filter (mg/kg)	800	800	800
Bio	Cat4 - bioretention basin	Exfiltration Rate (mm/hr)	None	None	10
Bio	Cat4 - bioretention basin	Extended detention depth (m)	None	None	0.2
Bio	Cat4 - bioretention basin	Filter depth (m)	None	None	0.5
Bio	Cat4 - bioretention basin	Hi-flow bypass rate (cum/sec)	None	None	100
Bio	Cat4 - bioretention basin	Orthophosphate Content in Filter (mg/kg)	50	50	50
Bio	Cat4 - bioretention basin	PET Scaling Factor	2.1	2.1	2.1
Bio	Cat4 - bioretention basin	Saturated Hydraulic Conductivity (mm/hr)	100	100	100
Bio	Cat4 - bioretention basin	Total Nitrogen Content in Filter (mg/kg)	800	800	800
Rain	Cat2 - tank	% Reuse Demand Met	None	None	68.24
Rain	Cat3 - tank	% Reuse Demand Met	None	None	69.34
Rain	Cat4 - tank	% Reuse Demand Met	None	None	69.9808
Receiving	Receiving Node	% Load Reduction	None	None	15.5
Receiving	Receiving Node	GP % Load Reduction	90	None	100
Receiving	Receiving Node	TN % Load Reduction	45	None	58
Receiving	Receiving Node	TP % Load Reduction	60	None	63.7
Receiving	Receiving Node	TSS % Load Reduction	85	None	88.4
Urban	Cat2 - residual	Area Impervious (ha)	None	None	0.302
Urban	Cat2 - residual	Area Pervious (ha)	None	None	5.294
Urban	Cat2 - residual	Total Area (ha)	None	None	5.597
Urban	Cat2 - road	Area Impervious (ha)	None	None	1.717
Urban	Cat2 - road	Area Pervious (ha)	None	None	1.039
Urban	Cat2 - road	Total Area (ha)	None	None	2.757
Urban	Cat2 - roof bypass	Area Impervious (ha)	None	None	0.496
Urban	Cat2 - roof bypass	Area Pervious (ha)	None	None	0

Only certain parameters are reported when they pass validation

Node Type	Node Name	Parameter	Min	Max	Actual
Urban	Cat2 - roof bypass	Total Area (ha)	None	None	0.496
Urban	Cat2 - roof to tank	Area Impervious (ha)	None	None	1.984
Urban	Cat2 - roof to tank	Area Pervious (ha)	None	None	0
Urban	Cat2 - roof to tank	Total Area (ha)	None	None	1.984
Urban	Cat3 - residual	Area Impervious (ha)	None	None	0.895
Urban	Cat3 - residual	Area Pervious (ha)	None	None	4.716
Urban	Cat3 - residual	Total Area (ha)	None	None	5.612
Urban	Cat3 - road	Area Impervious (ha)	None	None	2.124
Urban	Cat3 - road	Area Pervious (ha)	None	None	1.285
Urban	Cat3 - road	Total Area (ha)	None	None	3.41
Urban	Cat3 - roof bypass	Area Impervious (ha)	None	None	1.323
Urban	Cat3 - roof bypass	Area Pervious (ha)	None	None	0
Urban	Cat3 - roof bypass	Total Area (ha)	None	None	1.323
Urban	Cat3 - roof to tank	Area Impervious (ha)	None	None	3.288
Urban	Cat3 - roof to tank	Area Pervious (ha)	None	None	0
Urban	Cat3 - roof to tank	Total Area (ha)	None	None	3.288
Urban	Cat4 - residual	Area Impervious (ha)	None	None	0.129
Urban	Cat4 - residual	Area Pervious (ha)	None	None	1.476
Urban	Cat4 - residual	Total Area (ha)	None	None	1.606
Urban	Cat4 - road	Area Impervious (ha)	None	None	0.707
Urban	Cat4 - road	Area Pervious (ha)	None	None	0.388
Urban	Cat4 - road	Total Area (ha)	None	None	1.096
Urban	Cat4 - roof bypass	Area Impervious (ha)	None	None	0.264
Urban	Cat4 - roof bypass	Area Pervious (ha)	None	None	0
Urban	Cat4 - roof bypass	Total Area (ha)	None	None	0.264
Urban	Cat4 - roof to tank	Area Impervious (ha)	None	None	1.056
Urban	Cat4 - roof to tank	Area Pervious (ha)	None	None	0
Urban	Cat4 - roof to tank	Total Area (ha)	None	None	1.056

Only certain parameters are reported when they pass validation

Failing Parameters

Node Type	Node Name	Parameter	Min	Max	Actual
Urban	Cat2 - road	Impervious Area Rainfall Threshold (mm/day)	1	1	1.5
Urban	Cat2 - roof bypass	Impervious Area Rainfall Threshold (mm/day)	1	1	0.3
Urban	Cat2 - roof to tank	Impervious Area Rainfall Threshold (mm/day)	1	1	0.3
Urban	Cat3 - road	Impervious Area Rainfall Threshold (mm/day)	1	1	1.5
Urban	Cat3 - roof bypass	Impervious Area Rainfall Threshold (mm/day)	1	1	0.3
Urban	Cat3 - roof to tank	Impervious Area Rainfall Threshold (mm/day)	1	1	0.3
Urban	Cat4 - road	Impervious Area Rainfall Threshold (mm/day)	1	1	1.5
Urban	Cat4 - roof bypass	Impervious Area Rainfall Threshold (mm/day)	1	1	0.3
Urban	Cat4 - roof to tank	Impervious Area Rainfall Threshold (mm/day)	1	1	0.3

Only certain parameters are reported when they pass validation

Appendix D

Bioretention Basins Maintenance Plan

Bioretention Basins Maintenance Plan

Lot 104 DP 751388, James Creek Road

Quality solutions. Sustainable future.

environment | engineering | planning | design

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info@geolink.net.au

Prepared for: MPD Investments

UPR	Description	Issued By	Date Issued
3204-1104	1st issue	Duncan Thomson	25/05/2022

Table of Contents

Appendices

1. Overview

The bioretention basins have been designed to provide the dual function of both treating and detaining stormwater. During smaller rainfall events, stormwater will temporarily pond on the surface of the basin and infiltrate down through the filter media (sandy loam) to be collected in the slotted under-drainage pipes. In larger rainfall events, stormwater will fill the basin to a greater depth and there will be outflow via the low flow culverts and the high flow weir.

The bioretention basins require ongoing inspection and maintenance to ensure they establish and operate in accordance with the design intent. Potential problems that may arise because of inadequate maintenance include:

- Decreased aesthetic amenity;
- Reduced functional performance;
- Public health and safety risks; and
- Decreased habitat diversity (e.g. dominance of exotic weeds).

Importantly, the most intensive period of maintenance is during the plant establishment period (initial one to two years) when weed removal and some replanting may be required.

It is recommended that the personnel who are to undertake the operation and maintenance of the bioretention basin be briefed and trained on procedures and protocols prior to commencement. Maintaining records on the condition of the systems and all maintenance works required will be important to inform and schedule future maintenance works.

This Maintenance Plan is based on information contained in the Water by Design (2012) publication called *Maintaining Vegetated Stormwater Assets* (Version 1). The Water by Design document should be consulted for additional information and details.

2. Inspection and Maintenance Tasks

Inflow pipes, headwalls, outlets and weirs require regular inspection, as these can be prone to scour, and litter build up. Debris can block inlets or outlets and can be unsightly, particularly in high visibility areas. Inspection and removal of debris should be done regularly, and debris should be removed whenever it is observed on a site.

Typical maintenance of a bioretention basin involves:

- Routine inspection of the bioretention basin to identify any areas of obvious increased sediment deposition, scouring from storm flows, rill erosion of the batters from lateral inflows, damage to the profile from vehicles and clogging of the bioretention basin filter media (evident by a 'boggy' surface).
- Routine inspection of inlets, outlets and weirs to identify, clean and repair any areas of scour, litter build up and blockage.
- Removal of sediment where it is smothering vegetation.
- Repairing damage to the basin profile resulting from scour, rill erosion or vehicle damage by replacement of appropriate fill (to match original soils) and revegetating.
- Tilling of the bioretention basin surface, or removal and reinstatement of the surface layer, if there is evidence of clogging.
- Regular watering/irrigation of vegetation until plants are established and self-sustaining.
- Removal and management of invasive weeds.
- Removal of plants that have died and replacement with plants of equivalent size and species as detailed in the plant schedule.
- Pruning to remove dead or diseased vegetation and to stimulate growth.
- Vegetation pest monitoring and control.

Rectification (i.e. resetting, reconstruction) of the bioretention basin will be required if the system fails to drain adequately after tilling of the surface and/or replacement of the surface layer. Regular inspections are required, as well as inspections following large storm events to check for scour and other damage. Major maintenance involving machinery should only occur after a reasonably rain free period when the soil in the bioretention system is relatively dry.

3. Inspection and Maintenance Schedule

3.1 Vegetation Establishment Period (first three months)

During the vegetation establishment period, inspections should be undertaken on a weekly basis and after rainfall events with greater than 25 mm of rain in a 24-hour period. The inspection and maintenance checklist provided in **Appendix A** should be used as a guide and filled in as part of each inspection. Any necessary remedial maintenance activities should be undertaken as soon as possible. The weed control measures and watering schedules summarised below are recommended to ensure successful plant establishment.

Conventional surface mulching of bioretention basins with organic material (e.g. tanbark) should not be undertaken. Most organic mulch floats and runoff typically causes this material to be washed away with a risk of blocking outlets and drains. Adopting high planting densities and, if necessary, applying a suitable biodegradable erosion control matting to the basin batters only (i.e. not the surface of the bioretention basin) will help to combat weed invasion and reduce labour intensive maintenance requirements for weed removal.

Regular watering of bioretention basin vegetation is essential for successful establishment and healthy growth. The frequency of watering to achieve successful plant establishment is dependent upon rainfall, maturity of planting stock and the water holding capacity of the soil. The following watering program is generally adequate but should be adjusted to suit the site conditions:

Week 1 - 2: three visits per week

Week 3 - 6: two visits per week

Week 7 - 12: one visit per week

3.2 Ongoing Maintenance

After the vegetation establishment period, maintenance inspections should be undertaken every three months. Once again, the maintenance checklist provided in **Appendix A** should be used as a guide and filled in as part of each inspection. Any necessary remedial maintenance activities should be undertaken as soon as possible. Watering may still be required, particularly during the first winter (dry period). Watering requirements to sustain healthy vegetation should be determined during ongoing maintenance site visits.

References

Water by Design, (2012). *Maintaining Vegetated Stormwater Assets* (Version 1). Healthy Waterways Ltd, Brisbane

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Appendix A

Inspection and Maintenance Checklist

General Information	
Asset Type	
Asset ID	
Description / name of asset	
Location	
Date of inspection / maintenance	
Date & amount of last rainfall	
Current weather	
Personnel involved in inspection / maintenance	
General comments / sketches	

Issue (what to look for)	Performance Indicator (PI)	Condition Rating *	Maintenance undertaken **	Additional work needed
* Condition Ratings: 1 = PI is met; 2 = PI is met after maintenance completed; 3 = Additional maintenance required; 4 = Rectification may be needed; NI = not inspected; NA = not applicable ** Quantify where possible. e.g. amount of sediment or litter removed				
SURROUNDS				
Damaged or removed structures e.g. traffic bollards	No damage that poses a risk to public safety or structural integrity			
INLET				
Erosion	Inlet is structurally sound and there is no evidence of erosion or subsidence/ settlement			
Damaged or removed structures e.g. pit lids or grates	No damage that poses a risk to public safety or structural integrity			
Sediment, litter or debris	No blockage			
COARSE SEDIMENT FOREBAY (if present)				
Erosion	Minor erosion only that does not pose a risk to public safety or structural integrity and would not worsen if left unattended			
Sediment	Coarse sediment forebay <75% full and no litter			

Issue (what to look for)	Performance Indicator (PI)	Condition Rating *	Maintenance undertaken **	Additional work needed
* Condition Ratings: 1 = PI is met; 2 = PI is met after maintenance completed; 3 = Additional maintenance required; 4 = Rectification may be needed; NI = not inspected; NA = not applicable ** Quantify where possible. e.g. amount of sediment or litter removed				
BATTER SLOPES AND BASE OF BASIN				
Erosion	Minor erosion only that does not pose a risk to public safety or structural integrity and would not worsen if left unattended			
Crust of fine sediment	No surface crusting			
Depressions or mounds	No surface depressions or mounds >100 mm			
Hydraulic conductivity or permeability	Filter media is draining freely, whereby water is not ponded on the surface for more than 12 hours after rainfall and there is no obvious impermeable or clay-like surface on the filter media			
Underdrains / clean out points	Clean out points not damaged and end caps securely in place			
Litter	Maximum 1 piece of litter per 4 m²			
Unusual odours, colours, or substances e.g. oil and grease	None detected			

Issue (what to look for)	Performance Indicator (PI)	Condition Rating *	Maintenance undertaken **	Additional work needed
* Condition Ratings: 1 = PI is met; 2 = PI is met after maintenance completed; 3 = Additional maintenance required; 4 = Rectification may be needed; NI = not inspected; NA = not applicable ** Quantify where possible. e.g. amount of sediment or litter removed				
Vegetation	Minimum 95% vegetation cover (minimal bare patches)			
	Plants healthy and free from disease			
	Average plant height > 500 mm			
Algal or moss growth	Maximum 10% of surface covered in algae; No moss growth			
OUTLET (overflow weir, pipe and/or outfall)				
Erosion	Outlet is structurally sound and there is no evidence of erosion or subsidence/ settlement, including around edges of rock protection or toe of spillway for large systems			
Damaged or removed structures e.g. pit lids or grates	No damage that poses a risk to public safety or structural integrity			
Sediment, litter or debris	No blockage			

Issue (what to look for)	Performance Indicator (PI)	Condition Rating *	Maintenance undertaken **	Additional work needed
* Condition Ratings: 1 = PI is met; 2 = PI is met after maintenance completed; 3 = Additional maintenance required; 4 = Rectification may be needed; NI = not inspected; NA = not applicable ** Quantify where possible. e.g. amount of sediment or litter removed				
Outlet freely draining to receiving drainage or waterway	No downstream impediments to the release of water, no erosion or damage to the outfall structure, and no evidence of malfunction (e.g. excessive sediment accumulated)			