VIMC — Circuit Extension

Storm Water and Rain Water Management Plan
June 13, 2019
JE Anderson File #88804

Prepared for:
VIMC
1.0 INTRODUCTION

Vancouver Island Motorsports Circuit (VIMC) is planning to extend their existing paved circuit to the northeast. The Circuit will be located on Section 4, Range 1, Somenos District at the end of Drinkwater Road. The circuit and related work will include:
- A 2500 metre long paved circuit
- An Experience Center
- A 600 metre long off road circuit

The site is 42 hectares, and is presently zoned I2 - Heavy industrial. The proposed use will have fewer drainage issues and will be much cleaner than other expected industrial uses. More existing vegetation will remain to reduce drainage impacts and filter out potential sediments.

Two Development Permit applications have previously been made for this site.

In 2015, a DP application was made for car storage buildings at the southeast corner of the site. The plan for this has changed as a result of circuit encroachment, and we have included the drainage related to car storage as part of this report.

In 2018, a DP application was made for the proposed paved circuit and car storage buildings. This Report is an update of the 2018 Report as bridges rather than culverts are now proposed for the Menzies Creek Crossings.

2.0 EXISTING DRAINAGE

The proposed site is mostly treed, except for an area in the southeast corner that has been used as a fill site. The northeast corner of the site has been cleared in the last 15 years, and is now vegetated with bush and small trees. The west side of the site is generally mature trees. Aquarian Environmental Consulting Ltd. has prepared a drawing showing the different ground covers on the site.

Soil conditions are expected to be glacial till per the existing circuit. Ryzuk Geotechnical has advised that they cannot provide specific soils condition and infiltration information at the ponds and detention systems until they have dug test holes at the proposed facilities.

Two creeks run through the site, Menzies Creek and Bings Creek. Menzies Creek splits into two channels at the east side of the site. Both Menzies and Bings Creeks have steep ravines through portions of their length. A 2400mm aluminized CSP culvert (in place of a 1500mm steel culvert) has recently been installed on Menzies Creek at the lower end of the site.

There is an existing forest road and old logging road on the east side of Menzies Creek with associated culverts and cross ditches. The culverts and cross ditching have been causing erosion down the steep ravines. An off road circuit complete with ditching and culverts was recently constructed along old logging roads, and this will be abandoned. There is a plan for a future culvert crossing the newly constructed Drinkwater Road at the east side of the site (water presently ponds and runs over the road).

See JE Anderson and Associates Drawing 88804 - SWM - SK1 in Appendix A for pre-development drainage.
3.0 DRAINAGE REQUIREMENTS

A Storm Water and Rain Water Management Plan is required. The Municipality of North Cowichan Storm Water and Rain Water Design Guidelines will be applicable. The plan provided in this report is general in nature, and more detailed plans and calculations will be required at detailed design stage. The following requirements must be met per Municipality of North Cowichan Storm Water and Rain Water Management Guidelines:

1. A site specific Stormwater Management Plan in accordance with MMCD Design Guideline Manual, Section 4.3.
2. Infiltration or ponding of 25% of the mean annual rainfall 24 hour event. The infiltration or ponding should be spread around the site so that infiltration takes place over a wide area.
3. Control of 25% of the mean annual rainfall 24 hour event from the hard surface areas to 1.4 L/s/ha.
4. Control of the 5 year return event to limit post development flows to pre-development flows via detention facilities.
5. Review downstream capacity and flood risk for the 10, 25, and 200 year return events. If necessary, upgrade downstream works / or provide additional detention and flow control.
6. For commercial, industrial, institutional, and high density residential development, design water quality treatment works to meet the following:
   A. treat 90% of the annual runoff volume of the catchment area
   B. meet removal targets of 80% TSS and 95% oil

Additional drainage issues for this site will include:

- Menzies Creek Bridges / Culverts
- Potential reduction in creek storage related to bridge installation
- Re-directing point discharges away from the steep ravine slopes
- Maintaining flows down the ravine slopes / toward vegetation
- Potential fuel filling areas
- Defining future flows from the southeast corner of the site.

This site will be a relatively low risk site compared to other industrial site options. Much of the site will remain vegetated, the use will be clean and controlled. Risks would be less than for a highway due to the low traffic volume and the proposed use of newer vehicles and a more controlled environment.

In some cases, there will be offsetting risks such as directing sheet flow from the circuit toward the ravine will be good for the ravine vegetation, but will also allow any spilling oil / fuel to flow toward the ravine. In this case, the higher priority may be drainage to the vegetation during every summer rain vs a very low risk of an oil /gas spill which would tend to be small.
4.0 PROPOSED DRAINAGE

Proposed drainage systems will include general drainage, circuit drainage, control and treatment. With respect to treatment, once constructed and vegetation is established on disturbed areas, there will be very little sediment or oil produced. The site could be considered a low volume, well controlled road.

General drainage will consist of Menzies Creek bridges and culverts, cutoff ditching to direct uphill drainage away from the circuit, directing point source drainage away from the ravines, and downstream drainage.

Circuit drainage will consist of the system of ditches, swales, French drains, gravel bed drainage, U drains, slot drains and overland flow that is required for directing drainage away from the circuit.

Drainage control will consist of infiltration and detention control rock storage, rock pits, chambers, and ponds. Drainage treatment will consist of directing drainage over vegetation, oil separators, infiltration, bioswales, pond controls, raingardens, fueling control pads with containment, etc. Since the site is spread out with multiple separate drainage areas, with most vegetation to remain, the preferred method of treatment would be to sheet flow drainage from the asphalt across wide areas of vegetation. However, this is subject to directing drainage to concentrated areas for drainage volume control.

See JE Anderson and Associates Drawing 88804 – SWM – SK2 and SK3 in Appendix A for post-development drainage areas and systems.

See Tilke Drawing C-DR 4-LP-100 for general circuit drainage. This general design will be adjusted to a more detailed and specific design at detailed design stage.

4.1 DRAINAGE PARAMETERS

The site is large and complicated, with Menzies Creek running through the site. It will be best to start with some parameters to follow before completing details:

1. Trees to remain where possible and minimize extent of vegetation disturbance.
2. The uphill portions of the site that do not drain any circuit areas can be directed to the creek without infiltration, detention, or treatment.
3. For a limited area of narrow hard surface areas flowing onto wide landscape areas, there will be no increase in flow.
4. Infiltration is best located at the drainage source before drainage is concentrated.
5. Given that the circuit is a relatively clean use of the site, it will be acceptable to direct non concentrated circuit drainage to vegetation a significant distance away from the creek.
6. Drainage down the steep ravines is acceptable as long as the drainage is not concentrated.
7. Oil will not be a significant concern except at fueling areas as proposed use is by newer cars. However, oil will have to be considered at all drainage areas.
8. It will be acceptable to cut into the upper property to make room for required ditches. If not, culverts in drain rock with perf drain with swale over will have to be considered.
9. The bottom of ditches or perf drain systems should ideally be below the bottom of the road gravel structure.
10. Locate manholes and surface works beyond the extent of asphalt. Locate beyond the extent of gravel if maintenance is expected to be required as they would have to be buried.

11. Try to locate infiltration / detention systems beyond the extent of the circuit / asphalt surface.

12. Consider leakage of infiltration / detention systems de-stabilizing bridge abutments / walls / fill slopes.

13. Drainage design will have to be broken up into multiple drainage areas with their own infiltration / detention / treatment systems.

14. The existing contours beyond the channels are based on lidar through thick trees, and will require confirmation, probably following clearing to check cut areas vs fill areas. Drainage treatments will be different in cuts vs fills.

15. At detailed design stage, the flow routing should be reviewed and coordinated with Aquaparian.

4.1 GENERAL DRAINAGE

Menzies Creek

Approximately 200 metre width of new bridges will be required for the four crossing of the two channels of Menzies Creek. Wing walls will also be required. Approximately 850 metres of channel through the site will remain open, which is approximately 80%.

Preliminary bridge layouts are provided in Appendix A and channel flow calculations are provided in Appendix B.

The bridge abutments will be set back from the high water mark as determined by Aquaparian and JEA legal surveyors. During a 200 year return storm, the channel water level will be well above the high water mark, and as such, there will be a reduction in channel storage. We expect that during the year 2020 200 year return flow there is a 100 cubic metre reduction in storage. This amounts to 28 L/s for 1 hour. The 200 year return flows from the ponds should be reduced to accommodate this.

Cutoff Ditches

Cutoff ditches will be provided above the site and through the site to protect the circuit. The cutoff ditch flows will be directed away from the steep ravine slopes.

Ditches on the north side of the circuit could be located above the cut slope or at the base of the cut slope. The circuit slopes away from the ditch, so the cutoff ditch at the base of the slope that will also act to keep the circuit dry gravel structure dry will be the best choice. The drainage volume will be high enough in most areas to require riprap, including down the cut slopes where uphill drainage is concentrated. A 0.6m to 0.9m deep ditch with 2:1 side slopes and 0.8m base would generally be sufficient, however the ditch should be deepened in areas where it is required to protect the circuit subgrade. The 0.9m ditch depth would be required for capacity where flows are high and the slope is under 2%. The ditches may require that the cut slope extend into the property to the north. If this is not possible, a culvert with perforated drain in drain rock with filter cloth over and a shallow surface swale will be required. An alternative would be a wall.

The cutoff ditches will increase flows to Menzies Creek between the bridges and the downstream side of the property. This will be acceptable as they are natural flows, minimal hard surface area.
On the east side of the site, the cutoff ditch will end up flowing through the site, along the circuit and into Menzies Creek where the ravine peters out. This will be an improvement over existing as ravine erosion will be reduced. This drainage should be independent of untreated circuit drainage.

**Downstream Drainage – Main Circuit Area**

The majority of the drainage flows will be toward Menzies Creek. The 2400mm culvert at the downhill property line was installed in 2016. The culvert at the Cowichan Valley Highway is 2700mm to 2900mm. The culvert sizes are as expected. We have limited our downstream review to these culverts as we will be limiting the post development flows for the 5 to 200 year storms to pre-development levels.

**2400mm Culvert Flow and capacity from 2016 design (year 2016 rainfall)**

Drainage area 550 ha, square edge headwall, 600mm infill.

Q25 Flow 7,500 L/s, Capacity 8,000 L/s at HW/D = 1

Q200 Flow 13,500 L/s, Capacity 15,000 L/s at HW/D = 1.9

**2700mm Culvert Flow and capacity relative other culvert drainage area (year 2019 rainfall)**

Drainage area 630 ha, projecting CSP pipe, no headwall, no infill (no allowance for future rainfall increase)

Q25 Flow 9,300 L/s, Capacity 13,500 L/s at HW/D = 1

Q200 Flow 14,300 L/s, Capacity 16,400 L/s at HW/D = 1.2

The 2400mm culvert at the south side of the site requires maintenance. A square edge headwall at the inlet is required for capacity, to direct drainage toward the culvert inlet, and for erosion protection. This will be done as part of the new circuit extension.

The proposed development will have a negligible impact on Bings Creek as the 0.3 hectare area affected is very small compared to the overall drainage area.

**Downstream Drainage - Southeast Corner of Site**

In 2016 prior to construction of the Drinkwater Road extension, the existing drainage area flowing to the south side of this portion of the site was approximately 17 ha in size, including drainage areas from EX B, EX C, and EX D. There was a ditch along the uphill side of the logging road, along the Drinkwater Road Right of Way, and crossing onto private property approximately at the future culvert location. This drainage route wound through the downstream property via ditches, and eventually reached Menzies Creek.

When the watermain was installed and Drinkwater Road was extended, the flow across private property was considered a drainage route that would remain without requirement for an easement as long as flows were not increased. The design drawings for the road reviewed by MNC showed that this drainage route was to remain, and also showed an option to re-route a portion of the uphill drainage down the old logging road to Menzies Creek via the Drinkwater Road Ditch. A high point in Drinkwater Road was forced at the old logging road ditch so that the Drinkwater Road extension ditch could grade toward Menzies Creek. During construction, a ditch was installed across the old logging road to direct drainage to Menzies Creek, and the proposed culvert was not installed across the Drinkwater Road extension but was shown on the record drawings as a future 600mm culvert.
At the start of the DP process related to the car storage, discussions with MNC indicated that their preference was to generally direct water from the car storage site to Menzies Creek via the road ditch, and the remainder toward the future culvert crossing Drinkwater Road (as this portion of the ditch could not be drained to Menzies Creek or Bings Creek). Based on the updated circuit drawings, not taking into account the car storage, the drainage area crossing Drinkwater Road via the future culvert is 3.5 ha. Based on the proposed car storage, the area is down to approximately 1.5 ha.

At this point the tributary drainage area for drainage being directed to the original flow route has been reduced from approximately 17 hectares to 1.5 hectares, and the downstream property owner will be responsible for accounting for this drainage flow. The proposed works have not increased drainage flows to this natural drainage area.

At this time, the downstream property owner should allow for an upstream drainage area of 1.5 hectares plus an allowance for overflow. This does not include Drinkwater Road right of way. Flows anticipated related to this based on a 15 minute time of concentration are expected to be as follows:

- Q5 pre = 236 L/s  Q5 post = 84 L/s
- Q25 pre = 370 L/s  Q25 post = 145 L/s
- Q200 pre = 680 L/s  Q200 post = 240 L/s

A 525mm culvert crossing Drinkwater Road would be reasonable.

The above takes into account a future 10% to 20% increase in rainfall intensities due to global warming.

**Southwest Corner of Site**

The southwest corner of the site presently drains toward the existing circuit. Planning for the existing circuit allowed for this drainage area to be directed toward the existing detention pond, however, the proposed hard surface is now greater than originally expected and covers a significant portion of this corner of the site, and detention in French drains per the Tilke plans and a pond at the uphill end of the existing culvert should be provided to moderate the peak flows. An alternative would be to increase the size of the existing circuit pond. This area can continue to drain toward the south through the existing circuit drain system.

The existing detention pond at the existing circuit should be completed prior to paving the new circuit.

**4.2 CIRCUIT DRAINAGE, CONTROL, AND TREATMENT**

Tilke drawings show a system of ditches, U drains, slot drains, French drains, and gravel bed drains. This system will be considered in the final drainage design but will be customized for the steep terrain and vegetation to remain. We will assume that the French drains on the lower side of the circuit are there to keep drainage away from the circuit subgrade, and will be obsolete in fill areas of 0.5m, and less than 0.5m where the ground is falling away. The final method and drainage routing will be site specific and will consider the following:

- Narrow asphalt widths can be allowed to sheet flow away from the site onto natural areas where there is a benefit in maintaining flows to vegetation. U drains and slot drains can also be directed downstream over vegetated areas as long as the tributary areas are small. There will be wider areas of asphalt where drainage can sheet flow, although these areas tend to have U drains.
Consideration will be given to eliminating some curb drains to allow better sheet flow to vegetation.

Larger asphalt widths will be subject to infiltration, detention, and treatment per MNC Standards where appropriate.

Where possible, gravel fills will be provided for infiltration.

A pond / ponds or underground storage will be necessary on the east side of Menzies Creek. Bioswales should also be considered.

A 5 to 200 year storage area will be provided in Area PR 1 where the circuit creates a natural berm. Vegetation removal will be minimized. Vegetation above the 2 year return water level will remain.

Produce a bioswale with wide base below the lower buildings (where it will fit) at the car storage areas, with overflow to the pond. This would provide groundwater flows to vegetated areas and reduce required pond retention volumes.

Erosion and sediment control during construction should be a priority, and an erosion and sediment control plan will be required at detailed design stage.

Drains will be sized to direct the 5 to 200 year drainage to Menzies Creek.

Details will be provided at detailed design stage.

Specific Control and Treatment

The first 12mm of rainfall from hard surface areas will be controlled through infiltration in gravel fills, French drains, and through existing and new vegetation, and through bioswales and ponds / rain gardens. The treatments will be spread out through the site. The best method will be to direct the drainage to wide areas of existing vegetation.

The second 12mm of rainfall will receive the same treatment as the first 12mm. Release will be limited to maximum 1.4 L/s per hectare of hard surface area.

5 to 200 year detention will be provided via underground storage in open graded rock or underground detention tanks or ponds.

We have prepared Hydrocad calculations for Areas PR3 and PR6 provided in Appendix B. Results are provided in the information and tables below. These calculations have been used to estimate storage volumes in other drainage areas.

Area PR-3 Modelling

Hard Surface Area 3.33 ha.
Disturbed Area 2.36 ha.
Undisturbed Area 0.28 ha.
Total Area 5.97 ha.

12mm Retention Volume = 3.33 ha x 10,000 x .012 = 400 cubic metres (try to locate much of this in the French drains, particularly in clean gravel fills (no French drains close to the bridges).
25% MAR requirement is 1.4 L/s x 3.33 ha = 4.7 L/s

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<th>Q25 (L/s)</th>
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<td>38.5</td>
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<td>Void Volume</td>
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<td>1335 cu. m.</td>
<td>1880 cu. m.</td>
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<td>Water Level</td>
<td>N/A</td>
<td>101.1 m.</td>
<td>101.41 m.</td>
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Volumes in table do not include the required retention.

Area PR-6 Modelling
Hard Surface Area 0.54 ha.
Disturbed Area 0.94 ha.
Undisturbed Area 0 ha.
Total Area 1.48 ha.
12mm Retention Volume = 0.54 ha x 10,000 x 0.012 = 65 cubic metres open, 162 cubic metres of drain rock at 25% voids.
25% MAR requirement is 1.4 L/s x 0.54 = 0.76 L/s

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<th>Q25 (L/s)</th>
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<td>Flow</td>
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<td>18.4</td>
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<td>Void Volume</td>
<td>N/A</td>
<td>84 cu. m.</td>
<td>135 cu. m.</td>
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<td>Water Level</td>
<td>N/A</td>
<td>100.84 m.</td>
<td>101.27 m.</td>
<td>101.7 m.</td>
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480 cubic metres of drain rock at 40% voids.
Volumes in table do not include the required retention.

Treatment will include:
- Directing drainage to vegetated areas.
- Drainage to pre-treatment sumps in ponds.
- Combined Oil / Water separators and detention control tanks at underground detention areas.
Disturbed Non Paved Areas
Disturbed non paved areas should be covered with minimum 200 mm of topsoil or minimum 200mm of permeable gravel (less than 5% silt and clay) to encourage infiltration / retention.

Erosion and Sediment Control
Erosion and sediment control during construction must be a priority, and the best methods will be directing clean water away from areas of disturbance, minimizing vegetation removal, sheet flow drainage into vegetated areas, and gravel surfacing in areas where this is not possible, and vegetating disturbed slopes prior to rainfalls. Drainage to ponds will also be applicable.

Drainage control at fill slopes that sheet flow asphalt drainage will require that vegetation is well established before paving, or slope treatment will be required. Erosion protection blanket and piping down steep banks may be applicable.

An erosion and sediment control plan will be required at detailed design stage.

Aquaparion Environmental Consultants Ltd. has prepared some erosion and sediment control recommendations. These recommendations must be followed.

Fueling Areas
There are no fueling areas shown on the DP drawings. At some point, a fueling station may be proposed. If a fueling area is proposed, it should be arranged per fueling station requirements. In addition, it must include the following relative to water quality:

- A fueling tank with spill storage at least equal to the storage volume of the tank.
- A small and specific drainage area complete with oil / water separator sized per Best Management Practices.

Other
We recommend the following:

- Any buildings to include an environmentally friendly roof – in particular, a roof that does not produce heavy metals.
- Limit fertilizer use.
- Do not enter oil interceptors unless properly trained. Follow WCB requirements for confined space entry as air in tank may be unsafe to breathe, and may be explosive.
- Additional recommendations may be required as design proceeds and site is used.

9.0 SITE OPERATION AND MAINTENANCE
The circuit operator should prepare a plan to maintain the systems to control flow and maintain water quality.
Flow Control

- Review control outlets and culverts minimum twice per year and during heavy rainfalls to confirm satisfactory operation.
- Review drainage systems minimum once per year and during heavy rainfalls to ensure no damage.
- Clean out ponds as bottom fills in with sediment, vegetation.
- Replace systems as required.

Water Quality

- Identify all potential sources of contamination.
- Create a plan to prevent contamination of the storm water. Review and update the plan at least once per year.
- Provide a treatment system for drainage that may become contaminated.
- Maintain vegetation in good condition.
- Maintain all permeable areas to keep them permeable.
- Dispose of sediment and contaminated water and material in a legal manner.
- Avoid use of pesticide and herbicide, and minimize the use of fertilizer. Follow MNC and CVRD Bylaws.
- Maintain, upgrade, and replace the systems as required.
- Provide signage and staff education as required.
- Clean out catch basins and oil interceptor/sediment sumps whenever depth of sediment is over 100mm.
- Clean out oil separator oil whenever depth is over 10mm.

10.0 DETENTION OPTIONS

During previous public meetings, there was some discussions about global warming and a reduction in rainfall during the summers. To maintain water flows in the creeks during the summer, a large reservoir could be created. At 5 L/s for 2 months, 26,000 cubic metres of storage plus an allowance for evaporation would be required.

If planning could be completed in time, a contribution could be provided toward a community system that could control flows rather than trying to control the 5 to 200 year return flow on site. The main method for drainage control would then be directing drainage toward vegetated areas.
11.0 SUMMARY

The proposed circuit will be located on land zoned Heavy Industrial. The proposed circuit will be a cleaner and lower risk use than normal industrial use. Most of the site will remain vegetated / will be re-vegetated following construction.

Pre development drainage is shown on JE Anderson and Associates Drawings 88804 – SWM – SK1. Post Development drainage is shown on JEA Drawings 88804 – SWM – SK2 and SK3. Details are shown on Drawing 88804 – SWM – SK3.

Development of the site to meet MNC Drainage Guidelines includes the following:

1. The first 12mm of drainage will be controlled where possible by directing asphalt drainage to wide expanses of vegetation. Control will also be via storage in gravel fill, French drains, swales, ponds. Based on 9.0 hectares of new asphalt, 1,080 cubic metres of voids will be required.

2. The second 12mm of drainage will be controlled to a maximum of 1.4 L/s/ha via infiltration of ponding areas, French drains, detention control, and directing drainage off the asphalt to wide areas of vegetation.

3. A cutoff ditch will be constructed to direct uphill drainage away from the circuit and the ravine. Riprap will be placed where required. The concentrated flows presently causing erosion down the existing ravine will be eliminated.

4. Detention for the 5 year to 200 year return storms will be underground rock / tank storage and ponds. These will control the 5, 25, and 200 year return flows to pre-development levels.

5. Water quality will be maintained via sheet flow crossing wide expanses of vegetation, and infiltration, where possible. Sediment sumps, particularly prior to infiltration, bioswales, and oil interceptors will also be applicable in some areas. We note that oil will not be a major issue on the site, and once vegetation is established, erosion and sediment production will be minimal.

6. Erosion and sediment control during construction and until vegetation is established must be a priority. An erosion and sediment control plan should be prepared at detailed design stage. Aquaparian Environmental Consultants has prepared some erosion and sediment control recommendations, and these must be followed.

7. The results of the downstream drainage capacity and flood risk review indicate the culvert at the south end of the site requires maintenance. In addition, the developer downstream of the east side of the site will have to accommodate some upstream flows and Drinkwater Road flows, but these flows will be much less than they were prior to Drinkwater Road extension.

8. The site should be operated and maintained to ensure that flows are controlled, and sediment, oil, and other contaminants are minimized in the runoff.

9. We will coordinate drainage plans with Aquaparian at design stage. Consideration will be given to eliminating some on circuit curb drains on the lower side of the circuit and directing the drainage toward the vegetation in the ravine. No point source flows.

10. Details will be provided at detailed design stage.
All the District of North Cowichan Rain Storm Water and Rain Water Guidelines will be met.

Yours Truly
JE Anderson and Associates

Jim Buchanan, P. Eng.

June 13/19
Appendix A

JEA DWG 88804 SWM SK1
Pre-Development Drainage (2016)

JEA DWG 88804 SWM SK2
Post Development Drainage – West End

JEA DWG 88804 SWM SK3
Post Development Drainage – East End and Pond Details

Tilke DWG C-DR 4-LP-100
Drainage Concept

JEA DWG 88804 DP D5
South Menzies Creek Crossing – Plan, Sections and Calculations

JEA DWG DP D6
North Menzies Creek Crossing – Plan, Sections and Calculations
Appendix B

Drainage Calculations

PR3 Pre-Development Flows – 200 Year
PR3 Post Development Flow – 200 Year
PR6 Pre-Development Flows – 200 Year
PR6 Post Development Flow – 200 Year

Pre-Development Year 2100 Flows and Depths at Bridges
Post Development Year 2100 Flows and Depths at Bridges
PR3 Pre-Development Flows – 200 Year
Summary for Subcatchment 10S: PR3 PRE-5.97

Runoff = 0.24698 m³/s @ 8.63 hrs, Volume = 4.932 ML, Depth > 83 mm

Runoff by SCS TR-20 method, UH=Gamma-600, Time Span = 0.00-24.00 hrs, dt = 0.04 hrs
Type IA 24-hr Rainfall=160 mm

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<th>CN</th>
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<td>73</td>
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5.9700
100.00% Pervious Area

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<tr>
<th>Tc (min)</th>
<th>Length (meters)</th>
<th>Slope (m/m)</th>
<th>Velocity (m/sec)</th>
<th>Capacity (m³/s)</th>
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Subcatchment 10S: PR3 PRE-5.97

Hydrograph

Type IA 24-hr Rainfall=160 mm
Runoff Area = 5.9700 ha
Runoff Volume = 4.932 ML
Runoff Depth > 83 mm
Tc = 60.0 min
CN = 73
PR3 Post Development Flow - 200 Year

10S
PR3-3.33 Hard

7S
2.36 Disturbed

8S
.28 Undisturbed

6P
PR# Pond

Routing Diagram for 20190522-88804-PR3-POST
HydroCAD® 10.03 s/n 03581 © 2012 HydroCAD Software Solutions LLC
Summary for Subcatchment 7S: 2.36 Disturbed

Runoff = 0.16616 m³/s @ 8.10 hrs, Volume = 2.412 M³, Depth > 102 mm

Runoff by SCS TR-20 method, UH=Gamma-600, Time Span = 0.00-24.00 hrs, dt= 0.04 hrs

Type IA 24-hr Rainfall=160 mm

<table>
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<tr>
<th>Area (ha)</th>
<th>CN</th>
<th>Description</th>
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<tbody>
<tr>
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<th>Tc (min)</th>
<th>Length (meters)</th>
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Subcatchment 7S: 2.36 Disturbed

Type IA 24-hr Rainfall=160 mm
Runoff Area=2.3600 ha
Runoff Volume=2,412 M³
Runoff Depth > 102 mm
Tc=20.0 min
CN=80
Summary for Subcatchment 8S: .28 Undisturbed

Runoff = 0.01434 m³/s @ 8.23 hrs, Volume= 0.235 Ml, Depth> 84 mm

Runoff by SCS TR-20 method, UH=Gamma-600, Time Span= 0.00-24.00 hrs, dt= 0.04 hrs
Type IA 24-hr Rainfall=160 mm

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Subcatchment 8S: .28 Undisturbed

Type IA 24-hr Rainfall=160 mm
Runoff Area=0.2800 ha
Runoff Volume=0.235 Ml
Runoff Depth>84 mm
Tc=30.0 min
CN=73
Summary for Subcatchment 10S: PR3-3.33 Hard

Runoff = 0.35271 m³/s @ 7.92 hrs, Volume = 5.114 Ml, Depth > 154 mm

Runoff by SCS TR-20 method, UH = Gamma-600, Time Span = 0.00-24.00 hrs, dt = 0.04 hrs
Type IA 24-hr Rainfall = 160 mm

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<th>Area (ha)</th>
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3.3300 100.00% Impervious Area

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Subcatchment 10S: PR3-3.33 Hard

Hydrograph

Type IA 24-hr
Rainfall = 160 mm
Runoff Area = 3.3300 ha
Runoff Volume = 5.114 Ml
Runoff Depth > 154 mm
Tc = 10.0 min
CN = 98
Summary for Pond 6P: PR# Pond

Inflow Area = 5.9700 ha, 55.78% Impervious, Inflow Depth > 130 mm
Inflow = 0.51777 m³/s @ 8.00 hrs, Volume= 7.760 ML
Outflow = 0.23289 m³/s @ 8.51 hrs, Volume= 6.686 ML, Atten= 55%, Lag= 30.4 min
Primary = 0.23289 m³/s @ 8.51 hrs, Volume= 6.686 ML

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.04 hrs
Peak Elev= 101.788 m @ 8.51 hrs Surf.Area= 0.1545 ha Storage= 1.879 ML

Plug-Flow detention time= 187.1 min calculated for 6.675 ML (86% of inflow)
Center-of-Mass det. time= 93.0 min (784.3 - 691.3 )

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<th>Storage Description</th>
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<tr>
<td>#1</td>
<td>100.000 m</td>
<td>7.065 ML</td>
<td>25.00 mW x 25.00 mL x 4.00 mH Prismatoid Z=4.0</td>
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<table>
<thead>
<tr>
<th>Device</th>
<th>Routing</th>
<th>Invert</th>
<th>Outlet Devices</th>
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</thead>
<tbody>
<tr>
<td>#1</td>
<td>Primary</td>
<td>100.000 m</td>
<td>80 mm Horiz. Orifice/Grate C= 0.600</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Limited to weir flow at low heads</td>
</tr>
<tr>
<td>#2</td>
<td>Primary</td>
<td>100.080 m</td>
<td>110 mm Vert. Orifice/Grate C= 0.600</td>
</tr>
<tr>
<td>#3</td>
<td>Primary</td>
<td>101.100 m</td>
<td>300 mm Vert. Orifice/Grate C= 0.600</td>
</tr>
<tr>
<td>#4</td>
<td>Primary</td>
<td>101.400 m</td>
<td>200 mm Vert. Orifice/Grate C= 0.600</td>
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</table>

Primary OutFlow Max=0.23282 m³/s @ 8.51 hrs HW=101.788 m (Free Discharge)
-1=Orifice/Grate (Orifice Controls 0.01786 m³/s @ 3.55 m/s)
-2=Orifice/Grate (Orifice Controls 0.03247 m³/s @ 3.42 m/s)
-3=Orifice/Grate (Orifice Controls 0.13778 m³/s @ 1.95 m/s)
-4=Orifice/Grate (Orifice Controls 0.04480 m³/s @ 1.43 m/s)
Pond 6P: PR# Pond

Hydrograph

Inflow Area = 5.9700 ha
Peak Elev = 101.788 m
Storage = 1.879 Ml
Summary for Subcatchment 10S: PR6 PRE-1.48

Runoff = 0.09174 m³/s @ 8.22 hrs, Volume= 1.429 Ml, Depth> 97 mm

Runoff by SCS TR-20 method, UH=Gamma-600, Time Span= 0.00-24.00 hrs, dt= 0.04 hrs
Type IA 24-hr Rainfall=160 mm

<table>
<thead>
<tr>
<th>Area (ha)</th>
<th>CN</th>
<th>Description</th>
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<tbody>
<tr>
<td>1.4800</td>
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<td>100.00% Pervious Area</td>
</tr>
</tbody>
</table>

Tc | Length (meters) | Slope (m/m) | Velocity (m/sec) | Capacity (m³/s) | Description |
---|-----------------|-------------|------------------|-----------------|-------------|
30.0 | Direct Entry, |

Subcatchment 10S: PR6 PRE-1.48

Type IA 24-hr Rainfall=160 mm
Runoff Area=1.4800 ha
Runoff Volume=1.429 Ml
Runoff Depth>97 mm
Tc=30.0 min
CN=78
PR6 Post Development Flow – 200 Year

10S
0.54 PR6 - HARD-POST

11S
0.94 PR6 - DISTURBED - POST

12P
U/G STORAGE

Routing Diagram for 20190523-88804-PR6-POST
Prepared by JE Anderson and Associates, Printed 5/24/2019
HydroCAD® 10.09 s/n 63581 © 2012 HydroCAD Software Solutions LLC
Summary for Subcatchment 10S: 0.54 PR6 -HARD-POST

Runoff = 0.05720 m³/s @ 7.92 hrs, Volume= 0.829 Ml, Depth>154 mm

Runoff by SCS TR-20 method, UH=Gamma-600, Time Span= 0.00-24.00 hrs, dt= 0.04 hrs
Type IA 24-hr Rainfall=160 mm

<table>
<thead>
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<tbody>
<tr>
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<td></td>
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<td>Direct Entry,</td>
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Subcatchment 10S: 0.54 PR6 -HARD-POST

Type IA 24-hr Rainfall=160 mm
Runoff Area=0.5400 ha
Runoff Volume=0.829 Ml
Runoff Depth>154 mm
Tc=10.0 min
CN=98
Summary for Subcatchment 11S: .94 PR6 - DISTURBED - POST

Runoff = 0.06618 m³/s @ 8.10 hrs, Volume = 0.961 MI, Depth > 102 mm

Runoff by SCS TR-20 method, UH = Gamma-600, Time Span = 0.00-24.00 hrs, dt = 0.04 hrs
Type IA 24-hr Rainfall = 160 mm

<table>
<thead>
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<th>Area (ha)</th>
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<th>Tc (min)</th>
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<th>Slope (m/m)</th>
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Direct Entry,

Subcatchment 11S: .94 PR6 - DISTURBED - POST

Hydrograph

Type IA 24-hr Rainfall = 160 mm
Runoff Area = 0.9400 ha
Runoff Volume = 0.961 MI
Runoff Depth > 102 mm
Tc = 20.0 min
CN = 80
Summary for Pond 12P: U/G STORAGE

Inflow Area = 1.4800 ha, 36.49% Impervious, Inflow Depth > 121 mm
Inflow = 0.12034 m³/s @ 8.03 hrs, Volume= 1.790 ML
Outflow = 0.09052 m³/s @ 8.24 hrs, Volume= 1.741 ML, Atten= 25%, Lag= 12.7 min
Primary = 0.09052 m³/s @ 8.24 hrs, Volume= 1.741 ML

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.04 hrs
Peak Elev= 101.695 m @ 8.24 hrs Surf.Area= 0.0338 ha Storage= 0.190 ML

Plug-Flow detention time= 60.0 min calculated for 1.738 ML (97% of inflow)
Center-of-Mass det. time= 40.4 min (752.5 - 712.1)

Volume Invert Avail.Storage Storage Description
#1 100.000 m 0.392 ML 15.00 mW x 15.00 mL x 3.00 mH Prismatoid Z=1.0
                                           0.981 ML Overall x 40.0% Voids

Device Routing Invert Outlet Devices
#1 Primary 100.000 m 38 mm Horiz. Orifice/Grate C= 0.600
                         Limited to weir flow at low heads
#2 Primary 100.100 m 95 mm Vert. Orifice/Grate C= 0.600
#3 Primary 100.900 m 150 mm Vert. Orifice/Grate C= 0.600
#4 Primary 101.300 m 140 mm Vert. Orifice/Grate C= 0.600

Primary OutFlow Max=0.09052 m³/s @ 8.24 hrs HW=101.685 m (Free Discharge)
1=Orifice/Grate (Orifice Controls 0.00392 m³/s @ 3.46 m/s)
2=Orifice/Grate (Orifice Controls 0.02343 m³/s @ 3.31 m/s)
3=Orifice/Grate (Orifice Controls 0.03985 m³/s @ 2.25 m/s)
4=Orifice/Grate (Orifice Controls 0.02332 m³/s @ 1.51 m/s)
Pond 12P: U/G STORAGE

Hydrograph

Inflow Area = 1.4800 ha
Peak Elev = 101.695 m
Storage = 0.190 ML
Pre-Development Year 2100 Flows and Depths at Bridges
Summary for Subcatchment 1S: 321 ha.

Runoff = 12.33311 m³/s @ 8.49 hrs, Volume = 315.556 Ml, Depth > 98 mm

Runoff by SCS TR-20 method, UH=Gamma-600, Time Span = 0.00-24.00 hrs, dt = 0.04 hrs
Type IA 24-hr Rainfall = 192 mm

<table>
<thead>
<tr>
<th>Area (ha)</th>
<th>CN</th>
<th>Description</th>
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<tbody>
<tr>
<td>321.0000</td>
<td>70</td>
<td>100.00% Pervious Area</td>
</tr>
</tbody>
</table>

Tc, Length, Slope, Velocity, Capacity, Description

120.0 Direct Entry,

Subcatchment 1S: 321 ha.

Type IA 24-hr Rainfall = 192 mm
Runoff Area = 321.0000 ha
Runoff Volume = 315.556 Ml
Runoff Depth > 98 mm
Tc = 120.0 min
CN = 70
Summary for Subcatchment 3S: 175 ha.

Runoff = 6.72386 m³/s @ 9.49 hrs, Volume = 172.032 Ml, Depth > 98 mm

Runoff by SCS TR-20 method, UH=Gamma-600, Time Span= 0.00-24.00 hrs, dt= 0.04 hrs
Type IA 24-hr Rainfall=192 mm

### Subcatchment 3S: 175 ha.

- **Area (ha)**: 175.0000
- **CN**: 70
- **Tc**: 120.0
- **Length (meters)**: Direct Entry
- **Slope (m/m)**: 100.00% Pervious Area
- **Velocity (m/sec)**: 0.04
- **Capacity (m³/s)**: 0.0
- **Description**: Pervious

**Hydrograph**

- Type IA 24-hr Rainfall=192 mm
- Runoff Area=175.0000 ha
- Runoff Volume=172.032 Ml
- Runoff Depth>98 mm
- Tc=120.0 min
- CN=70
I

Prepared by JE Anderson and Associates

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Page 5

Summary for Reach 2R: SOUTH

Inflow Area = 175.000 ha, 0.00% Impervious, Inflow Depth > 98 mm
Inflow = 6.72366 m³/s @ 9.46 hrs, Volume = 172.032 Ml
Outflow = 6.71889 m³/s @ 9.53 hrs, Volume = 171.770 Ml, Atten = 0%, Lag = 2.4 min

Routing by Stor-Ind+Trans method, Time Span = 0.00-24.00 hrs, dt = 0.04 hrs
Max. Velocity = 2.00 m/s, Min. Travel Time = 1.1 min
Avg. Velocity = 1.47 m/s, Avg. Travel Time = 1.5 min

Peak Storage = 435.8 m³ @ 9.50 hrs
Average Depth at Peak Storage = 0.70 m
Bank-Full Depth = 0.80 m, Flow Area = 4.40 m², Capacity = 9.28719 m³/s

Custom cross-section, Length = 130.00 m, Slope = 0.0246 m/m (102 Elevation Intervals)
Constant n = 0.040 Winding stream, pools & shoals
Inlet Invert = 10.000 m, Outlet Invert = 6.800 m

<table>
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<th>Offset (meters)</th>
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<th>Chan. Depth (meters)</th>
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<th>Discharge (m³/s)</th>
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Reach 2R: SOUTH

Hydrograph

Inflow Area=175.0000 ha
Avg. Flow Depth=0.70 m
Max Vel=2.00 m/s
n=0.040
L=130.00 m
S=0.0246 m/m
Discharge=9.28719 m³/s

Type IA 24-hr Rainfall=192 mm
Summary for Reach 3R: NORTH

Inflow Area = 321,000 ha, 0.00% Impervious, Inflow Depth > 98 mm
Inflow = 12.33311 m³/s @ 9.49 hrs, Volume = 315.556 Ml
Outflow = 12.32842 m³/s @ 9.50 hrs, Volume = 315.398 Ml, Altern = 0%, Lag = 0.6 min

Routing by Stor-Ind+Trans method, Time Span = 0.00-24.00 hrs, dt = 0.04 hrs
Max. Velocity = 2.51 m/s, Min. Travel Time = 0.3 min
Avg. Velocity = 1.75 m/s, Avg. Travel Time = 0.5 min

Peak Storage = 255.3 m³ @ 9.49 hrs
Average Depth at Peak Storage = 0.84 m
Bank-Full Depth = 0.90 m Flow Area = 5.53 m², Capacity = 14.50619 m³/s

Custom cross-section, Length = 52.00 m Slope = 0.0250 m/m (101 Elevation Intervals)
Constant n = 0.040 Winding stream, pools & shoals
Inlet Invert = 10.000 m, Outlet Invert = 8.700 m

<table>
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<tr>
<th>Offset (meters)</th>
<th>Elevation (meters)</th>
<th>Chan. Depth (meters)</th>
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<th>Depth (meters)</th>
<th>End Area (sq-meters)</th>
<th>Perim. (meters)</th>
<th>Storage (cubic-meters)</th>
<th>Discharge (m³/s)</th>
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Reach 3R: NORTH

Inflow Area = 321,000 ha
Avg. Flow Depth = 0.84 m
Max Vel = 2.51 m/s
n = 0.040
L = 52.00 m
S = 0.0250 m/m
Discharge = 14,506.19 m³/s
Post Development Year 2100 Flows and Depths at Bridges
Summary for Subcatchment 1S: 321 ha.

Runoff = 12.3331 m³/s @ 9.49 hrs, Volume = 315.556 Ml, Depth > 98 mm

Runoff by SCS TR-20 method, UH=Gamma-600, Time Span = 0.00-24.00 hrs, dt = 0.04 hrs
Type IA 24-hr Rainfall = 192 mm

<table>
<thead>
<tr>
<th>Area (ha)</th>
<th>CN</th>
<th>Description</th>
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<tbody>
<tr>
<td>321.0000</td>
<td>70</td>
<td>100.00% Pervious Area</td>
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Direct Entry,

Subcatchment 1S: 321 ha.

Type IA 24-hr Rainfall = 192 mm
Runoff Area = 321.0000 ha
Runoff Volume = 315.556 Ml
Runoff Depth > 98 mm
Tc = 120.0 min
CN = 70
Summary for Subcatchment 3S: 175 ha.

Runoff = 6.72366 m³/s @ 9.49 hrs, Volume = 172.032 Ml, Depth > 98 mm

Runoff by SCS TR-20 method, UH=Gamma-600, Time Span = 0.00-24.00 hrs, dt = 0.04 hrs
Type IA 24-hr Rainfall = 192 mm

<table>
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<tr>
<th>Area (ha)</th>
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<td>175.0000</td>
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<td>175.0000</td>
<td>100.00% Pervious Area</td>
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Direct Entry,

Subcatchment 3S: 175 ha.

Type IA 24-hr Rainfall = 192 mm
Runoff Area = 175.0000 ha
Runoff Volume = 172.032 Ml
Runoff Depth > 98 mm
Tc = 120.0 min
CN = 70
Summary for Subcatchment 6S: Site 26 ha

Runoff = 1.42307 m³/s @ 8.61 hrs, Volume = 27.393 Ml, Depth > 110 mm

Runoff by SCS TR-20 method, UH=Gamma-600, Time Span = 0.00-24.00 hrs, dt = 0.04 hrs
Type IA 24-hr Rainfall = 192 mm

Area (ha) CN Description
25.0000 73

Tc Length Slope Velocity Capacity Description
60.0 (min) (meters) (m/m) (m/sec) (m³/s) Direct Entry,

Subcatchment 6S: Site 25 ha

Hydrograph:
Type IA 24-hr Rainfall = 192 mm
Runoff Area = 25.0000 ha
Runoff Volume = 27.393 Ml
Runoff Depth > 110 mm
Tc = 60.0 min
CN = 73
Summary for Reach 2R: SOUTH

Inflow Area = 175.0000 ha, 0.00% Impervious, Inflow Depth > 98 mm
Inflow = 6.72266 m³/s @ 9.49 hrs, Volume = 172.032 Ml
Outflow = 6.71321 m³/s @ 9.52 hrs, Volume = 171.783 Ml, Atten= 0%, Lag= 2.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.04 hrs
Max. Velocity= 2.29 m/s, Min. Travel Time= 0.9 min
Avg. Velocity = 1.61 m/s, Avg. Travel Time= 1.4 min

Peak Storage= 382.1 m³ @ 9.50 hrs
Average Depth at Peak Storage= 0.69 m
Bank-Full Depth= 3.00 m Flow Area= 17.07 m², Capacity= 88.51059 m³/s

Custom cross-section, Length= 130.00 m Slope= 0.0246 m/m (101 Elevation Intervals)
Constant n= 0.040 Winding stream, pools & shoals
Inlet Invert= 10.000 m, Outlet Invert= 6.800 m

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<th>Depth (meters)</th>
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<th>Perim. (meters)</th>
<th>Storage (cubic-meters)</th>
<th>Discharge (m³/s)</th>
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Reach 2R: SOUTH

Hydrograph

Inflow Area = 175.0000 ha
Avg. Flow Depth = 0.69 m
Max Vel = 2.29 m/s
n = 0.040
L = 130.00 m
S = 0.0246 m/m
Qmax = 88.51059 m³/s
Summary for Reach 3R: NORTH

Inflow Area = 346.0000 ha, 0.00% Impervious, Inflow Depth > 99 mm
Inflow = 13.14582 m³/s @ 9.47 hrs, Volume = 342.949 MI
Outflow = 13.14332 m³/s @ 9.46 hrs, Volume = 342.794 MI, Atten= 0%, Lag= 0.4 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.04 hrs
Max. Velocity= 2.92 m/s, Min. Travel Time= 0.3 min
Avg. Velocity = 1.89 m/s, Avg. Travel Time= 0.5 min

Peak Storage= 233.9 m³ @ 9.47 hrs
Average Depth at Peak Storage= 0.89 m
Bank-Full Depth= 1.20 m Flow Area= 6.38 m², Capacity= 22.26937 m³/s

Custom cross-section, Length= 52.00 m Slope= 0.0250 m/m (102 Elevation Intervals)
Constant n= 0.040 Winding stream, pools & shoals
Inlet Invert= 10.000 m, Outlet Invert= 8.700 m

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Reach 3R: NORTH

Hydrograph

Inflow Area = 346,000 ha
Avg. Flow Depth = 0.89 m
Max Vel = 2.92 m/s
n = 0.040
L = 52.00 m
S = 0.0250 m/m

Discharge = 22,269.37 m³/s

Type IA 24-hr Rainfall = 192 mm

Prepared by JE Anderson and Associates
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