5. MUSIC Modelling

The above systems are modelled in the MUSIC program, to determine the annual pollutant load on the receiving environment for the base case (pre-development) and for the developed case (including a range of stormwater treatment devices). Outputs from the MUSIC modelling are reproduced as Appendices to this report. The intermediate "earthworks" case (when fill is in place but infrastructure is not) cannot be modelled, as outlined in Section 5.5 below.

MUSIC is a conceptual design tool only and is used in this capacity for assessment of stormwater discharge quality. Detailed design and sizing of stormwater structures will be undertaken separately. The modelling undertaken is based on the following reference materials as well as the site assumptions listed below:

MUSIC References

- Soil information gathered from a site inspection and geotechnical assessment by Soil Surveys Pty Ltd.
- Data provided in the MUSIC Users Guide, December 2005.
- Ballina Shire Council DCP 13 – Stormwater Management Strategies.

Model Assumptions

(a) Site location

South of the Pacific Highway, West Ballina, NSW.

(b) Catchments

Eight separate internal catchments are considered for the pre-development and earthworks construction phases. The total catchment area is 24 ha.

For the pre and post developed models a single catchment of 24 ha was modelled. For the post developed stage with treatment nine internal catchments where used according to where stormwater will flow and what different catchments will be treated in what different areas.

(c) Vegetation

Presently the site is grass covered.

(d) Soil Classification

The natural site soil is classified as Tyagarah (ty). This soil is described by Morand (1994) as dark coarse sand topsoil overlying black sandy clay-loam with brown mottled sandy clay subsoil.

(e) Weather data

The model uses 6-minute time step data from Alstonville (1985 – 2000).

(f) Pollutants modelled

MUSIC models water quality parameters for Flow; TSS = Total Suspended Solids; TP = Total Phosphorus; TN = Total Nitrogen; and Gross Pollutants.

(g) Catchment node parameters

Three sets of pollutant parameters were examined: (i) model default values; (ii) Tweed Shire Council's "Development Design Specification - D7 - Stormwater Quality"; (iii) Brisbane City Council's "Guidelines for Pollutant Export Modelling in Brisbane Version 7 – Draft" of October 2003.

Each set has three source types, each named according to the data from which it was derived. LP believes they are comparable as follows:

this investigation	the Model	Tweed S C	Brisbane C C
proposed	Urban	Urban	Urban Residential
existing	Agricultural	Rural	Rural Residential
not used	Forest	Undeveloped	Agricultural *

* note: these Agricultural values are the model default Agricultural values.

LP has examined each set of values and adopts Tweed Rural and Urban as the best matches for the existing pre and post-development cases respectively, in this investigation. There is no set of values to emulate the intermediate case of fill when it is newly placed. Should that fill remain undeveloped for some time however, it will revert to "Rural" once adequate ground cover has been established.

The Earthworks case in this investigation could have been modelled using Tweed's Undeveloped values for TP and TN, combined with the model's Agricultural value for TSS. The first two values reflect the lack of any activity on the fill. The Agricultural TSS has the highest numeric values of all sets.

However, LP does not support modelling based on poor inputs and thus proposes works on a different basis, as described in Section 5.5 below.

5.1 Modelling the Pre–Development Case

The first step in the modelling is to establish the pre-development conditions. This model is run with the following input variables:

- Total catchment area – 24ha (total area effected from the proposed development)
- Pervious area – 100% (assuming negligible impervious surface area)
- Catchment node parameters use 'Rural' factors from Tweed Council's "Development Design Specification - D7 - Stormwater Quality". Where data is not specified the default values provided with the MUSIC model (derived from worldwide literature) are assumed.

The results of this model identify output pollutant loads as follows:

Water Quality Parameter (Mean Annual Load)	Pre Development
Mean Annual Flow (ML/yr)	168
TSS Mean Annual Load (kg/yr)	7890
TP Mean Annual Load (kg/yr)	19.4
TN Mean Annual Load (kg/yr)	106
Gross Pollutant Mean Annual Load (kg/yr)	0

5.3 Modelling the Developed Case

The post developed case was run excluding mitigation measures to compare with pre-development modelling (again using Tweed Shire Council parameters); and determine the increase in pollutant loads from pre to post development. This model is run with the following input variables:

- Total catchment area – 24ha
- Pervious area – 50% (assumes 50% impervious surface area as per Tweed Specifications)
- Catchment node parameters are input as per 'urban' factors from Tweed Council's "Development Design Specification - D7 - Stormwater Quality". Where data is not specified, the default values provided with the MUSIC model (derived from worldwide literature) are assumed.

The post developed case identifies source pollutant loads before treatment compared with those attributed to the pre-development case, as summarised below:

Water Quality Parameter (Mean Annual Load)	Pre Development	Post Development	Increase
Mean Annual Flow (ML/yr)	168	275	x 1.6
TSS Mean Annual Load (kg/yr)	7890	28,200	x 3.6
TP Mean Annual Load (kg/yr)	19.4	69.5	x 3.6
TN Mean Annual Load (kg/yr)	106	425	x 4.0
Gross Pollutant Mean Annual Load (kg/yr)	0	5870	-

The results shown above signify that urbanising the catchment dramatically increases pollutant loads, when compared to current rural landuse. Treatment will be required to reduce these loads.

5.4 Modelling the Developed Case with Mitigation

As shown above there is a substantial increase in pollutant levels from the pre developed case to the post developed case. To reduce the post developed pollutant levels back to the pre developed levels a number of measures have been taken including bio retention systems and grassed swales as mentioned in section 3.2 of this report.

As there is a number of different treatment trains within the post developed catchment, 9 internal catchments have been modelled (see Appendix 1 - Fig 4).

- Catchment areas –

Catchment	Area (ha)
1	2.34
2	2.35
3	1.31
4	5.58
5	1.58
6	1.45
7	5.17
8	1.35
9	3
Total	**24**

- Pervious Area – 50% (assumes 50% impervious surface area as per Tweed specifications)
- Bio-retention systems/basins of over 6000m^2 plus and approximately 1500m of open swales used as treatment (see Appendix 1 - Fig 4)
- Catchment node parameters are input as per 'urban' factors from Tweed Council's "Development Design Specification - D7 - Stormwater Quality". Where data is not specified, the default values provided with the MUSIC model (derived from worldwide literature) are assumed.

This case compares pollutant loads after treatment with those attributed to the pre-development case, as summarised below:

Water Quality Parameter (Mean Annual Load)	Pre Development	Post Development	Post Development with Treatment
Mean Annual Flow (ML/yr)	168	275	76.2
TSS Mean Annual Load (kg/yr)	7890	28,200	1790
TP Mean Annual Load (kg/yr)	19.4	69.5	10.7
TN Mean Annual Load (kg/yr)	106	425	109
Gross Pollutant Mean Annual Load (kg/yr)	0	5870	0

These results signify that the treatment train proposed decreases the flow and pollutant levels to that approximately pre development levels or below.

5.5 Modelling of Earthworks Case

The MUSIC model has limitations on the extent to which it can model some of the stormwater management scenarios that are proposed for this project. This is due partly to inherent limitations within the software itself, but more to lack of data for computer modelling (of the Construction Phase in particular).

This limitation is also reflected in DCPNo13. Table 1 requires quantitative attention to Suspended Solids but not to other commonly measured pollutants (TP, TN, litter, coarse sediment, oil & grease). Similarly, the details required in the Consent Condition are for the Operational Phase, not for the Earthworks one.

This case is therefore not modelled using MUSIC. Stormwater management for earthworks/construction stage is discussed below.

6. Stormwater Management for Earthworks

Design will be based on Sediment & Erosion Control measures as described in "the Blue Book": Managing Urban Stormwater – Soils and Construction. Erosion and sediment control measures shall be employed until vegetation has stabilised the exposed areas.

Stormwater during the construction stages of the development will be diverted to run into a number of proposed sedimentation basins (see Appendix 1 - Fig 3) which will be filled at the completion of the development. Entrapped sediment that is collected within the basins may be removed (re-spread on the fill surface) when required. As the development is completed a number of bio retention systems will be constructed to treat the runoff during the operational phase (see Appendix 1 - Fig 4).

Over time, filled but not yet developed catchment surfaces will become vegetated and sediment production will drop, finally returning to pre-development levels. The effectiveness of vegetation to prevent erosion can be assessed by (i) noting the decreasing volumes of sediment after storms; and (ii) examination of the catchment surface itself. As that time draws nearer, sediment should no longer be removed from the basin areas and preference will then be given to allowing the natural re-vegetation of the basin areas until they are completely removed after construction work is completed.

Further factors that reduce erosion and thus require less sediment control include:

- Sequencing whereby downstream areas (those to be bunded) are filled to full height first, and thus become available for erosion that may occur from uphill areas filled later;
- Standard Erosion and Sediment Control measures.

7. Groundwater

The subject site has been recognised as a Coastal Sand Bed Groundwater System, supporting wetlands, terrestrial vegetation and hypogean ecosystems. The wetlands are often referred to as groundwater windows as they indicate the groundwater levels in the surrounding sand beds and ridges (DLWC, 2002). Maintenance of the existing salt water /fresh water interface is essential in order to prevent salt water intrusion following dewatering or excessive extraction of groundwater.

A search of the NSW Department of Natural Resources groundwater bore data identified twelve (12) licensed groundwater bores within a 1.5 km radius of the site. Available groundwater quality data was limited with GW039163 identifying the salinity of waters as 1001 – 3000 ppm (seawater 35000 ppm). No other data was specified.

The majority of bores (with the exception of GW039163) were of shallow construction, extracting ground waters from shallow, predominantly unconfined aquifers. Excavations as part of subsoil investigations revealed a relatively shallow groundwater table and subsequent site visits following moderate rainfalls across the region was observed to result in elevation of the groundwater levels within Lot 1.

Previous subsurface investigations undertaken by Soil Surveys Engineering Pty Ltd (Soil Surveys 2006) observed groundwater at depths of between 1.1 and 2.0 m, with a typical water table height during normal, non-flood conditions identified as RL 0.5 m (± 0.5 m). Given the proximity of the tidally influenced North Creek Canal and the sandy nature of the subsurface environment, groundwaters levels could be expected to vary in response to tidal influences and following periods of wet weather.

As the portion of impervious area will increase with development due to roads, houses, etc the natural replenishment of groundwater will decrease. The proposed stormwater treatment train for the subject site incorporates methods of infiltration through the application of bio retention systems, grassed swales and sedimentation basins. The use of this system will assist in maintaining the natural groundwater cycle of the site.

The site development does not involve the interception and/or diversion of groundwater and is therefore assessed as having negligible impact.

8. Conclusion

The drainage strategy for the site includes constructing a floodway through Lot 2, utilising an overland flow regime, incorporating bio retention and detention structures, minimising disturbance of the site and its neighbouring lands; and maximising opportunities for infiltration of stormwater.

Through the utilisation of detention basins and the implementation of rainwater tanks serving each of the residential lots within the proposed subdivision, as well as grassed swales and bio retention systems, the impact of the subdivision and subsequent development on downstream water quantity and quality can be managed so as to be within allowable guidelines.

The results of the MUSIC modelling show a reduction in the post developed flows and pollutant levels to approximately equal to or below that of the pre developed levels due to the proposed treatment system mentioned in this report.

LANDPARTNERS believes that the best management practices incorporated in the Water Sensitive Urban Design proposal for the subdivision site meet the requirements set by Ballina Shire Council in DCP 13 and their Urban Stormwater Management Code for new developments.

9. References

CRC for Catchment Hydrology, 2003, MUSIC Version 2.0 User Guide, Monash University, Australia

Ballina Shire Council DCP 13 – Stormwater

NSW Environmental Protection Authority, 1997, Managing Urban Stormwater: Treatment Techniques (DRAFT)

Managing Urban Stormwater - Soils and Construction, 4th Edition 2004

Wong. T, 2000, Australian Runoff Quality Design Guidelines.

10. Appendix

1 Figures

2 Hydrological calculations

3 Music Results

Appendix 1 Figures

List of Figures

Appendix 2 Hydrological calculations

Note: These "Standard Calculation" spreadsheets relate only to low erosion hazard lands as identified in figure 4.6 where the designer chooses to not use the RUSLE to size sediment basins. The more "Detailed Calculation" spreadsheets should be used on high erosion hazard lands as identified by figure 4.6 or where the designer chooses to run the RUSLE in calculations.

1. Site Data Sheet

Site name: River Oaks LM070113

Site location: Pacific Hwy

Precinct: Ballina

Description of site: Rural

Site area	Site						Remarks
	1	2	3	4			
Total catchment area (ha)	5.3	5.1	5.4	4.4			
Disturbed catchment area (ha)	4.3	5.1	5.4	4.4			

Soil analysis

Soil landscape	n/a (natural ground is ty - tyagarah)						DIPNR mapping (if relevant)
Soil Texture Group	F	F	F	F			Sections 6.3.3(c), (d) and (e)

Rainfall data

Design rainfall depth (days)	5	5	5	5			See Sections 6.3.4 (d) and (e)
Design rainfall depth (percentile)	75	75	75	75			See Sections 6.3.4 (f) and (g)
x-day, y-percentile rainfall event	28.6	28.6	28.6	28.6			See Section 6.3.4 (h)
Rainfall intensity: 2-year, 6-hour storm	18.1	18.1	18.1	18.1			See IFD chart for the site
Rainfall erosivity (R-factor)	7980	7980	7980	7980			Automatic calculation from above data

Comments:

2. Storm Flow Calculations

Peak flow is given by the Rational Formula:

$$Qy = 0.00278 \times C_{10} \times F_Y \times I_{y,\,tc} \times A$$

where:

- Q_y is peak flow rate (m^3/sec) of average recurrence interval (ARI) of "Y" years
- C_{10} is the runoff coefficient (dimensionless) for ARI of 10 years. Rural runoff coefficients are given in Volume 2, figure 5 of Pilgrim (1998), while urban runoff coefficients are given in Volume 1, Book VIII, figure 1.13 of Pilgrim (1998) and construction runoff coefficients are given in Appendix F
- F_y is a frequency factor for "Y" years. Rural values are given in Volume 1, Book IV, Table 1.1 of Pilgrim (1998) while urban coefficients are given in Volume 1, Book VIII, Table 1.6 of Pilgrim (1998)
- A is the catchment area in hectares (ha)
- $I_{y,\,tc}$ is the average rainfall intensity (mm/hr) for an ARI of "Y" years and a design duration of "tc" (minutes or hours)

Time of concentration (t_c) = $0.76 \times (A/100)^{0.38}$ hrs (Volume 1, Book IV of Pilgrim, 1998)

Note: For urban catchments the time of concentration should be determined by more precise calculations or reduced by a factor of 50 per cent.

Peak flow calculations, 1

Site	A (ha)	tc (mins)	Rainfall intensity, I, mm/hr						C_{10}
			$1_{yr,tc}$	$5_{yr,tc}$	$10_{yr,tc}$	$20_{yr,tc}$	$50_{yr,tc}$	$100_{yr,tc}$	
1	5.3	15	85.81	135.39	150.15	171.5	196.3	215.58	0.83
2	5.1	15	85.81	135.39	150.15	171.5	196.3	215.58	0.83
3	5.4	15	85.81	135.39	150.15	171.5	196.3	215.58	0.83
4	4.4	14	88.45	140.11	155.62	177.98	203.99	224.24	0.83

Peak flow calculations, 2

ARI yrs	Frequency factor (F_y)	Peak flows						Comment
		1	2	3	4			
		(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)	(m3/s)	
$1_{yr,\,tc}$	0.8	0.840	0.808	0.855	0.718			
$5_{yr,\,tc}$	0.95	1.573	1.514	1.603	1.351			
$10_{yr,\,tc}$	1	1.836	1.767	1.871	1.580			
$20_{yr,\,tc}$	1.05	2.202	2.119	2.244	1.897			
$50_{yr,\,tc}$	1.15	2.761	2.657	2.813	2.382			
$100_{yr,\,tc}$	1.2	3.164	3.044	3.223	2.732			

3. Volume of Sediment Basins: *Type C* Soils

Basin volume = settling zone volume + sediment storage volume

Settling Zone Volume

The settling zone volume for *Type C* soils is calculated to provide capacity to allow the design particle (e.g. 0.02 mm in diameter) to settle in the peak flow expected from the design storm (e.g. 0.25-year ARI). The volume of the basin's settling zone (V) can be determined as a function of the basin's surface area and depth to allow for particles to settle. Peak flow/discharge for the 0.25-year, ARI storm is given by the Rational Formula:

$$Q_{tc, 0.25} = 0.5 \times [0.00278 \times C_{10} \times F_y \times I_{1yr, tc} \times A] \ (m^3/sec)$$

where:

$Q_{tc,0.25}$ = flow rate (m^3/sec) for the 0.25 ARI storm event

C_{10} = runoff coefficient (dimensionless for ARI of 10 years)

F_y = frequency factor for 1 year ARI storm

$I_{1 yr,tc}$ = average rainfall intensity (mm/hr) for the 1-year ARI storm

A = area of catchment in hectares (ha)

Basin surface area (A) = area factor x $Q_{tc, 0.25}$ m^2

Particle settling velocities under ideal conditions (Section 6.3.5(e))

Particle Size	Area Factor
0.100	170
0.050	635
0.020	4100

Volume of settling zone = basin surface area x depth (Section 6.3.5(e)(ii))

Sediment Storage Zone Volume

In the standard calculation, the sediment storage zone is 100 percent of the setting zone. However, designers can work to capture the 2-month soil loss as calculated by the RUSLE (Section 6.3.5(e)(iv)), in which case the "Detailed Calculation" spreadsheets should be used.

Total Basin Volume

Site	$Q_{tc, 0.25}$ (m^3/s)	Area factor	Depth of settling zone (m)	Settling zone volume (m^3)	Sediment storage volume (m^3)	Total basin volume (m^3)
1	0.420	2000	0.3	504	504	1008
2	0.404	2000	0.3	485	485	970
3	0.428	2000	0.3	513	513	1026
4	0.359	2000	0.3	413	413	826

4. Volume of Sediment Basins, *Type D* and *Type F* Soils

Basin volume = settling zone volume + sediment storage zone volume

Settling Zone Volume

The settling zone volume for *Type F* and *Type D* soils is calculated to provide capacity to contain all runoff expected from up to the y-percentile rainfall event. The volume of the basin's settling zone (V) can be determined as a function of the basin's surface area and depth to allow for particles to settle and can be determined by the following equation:

$$V = 10 \times C_v \times A \times R_{y\text{-\%ile, x-day}} \ (m^3)$$

where:

10 = a unit conversion factor

C_v = the volumetric runoff coefficient defined as that portion of rainfall that runs off as stormwater over the x-day period

R = is the x-day total rainfall depth (mm) that is not exceeded in y percent of rainfall events. (See Sections 6.3.4(d), (e), (f), (g) and (h)).

A = total catchment area (ha)

Sediment Storage Zone Volume

In the standard calculation, the sediment storage zone is 50 percent of the setting zone. However, designers can work to capture the 2-month soil loss as calculated by the RUSLE (Section 6.3.4(i)(ii)), in which case the "Detailed Calculation" spreadsheets should be used.

Total Basin Volume

Site	C_v	R x-day y-%ile	Total catchment area (ha)	Settling zone volume (m^3)	Sediment storage volume (m^3)	Total basin volume (m^3)
1	0.70	28.6	5.3	1061.06	531	1591.59
2	0.70	28.6	5.1	1021.02	511	1531.53
3	0.70	28.6	5.4	1081.08	541	1621.62
4	0.70	28.6	4.4	880.88	440	1321.32

Example Catchment 8

Catchment PRE

Paved Area	0
Vegetated Area	30000
Total Area (m2)	**30000**
Duration (Tc) minutes	**12.03**
5yr	
Rainfall Intensity (mm/hr)	150.86
C10 (paved)	0.86
C10 (vegetated)	0.67
Stormwater Flow L/s	**836.02**

Catchment POST

Paved Area	12000
Vegetated Area	18000
Total Area	**30000**
Duration (Tc) minutes	**6.02**
20yr	
Rainfall Intensity (mm/hr)	192.81
C10 (paved)	0.95
C10 (vegetated)	0.74
Stormwater Flow L/s	**1315.93**
Storage Volume m3	**173.20**

Table 1

Intensity range 1I10	**Fraction Impervious** 0	0.2	0.4	0.6	0.8	0.9	1
39-44	0.32	0.44	0.55	0.67	0.78	0.84	0.9
45-49	0.39	0.49	0.6	0.7	0.8	0.85	0.9
50-54	0.46	0.55	0.64	0.72	0.81	0.86	0.9
55-59	0.53	0.6	0.68	0.75	0.83	0.86	0.9
60-64	0.59	0.65	0.72	0.78	0.84	0.87	0.9
65-69	0.66	0.71	0.76	0.8	0.85	0.88	0.9
70-90	0.7	0.74	0.78	0.82	0.86	0.88	0.9

Land Use	**n**
Paved Surface	0.015
Bare Soil	0.0275
Poorley Grassed	0.035
Average Grassed	0.045
Densly Grassed	0.06

ARI	Frequency Factor
1	0.8
2	0.85
5	0.95
10	1
20	1.05
50	1.15
100	1.2

Catchment	**Area (ha)**	**Storage(m3)**
1	2.34	165
2	2.35	164
3	1.31	84
4	5.58	710
5	3.03	176
6	5.17	636
7	1.35	88
8	3	173

Appendix 3 Music Results

Pre Development

Source nodes
Location,Rural Tweed 1
ID,2
Node Type,AgriculturalSourceNode
Total Area (ha),24
Area Impervious (ha),0
Area Pervious (ha),24
Field Capacity (mm),50
Pervious Area Infiltration Capacity coefficient - a,50
Pervious Area Infiltration Capacity exponent - b,2
Impervious Area Rainfall Threshold (mm/day),1
Pervious Area Soil Storage Capacity (mm),150
Pervious Area Soil Initial Storage (% of Capacity),25
Groundwater Initial Depth (mm),50
Groundwater Daily Recharge Rate (%),0.65
Groundwater Daily Baseflow Rate (%),0.85
Groundwater Daily Deep Seepage Rate (%),5
Stormflow Total Suspended Solids Mean (log mg/L),1.627
Stormflow Total Suspended Solids Standard Deviation (log mg/L),0.2
Stormflow Total Suspended Solids Estimation Method,Stochastic
Stormflow Total Suspended Solids Serial Correlation,0
Stormflow Total Phosphorus Mean (log mg/L),-0.95
Stormflow Total Phosphorus Standard Deviation (log mg/L),0.1
Stormflow Total Phosphorus Estimation Method,Stochastic
Stormflow Total Phosphorus Serial Correlation,0
Stormflow Total Nitrogen Mean (log mg/L),-0.25
Stormflow Total Nitrogen Standard Deviation (log mg/L),0.197
Stormflow Total Nitrogen Estimation Method,Stochastic
Stormflow Total Nitrogen Serial Correlation,0
Baseflow Total Suspended Solids Mean (log mg/L),0.6
Baseflow Total Suspended Solids Standard Deviation (log mg/L),0.2
Baseflow Total Suspended Solids Estimation Method,Stochastic
Baseflow Total Suspended Solids Serial Correlation,0
Baseflow Total Phosphorus Mean (log mg/L),-1.4
Baseflow Total Phosphorus Standard Deviation (log mg/L),0.4
Baseflow Total Phosphorus Estimation Method,Stochastic
Baseflow Total Phosphorus Serial Correlation,0
Baseflow Total Nitrogen Mean (log mg/L),-0.15
Baseflow Total Nitrogen Standard Deviation (log mg/L),0.4
Baseflow Total Nitrogen Estimation Method,Stochastic
Baseflow Total Nitrogen Serial Correlation,0
OUT - Mean Annual Flow (ML/yr),168
OUT - TSS Mean Annual Load (kg/yr),7.73E3
OUT - TP Mean Annual Load (kg/yr),19.1
OUT - TN Mean Annual Load (kg/yr),105
OUT - Gross Pollutant Mean Annual Load (kg/yr),0.00

No Imported Data Source nodes

No USTM treatment nodes

No Generic treatment nodes

Other nodes
Location,Receiving Node

ID,1
Node Type,ReceivingNode
IN - Mean Annual Flow (ML/yr),168
IN - TSS Mean Annual Load (kg/yr),7.73E3
IN - TP Mean Annual Load (kg/yr),19.1
IN - TN Mean Annual Load (kg/yr),105
IN - Gross Pollutant Mean Annual Load (kg/yr),0.00
OUT - Mean Annual Flow (ML/yr),0.00
OUT - TSS Mean Annual Load (kg/yr),0.00
OUT - TP Mean Annual Load (kg/yr),0.00
OUT - TN Mean Annual Load (kg/yr),0.00
OUT - Gross Pollutant Mean Annual Load (kg/yr),0.00

Links
Location,Drainage Link
Source node ID,2
Target node ID,1
Muskingum-Cunge Routing,Not Routed
Muskingum K,
Muskingum theta,
IN - Mean Annual Flow (ML/yr),168
IN - TSS Mean Annual Load (kg/yr),7.73E3
IN - TP Mean Annual Load (kg/yr),19.1
IN - TN Mean Annual Load (kg/yr),105
IN - Gross Pollutant Mean Annual Load (kg/yr),0.00
OUT - Mean Annual Flow (ML/yr),168
OUT - TSS Mean Annual Load (kg/yr),7.73E3
OUT - TP Mean Annual Load (kg/yr),19.1
OUT - TN Mean Annual Load (kg/yr),105
OUT - Gross Pollutant Mean Annual Load (kg/yr),0.00

Post Development with Mitigation Measures

Source nodes
Location,Urban Tweed 1,Urban Tweed 2,Urban Tweed 3,Urban Tweed 4,Urban Tweed 6,Urban Tweed 7,Urban Tweed 8,Urban Tweed 9 (playing field),Urban Tweed 5
ID,1,2,3,4,8,9,10,21,23
Node Type,UrbanSourceNode,UrbanSourceNode,UrbanSourceNode,UrbanSourceNode,UrbanSourceNode,UrbanSourceNode,UrbanSourceNode,UrbanSourceNode,UrbanSourceNode
Total Area (ha),2.34,2.35,1.31,5.58,1.45,5.17,1.35,3,1.58
Area Impervious (ha),1.16096842105263,1.15551973684211,0.649943859649122,2.76846315789474,0.725826754385965,2.58794780701754,0.675769736842105,0.292368421052632,0.790900877192983
Area Pervious (ha),1.17903157894737,1.19448026315789,0.660056140350878,2.81153684210526,0.724173245614035,2.58205219298246,0.674230263157895,2.70763157894737,0.789099122807018
Field Capacity (mm),50,50,50,50,50,50,50,50,50
Pervious Area Infiltration Capacity coefficient - a,50,50,50,50,50,50,50,50,50
Pervious Area Infiltration Capacity exponent - b,2,2,2,2,2,2,2,2,2
Impervious Area Rainfall Threshold (mm/day),1,1,1,1,1,1,1,1,1
Pervious Area Soil Storage Capacity (mm),150,150,150,150,150,150,150,150,150
Pervious Area Soil Initial Storage (% of Capacity),25,25,25,25,25,25,25,25,25
Groundwater Initial Depth (mm),50,50,50,50,50,50,50,50,50
Groundwater Daily Recharge Rate (%),0.65,0.65,0.65,0.65,0.65,0.65,0.65,0.65,0.65
Groundwater Daily Baseflow Rate (%),0.85,0.85,0.85,0.85,0.85,0.85,0.85,0.85,0.85

Groundwater Daily Deep Seepage Rate (%),0,0,0,0,0,0,0,0,0
Stormflow Total Suspended Solids Mean (log mg/L),2,2,2,2,2,2,2,2,2
Stormflow Total Suspended Solids Standard Deviation (log mg/L),0.145,0.145,0.145,0.145,0.145,0.145,0.145,0.145,0.145
Stormflow Total Suspended Solids Estimation Method,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic
Stormflow Total Suspended Solids Serial Correlation,0,0,0,0,0,0,0,0,0
Stormflow Total Phosphorus Mean (log mg/L),-0.68,-0.68,-0.68,-0.68,-0.68,-0.68,-0.68,-0.68,-0.68
Stormflow Total Phosphorus Standard Deviation (log mg/L),0.28,0.28,0.28,0.28,0.28,0.28,0.28,0.28,0.28
Stormflow Total Phosphorus Estimation Method,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic
Stormflow Total Phosphorus Serial Correlation,0,0,0,0,0,0,0,0,0
Stormflow Total Nitrogen Mean (log mg/L),0.193,0.193,0.193,0.193,0.193,0.193,0.193,0.193,0.193
Stormflow Total Nitrogen Standard Deviation (log mg/L),0.05,0.05,0.05,0.05,0.05,0.05,0.05,0.05,0.05
Stormflow Total Nitrogen Estimation Method,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic
Stormflow Total Nitrogen Serial Correlation,0,0,0,0,0,0,0,0,0
Baseflow Total Suspended Solids Mean (log mg/L),0.8,0.8,0.8,0.8,0.8,0.8,0.8,0.8,0.8
Baseflow Total Suspended Solids Standard Deviation (log mg/L),0.2,0.2,0.2,0.2,0.2,0.2,0.2,0.2,0.2
Baseflow Total Suspended Solids Estimation Method,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic
Baseflow Total Suspended Solids Serial Correlation,0,0,0,0,0,0,0,0,0
Baseflow Total Phosphorus Mean (log mg/L),-1,-1,-1,-1,-1,-1,-1,-1,-1
Baseflow Total Phosphorus Standard Deviation (log mg/L),0.34,0.34,0.34,0.34,0.34,0.34,0.34,0.34,0.34
Baseflow Total Phosphorus Estimation Method,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic
Baseflow Total Phosphorus Serial Correlation,0,0,0,0,0,0,0,0,0
Baseflow Total Nitrogen Mean (log mg/L),-0.1,-0.1,-0.1,-0.1,-0.1,-0.1,-0.1,-0.1,-0.1
Baseflow Total Nitrogen Standard Deviation (log mg/L),0.05,0.05,0.05,0.05,0.05,0.05,0.05,0.05,0.05
Baseflow Total Nitrogen Estimation Method,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic
Baseflow Total Nitrogen Serial Correlation,0,0,0,0,0,0,0,0,0
OUT - Mean Annual Flow (ML/yr),27.6,27.6,15.5,65.9,17.1,61.1,15.9,25.1,18.7
OUT - TSS Mean Annual Load (kg/yr),2.85E3,2.83E3,1.60E3,6.77E3,1.76E3,6.30E3,1.66E3,2.50E3,1.93E3
OUT - TP Mean Annual Load (kg/yr),7.03,6.93,3.94,16.7,4.31,15.5,4.06,6.26,4.75
OUT - TN Mean Annual Load (kg/yr),42.9,42.7,24.0,102,26.5,94.6,24.8,38.3,29.0
OUT - Gross Pollutant Mean Annual Load (kg/yr),624,620,349,1.49E3,387,1.38E3,360,244,421

No Imported Data Source nodes

USTM treatment nodes
Location,Swale 1,Bio-Ret 1,Bio-Ret 2,Swale 2,Swale 3,Swale 5,Swale 4,Swale 6,Sports Field,Swale 7,Bio-Ret 3, Swale 8
ID,5,6,7,11,12,13,14,15,16,17,18,19
Node Type,SwaleNode,BioRetentionNode,BioRetentionNode,SwaleNode,SwaleNode,SwaleNode,SwaleNode,SwaleNode,SedimentationBasinNode,SwaleNode,BioRetentionNode,SwaleNode
Lo-flow bypass rate (cum/sec),0,0,0,0,0,0,0,0,0,0,0,0
Hi-flow bypass rate (cum/sec), ,100,100, , , , , ,100, ,100,
Inlet pond volume, , , , , , , , ,0, , ,
Area (sqm), ,1700,1000, , , , , ,6000, ,2000,
Extended detention depth (m),0.5,0.5,0.5,0.5,0.5,0.5,0.5,0.5,0.3,0.5,0.5,0.5
Permanent pool volume (cum), , , , , , , , ,0, , ,
Proportion vegetated, , , , , , , , ,0, , ,
Equivalent pipe diameter (mm), , , , , , , , ,100, , ,
Overflow weir width (m), ,20,20, , , , , ,60, ,20,
Notional Detention Time (hrs), , , , , , , , ,39.2, , ,
Orifice discharge coefficient, , , , , , , , ,0.6, , ,

Weir coefficient, ,1.7,1.7, , , , , ,1.7, ,1.7,
Number of CSTR cells,10,3,3,10,10,10,10,10,1,10,3,10
Total Suspended Solids k (m/yr),8000,8000,8000,8000,8000,8000,8000,8000,8000,8000,8000,8000
Total Suspended Solids C* (mg/L),20,20,20,20,20,20,20,20,20,20,20,20
Total Suspended Solids C** (mg/L),14, , ,14,14,14,14,14,20,14, ,14
Total Phosphorus k (m/yr),6000,6000,6000,6000,6000,6000,6000,6000,6000,6000,6000,6000
Total Phosphorus C* (mg/L),0.13,0.13,0.13,0.13,0.13,0.13,0.13,0.13,0.13,0.13,0.13,0.13
Total Phosphorus C** (mg/L),0.13, , ,0.13,0.13,0.13,0.13,0.13,0.13,0.13, ,0.13
Total Nitrogen k (m/yr),500,500,500,500,500,500,500,500,500,500,500,500
Total Nitrogen C* (mg/L),1.4,1.4,1.4,1.4,1.4,1.4,1.4,1.4,1.4,1.4,1.4,1.4
Total Nitrogen C** (mg/L),1.4, , ,1.4,1.4,1.4,1.4,1.4,1.4,1.4, ,1.4
Threshold hydraulic loading for C** (m/yr),3500, , ,3500,3500,3500,3500,3500,3500,3500, ,3500
Extraction for Re-use,Off,Off,Off,Off,Off,Off,Off,Off,Off,Off,Off,Off
Annual Re-use Demand - scaled by daily PET (ML), , , , , , , , , , , ,
Constant Daily Re-use Demand (kL), , , , , , , , , , , ,
User-defined Annual Re-use Demand (ML), , , , , , , , , , , ,
Percentage of User-defined Annual Re-use Demand Jan, , , , , , , , , , , ,
Percentage of User-defined Annual Re-use Demand Feb, , , , , , , , , , , ,
Percentage of User-defined Annual Re-use Demand Mar, , , , , , , , , , , ,
Percentage of User-defined Annual Re-use Demand Apr, , , , , , , , , , , ,
Percentage of User-defined Annual Re-use Demand May, , , , , , , , , , , ,
Percentage of User-defined Annual Re-use Demand Jun, , , , , , , , , , , ,
Percentage of User-defined Annual Re-use Demand Jul, , , , , , , , , , , ,
Percentage of User-defined Annual Re-use Demand Aug, , , , , , , , , , , ,
Percentage of User-defined Annual Re-use Demand Sep, , , , , , , , , , , ,
Percentage of User-defined Annual Re-use Demand Oct, , , , , , , , , , , ,
Percentage of User-defined Annual Re-use Demand Nov, , , , , , , , , , , ,
Percentage of User-defined Annual Re-use Demand Dec, , , , , , , , , , , ,
Filter area (sqm), ,1000,500, , , , , , , ,1000,
Filter depth (m), ,0.3,0.3, , , , , , , ,0.3,
Filter median particle diameter (mm), ,20,20, , , , , , , ,20,
Saturated hydraulic conductivity (mm/hr), ,100,100, , , , , , , ,100,
Voids ratio, ,0.3,0.3, , , , , , , ,0.3,
Length (m),360, , ,85,60,180,280,260, ,170, ,290
Bed slope,0.005, , ,0.005,0.005,0.005,0.005,0.005, ,0.005, ,0.005
Base Width (m),3, , ,3,3,5,0.5,0.5, ,3, ,3
Top width (m),7, , ,7,7,7,4.5,4.5, ,7, ,7
Vegetation height (m),0.15, , ,0.15,0.15,0.15,0.15,0.15, ,0.15, ,0.15
Proportion of upstream impervious area treated, , , , , , , , , , , ,
Seepage Rate (mm/hr),36,10,10,36,36,36,36,36,36,36,10,36
Evap Loss as proportion of PET, , , , , , , , ,0.75, , ,
Depth in metres below the drain pipe, ,0,0, , , , , , , ,0,
IN - Mean Annual Flow (ML/yr),20.0,27.6,29.8,27.6,35.3,35.8,65.9,61.1,104,73.5,58.0,51.3
IN - TSS Mean Annual Load (kg/yr),459,2.85E3,969,2.83E3,2.23E3,3.69E3,6.77E3,6.30E3,6.04E3,1.87E3,1.32E3,701
IN - TP Mean Annual Load (kg/yr),2.44,7.03,4.70,6.93,7.06,9.05,16.7,15.5,20.1,10.2,8.17,5.34
IN - TN Mean Annual Load (kg/yr),23.9,42.9,45.4,42.7,54.3,55.5,102,94.6,159,105,84.3,64.0
IN - Gross Pollutant Mean Annual Load (kg/yr),0.00,624,0.00,620,349,808,1.49E3,1.38E3,604,0.00,0.00,0.00
OUT - Mean Annual Flow (ML/yr),6.23,20.0,25.8,19.8,29.8,18.4,47.7,44.5,30.9,58.0,51.3,35.3
OUT - TSS Mean Annual Load (kg/yr),92.8,459,360,637,969,468,1.51E3,1.42E3,990,1.32E3,701,618
OUT - TP Mean Annual Load (kg/yr),0.817,2.44,2.66,3.13,4.70,2.73,7.52,7.01,4.73,8.17,5.34,4.68
OUT - TN Mean Annual Load (kg/yr),8.45,23.9,32.6,30.3,45.4,27.8,72.7,67.8,46.9,84.3,64.0,47.8
OUT - Gross Pollutant Mean Annual Load (kg/yr),0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00

No Generic treatment nodes

Other nodes
Location,Junction,Receiving Node
ID,20,22
Node Type,JunctionNode,ReceivingNode
IN - Mean Annual Flow (ML/yr),73.5,72.5
IN - TSS Mean Annual Load (kg/yr),1.87E3,1.70E3
IN - TP Mean Annual Load (kg/yr),10.2,10.2
IN - TN Mean Annual Load (kg/yr),105,103
IN - Gross Pollutant Mean Annual Load (kg/yr),0.00,0.00
OUT - Mean Annual Flow (ML/yr),73.5,0.00
OUT - TSS Mean Annual Load (kg/yr),1.87E3,0.00
OUT - TP Mean Annual Load (kg/yr),10.2,0.00
OUT - TN Mean Annual Load (kg/yr),105,0.00
OUT - Gross Pollutant Mean Annual Load (kg/yr),0.00,0.00

Links
Location,Drainage Link
Source node ID,1,6,2,3,4,14,8,9,21,15,13,10,11,20,17,18,5,19,16,12,7,23
Target node ID,6,5,11,12,14,20,13,15,16,16,16,16,12,17,18,19,22,22,22,7,20,13
Muskingum-Cunge Routing,Not Routed
Muskingum K, ,
Muskingum theta, ,
IN - Mean Annual Flow (ML/yr),27.6,20.0,27.6,15.5,65.9,47.7,17.1,61.1,25.1,44.5,18.4,15.9,19.8,73.5,58.0,51.3,6.23,35.3,30.9,29.8,25.8,18.7
IN - TSS Mean Annual Load (kg/yr),2.85E3,459,2.83E3,1.60E3,6.77E3,1.51E3,1.76E3,6.30E3,2.50E3,1.42E3,468,1.66E3,637,1.87E3,1.32E3,701,92.8,618,990,969,360,1.93E3
IN - TP Mean Annual Load (kg/yr),7.03,2.44,6.93,3.94,16.7,7.52,4.31,15.5,6.26,7.01,2.73,4.06,3.13,10.2,8.17,5.34,0.817,4.68,4.73,4.70,2.66,4.75
IN - TN Mean Annual Load (kg/yr),42.9,23.9,42.7,24.0,102,72.7,26.5,94.6,38.3,67.8,27.8,24.8,30.3,105,84.3,64.0,8.45,47.8,46.9,45.4,32.6,29.0
IN - Gross Pollutant Mean Annual Load (kg/yr),624,0.00,620,349,1.49E3,0.00,387,1.38E3,244,0.00,0.00,360,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,421
OUT - Mean Annual Flow (ML/yr),27.6,20.0,27.6,15.5,65.9,47.7,17.1,61.1,25.1,44.5,18.4,15.9,19.8,73.5,58.0,51.3,6.23,35.3,30.9,29.8,25.8,18.7
OUT - TSS Mean Annual Load (kg/yr),2.85E3,459,2.83E3,1.60E3,6.77E3,1.51E3,1.76E3,6.30E3,2.50E3,1.42E3,468,1.66E3,637,1.87E3,1.32E3,701,92.8,618,990,969,360,1.93E3
OUT - TP Mean Annual Load (kg/yr),7.03,2.44,6.93,3.94,16.7,7.52,4.31,15.5,6.26,7.01,2.73,4.06,3.13,10.2,8.17,5.34,0.817,4.68,4.73,4.70,2.66,4.75
OUT - TN Mean Annual Load (kg/yr),42.9,23.9,42.7,24.0,102,72.7,26.5,94.6,38.3,67.8,27.8,24.8,30.3,105,84.3,64.0,8.45,47.8,46.9,45.4,32.6,29.0
OUT - Gross Pollutant Mean Annual Load (kg/yr),624,0.00,620,349,1.49E3,0.00,387,1.38E3,244,0.00,0.00,360,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,421