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Caloundra South
Water Quality Management Plan

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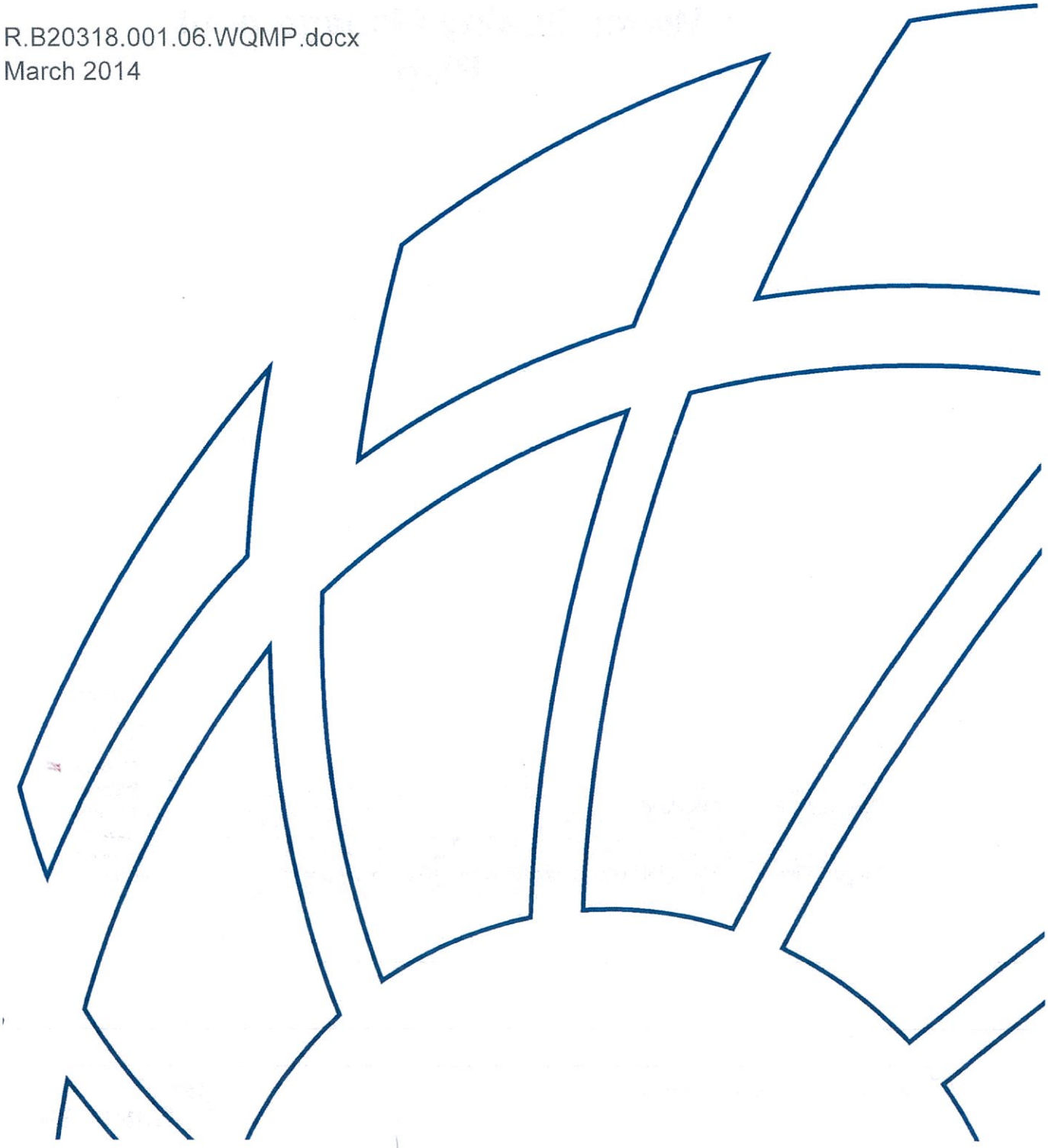

Caloundra South Water Quality Management Plan

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1 INTRODUCTION

This Water Quality Management Plan (WQMP) addresses the management and monitoring of surface water and groundwater on and adjacent to the Caloundra South site and addresses the following:

a) Outlines baseline water quality data (Section 2);

b) Sets out water quality performance objectives and parameters (Section 3);

c) Sets monitoring and reporting periods (Section 4);

d) Sets out scientifically robust methods for sampling and data collection (Section 5);

e) Includes a risk assessment of any modelling, assumptions and predictions used (Section 6);

f) Identifies readily measurable performance indicators and goals and performance indicators at which point corrective actions will be taken (Section 7);

g) Identifies corrective actions, and/or mechanisms for developing corrective actions, and the parties responsible for implementing corrective actions (Section 8);

h) Includes a scientifically robust method for detecting relevant changes in water quality parameters in Bell's Creek and Pumicestone Passage (Section 7); and

i) Identifies adaptive management mechanisms to ensure current industry best practice is being implemented on the site (Section 9).

The recommended monitoring activities outlined in this report also address the requirements of Condition 8 (Water Quality and Monitoring) and Condition 31 (Earthworks Strategy) of the June 2012 Urban Land Development Authority (ULDA) approval for the Caloundra South project.

2 BASELINE WATER QUALITY DATA

Baseline water quality data have been collected in and around Caloundra South for many years by Stockland, Sunshine Coast Council and the Ecosystem Health Monitoring Program. These data are presented in detail in other reports, with a summary provided below.

2.1 Pumicestone Passage Water Quality

Pumicestone Passage has a large catchment containing a mix of mostly rural land uses, with large areas of intensive agricultural activities (horticulture) and plantation forestry (pine). Urban development is primarily located within the northernmost portions of the catchment where tidal flushing is highest, with the majority of the rural catchments discharging to the more poorly mixed zones in the central part of the estuary. The Caloundra South development will discharge into the northern part of Pumicestone Passage via Bells Creek and Lamerough Creek.

The Ecosystem Health Monitoring Program (EHMP), a multi-agency funded (lead by the Queensland Government) environmental monitoring program, has been collecting water quality data at monthly intervals at a number of sites within Pumicestone Passage for more than 10 years. The following summary of ambient water quality levels in Pumicestone Passage is drawn from an earlier interpretation of this highly valuable data set.

2.1.1 Water Quality Objectives

Water Quality Objectives for Pumicestone Passage are defined in Schedule 1 of the Environmental Protection (Water) Policy 2009. The set of generic objectives relevant to the region as a whole are contained in an extract of the Queensland Water Quality Guidelines for Basin 141 which covers the entire Passage and contributing waterways such as Coochin Creek and Bells Creek and are included for comparison purposes in Table 2-2.

This area lies within the defined region PLE1 in Plan WQ1413 (see Figure 2-1 which refers to the northern enclosed coastal estuarine section). This area and others in the Passage have been defined as having 'High Ecological Value' and relevant performance objectives for such waters are defined as ensuring that 20th, 50th and 80th percentile water quality parameters are maintained. Relevant Water Quality Objectives using these percentiles have been derived for a specific site at the mouth of Bells Creek in Pumicestone Passage using the more than 10 years of EHMP data and are presented in Table 2-1.

These **site specific** objectives having been used for impact assessment purposes for the Caloundra South site as the more generic scheduled objectives (see Table 2-2) are intended to represent average water quality in this entire zone, and hence are not considered appropriate targets to use for one particular project (that is Caloundra South) which will affect one particular section of the entire PLE1 region (near to the mouth of Bells Creek).

Table 2-1 Site Specific WQOs Derived for EHMP Site 1311 (at the Mouth of Bells Creek)

Parameter	WQO			Units
	20%ile	50%ile	80%ile	
turbidity	5.4	8.8	11.5	NTU
chlorophyll a	1.4	2.6	4.0	µg/L
total nitrogen	220	260	330	µg/L
total phosphorus	14	18	24	µg/L
dissolved oxygen	88.4	94.8	102.0	% saturation
pH	7.9	8.1	8.2	

Table 2-2 Pumicestone Passage WQOs provided for Region PLE1 in Plan WQ1413

Parameter	WQO			Units
	20%ile	50%ile	80%ile	
turbidity	2	4	6	NTU
chlorophyll a	1.0	1.6	2.5	µg/L
total nitrogen	150	190	220	µg/L
total phosphorus	15	18	25	µg/L
dissolved oxygen	90	95	105	% saturation
pH	8.0	8.2	8.3	

2.1.2 Pumicestone Passage Zones

Pumicestone Passage can be considered as consisting of several 'zones' which are relevant to both the establishment of water quality objectives and the performance of water quality assessments. In Plan WQ1413 in Figure 2-1, the northern zone of the Passage can be considered as those areas covered by area PLE1 towards Caloundra. The middle estuary zone is defined as area PME1 from just north of Halls Creek to the southern area of Tripcony Bight and the southern part of the passage is all areas south of Tripcony Bight to the southern tip of Bribie Island. Subsequent sections of this report review ambient water quality behaviour with reference to these 'zones'.

2.1.3 Salinity

- Pumicestone Passage effectively behaves as a 'double ended' estuary. Tidal flows and associated salinity levels propagate into the Passage from each end, producing lowest salinities approximately midway along the Passage in the general vicinity of the middle estuary zone near Tripcony Bight (see Figure 2-1).
- Salinities in the middle/poorest flushed zone of Pumicestone Passage range from those of effectively freshwater to fully marine concentrations.
- Lowest salinities are somewhat to the north of the middle zone of Pumicestone Passage, this being reflective of recognised net northerly flows in the Passage.

- There would appear to have been lower typical salinities and far greater variations in salinity levels in Pumicestone Passage in recent years than those observed beforehand, reflective of the breaking of significant drought conditions in the region over this time period.

2.1.4 Temperature

Temperatures would appear to be largely consistent along the length of Pumicestone Passage, with a potentially slight (less than 1° C) elevation in mean temperature levels in the middle zone of the Passage; and

Sites near Caloundra South exhibit almost identical temperature behaviour.

2.1.5 pH

pH levels appear to show similar spatial and temporal trends to salinity, which could be expected.

Of the more than 1030 samples analysed, only 4 were below neutral (pH 7). This indicates that there are no obvious manifestations of any particular influence of actual acid sulphate soil conditions in the catchment and acidic coastal heathlands are not dominant in the catchment.

Like salinity, pH levels seem to have been lower (reflecting more near neutral stormwater run-off) and more varied in the last 2 to 3 years than beforehand.

Pumicestone Passage near the Caloundra South site is naturally not compliant with (i.e. in the case of pH, less than) relevant water quality objectives.

2.1.6 Dissolved Oxygen

The majority of DO levels are typically quite high within Pumicestone Passage, reflecting the high tidal velocities and relatively good tidal flushing, predominantly un-urbanised catchment and absence of major point source sewage discharges.

There are occasional occurrences of low DO in the middle zone of the Passage. The lower DO levels typically coincide with lower salinity levels when catchment run-off (causing the lower salinities) will typically have lower dissolved oxygen concentrations and also convey oxygen demanding substances into the Passage, thereby reducing DO levels. DO levels in the waterways may also be affected sediment oxygen demand and water column algal respiration/photosynthesis activities.

Like salinity, DO levels seem to have been lower (reflecting the aforementioned influence of catchment run-off) in the last 2 to 3 years than previously in the data record.

Pumicestone Passage near the Caloundra South site is naturally compliant with (i.e. in the case of DO, greater than) relevant water quality objectives.

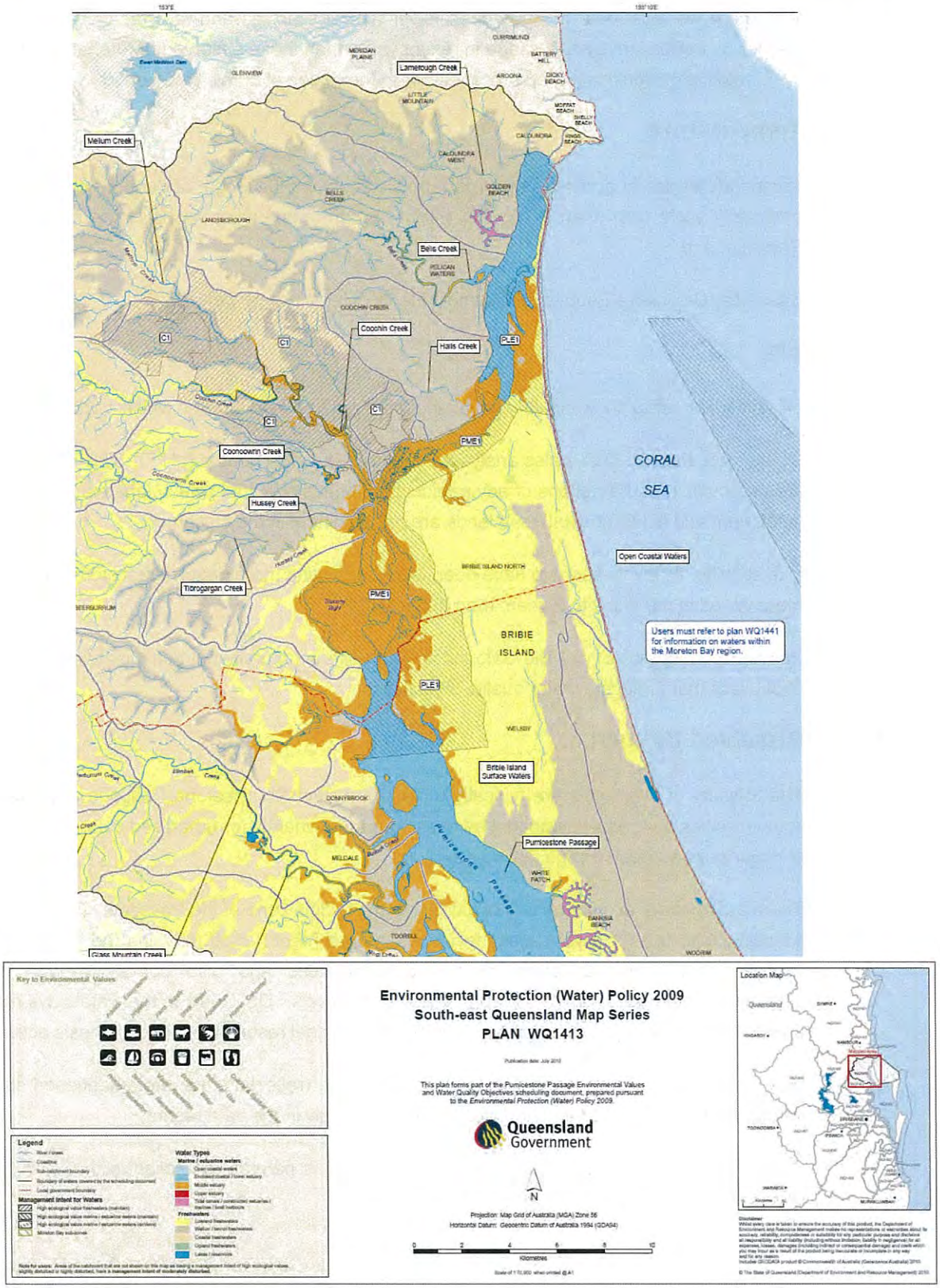

Figure 2-1 Plan WQ1413 (Extract to Highlight Relevant Area for Caloundra South)

2.1.7 Turbidity

Turbidity levels peak in the central to northern zones of Pumicestone Passage, reflecting the combination of maximum catchment influences, longest residence times and lowest salinities (salinity tends to flocculate fine sediments, thereby reducing turbidity, hence the lower salinities in this section will see a reduced level of such flocculation occurring). The highest median turbidities are observed just to the south of the Caloundra South landholding.

There would not appear to be any major change in turbidity levels over the last (wetter) 2-3 years, which may indicate that turbidities are predominantly generated by processes within the Passage (e.g. fine sediment resuspension due to tide, wind and wave action, algal growth, etc) other than being strongly influenced by catchment runoff. Alternatively, it may indicate settling of catchment derived sediments in the areas upstream of the EHMP monitoring points – neither hypothesis can be confirmed at this time.

The sections of Pumicestone Passage adjacent to and extending north and south of the Caloundra South landholding are naturally not compliant with (i.e. in the case of turbidity, greater than) relevant water quality objectives.

2.1.8 Total Nitrogen

TN levels are elevated in the central reaches of Pumicestone Passage, with the relevant zone of elevated levels being somewhat larger than that evidenced by the previous water quality parameters.

There would appear to be a correlation between elevated TN levels and reduced salinities, indicating a link between catchment run-off and estuarine nutrient concentrations. Similarly, there would appear to be a trend to higher average and extreme TN levels in the Passage in the (wetter) recent years.

Much of the central and northern sections of Pumicestone Passage are already exhibiting total nitrogen levels which are naturally not compliant with (i.e. in the case of TN, greater than) relevant water quality objectives.

2.1.9 Total Phosphorus

TP levels appear to be surprisingly consistent throughout the length of Pumicestone Passage. There are elevated peak levels in the central portions of the Passage, typically associated with run-off and reduced salinities.

There would not appear to be any major signal or change in TP levels within the Passage due to the greater rainfall/run-off which occurred over recent years.

The sections of Pumicestone Passage, adjacent to and extending north and south of, the Caloundra South landholding are largely compliant with relevant water quality objectives.

2.1.10 Chlorophyll a

Chlorophyll *a* levels appear to emulate previous water quality trends in Pumicestone Passage, these being elevated concentrations in the central and northern regions.

There would not appear to be any major signal or change in chlorophyll *a* levels within the Passage due to the greater rainfall/run-off which occurred over recent years.

The sections of Pumicestone Passage adjacent to and extending north and south of the Caloundra South landholding are currently exhibiting chlorophyll a levels which are naturally compliant with (i.e. in the case of chlorophyll *a*, less than) relevant water quality objectives.

2.1.11 Summary of Key Pumicestone Passage Water Quality Findings

Table 2-3 Existing WQO Compliance in Pumicestone Passage near Bells Creek

Parameter	Currently Compliant
turbidity	×
chlorophyll a	√
total nitrogen	×
total phosphorus	√
dissolved oxygen	√
pH	×

- Water quality in the northern sections of Pumicestone Passage is generally of a high quality. The area has significant environmental values which require water quality protection.
- The northern sections of Pumicestone Passage, which receive runoff from the Caloundra South site and adjacent catchment areas, are well flushed, as evidenced by the relatively high salinity levels in this region.
- pH levels are typically near neutral, indicating no significant ASS runoff or other such influences from the catchment.
- Dissolved oxygen levels are typically quite high, with the possible exception of when heavy rainfall conditions trigger significant catchment runoff.
- Nutrient levels are typically quite low, with the exception of when heavy rainfall conditions trigger significant catchment runoff. Nitrogen levels typically currently exceed relevant overall regional water quality objectives while phosphorus levels are compliant, indicating that the catchment is contributing very low levels of phosphorus.
- Turbidity/suspended sediment levels typically currently exceed relevant overall regional water quality objectives, reflecting the influence of rural land disturbance to the south of the Caloundra South site.
- Pumicestone Passage adjacent to the Caloundra South site currently exhibits chlorophyll a levels that are complaint with relevant water quality objectives.

2.2 Bells Creek Water Quality

2.2.1 Background

The Bells Creek catchment area is currently occupied by active and dormant (fallow) plantation forestry, with some casual grazing in places and several pockets of conservation zones. Urban development is currently confined to the mouth of the creek only. The western part of the catchment is intersected by the four lane Bruce Highway which travels through both the Bells Creek North and South catchments.

The following summary of ambient water quality is provided based on a limited data set collected in this waterway by both Sunshine Coast Council and Stockland. This data set encompasses a period in total of a little over 3 years, not the more than 10 years available in Pumicestone Passage via the EHMP. Also, certain key water quality parameters were not analysed by Council for various reasons, which somewhat limits the value of their data. We do note however that EHMP monitoring has now started in Bells Creek (at the instigation of Stockland) and will be the benchmark against which future water quality assessments are conducted.

2.2.2 Water Quality Objectives

Relevant State water quality objectives for Bells Creek are set out in Table 2-4 below.

Table 2-4 Water Quality Objectives for Bells Creek

Parameter	Units	WQO for Mid Estuary	WQO for Lower Estuary
Turbidity	NTU	<8	<6
Chlorophyll a	µg/L	<4	<2.5
Total nitrogen	µg/L	<300	<220
Total phosphorus	µg/L	<25	<25
Dissolved oxygen	% saturation	85-105	90-105
pH	-	7-8.4	8.0-8.3

These WQOs are given in "*Environmental Protection (Water) Policy 2009: Pumicestone Passage environmental values and water quality objectives – Basin No. 141 (part), including waters of Bribie Island and Bells, Coochin, Dux, Elimbah, Mellum, Ningi and Tibrogargan Creeks*". See Figure 2-1 for the location of the areas classified as mid and lower estuaries within Bells Creek.

2.2.3 Salinity

- Bells Creek exhibits similar salinity levels in its lower reaches to those seen in proximate sections of Pumicestone Passage. With movement upstream along Bells Creek, salinity levels typically reduce and salinity variations markedly increase. Salinity levels at the junction of Bells Creek North and South vary from completely fresh to in some cases hypersaline.
- Salinities in Bells Creek can fluctuate rapidly, varying from almost oceanic levels to fresh in periods of less than a month, with salinity recovery taking somewhat longer, of the order of 3 to 4 months.

- There are no salinity recommendations by way of water quality guidelines within the EPP (Water).
- Salinity levels in the January '07 to January '09 period were consistently higher than those following January '09, reflecting the breaking of significant drought conditions in the region around this time.

2.2.4 Temperature

- Temperatures are largely consistent along the length of Bells Creek.
- Temperatures in Bells Creek appear to be similar to those in Pumicestone Passage, typically varying from a minimum of around 15 deg C in winter to a maximum of around 30 deg C in summer.
- There are no specific temperature recommendations by way of water quality guidelines within the EPP (Water).

2.2.5 pH

- Median pH levels downstream of the junction of Bells Creek North and South are above 7, with those more upstream sites showing regular pH levels lower than 7, in some cases dropping to levels between 5 and 6 due to existing/pre-development related runoff from upstream pine plantation areas and former melaleuca wetlands.
- pH levels for waters passing on to the site from upstream catchments are typically near neutral.
- The absence of extremely low pH levels (i.e. less than 5) indicates that there are no significant amounts of acid sulphate bearing soils present on the site as indicated in the PER, i.e. soils across the site have generally low concentrations of natural acidity across the site, and a very low potential for additional acidity to be generated from oxidation of the in-situ soils as a result of excavation or filling.
- Like salinity, pH levels were higher (reflecting less inflows of near neutral catchment stormwater run-off) prior to January '09 than after, reflecting the breaking of significant drought conditions in the region around this time.
- In regard to compliance with water quality objectives (WQO's), relevant state guidelines recommend median pH levels of 8.0 to 8.3 for the lower reaches of Bells Creek and pH levels of 7.0 to 8.4 for all other sites. Comparing these WQO's with available data, the waterway is effectively compliant.

2.2.6 DO

- Median DO levels for the downstream sites are typically modest to high (above 80% saturation) with progressive reductions with passage upstream, with upper sites exhibiting median levels below 60% (and occasionally significantly lower in the order of 20% saturation).
- DO levels in sites upstream of the Caloundra South landholding are typically between 60 and 80% saturation.
- The low DO levels in the upper parts of Bells Creek will reflect the influence of lower tidal velocities (and hence less re-aeration) and longer residence times of waters in these reaches.

- Unlike salinity, DO levels seem to have increased after January '09, this trend will reflect the increased catchment flows and lower residence times in the upper estuary in this period of time.
- In regard to compliance with WQO's, relevant state guidelines recommend median DO levels of 90-105% for the lower reaches of Bells Creek and DO levels of 85-105% saturation for all other sites. Comparing these WQO's with available data, the following comments can be made:
  - For the lower reaches of Bells Creek, available data indicates compliance with guideline levels; and
  - There is considerable non-compliance with all guideline levels for the mid to upper reaches of the Creek, especially under dry weather conditions.
- Interestingly, the above does not reflect the non-compliance of proximate reaches of Pumicestone Passage with relevant DO guidelines, presumably as guidelines for the Passage are stricter due to their relating to 'High Ecological Value' waterways, whereas Bells Creek is designated as being 'Slightly to Moderately Disturbed'.

2.2.7 Turbidity

- Turbidity levels throughout the tidally influenced sections of Bells Creek are relatively consistent, with much higher turbidities typically being seen at the most upstream (freshwater) sites where the Bruce Highway crosses Bells Creek North and South.
- In regard to compliance with WQO's, relevant state guidelines recommend median turbidity levels of <6 NTU for the lower reaches of Bells Creek and median turbidity levels of <8 NTU for upstream sites. Comparing these WQO's with available data indicates compliance with the guideline level.
- Similarly to dissolved oxygen, it is interesting to note that the above does not reflect the non-compliance of proximate reaches of Pumicestone Passage with relevant turbidity guidelines, presumably for a similar reason as previously postulated.

2.2.8 Total Nitrogen

- Total Nitrogen in Bells Creek shows a consistent trend of increasing levels from the junction with Pumicestone Passage with distance upstream to the tidal limit. As could be expected, levels in the lower reaches of Bells Creek are directly comparable to those in Pumicestone Passage, while those near the tidal limit more closely resemble the quality of water washing from the upstream catchment.
- In regard to compliance with WQO's, relevant state guidelines recommend median total nitrogen levels of <0.22 mg/L in the lower reaches of Bells Creek and median total nitrogen levels of <0.3 mg/L for all upstream sites. Comparing these WQO's with available data, the following comments can be made:
  - For the lower reaches of Bells Creek, available data indicates marginal compliance or slight exceedances of the guideline values; and
  - For the upper reaches of Bells Creek, available data show the mid-levels of the creek as being mostly compliant, whilst the upstream levels are non-compliant.
- It is worth noting that the exceedance of the Total Nitrogen guideline level in Bells Creek reflects the previously described exceedance of guideline levels in Pumicestone Passage.

2.2.9 Total Phosphorus

- Total phosphorus in Bells Creek shows a consistent trend of almost uniformly low TP levels along the entire creek. There is no significant longitudinal gradient in TP as was observed for TN, presumably due to the recognised low levels of TP in site surface water and groundwater discharges from the site.
- In regard to compliance with WQO's, relevant state guidelines recommend median total phosphorus levels of <25 µg/L throughout Bells Creek (that is for the entire estuary). Comparing this guideline level with available data, it is apparent that Bells Creek is essentially compliant with the relevant water quality objective. This finding reflects the low levels of phosphorus currently washing off the site and the existing compliance of proximate sections of Pumicestone Passage with relevant water quality guidelines.

2.2.10 Chlorophyll a

- The available data set shows median levels in the lower reaches of the creek which are slightly higher than those in proximate sections of Pumicestone Passage. This indicates that there is some additional primary productivity occurring within Bells Creek to that which is already taking place within the waters of Pumicestone Passage which tidally influence Bells Creek.
- There would appear to be a very slight trend of increasing chlorophyll *a* levels with passage upstream along Bells Creek.
- Chlorophyll *a* levels for waters passing onto the site from upstream catchments are quite high.
- In regard to compliance with WQO's, relevant state guidelines recommend median chlorophyll a levels of <2.5 µg/L in the lower reaches of Bells Creek and levels of <4.0 µg/L for all upstream sites. Comparing these WQO's with the available data set, it is apparent that there is non-compliance with the relevant WQO at all percentile levels.
- It is worth noting that the non-compliance of waters in Bells Creek with chlorophyll *a* guideline levels reflects the previously described non-conformance of proximate sections of Pumicestone Passage with appropriate guideline levels in this area.

2.2.11 Summary of Key Bells Creek Water Quality Findings

Table 2-5 Existing WQO Compliance in Bells Creek

Parameter	Currently Compliant
Turbidity	√
Chlorophyll a	×
Total nitrogen	√
Total phosphorus	√
Dissolved oxygen	×
pH	√

- Water quality in the Bells Creek is generally of a high quality.
- The waterway receives significant catchment runoff as evidenced by the regular and significant variations in salinity levels.

- pH levels vary from those expected of marine waters (>7.5) under dry conditions to near neutral when there is significant freshwater inflow, indicating no significant ASS runoff or other such influences from the catchment.
- Dissolved oxygen levels reduce with passage along the creek, reflecting the lower tidal flows and low reaeration rates.
- Nutrient levels are typically quite low, with the exception of when heavy rainfall conditions trigger significant catchment runoff. Nitrogen and phosphorus levels are typically complaint with water quality objectives, indicating that the catchment is contributing very low levels of nutrients.
- Turbidity levels typically comply with relevant water quality objectives, reflecting the small influence of existing land use within the site on Bells Creek.
- Bells Creek currently exhibits chlorophyll a levels greater than relevant water quality objectives, indicating that even though the nutrient levels are compliant that primary productivity is occurring within the creek itself.

2.3 Lamerough Creek Water Quality

2.3.1 Water Quality Objectives

Relevant State water quality objectives for Lamerough Creek are set out in Table 2-6 below.

Table 2-6 Water Quality Objectives for Lamerough Creek

Parameter	Units	WQO
Turbidity	NTU	<20
Chlorophyll a	µg/L	<6
Total nitrogen	µg/L	<500
Total phosphorus	µg/L	<50
Dissolved oxygen	% saturation	85-105
pH	-	5-7.0

These WQOs are given in "*Environmental Protection (Water) Policy 2009: Pumicestone Passage environmental values and water quality objectives – Basin No. 141 (part), including waters of Bribie Island and Bells, Coochin, Dux, Elimbah, Mellum, Ningi and Tibrogargan Creeks*".

2.4 Groundwater Quality

Over the last decade or so there have been major changes in groundwater levels on the site due to various land uses practices that have been enacted on the site as well as major climatic patterns due to El Nino induced processes. These changes haven seen groundwater levels vary by in some cases over a metre due to changes from a vegetated site under moderate rainfall conditions (moderate groundwater conditions) to a cleared site under low rainfall conditions (low groundwater conditions) and now its current state of a cleared site under high rainfall conditions (high groundwater conditions).

Throughout the above period of change in groundwater levels on the site, a considerable body of groundwater chemistry data have been collected from a range of locations. Based on these data, the following groundwater quality summaries can be presented.

By way of an overall summary comment, the site has no significant groundwater quality issues.

2.4.1 Physicochemical Data

Shallow groundwater has an electrical conductivity range of 92 to 3,266 μS/cm with a median value of 236 μS/cm and a mean value of 502 μS/cm, meaning that the groundwater is effectively freshwater at nearly all times and shows little indication of saline intrusion. Shallow groundwater sampled across the site has relatively low to moderate salinity only. Shallow groundwater samples have a pH range of 3.82 to 6.86 with a median of 5.07 and mean of 5.15.

2.4.2 Nutrient Data

Available data indicates slightly elevated concentrations of nitrogenous compounds in the shallow groundwater. The total nitrogen data has a mean of 0.59 mg/L as N and a median of 0.52 mg/L as N. Similarly, total Kjeldahl nitrogen data has a mean of 0.56 mg/L and median of 0.465 mg/L. Ammonia has a mean of 0.14 mg/L and a median of 0.019 mg/L. Nitrate data has a mean of 0.18 mg/L and a median value of 0.015 mg/L.

Total phosphorus data has a mean of 0.184 mg/L as P and a median of 0.054 mg/L as P. Reactive phosphorus data has a mean of 0.006 mg/L and a median of 0.002 mg/L.

2.4.3 Metals Data

The site in its entirety has low levels of metals present in groundwater as summarised below.

- The peak recorded dissolved iron level was 9.36 mg/L with mean and median values of less than 2.33 and 0.33 mg/L respectively;
- The peak recorded aluminium level was 2.04 mg/L with mean and median values of less than 0.2 and 0.02 mg/L respectively;
- No arsenic concentrations were recorded above the detection limit of 0.001 mg/L;
- The peak recorded cadmium level was 0.0012 mg/L with mean and median values less than 0.0003 and 0.0002 mg/L respectively;
- The peak recorded chromium level was 0.0004 mg/L with the other bores all recording values less than the detection limit of <0.001 mg/L;
- The peak recorded copper level was 0.007 mg/L with mean and median values less than 0.0038 and 0.004 mg/L respectively;
- No mercury values were recorded above a detection limit of 0.0001 mg/L;
- The peak recorded nickel level was 0.021 mg/L with mean and median values less than 0.0067 and 0.006 mg/L respectively;

- The peak recorded lead level was 0.08 mg/L with mean and median values less than 0.014 and 0.0015 mg/L respectively;
- The peak recorded manganese level was 0.159 mg/L with mean and median values of 0.08 and 0.089 mg/L respectively; and
- The peak recorded zinc level was 0.159 mg/L with mean and median values of 0.038 and 0.034 mg/L respectively.

2.4.4 Organic Carbon and Iron

Data shows a range of dissolved iron levels with a mean concentration of 2.33 mg/L and a median concentration of 0.33 mg/L. At one site only a detectable dissolved organic carbon concentration of 12 mg/L was recorded. These results indicate that the presence of organically complexed iron in the groundwater at that site is unlikely.

2.4.5 Summary of Key Groundwater Quality Findings

- Groundwater levels on the site are heavily influenced by site vegetation cover and prevailing climatic conditions.
- All site groundwater is effectively fresh with little indication of saline intrusion.
- Groundwater nutrient levels are slightly elevated.
- The site in its entirety has low levels of metals and organic carbon present in groundwater

2.5 Summary

- Water quality in Pumicestone Passage adjacent to the site is largely controlled by rural catchment sources to the south of the Caloundra South landholding. There is minimal existing compliance with desired water quality objectives and a high standard of management of water quality on the site will be required to ensure that WQO compliance levels do not worsen.
- Water quality levels in Bells Creek are largely compliant with water quality objectives and some impacts due to development of the Caloundra South could be accepted.
- There are no existing groundwater quality issues at the Caloundra South site. Surveillance of same during and after construction will be required.

3 WATER QUALITY PERFORMANCE OBJECTIVES AND PARAMETERS

3.1 Surface Water

From a surface water quality and quantity perspective, key objectives that the development of the Caloundra South site will be required to satisfy are as follows:

- The Queensland Department of Environment and Heritage Protection (DEHP) has defined adjacent sections of Pumicestone Passage as having High Ecological Value (HEV) status in the Environmental Protection (Water) Policy (EPP Water) –2009. The commensurate Water Quality Objective (WQO) which accompanies this designation is of the nature of 'no change', but more specifically is quantified as:

  "maintain existing water quality (20th, 50th and 80th percentiles)".

- DEHP has also stipulated WQOs for Bells Creek for particular parameters as defined in Schedule 1 of the Environmental Protection (Water) Policy 2009. These have been identified in the previous sections under the relevant parameter and form the basis of the water quality performance criteria for many of the environmental management measures across the Caloundra South site.

- The Federal Department of Sustainability, Environment, Water, Population and Communities (SEWPaC), with others, has defined large sections of Pumicestone Passage and associated waterways as having Ramsar wetland status. The associated significance criteria which accompany this designation are as follows (Australian Government, 2013[1]):

  a) Areas of the wetland being destroyed or substantially modified;

  b) A substantial and measurable change in the hydrological regime of the wetland (e.g. volume, timing, duration and frequency of surface and groundwater flows);

  c) The habitat or lifecycle of native species being seriously affected;

  d) A substantial and measurable change in the water quality of the wetland (e.g. salinity, pollutants, nutrients and water temperature) which may adversely impact on biodiversity, ecological integrity, social amenity or human health; and

  e) An invasive species that is harmful to the ecological character of the wetland becoming established, or an existing invasive species spreading.

3.2 Groundwater

The fundamental groundwater quality performance objective is for site development to have no adverse impacts on groundwater quality or levels outside the site domain as such changes could affect either any groundwater dependent ecosystems in these areas or, through interaction with surface water bodies (creeks and estuaries), could affect receiving water quality levels in downstream environments.

[1] "*Matters of National Environmental Significance: Significant impact guidelines 1.1*", Environment Protection and Biodiversity Conservation Act 1999.

4 MONITORING AND REPORTING PERIODS

4.1 Surface Water Quality Monitoring

Surface water quality monitoring will provide both certainty that earlier impact assessment predictions are being achieved or complied with and also relevant information with which to refine or optimise design elements of the project to ensure such compliance occurs. Also, in the unlikely event that impact assessment predictions are not being complied with, these monitoring data will be invaluable in regard to guiding and assessing relevant corrective actions. To achieve these objectives, monitoring will need to be both ambient or condition based (e.g. monthly background water quality surveys) and also targeted towards specific water related elements of the site (e.g. efficacy monitoring of a particular water sensitive urban design device).

Given the above, the following surface water quality monitoring actions are proposed. These actions are expanded upon in Section 5 below.

Table 4-1 Surface Water Quality Monitoring Recommendations

Monitoring Activity	Monitoring	
	Commencement	Cessation
Ambient	A minimum of six months[2] prior to construction commencement within a particular catchment	A minimum of 12 months after all development work has been completed within the respective catchment
Event Based	A minimum of six months[3] prior to construction commencement	12 months after all development work has been completed within the respective catchment
EHMP (water quality)	Two monitoring sites have already been established and data collection has been occurring since mid 2012	3 years after all development work has been completed on the site
Real Time Turbidity	A minimum of six months[1] prior to construction commencement	12 months after all development work has been completed within the respective catchment
Load Based	Commenced within one year of construction commencing elsewhere on the site	10 representative storms from each of two years are required to be monitored
Treatment Device	Upon the effective completion of the earlier stages of the Northern Residential and Northern Employment Precincts	After data have been collected from 10 representative storms (that is storms with greater than 20mm of rainfall)
Construction Stage	During the construction phase of development works	At the completion and stabilisation of 'active' works in any locality.

[2] There will be a need to ensure that this six month period encompasses a suitable range of wet and dry weather conditions, with special emphasis on wet conditions when any potential impacts from the site will be most noticeable. Sufficient wet weather data would constitute several storm events of greater then 20mm magnitude being sampled prior to construction commencing, with ongoing data collection to extend the available record as time passes.

[3] Ambient data collection should also encompass wet and dry periods

Development works in the above table refers to site establishment activities such as ground preparatory works, drainage works, bulk earthworks, vegetation clearing and grubbing, but does not include construction of residential housing or commercial premises.

4.2 Groundwater Quality Monitoring

Groundwater quality monitoring will provide certainty that previous impact predictions are being achieved or complied with. Also, in the unlikely event that this is not the case, these monitoring data will be invaluable in regard to guiding and assessing relevant corrective actions.

The following groundwater quality monitoring actions are proposed.

Table 4-2 Groundwater Quality Monitoring Recommendations

Monitoring Activity	Monitoring	
	Commencement	Cessation
Groundwater	Sampling of baseline condition should occur within the six months period prior to construction works. Once construction has commenced: • All bores within the site will be sampled on a biannual basis, up to and for 12 months after active development works are completed in respective catchments; • Those bores within catchments where there are construction activities occurring, but which are not in close proximity to areas of active development works will be sampled on a 3 monthly basis; and • Those bores within catchments where there are construction activities occurring and which are in close proximity (i.e. within 500m) to areas of active development works will be sampled on a monthly basis.	12 months after active construction works are completed in respective catchments

4.3 Reporting and Review

An Annual Environmental Report (AER) will be prepared and published on the project website within three (3) months of every twelve (12) month anniversary of the commencement of works on the site until 12 months after cessation of activities on the site to present the various aspects of the implementation of the Caloundra South project including water quality monitoring activities outlined in this Plan.

This report will summarise compliance with the conditions of approval and the implementation of any management plans, reports, strategies and methods over the previous twelve (12) month period as required under the conditions of approval. Within five (5) days of publication, a copy of the report will be forwarded to the relevant federal government minister responsible for the approval.

Non-compliance with any of the conditions of the approval (e.g. compliance with water quality objectives) must be reported to the relevant federal government minister responsible for the approval within two (2) business days of becoming aware of the non-compliance. Any non-compliance must also be reported to relevant State and Local Government agencies. Triggers for water quality related corrective actions to prevent non-compliance are outlined in the sections below.

The monitoring of triggers for corrective action, implementation of corrective actions and reporting will be overseen by the superintendent for the site. This activity will continue throughout construction phases (during bulk earthworks and other preparation activities) and during operational phases until indicated under the different monitoring programmes of this plan.

Within five days of the receipt of laboratory results (from collected water samples), the data will be reviewed and an email provided to the developer indicating whether action is required.

Available water quality monitoring data (and a succinct commentary of the results) will be also provided to the planning authority at quarterly intervals.

Within three (3) months of every three (3) year anniversary of the commencement of works for the first nine (9) years from commencement of works and then within three (3) months of every five (5) year anniversary thereafter until cessation of activities on the site, an independent audit of compliance will be undertaken to evaluate accordance with the conditions of approval and all associated management plans, reports, strategies and methods. The audit report will be submitted to the relevant federal government minister responsible for the approval within three (3) months of the date of completion of the audit and will identify any remedial actions that have been taken in response to the audit in addition to any proposed changes to management plans, reports, strategies or methods.

5 METHODS FOR SAMPLING AND DATA COLLECTION

5.1 Surface Water Quality and Hydrology Monitoring

5.1.1 Scope of Monitoring Proposed

The primary surface water quality issues to consider for monitoring include:

- Construction works discharges;
- Wastewater discharges;
- Treatment measure performance; and
- Disturbed/exposed acid sulphate soils.

In terms of monitoring parameters, the following primary parameters need to be considered in developing the monitoring program:

- pH;
- Turbidity and Total Suspended Solids;
- Nutrients (Nitrogen and Phosphorus);
- Heavy metals and metalloids; and
- Hydrocarbons and their derivatives.

These parameters have been reviewed and will be assessed with the exception of the following which have been effectively discounted as needing measurement as described:

- In regard to heavy metals and metalloids (with the exception of aluminium and iron – which may be related to potential acid sulphate soils on site), based on data collected in South East Queensland, including sites on the Sunshine Coast, there should be minimal sources of such materials from this predominantly urban residential site other than in road runoff. As all road runoff will be extensively treated using advanced Water Sensitive Urban Design (WSUD) techniques (which are highly effective at removing particulate bound metals), monitoring for these constituents is not considered necessary.
- In regard to hydrocarbons, the same comment as per heavy metals is made.
- As there are no wastewater discharges from the site to Bells Creek or Pumicestone Passage, monitoring for same is also not required. Any impacts of accidental spills will be detected by the ambient nutrient monitoring.

Noting these exceptions, the proposed surface water quality monitoring plan consists of the following components:

- Freshwater Ambient Monitoring;
- Event Based Monitoring;
- Estuarine EHMP Monitoring;
- Real Time Turbidity Monitoring;

- Load Based Monitoring;
- Treatment Device Monitoring; and
- Construction Stage Monitoring.

Figure 5-1 presents the locations at which surface water monitoring activities will take place. The monitoring activities which will occur at each of these locations are described below and summarised in their entirety in Table 5-1.

5.1.2 Freshwater Ambient Monitoring

Monthly ambient water quality surveys will be conducted at eight locations within the site, three each respectively on Bells Creek North and Bells Creek South and two on Lamerough Creek. Sites will commence being monitored in the respective waterways a minimum of six months ahead of any development works occurring within local catchments (encompassing wet and dry conditions as discussed previously) and will continue for a minimum of 12 months after all development work has been completed within the respective catchments, or sooner if deemed appropriate by the relevant nominated assessing authority.

The following water quality parameters will be measured by these surveys via a combination of in situ measurements using a pre-calibrated water quality instrument and water sampling and subsequent laboratory analyses:

- pH;
- Conductivity;
- Temperature;
- Turbidity;
- Dissolved oxygen
- Total Suspended Solids;
- Total nitrogen, Organic N, Ammonia N and NOx;
- Total phosphorus and filterable reactive phosphorus;
- Chlorophyll 'a';
- Iron; and
- Aluminium.

5.1.3 Event Based Monitoring

Event based water quality samplers will be installed at appropriate locations on Bells Creek North and South at the upper and lower boundaries of the Caloundra South site. Monitoring in the respective waterways will commence a minimum of six months ahead of any development works occurring within local catchments (encompassing wet and dry conditions as discussed previously) and will continue for a minimum of 12 months after all development work has been completed within the respective catchments, or sooner if deemed appropriate by the relevant nominated assessing authority. Additional monitoring stations will be deployed midway along Bells Creek North and South

six (6) months before substantial urban land development works are to commence in the areas upstream of these locations.

These samplers will be triggered by flows in either of the creeks, and will collect composited, flow proportional samples from significant run-off events. These samples will be analysed for the following parameters:

- Flow
- Total Suspended Solids;
- Total Nitrogen; and
- Total Phosphorus.

Whilst it is acknowledged that the collection of event samples will be dependent on weather conditions, it is recommended that a minimum of three samples be collected and analysed every year from the event based water quality samplers (whilst they are in operation). To avoid excessive expenditure, it is recommended that a maximum of ten samples be analysed from those collected in event based water quality samplers.

5.1.4 Estuarine EHMP Monitoring

Two Ecosystem Health Monitoring Program (EHMP) sites have been located within Bells Creek downstream of the development (see Figure 5-1). These sites are being tested on a monthly basis by Queensland Department of Environment and Heritage Protection (DEHP) staff as a component of regular monthly surveys of Pumicestone Passage. The full suite of regular EHMP analyses will be conducted at each of these sites.

At the time of preparation of this report, these sites had been established and monitoring has been under way since mid-2012. The data are being included in current EHMP reporting regimes.

5.1.5 Real Time Turbidity Monitoring

Coincident and concurrent with the event based samplers on Bells Creek North and South it is proposed to establish real time turbidity monitoring stations, with additional instruments also being located at the following locations (that is up to five stations in total):

- The upstream confluences of the site with Bells Creek North and South; and
- The downstream extent of the development footprint within the Lamerough Creek Catchment.

Turbidity monitoring in the respective waterways will commence a minimum of six (6) months ahead of any development works occurring within local catchments (encompassing wet and dry conditions as discussed previously) and will continue for a minimum of twelve (12) months after all development work has been completed within the respective catchments, or sooner if deemed appropriate by the relevant nominated assessing authority. These stations will collect and transmit water level and turbidity data in real-time mode for stream flows passing their respective locations. Relevant alarm systems will be installed on the site such that should predefined triggers or increases in turbidity levels occur, appropriate site personnel will be notified via text message and email such that rectification actions to address the causes of the turbidity exceedance can be immediately undertaken.

5.1.6 Load Based Monitoring

Load based monitoring will be conducted on catchments within the site to better understand the quality of water washing from the site. Two sites will be established within the ultimate development footprint from which data will be collected for a two (2) year period to thoroughly quantify the quality of run-off from the site. Indicative locations for these sites are shown in Figure 5-2. These site locations may be refined somewhat depending on subsequent local suitability investigations.

At each of these sites, an event-based stormwater sampler will be installed and stormwater flow and quality data collected from at least twenty (20) representative storms over a two (2) year period. Samples collected by the stormwater samplers will be composited and the event mean concentration for each storm event derived.

5.1.7 Treatment Device Monitoring

Load based monitoring of treatment devices will be conducted to confirm the efficacy of these devices and to allow the refinement of device designs as the development proceeds. As the development layout is not completely finalised, and as such monitoring cannot take place until development works are largely complete and the treatment devices are established, it is premature for this WQMP to specify exactly how and where such treatment device monitoring will take place.

Upon the effective completion of some of the earlier parts of the Northern Residential and Northern Employment precincts, especially those areas draining towards Bells Creek North, further assessment will be undertaken as to where and how such treatment device monitoring can take place.

Treatment device monitoring will occur for one representative established bioretention system and one representative established wetland system. For each of these systems, event-based stormwater samplers will be installed upstream and downstream of the device and stormwater flow and quality data collected from ten (10) representative storms. Samples collected by the stormwater samplers will be composited and the event mean concentration for each upstream and downstream sampling site derived such that load reductions can be calculated.

5.1.8 Construction Stage Monitoring

Construction stage monitoring will be included in the details of precinct scale Construction Environmental Management Plans (CEMP's). The following monitoring regime will be integrated into each Precinct-based CEMP:

- Regular (daily and after major rain events) site inspections of all erosion and sediment control measures.
- Regular (daily and after major rain events) inspections of areas surrounding construction site to detect and manage any occurrence of sediment deposition off-site.
- Rainfall will be recorded at 9am each working day from an installed rain gauge.
- All construction activities will be monitored daily for compliance with erosion and sediment control measures.

Within sediment basins within each precinct, turbidity and pH will be measured daily. Monitoring measures related to receiving water quality (e.g. outside of the sedimentation basins) are described in Sections 5.1.2, 5.1.3, 5.1.4 and 5.1.5 above.

Specific within site construction stage monitoring will cease at the completion and stabilisation of 'active' works in any precinct, which refers to those works associated with land forming and bulk excavation and filling works, not the house construction phase which will follow, as the majority of erosion and sediment controls will be the responsibility of each construction contractor responsible for lot scale works.