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Via email: robv@planitconsulting.com.au

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AWC Reference: 1-191194_3b

Water | Ecology | Management

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Dear Rob

RE: Sandhills Wetland Project, Lot 457 DP1087879 and Lot 383 DP 728202, Byron Bay – Response to SEARs 1587

I refer to the proposed development of Lot 457 DP1087879 and Lot 383 DP 728202 - 1 Gilmore Crescent Byron Bay ('the site') and the construction of a treatment wetland system in the eastern portion of the site.

Development of the site requires an Environmental Impact Statement ('designated development'), requirements for which are outlined in the Planning Secretary's Environmental Assessment Requirements (SEARs 1587), issued 27 July 2021.

This letter assesses impacts to soil and water including:

- Soils, topography, drainage, landscape and hydrology
- Water usage
- Site water balance
- Assessment of proposal with regards to NRAR guidelines
- Stormwater management systems and monitoring
- Description and appraisal of impact mitigation and monitoring methods.

Australian Wetlands Consulting Pty Ltd
ABN 81 140 533 919

Several studies and background investigations were completed in the design development phase for the Sandhills wetland system; these are summarised inTable 1.

Table 1 Background studies

Study / Information	Description / Relevant findings	Authors	Date
Concept Design	A concept design for a constructed stormwater wetland system, following consultation with Council and Arakwal Aboriginal Lands Council, revised to include three layout options and a preferred option chosen.	AWC	June 2019
Revised Concept Design		AWC	2021
Basis of Design report	Summarises the concept design, the information used to prepare the detailed design and information gaps.	AWC	February 2022
Contamination Assessment	The site is considered suitable from a contamination perspective for the proposed wetland development (i.e. recreational use).	ENV solutions	July 2021
Acid Sulfate Management Plan	Laboratory analysis of 6 boreholes within the site indicated the presence of Actual Acid Sulfate Soil (AASS) and Potential Acid Sulfate Soil (PASS). The plan provides management and treatment measures to be employed during excavation at the site.	ENV solutions	August 2021
Biodiversity Development Assessment Report (BDAR)	Outlines the measures taken to avoid, minimise and mitigate impacts to the vegetation and habitats present within the development site during the design, construction, and operation of the development. The residual unavoidable impacts of the proposed development were calculated using the Biodiversity Assessment Method Credit Calculator (BAM-C).	Planit Consulting	August 2022

Description of development

The constructed wetland treatment system consists of three wetland cells or tiers. Local stormwater and seasonal groundwater flows are conveyed through the wetland cells. The wetland has been designed specifically to improve the quality of water flowing through the wetland it is discharged via the existing stormwater outlet to Clarkes Beach.

The cells will have a standing or operating water level which is set by pipes which discharge water downstream from the cell when it raises above the standing water level. Each cell has a weir set at the extended detention level so that high flows can be safely conveyed through and across the wetland system.

The macrophyte zones of the cells will be unlined, meaning that a portion of the stormwater that flows into the cells will infiltrate the soil. Deep zones have been included to provide refugia for aquatic plants and animals between rainfall events. The deep zones will be lined with an impermeable liner to better retain water between events.

Soils, topography, drainage, landscapes, and hydrology

The proposed Sandhills wetland is located in an undeveloped parcel of land behind Clarkes Beach. The main feature of the eastern portion of the site is a highly degraded waterway and drain that is likely to have been constructed during sandmining activities and further deepened during urban development (Attachment 1, Plate 1 and Plate 2). The Sandhills site was subject to extensive sand mining activities in the 1950's and 60's with the original dunal landscape significantly altered. Due to its location behind a large dunal system, prior to settlement the site would have received dispersed flows that spread out and slowly moved west towards the Belongil Estuary.

The site is relatively flat and low-lying, with an elevation ranging between 7m and 11m AHD. Land surrounding the site generally grades down to the southwest towards a pit which conveys stormwater flows to Clarkes Beach (Attachment 1, Plates 2 and 3).

The hydrology of the Sandhills Estate is highly altered from its original state. Currently, piped stormwater flows are conveyed to the site from the east and northeast to an open drainage feature which conveys flows to an inlet pit and stormwater pipe which outfalls to Clarkes Beach. The current inflow and outflow pipe work and the main drivers of site hydrology will not be altered with this current proposal. It is anticipated that there will be some increase in infiltration to site groundwater, this is further discussed below in the section dealing specifically with groundwater.

Figure 1 Stormwater infrastructure plan with piped network shown in yellow and surface system shown in green

Soil sampling was conducted on the 29 June 2021 (ENV, 2021) comprising six boreholes (BH1 – BH6), located within the footprint of the three wetland cells, to a maximum depth of 5.0 m BGL (Below Ground Level). The typical soils found during the soil investigation were sandy clay and sand overlying sand and clay as shown in Table 1. Borehole locations are shown in Figure 2. Due to its position in the landscape the soil materials are Acid Sulphate Soils (ASS) and a Acid Sulphate Soil Management Plan has been prepared.

Table 2 Typical soils

Depth Interval* (mBGL)	Typical Soils
BH1 – 0.0 to 1.0 And BH5 – 0.0 to 0.5	Silt
0.0 to 2.5 (Excluding top layer of BH1 and BH5)	Sandy Clay overlaying Sand
2.5 to 4.0	Sand
4.0 to 5.0	Clay

Figure 2 Acid Sulphate Soil Borehole locations overlain on the Sandhills Wetland Concept layout.

Water usage

No additional water usage is proposed either from reticulated or recycled water supply. As described the site is fed by stormwater flows and rainfall. The installation of wetlands on the site will increase the amount of water stored on the site and slow the movement of water to Clarkes Beach following rainfall events. Further detail on site water use is described below.

In the event of extended dry periods the addition of recycled water may be undertaken to sustain plants installed within the wetland. The addition of recycled water would likely be through surface irrigation preventing the release of any flow from the wetland system.

Water Balance

A water balance at the site has been investgated using eWater modelling software MUSICX. Music is typically used in the assessment of water sensitive designs to provide understanding of how rainfall and stormwater generated can be captured and treated. The model can be set at a range of time-steps from 6 minutes through to daily and a water balance model simulates using a 10 year time frame. Data inputs include historical rainfall from the nearest meteorological station that records rainfall intensity.

Simulated flows enter the wetlands as runoff from the surrounding catchments. Flows leave the wetlands via evapotranspiration (ET), infiltration and the designed pipes and overflow weirs. The mean annual water balance for each constructed wetland node as modelled by MUSIC is provided in Table 3, flows are provided as average daily flows in ML/d.

Table 3 Sandhills Wetland Music model results for the wetland node water balance (ML/d)

	Wetland 1	Wetland 2	Wetland 3
Flow In (ML/d)	24.953	267.352	202.19
ET Loss (ML/d)	0.676	3.311	2.471
Infiltration (ML/d)	13.075	61.985	54.951
Pipe Out (ML/d)	4.673	44.4	0.01
Weir Out (ML/d)	6.582	157.789	145.829

Figures 3 -5 show the fluctuations of the water level within each wetland tier over the 10-year modelling period. For reference, a breakdown of the depth of each wetland is provided in Table 4.

Table 4 Wetland depths

	Wetland 1 (m)	Wetland 2 (m)	Wetland 3 (m)
Standing Water Depth (m)	0.3	0.2	0.1
Extended detention depth (m)	0.3	0.2	0.0

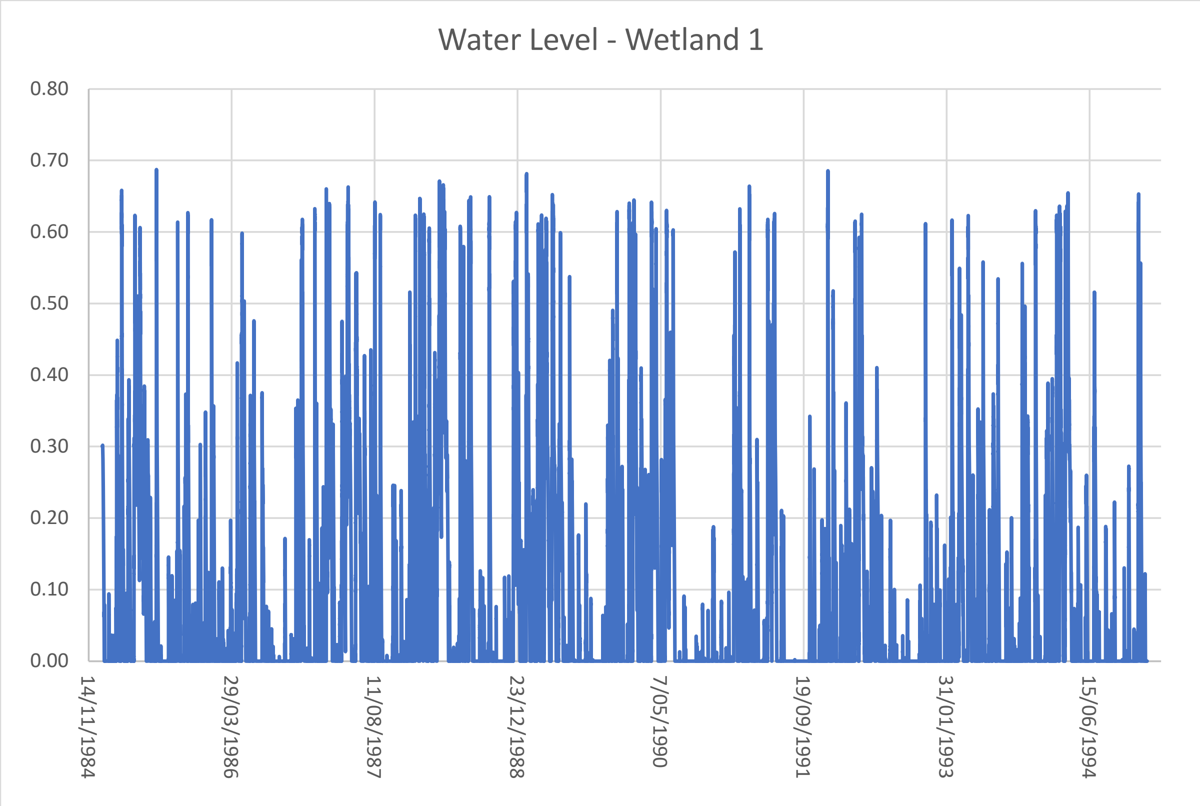

Figure 3 Modelled water level fluctuations in Wetland Cell 1 (1984-1994)

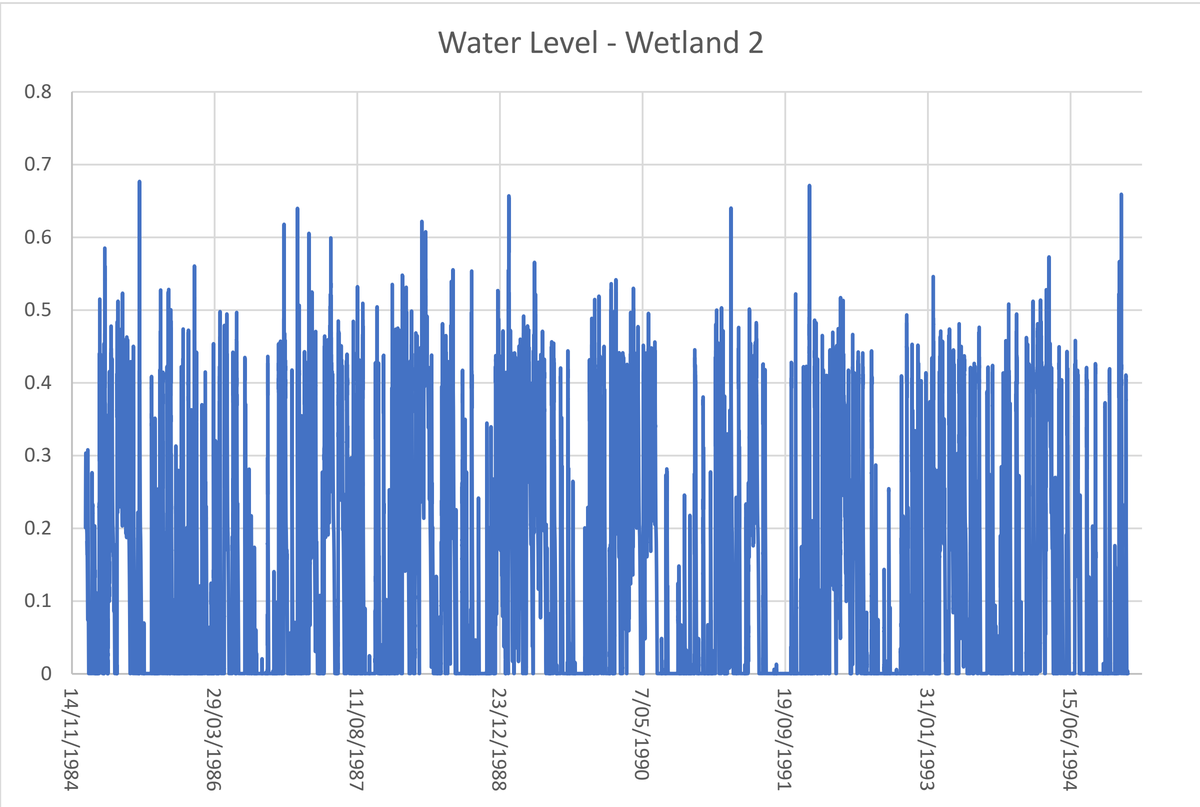

Figure 4 Modelled water level fluctuations in Wetland Cell 2 (1984-1994)

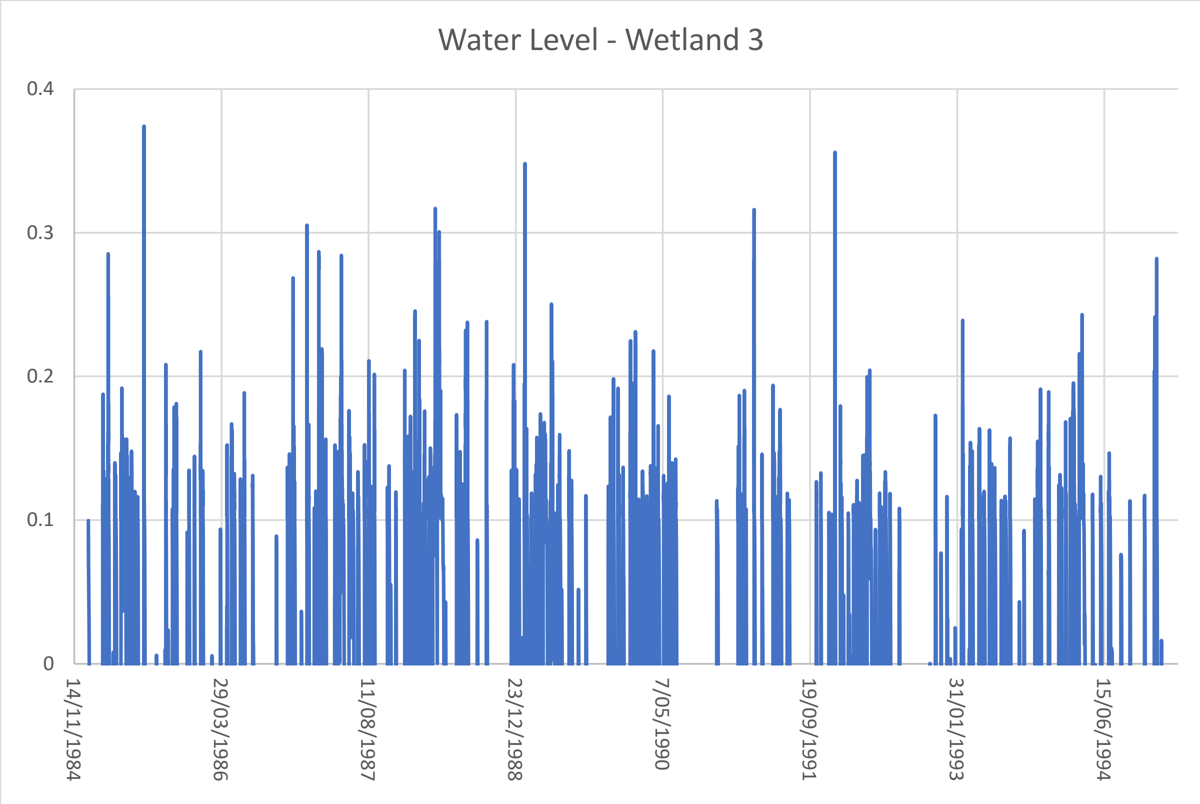

Figure 5 Modelled water level fluctuations in Wetland Cell 3 (1984-1994)

These results show that water levels will be above the wetland soil substrate in Cells 1 and 2 most of the time. This due to the design water depth in these cells being intentionally deeper to support the selected wetland plant communities within these wetlands.

Cell 3 is intended to be more ephemeral and will feature some wetland forest plantings this the weir heights and extended detention depths are set lower to provide the appropriate hydrology for these communities. Cell 3 will also have periods where there is no standing water present as would typically be seen in natural wetland systems. As discussed previously if plant stress is observed, additional water can be supplied to the wetland via recycled water irrigation.

NRAR Assessment

The following sections detail the key elements of the proposal with respect to the NRAR Guidelines. Critically these documents have been considered in the design development of the wetland

We note the following guidelines prepared by the Office of Water:

- *Guidelines for instream works on waterfront land*
- *Guidelines for laying pipes and cables in watercourses on waterfront land*
- *Guidelines for outlet structures on waterfront land*
- *Guidelines for watercourse crossings on waterfront land.*

Watercourses

As shown in Figure 1 the site features one highly modified watercourse (a constructed drain) that is fed by a piped urban network with flows entering from the north-east, east and south. This watercourse is classed as a first order stream and as such would have a riparian corridor width of 10m either side of the existing channel in accordance with NRAR requirements. The works proposed include widening and deepening of the existing channel to allow for flows to spread out through the wetland. Whilst initially removing some of the existing riparian vegetation, the proposal will involve significant planting of wetland, forest and wet heath vegetation following earthworks, in addition to weed control and remediation of the littoral rainforest. Planting plans are provided in the Detailed Design Drawings.

Structures and Treatments

A summary of the various structures and outlets are provided in Table 5. Plans showing structures and treatments at each watercourse are provided in the Detailed Design drawing set.

Where practicable outlets have been naturalised with rock work rip rap and planting in voids.

Table 5 Structures and treatments for inlets, outlets and hydraulic control structures.

Structure	Treatment
Existing inlets on Massinger Street	No works proposed, inlet to be retained
Existing inlet in the north east	Outlet structure to be constructed in accordance with *Guidelines for outlet structures on waterfront land* Outlet to include rock rip rap and planting in voids as shown in Detailed Design Drawings
Outlets between wetland cells (low flow outlet)	Outlet to include stone stacking, rock rip rap and planting in voids as shown in 1-191194_301 1-191194_DD_302, and 1-191194_DD_304).
High flow conveyance weirs	Weirs have been designed to convey high flows safely across the wetland and allow for trafficable access for maintenance. They will only operate in the medium to large size events with all smaller flows being conveyed through low flow outlets.

The Sandhills concept and project design broadly meets the specifications and guidelines provided by the Office of Water. Where structures and treatments are proposed to channel or pipe watercourses, design principles will be met and hydrological function maintained.

Groundwater impact assessment

Groundwater levels at the site were measured at the three boreholes (shown in Figure 2) from10th of January 2022 and monitoring has continued monthly until October 2022. Figure 6 displays the groundwater level at each bore in mAHD and rainfall. Elevated groundwater levels in response to rainfall events are evident in the data collected.

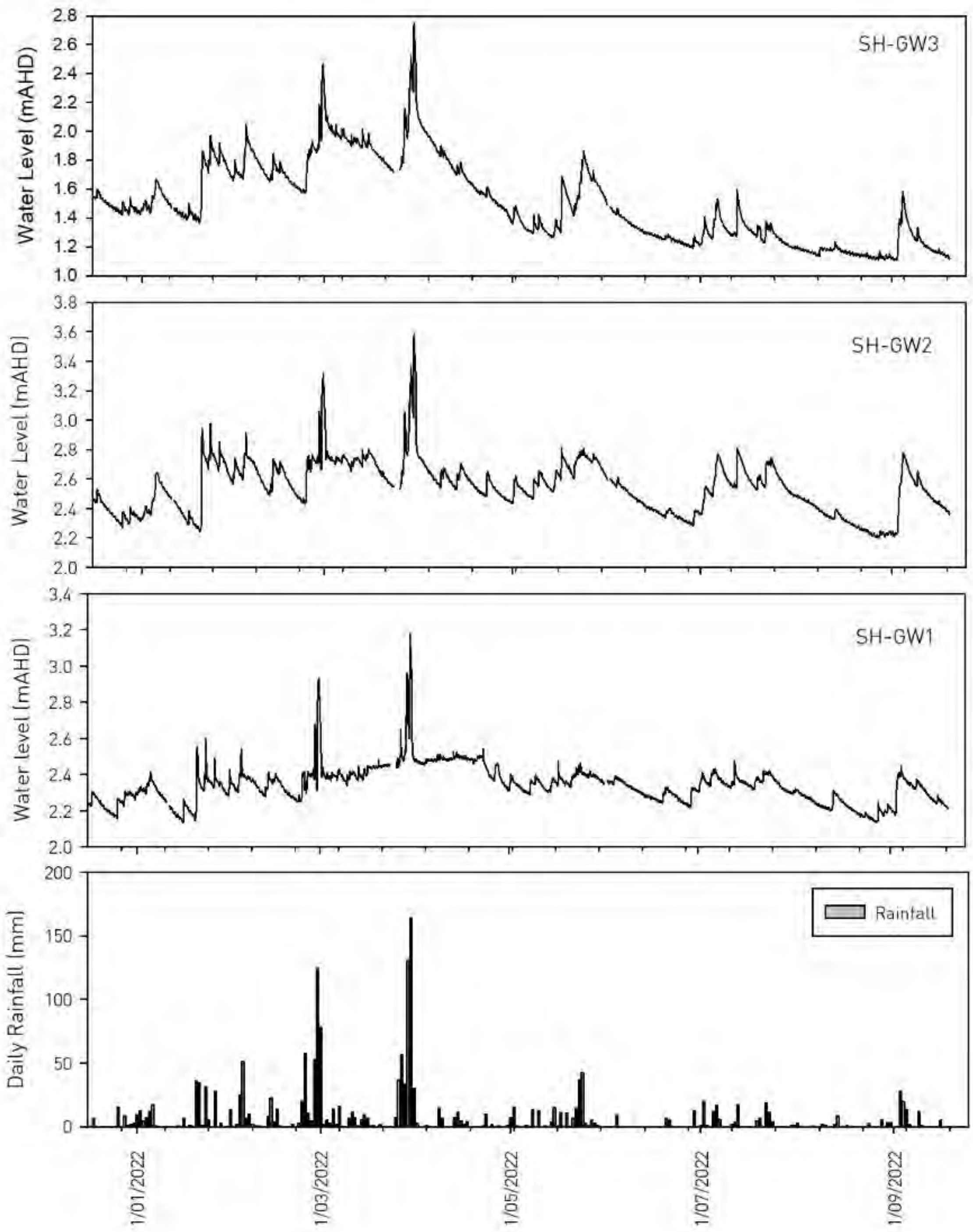

Figure 6 Groundwater monitoring data and rainfall for the Sandhill site January 2022 - October 2022.

The borehole sampled adjacent to the existing drain show the local water table is lowered around the drain as would be expected (GW3). This indicates that the existing drain acts as a control on local groundwater levels.

In addition to groundwater monitoring, a surface water level logger was installed in the vicinity of the identified frog habitat. The water level data again shows variations in water level that correlates to rainfall events plus the effect of the status of the outlet (submerged or free flowing) on site hydrology. Clearly water levels are higher throughout the waterway when the outlet at Clarkes Beach is covered by sand.

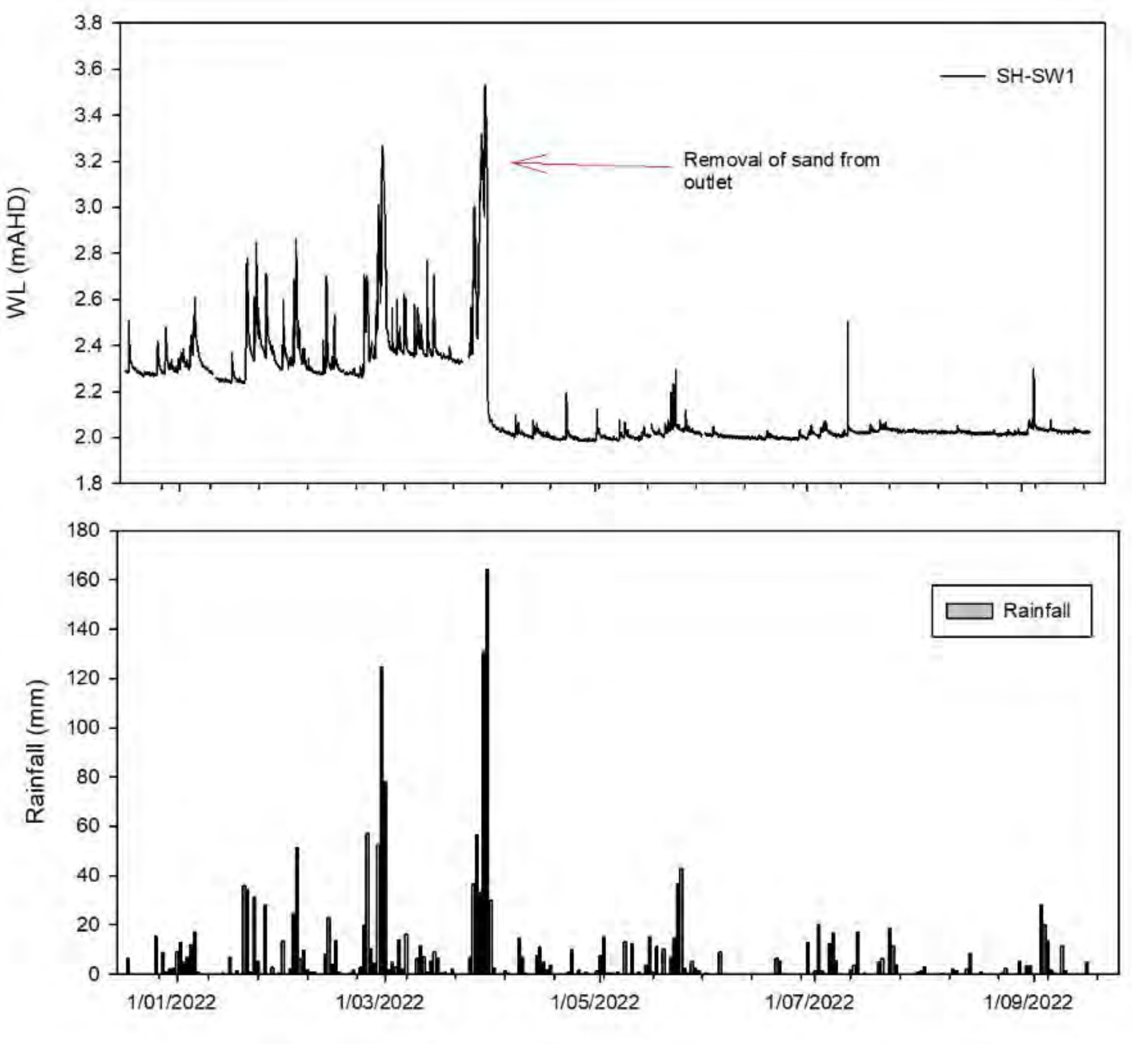

Figure 7 Surface water quality monitoring data and rainfall for the Sandhill site January 22 -October 22.

The design of the wetland and floor levels have considered the existing groundwater levels as described in the soil investigations (Table 5). Care has been taken to ensure that the wetland design floor levels are above recorded groundwater levels and above the level set by the system outlet. This has been completed to ensure that there is both storage available for flood flows and to reduce the impact on local water tables and associated groundwater dependent vegetation.

Table 6 Summary of groundwater level results from borehole log records

BH	Existing surface level (m AHD)	GW (m BGL)	GW level (m AHD)	Wetland design floor (m AHD)
1	3.3	1.5	1.5	1.8
2	4.49	2.45	2.04	2.6
3	2.75	2.0	0.75	2.6
4	2.74	1.0	1.75	2.0
5	2.68	1.5	1.18	1.8
6	2.95	1.5	1.45	1.8

Groundwater Quality

Monthly groundwater quality monitoring was initiated in January 2022. An additional two rounds of wet-weather sampling has been conducted when >25mm of rainfall is recorded during a 24-hour period. Results for groundwater quality monitoring are provided in Attachment 2.

The groundwater quality results reveal varying water quality between the sampling sites. The laboratory results indicate there are significant existing pollutant issues with elevated nutrient concentrations observed in the groundwater. This indicates that the risk to groundwater quality is minimal as the water quality is already poor. The results also indicate an influence on groundwater quality from acid sulfate soils with the SO_4/Alkalinity ratio, Al/Ca and the SO_4/Cl ratios routinely above the indicative values of 0.2, 1, and 0.5 respectively, coinciding with elevated concentrations of dissolved Aluminium and dissolved Iron.

Summary

The proposed wetlands will be unlined and will have a combined capacity of 2,535m^3 of standing water that will be engaged following rainfall. The wetland will allow runoff to be stored and infiltrate the soil layer. The proposed wetlands will have a beneficial impact on groundwater quality and quantity as stormwater will receive treatment and standing water will infiltrate the soil following treatment. The construction of the wetland cells will increase the amount the water held on the site, increasing the volume of infiltration of surface water and reduce peak discharge to Clarkes Beach.

Stormwater management systems and monitoring

The proposed wetlands form part of a larger strategy to manage stormwater in Byron Bay. Flows reaching the site and flowing to Clarkes Beach currently do not receive any treatment and as a result water discharging to the beach has poor quality. The proposed project will manage and treat stormwater flows to improve water quality and provide flood storage. An operation and maintenance plan has been prepared for the stormwater management system to ensure that the system functions optimally.

Water quality monitoring is currently undertaken on a monthly basis at the Clarkes Beach outlet by Byron Shire Council; this will continue following project construction and establishment.

Impact mitigation and monitoring

A 12 month groundwater and surface water level monitoring program has been developed to inform the wetland design. This program should be continued for a minimum of 12 months following system establishment and planting. This will allow for understanding and mitigation of impacts in the event that levels drop below the phreatophytic zone of groundwater dependent vegetation for extended periods as a result of wetland installation. In the event that groundwater levels drop below levels recorded in the monitoring data for extended periods potential mitigation through raising of water levels in the wetland cells can be investigated.

Yours sincerely,

Katrina Curran
Senior Environmental Scientist

Attachment 1 – Site Photographs

Attachment 1

Plate 1 – Sandhills waterway viewed from Cowper St

Plate 2- Massinger Street inlets Sandhills

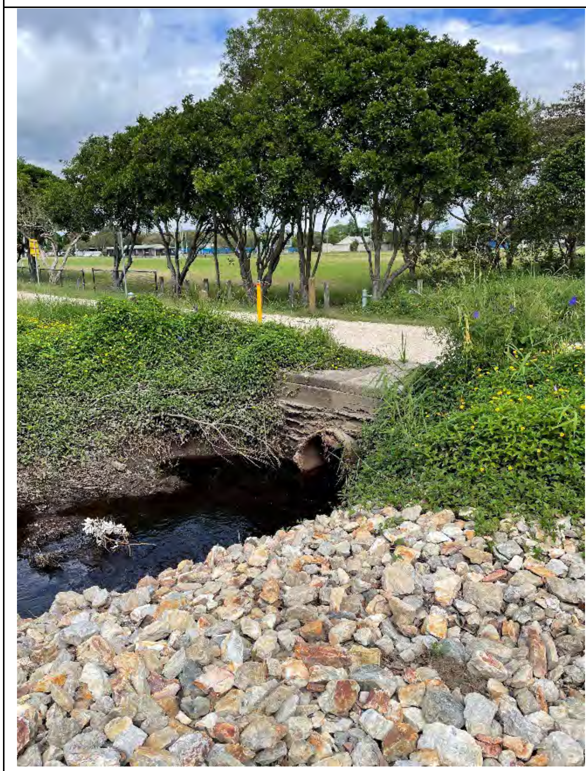

Plate 2 Sandhills waterway outlet to Clarkes Beach

Plate 3 -Clarkes beach outlet

Attachment 2 – Groundwater Quality Data

Parameter	Max	75th%ile	Ave	Median	25th%ile	Min
pH	6.10	6.01	5.95	5.95	5.86	5.79
Conductivity (EC) (dS/m)	0.54	0.45	0.42	0.42	0.41	0.28
Total Dissolved Salts (mg/L)	344.08	308.72	288.92	286.96	276.08	191.08
Total Suspended Solids (mg/L)	7120.00	5020.00	4111.44	4100.00	2963.00	1450.00
Bicarbonate (Alkalinity) (mg/L CaCO3 equivalent)	76.00	74.14	74.16	71.34	65.04	59.88
Acidity (mg/L CaCO3)	0.00	0.00	0.00	0.00	0.00	0.00
Acidity (mg/L CaCO3)	55.05	77.85	59.67	55.05	42.45	22.50
Acidity (mg/L CaCO3)	83.39	140.70	107.25	136.85	82.65	24.50
Water Hardness (mg/L CaCO3 equivalent)		89.94	81.69	85.65	71.91	55.39
Biochemical Oxygen Demand5 (mg/L O2)	6.60	4.20	3.42	2.80	2.60	2.30
Total Phosphorus (mg/L P)	4.76	2.44	2.11	2.20	1.41	0.20
Phosphate (mg/L P)		0.01	0.01	0.01	0.01	0.01
Total Nitrogen (mg/L N)	5.38	3.52	3.03	3.17	2.47	0.72
Total Kjeldahl Nitrogen (mg/L N)	5.34	3.68	3.14	3.21	2.53	0.71
NOx	0.04	0.03	0.02	0.01	0.01	0.00
Nitrate (mg/L N)		0.03	0.02	0.03	0.02	0.01
Nitrite (mg/L N)	0.03	0.01	0.01	0.01	0.01	0.01
Ammonia (mg/L N)	0.17	0.18	0.15	0.17	0.10	0.09
Sodium (mg/L)	86.02	79.03	72.91	69.25	65.83	51.62
Potassium (mg/L)		2.73	2.39	2.36	2.05	1.84
Calcium (mg/L)	18.58	15.31	13.48	13.86	11.51	8.86
Magnesium (mg/L)	13.76	12.84	11.66	11.76	10.66	8.08
Sodium Absorption Ratio (SAR)		3.67	3.50	3.50	3.25	3.02
Chloride (mg/L)	103.70	99.19	90.55	98.26	79.17	52.78
Sulfur	30.87	6.29	9.13	3.73	3.05	1.68
Sulfate (mg/L SO42-)	92.62	18.87	27.38	11.19	9.16	5.05
Chloride/Sulfate Ratio	19.51	10.73	8.74	8.58	4.19	0.68
Aluminium (mg/L)		0.20	0.19	0.16	0.14	0.12
Iron (mg/L)	0.99	0.68	0.44	0.29	0.18	0.15

Parameter	Max	75th%ile	Ave	Median	25th%ile	Min
pH	8.40	6.19	6.36	6.09	6.05	5.86
Conductivity (EC) (dS/m)	0.68	0.47	0.45	0.43	0.40	0.35
Total Dissolved Salts (mg/L)	463.08	317.56	306.45	295.12	270.64	237.32
Total Suspended Solids (mg/L)	8780.00	4950.00	4606.44	3480.00	3320.00	1475.00
Bicarbonate (Alkalinity) (mg/L CaCO3 equivalent)	233.00	103.00	89.76	62.60	54.78	34.58
Acidity (mg/L CaCO3)	0.00	0.00	0.00	0.00	0.00	0.00
Acidity (mg/L CaCO3)	23.95	26.60	21.83	23.95	17.50	0.00
Acidity (mg/L CaCO3)	50.90	75.00	52.42	50.90	33.50	0.00
Water Hardness (mg/L CaCO3 equivalent)		116.78	138.80	108.20	100.90	85.96
Biochemical Oxygen Demand5 (mg/L O2)	13.60	8.13	5.68	3.00	2.60	1.70
Total Phosphorus (mg/L P)	1.54	1.85	1.41	1.54	1.24	0.20
Phosphate (mg/L P)		0.01	0.01	0.01	0.01	0.01
Total Nitrogen (mg/L N)	5.39	3.57	5.89	3.08	2.78	1.93
Total Kjeldahl Nitrogen (mg/L N)	5.36	4.00	6.16	3.08	2.69	1.93
NOx	0.03	0.03	0.11	0.02	0.01	0.00
Nitrate (mg/L N)		0.04	0.18	0.02	0.01	0.01
Nitrite (mg/L N)	0.02	0.02	0.01	0.01	0.01	0.01
Sodium (mg/L)	94.47	61.92	60.91	56.08	54.86	51.08
Potassium (mg/L)		2.11	1.71	1.36	1.16	1.02
Calcium (mg/L)	102.72	28.53	39.64	27.60	25.15	21.00
Magnesium (mg/L)	11.62	10.12	9.67	9.54	9.25	7.96
Sodium Absorption Ratio (SAR)		2.41	2.34	2.39	2.33	1.59
Chloride (mg/L)	105.16	92.75	86.31	83.90	78.37	73.49
Sulfur	45.08	10.42	12.00	6.50	4.76	3.57
Sulfate (mg/L SO42-)	135.23	31.25	36.00	19.51	14.28	10.70
Chloride/Sulfate Ratio	7.76	7.36	4.35	3.99	2.50	0.58
Aluminium (mg/L)		0.24	0.19	0.22	0.10	0.07
Iron (mg/L)	1.69	0.24	0.35	0.19	0.15	0.07

Parameter	Max	75th%ile	Ave	Median	25th%ile	Min
pH	5.69	5.52	5.44	5.45	5.32	5.11
Conductivity (EC) (dS/m)	0.47	0.37	0.28	0.30	0.12	0.11
Total Dissolved Salts (mg/L)	316.88	251.60	188.93	201.28	82.96	74.12
Total Suspended Solids (mg/L)	23280.00	8310.00	7938.94	5408.50	4846.20	3325.00
Bicarbonate (Alkalinity) (mg/L CaCO3 equivalent)	52.00	22.74	21.01	17.97	13.46	10.60
Acidity (mg/L CaCO3)	15.70	7.79	5.21	2.58	0.00	0.00
Acidity (mg/L CaCO3)	76.30	48.35	42.61	38.35	30.97	27.10
Acidity (mg/L CaCO3)	108.00	97.86	70.85	67.00	48.96	18.75
Water Hardness (mg/L CaCO3 equivalent)	74.29	59.79	47.77	45.09	27.62	24.57
Biochemical Oxygen Demand5 (mg/L O2)	4.80	2.30	2.21	2.00	1.78	1.00
Total Phosphorus (mg/L P)	6.03	3.54	2.79	3.13	1.33	0.39
Phosphate (mg/L P)	0.08	0.01	0.02	0.01	0.01	0.01
Total Nitrogen (mg/L N)	8.79	6.28	5.01	4.54	3.63	1.93
Total Kjeldahl Nitrogen (mg/L N)	8.74	6.50	5.03	4.51	3.47	1.93
NOx	0.18	0.06	0.06	0.05	0.02	0.01
Nitrate (mg/L N)	0.16	0.07	0.07	0.05	0.04	0.03
Nitrite (mg/L N)	0.03	0.03	0.02	0.02	0.02	0.01
Ammonia (mg/L N)	0.28	0.10	0.09	0.07	0.02	0.01
Sodium (mg/L)	64.78	64.15	46.47	53.04	22.20	20.05
Potassium (mg/L)	2.37	0.91	0.85	0.63	0.32	0.28
Calcium (mg/L)	8.30	7.00	5.15	4.57	3.31	2.20
Magnesium (mg/L)	13.48	10.52	8.48	8.18	4.74	4.57
Sodium Absorption Ratio (SAR)	3.61	3.37	2.86	3.29	1.91	1.65
Chloride (mg/L)	80.77	62.53	47.75	51.73	27.80	12.13
Sulfur	43.34	18.13	18.18	16.02	13.48	4.25
Sulfate (mg/L SO42-)	130.03	54.40	54.54	48.05	40.43	12.75
Chloride/Sulfate Ratio	2.02	1.25	1.13	1.09	0.87	0.52
Aluminium (mg/L)	2.89	1.08	1.01	0.73	0.62	0.49
Iron (mg/L)	2.44	1.46	1.06	0.93	0.48	0.16