7. Stormwater Quality

Stormwater Quality for the site looks at two phases:

- One during construction which will involve the use of temporary controls to minimise the export of sediments and control storm flows to reduce the incidences of erosion caused by the development;
- During Operation which involves the management of stormwater to minimise sediment and erosion potential for flows from the site, but to also provide for oils and nutrient and litter treatment to reduce the impacts on the downstream environment.

7.1 Construction Stormwater Quality

Temporary (Construction) Controls

The purpose of temporary controls is to retain sediment on site and minimise erosion from flows off site during the construction phase. The design will be a guidance document for the constructor and would be consistent with the Blue Book.

The basis of the temporary controls will be the utilisation of the channel and proposed basins detailed above as sediment basins to retain sediment from the construction activities. When construction has been completed the captured sediments would be removed and disposed of and the final earthworks and planting of the basin would occur.

For areas that do not drain to the basins, localised source treatment would be specified such as sediment fencing and check dams and shall be consistent with the Blue Book.

7.2 Operational Stormwater Quality

The stormwater quality assessment for the development has been undertaken utilising the MUSIC software (ver 5.1.16). MUSIC provides an annualised assessment of water quality performance for key urban pollutants including nutrients of nitrogen, and phosphorus and Total Suspended Solids and Gross Pollutants.

To provide water quality for the development a treatment train approach has been adopted based on utilising gross pollutant traps to capture and contain litter and large debris, sediment ponds to remove coarse and fine sediments, wetlands to provide fine sediment and nutrient removal. Free oils will be captured by a proprietary over under weir pit.

7.2.1 MUSIC Input Parameters

The input parameters required for the MUSIC model include the following:

- Meteorological Data – Including rainfall and evaporation data;
- Contributing Catchment – Details of the contributing catchment include area and fraction impervious and runoff parameters ; and
- Treatment Information – Treatment train parameters for each component of the system.

The details of the assumptions for these are outlined below.

Meteorological Data

The model runs were based on assessing the Monthly average areal potential evapotranspiration data from Newcastle University station as summarised in Figure 7-1 and rainfall data for two Bureau of Meteorology (BoM) data stations:

- Newcastle University (Station 61390) for 1999-2006. This site was selected as it represented the closed BoM station to the Hexham site. The period represented the period where the data was most complete based on the data codes. The average annual rainfall from the pluviograph data for the assessed period was 913 mm as calculated by MUSIC. This was lower than that of the lowest annual year recorded at the site and substantially lower than the Annual Average for the site of 1129 mm. These figures indicate an incomplete data set contrary to the BoM data codes. Subsequently a second nearby station was included
- Williamtown (Station 061078) for 1990 – 2007. This site was selected as it had a longer period of consistent data and was better reprehensive of the long-term averages of Williamtown site. The average annual rainfall for the 18 year period assessed was 1106 mm. The long term average rainfall for the site of 1121 mm correlates well to the, the annual average for the Newcastle University station and that of the historical average provides a comparison on the monthly rainfall for the two sites.

Table 7-1 Monthly evapotranspiration adopted for MUSIC modelling

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Et (mm)	188	148	148	96	66	53	56	72	100	138	162	180

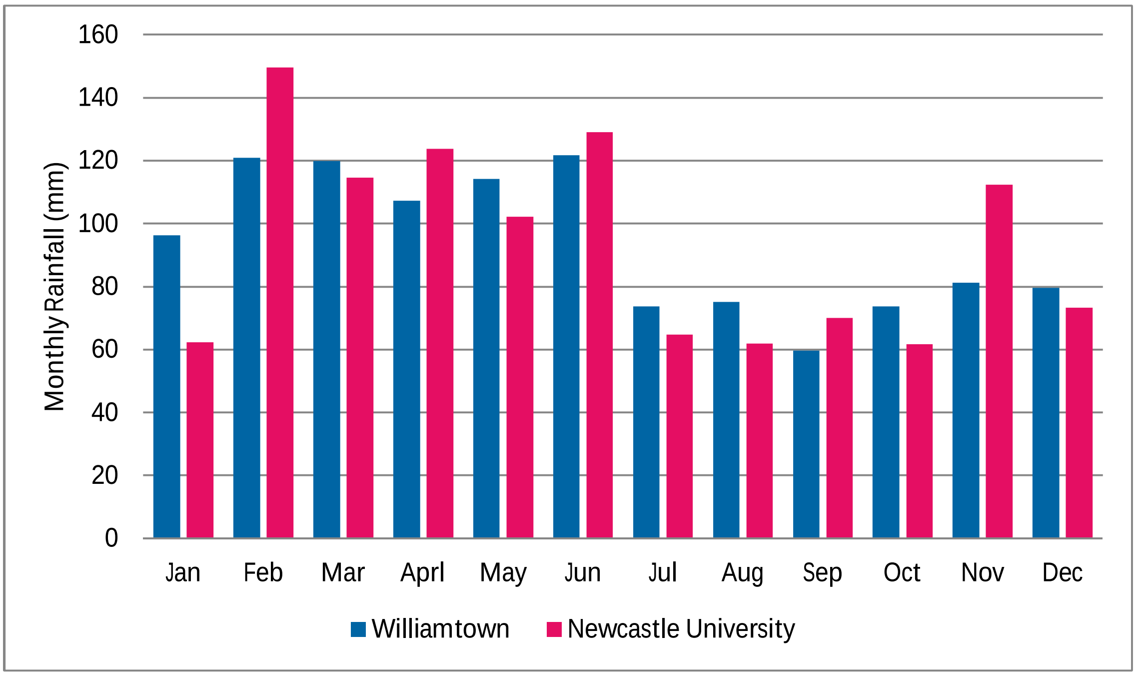

Figure 7-1 Williamtown and Newcastle University Average Rainfall (Bureau of Meteorology , 2013)

Catchment Parameters

For the purposes of the water quality modelling, the following catchment parameters were adopted:

- Catchment delineation based on the drainage network as detailed in Section 6.3.1;
- Impervious fraction of 90%. Although the majority of the site is earth and allows infiltration, the high impervious fraction has been adopted to account for the capture of the of stormwater runoff into the subsoil system which would require treatment.
- Urban pollutant loads stochastically generated using parameters detailed in Table 3.8 in Water by Design, 2010 MUSIC Modelling Guidelines; and
- Soil storage and field capacity are the default MUSIC rainfall-runoff parameters as summarised in Table 7-2. However as the site is predominantly modelled as impervious these will have minor impacts on the modelling.

Table 7-2 Rainfall-Runoff Parameter Inputs

Rainfall-Runoff Parameter	Input
Field Capacity	80 mm
Impervious Area Rainfall Threshold	1 mm/day
Pervious Area Soil Storage Capacity	30 mm
Pervious Area Soil Initial Storage	30% (of capacity)
Groundwater Initial Depth	10 mm
Groundwater Daily Recharge Rate	25%
Groundwater Daily Base flow Rate	5%
Groundwater Daily Deep Seepage Rate	0%

7.2.2 Stormwater Quality Treatment

The Aurizon site will consist of different types of areas depending on the type of works to be undertaken and for each of these areas a specific treatment approach will be implemented to target specific pollutants.

Provisioning and Maintenance Facilities

The areas relating to the provisioning building, bulk fuel transfer and combined locomotive and wagon maintenance facility will be roofed to minimimse stormwater from coming into contact with contaminated areas. Hardstand areas within this area will be bunded such that any spills are contained and are able to be drained to a trade waste system which will be collected and removed offsite for licenced disposal.

Other areas of the site consisting of car parks, the rail lines and associated maintenance roads will drain to the stormwater system for disposal. For these areas the following treatment process will be constructed.

- Litter Trap baskets within pits associated with the car park areas and drainage around buildings (consisting of administration etc. not associated with servicing and maintenance). This will capture litter including cigarette butts, packaging and general litter that may be generated in these high traffic areas
- Gravel Screening and geofabric for the areas within the tracks, the drainage network. This provides a significant screen to remove litter, sediments and potential coal fines prior to being conveyed by the stormwater system

- Sediment Ponds on the inlets to the three basins to remove sediments and material that may be entering the basin
- Floating Wetland to provide nutrient and soluble pollutant treatment.

7.2.3 MUISIC Model Configuration

The MUSIC model was configured based on the proposed drainage system that will include treatment process for each of the catchments that drain into Basin 1 and 2 and the Southern catchment that will drain into Basin 3.

The layout of the MUSIC model is illustrated in Figure 7-2.

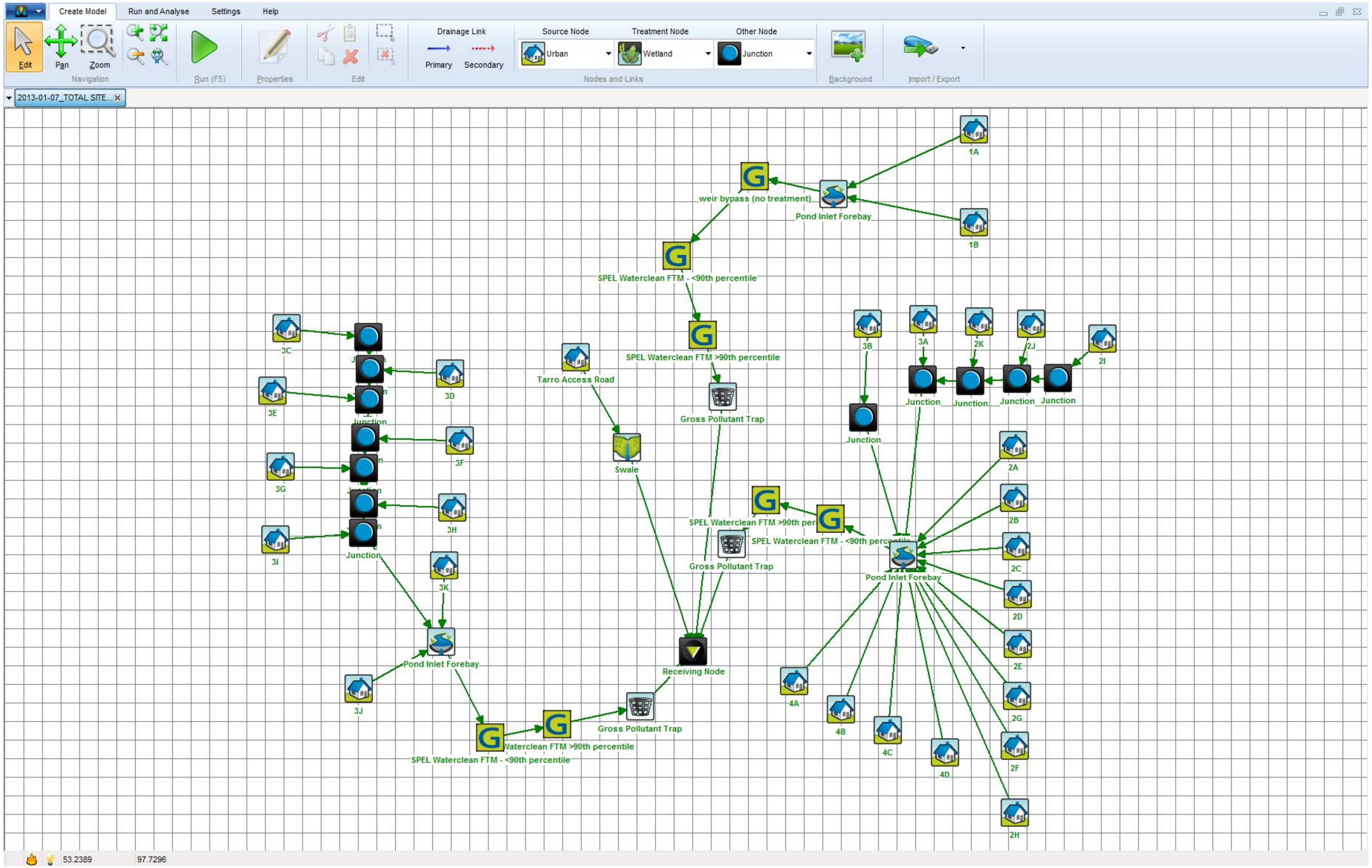

Figure 7-2 MUSIC Model

Litter Nets

As detailed above, there will be areas of the site that will have measures to exclude pollutants from the stormwater. There will only be a number of locations where litter and coarse sediments can enter the stormwater system. These would be centred on the roads and parking areas that service the site. These areas will have an Ecosol Net located in the pits that will capture these pollutants.

Floating Wetlands

Floating Wetlands have been designed to provide nutrient and enhanced sediment removal from stormwater discharged from the site. Wetlands have long been acknowledged as effective means to provide stormwater treatment however recent investigations in stormwater and wastewater treatment has indicated improved treatment efficiency with the adoption of floating wetlands.

The performance of these wetlands as compared to a conventional wetland has been investigated with the results indicating improved nutrient removal as well as enhanced metal uptake. The performance of these systems as detailed in Headley & Tanner, (2012), Tanner, Sukias, Park, Yates, & Headley, (2011) and (Duncan, 2011) indicate that the effectiveness of the wetlands are typically in the range of 40-80% for Nutrients and Sediments with Heavy Metal removal between 50 – 95%.

The difference between a floating wetland and a conventional wetland is that the plants in a floating wetland are on floating booms so that the root mass is in the water which forms the media for biological treatment of the stormwater whereas a conventional wetland has the leaf material as the prime media for biological treatment.

Figure 7-3 illustrates the two types of wetlands.

Floating Wetland Composition

Floating Wetland Arrangement

Constructed Wetlands Vegetation Density

Constructed Wetland with Retarding Basin

Figure 7-3 Wetland types for Consideration

The driving reasons for the adoption of floating wetlands for this project based on providing a robust solution with minimum maintenance requirements and high probability of long term survival. These are summarised below:

- The size of the floating wetlands will be 25% of the size of the conventional wetland reducing the footprint required for water quality but also the number of plants required and the long term maintenance burden for Aurizon
- The Hexham Swamp site is subject to frequent and extended flooding events. Under these conditions, the wetlands will be unable to drain until floodwaters recede. Based on BMT WBM flood modelling, for floods that exceed the 10% AEP event the duration of inundation is excess of 72 hours. This which would result in the wetland being above the NWL for an extended period. Should a conventional wetland be subject to such inundation periods, the plants will most probably need to be replanted. A floating wetland will rise above the flood and maintain plant functionality when the floodwaters recede avoiding the need for resetting of the conventional wetland.
- The susceptibility of the wetland on extended dry periods is a function of its surface area and depth. For a constructed wetland, due to the shallower depths and larger area, the evaporative losses are greater than that of a floating wetland. Given the climatic variability of the site, a deeper water reserve will provide a more robust water supply for the plants to survive.

- Plant selection for a conventional wetland is critical for the ongoing performance and robustness of the water quality system. Some plants are best selected for their robustness but are not as effective for pollutant removal however a Floating Wetland can have the species selected to provide the most appropriate traits which are water quality requirements.
- The maintenance of the wetland beds can be undertaken by lifting the pontoons from the water and onto a dry surface for plant harvesting and pontoon maintenance. This eliminates the need to either drain the water level down to harvest the plants in a conventional wetland and re-sprigging new stock. This also allows the gradual replacement of plants which would allow a gradual transition in restocking where as a conventional wetland may require a full reset after 10 years. It also limits the need for persons to enter the wetland; and
- The potential for Acid Sulphate Soils which in the site will add cost to the project proportional to the volume of material required to be excavated. Based on the site levels and hydraulic requirements, the use of a conventional wetland would require a larger footprint potentially increasing the required PASS treatment requirements.

Detailed correspondence from a potential supplier, SPEL™ has specified that a floating wetland is to be sized to be 1% of the contributing catchment. Based on these requirements the proposed wetland areas for each of the catchments are summarised in Table 7-3.

Table 7-3 Floating Wetland Areas

Catchment	Floating Treatment Wetland Area
1 (North Basin)	150 m2
2 (Central Basin)	1,400 m2
3 (Southern Basin)	1,000 m2
Total	2,350 m2

The MUSIC nodes representing the FTW were obtained from the supplier with the configuration consisting of the inlet basin and two generic nodes with transfer functions.

The inlet bays were modelled as the sediment ponds on the inlets to each basin as detailed below. The parameters for the ponds are detailed in Table 7-4 and are based on the volumes and areas extracted from the design.

Table 7-4 Sediment Pond MUSIC Parameters

	Pond Surface Area (m2)	Pond Permanent Water Volume (m3)	Extended Detention Depth (m)
Basin 1	2780	520	0.30
Basin 2	8500	390	0.20
Basin 3	6400	240	0.30

The Generic Treatment Node parameters are based on the SPEL™ provided nodes with the low and high flow parameters altered to match the 90%ile flow for the site. The parameters for the treatment effectiveness for the FTW are detailed in Table 7-6 and relate to transfer functions based on the incoming pollutant concentrations.

Table 7-5 FTW Transfer Functions

	<90th Percentile		>90th Percentile	
	Input	Output	Input	Output
TSS (mg/L)	1000	100	1000	400
TP (mg/L)	5	1.55	5	2.25
TN (mg/L)	50	5	50	55.5

For each of the catchments, the two generic FTW treatment nodes' transfer function is related to the incoming flow rate. For both of the catchments, the 90th percentile flow rate is approximately the three month flow from the catchment as summarised in Table 7-6.

Table 7-6 FTW Flow Thresholds

	<90th Percentile		>90th Percentile	
	Low Flow By Pass	High Flow By Pass	Low Flow By Pass	High Flow By Pass
Basin 1	0.00	0.009	0.009	0.580
Basin 2	0.00	0.075	0.075	3.50
Basin 3	0.00	0.075	0.075	3.50

7.2.4 MUSIC Results

The MUSIC models were run to assess the performance of the proposed stormwater treatment measures. The results for the Williamtown Climate data assessment are summarised in Table 7-7 below which identify that the proposed stormwater treatment measures treatment objectives are met for each pollutant type for the proposed catchment. For completeness, the performance of the system using the Newcastle University Climate Data is included in Table 7-8.

Table 7-7 Treatment Train Effectiveness with Williamtown Climate Data

Receiving Water	TSS	TP	TN	GP
Guidelines	80%	65%	45%	98%
Aurizon LTTSF	82%	74%	69%	99.5%

Table 7-8 Treatment Train Effectiveness with Newcastle University Climate Data

Receiving Water	TSS	TP	TN	GP
Guidelines	80%	65%	45%	98%
Aurizon LTTSF	82%	75%	70%	99.2%

For both climate data series, the performance of the system Aurizon Stormwater System exceeds the City of Newcastle stormwater treatment requirements.

Nutrient Concentrations

The background nutrient concentrations detailed in the Environmental Assessment (Douglas Partners, November 2012) are summarised in Table 7-9. The levels sampled are higher than those specified within the ANZECC Guidelines (Australian and New Zealand Environment and

Conservation Council, 2000) for Total Nitrogen (TN) and Total Phosphorus (TP) for estuaries or lowland rivers[1]. The ANZECC threshold levels for lowland rivers and esturies of 10 to 30 µg/L for TP and 300 to 350 µg/L for TN which compared to the sampled levels of 360 µg/L to 4700 µ/L for TN to 90 µ/L to 2000 µ/L for TP.

Table 7-9 Background Water Quality Readings (Douglas Partners, November 2012)

Sample	Total Nitrogen	Total Phosphorus
Units	mg/L	mg/L
SW201	2.60	0.53
SW202[2]	2.90	0.63
SW203[3]	2.40	0.74
SW204	0.36	1.40
SW205	1.00	1.80
SW206	2.00	2.00
SW207[4]	0.92	0.09
SW208	0.94	0.90
SW209	1.10	0.18
SW210	4.70	0.27
SW211	2.80	0.27

To assess the potential performance of the stormwater treatment train within the context of achieving water quality which would be below the existing levels of the swamp

Based on the estimated performance of the total stormwater system based on the cumulative frequency graphs, the concentrations of effluent illustrated below Figure 7-4, Figure 7-5, and Figure 7-6 indicate that the proposed stormwater system will discharge stormwater back into the Hexham Swamp system with significantly lower levels and what currently exists for over 95% of the flows events as estimated by MUSIC.

[1] There is no data provided for wetlands which would be appropriate for the area.
[2] Discharge Location for Basin 1
[3] Discharge Location for Basin 2
[4] Discharge Location for Basin 3

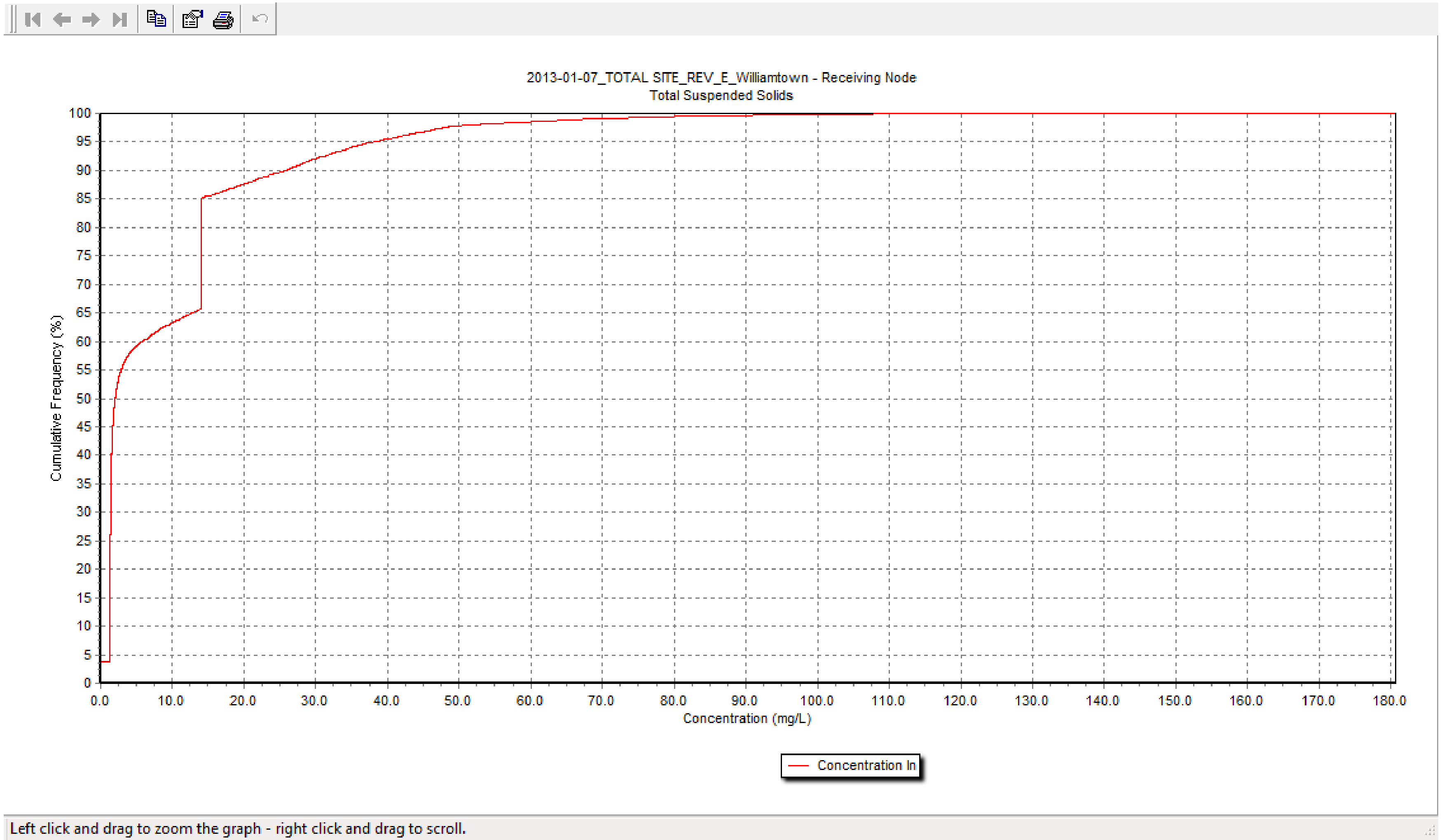

Figure 7-4 Hexham LTTSF Cumulative Frequency - Total Suspended Solids

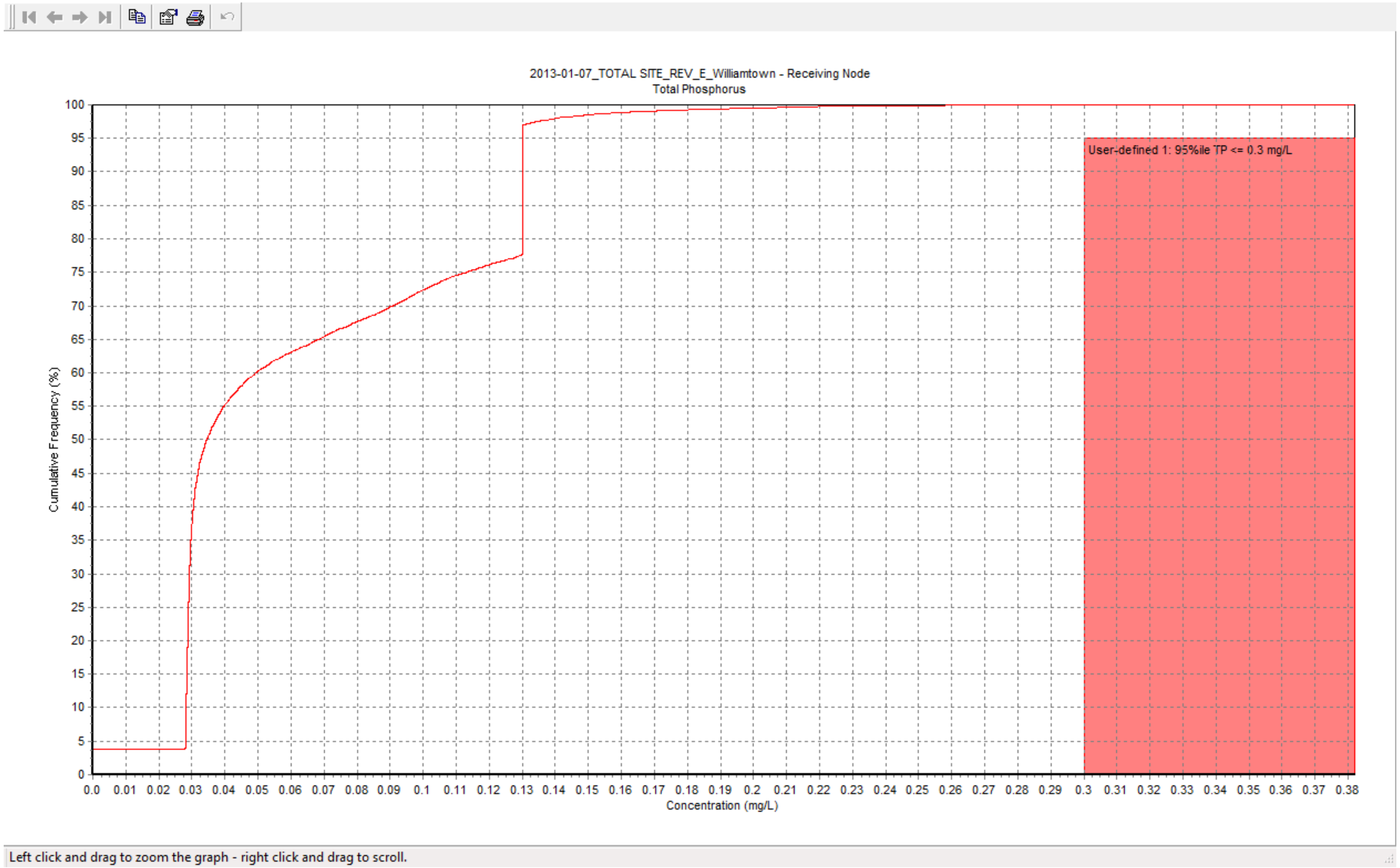

Figure 7-5 Hexham LTTSF Cumulative Frequency - Total Phosphorus Concentrations[5]

[5] 95%ile for the ANZECC Guidelines of 0.3 mg/L shown in red

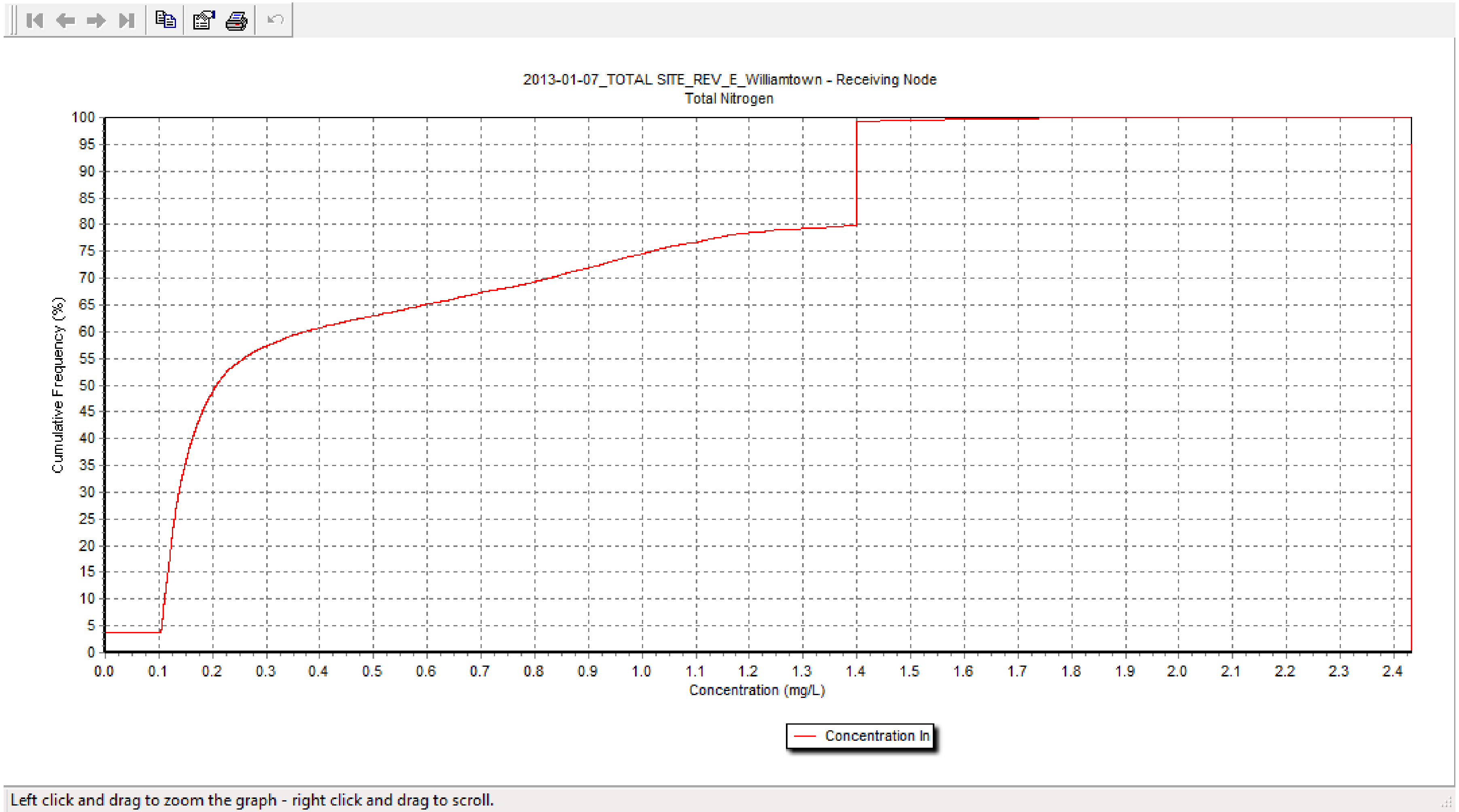

Figure 7-6 Hexham LTTSF Cumulative Frequency - Total Nitrogen Concentrations[6]

[6] 95%ile for the ANZECC Guidelines of 3.5 mg/L shown in red

7.2.5 Oils and Hydrocarbons

As detailed in Section 7.2.2, the areas of the site that will have a high probability of coming into contact with oils, hydrocarbons and contaminated materials or be subject to potential high volume spills will be excluded from the stormwater system. These areas will be bunded and be self-contained to drain to a trade waste system for licenced disposal.

The remainder of the site will have a lower possibility for free oils and hydrocarbons to be mobilised into the stormwater system. It is expected that any oils or hydrocarbons will originate from the car parking areas, the roads area in general and potential small leakages from locomotives as they pass through the site. The volumes of any oils and hydrocarbons anticipated under these conditions would be small and dispersed across the whole site.

As a precaution each detention basin is fitted with a proprietary under over weir pit to collect any minor oils prior to discharge. On the outlets of each of the basins, there are penstocks that can be closed to contain spills within the basins and any floating contaminates either skimmed off in the wetland and collected or skimmed in the oil trap.