



# FRIENDS OF NEW BRIGHTON MARINE LAKE

## Baseline Assessment and Rehabilitation Strategy



19th November 2024  
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# 1 INTRODUCTION

Laguna Science Ltd was commissioned by the Friends of New Brighton Marine Lake to undertake a baseline assessment of New Brighton Marine Lake (NBML).

The purpose of this assessment was to determine the current chemical and biological status of the marine waterbody with a view to developing a long-term rehabilitation and management strategy. The primary objective of the strategy will be to improve the water quality, ecological status and visual appearance of that the lake such that it provides a safe and attractive amenity on the New Brighton waterfront for recreational bathing and other water-based activities.

## 2 BACKGROUND

New Brighton Marine Lake was constructed around 1934 and has become a focal landscape feature of New Brighton waterfront. In recent years, the lake has displayed a range of management issues in terms of its water quality status and visual appearance. These management issues have included the presence of persistent phytoplankton (algae) blooms and low water transparency (including the development of potential harmful blue-green algae), accumulations of litter, and the generation of odour during the summer months.

The lake has become popular with recreational swimmers and is also informally used by day visitors particularly during the summer months, although the waterbody has no formal designation as a bathing water. The site was previously operated for recreational water sports and activities by 'Wildshore' and following their departure, routine maintenance has been voluntarily adopted by the local swimming groups. The regular swimmers have now formed an organisation called the 'Friends of New Brighton Marine Lake' whose primary objective is to improve the appearance, water quality and ecological functioning of the marine lake to provide a safe recreational open water swimming venue. The group is currently in negotiations with Wirral Council to develop an agreed Memorandum of Understanding in respect of future maintenance and management of the lake and its use for swimming.

## 3 ASSESSMENT METHODOLOGY

### 3.1 Assessment Approach

Baseline assessments of waterbodies are usually scheduled to be undertaken in the mid to late summer period when water temperatures are highest, biological activity peaks and the worst-case water quality conditions are normally likely to be displayed. The baseline assessment of NBML was undertaken on the 22<sup>nd</sup> August 2024. For the assessment and the site visit the following work was undertaken:

- Consultations with Wirral Council and United Utilities on the availability of plans on surface, combined sewer and foul drainage infrastructure in the vicinity of the lake to ascertain any connectivity between the waterbody and these systems;
- Visual appraisal of the marine lake to record observations on the visual quality of the lake, its physical features (i.e inflows and outflow), a visual inspection of water quality and ecological features, together with visible signs of management issues.
- Measurement of water and silt depths across the lake area by ranging pole;
- Collection of a surface water sample from the lake and tidal inflow for analyses of *E.coli* and Intestinal *enterococcus* to assess its status in relation to recreational bathing.
- Collection of surface water samples from the lake and inflow for an overview of the chemical water quality status of the marine lake;
- Collection of surface water samples for phytoplankton (algae) analysis to determine species composition and abundance and to determine if any potentially harmful species were present.
- Measurement of water transparency by Secchi disc; and
- *In-situ* measurement of dissolved oxygen, temperature and salinity profiles.

#### 3.1.1 Visual Appraisal

A visual assessment was undertaken during the visit to make notes on weather conditions and any gross visible indications of management or water quality issues. This included visible presence of foam, oils, other pollution, litter and debris, any indications of gas generation from sediments or odour being generated, the colour of the water and presence of algae blooms (represented either by water discolouration / turbidity or floating algal mats). Other observations on the overall physical and ecological features of the waterbody were recorded. A series of photographs were taken during the visit to record key features.

#### 3.1.2 Water and Sediment Depth Assessment

Water and sediment depth surveys were undertaken by boat across the entire marine lake area. The purpose of the survey was to establish retained water depths and sediment depths within the waterbody. This information is important in examining how the waterbody functions, its suitability for recreation activities, provides important information for the design of any aeration / mixing system and determines the degree of lake siltation. Measurements were recorded by ranging pole along a series of transects spaced at 25m intervals in a north to south direction across the lake. Measurements of water depth and sediment depth were recorded by ranging pole at 10m intervals along each transect line (see Figure 1).

Measurement of water depth was made by lowering the ranging pole until contact with the sediment surface / lakebed was made. The ranging pole was then gently pushed into the substrate until firm resistance was met and this was used to approximate the sediment depth at each location. It should be noted that at the time of the survey the surface water level in the marine lake was 25cm above normal level (defined as the lower level of the inflow pipes along the northern wall) due to tidal impoundment. Therefore, 25cm was subtracted from all water depth measurements to provide approximation of the normal water depths within the lake.

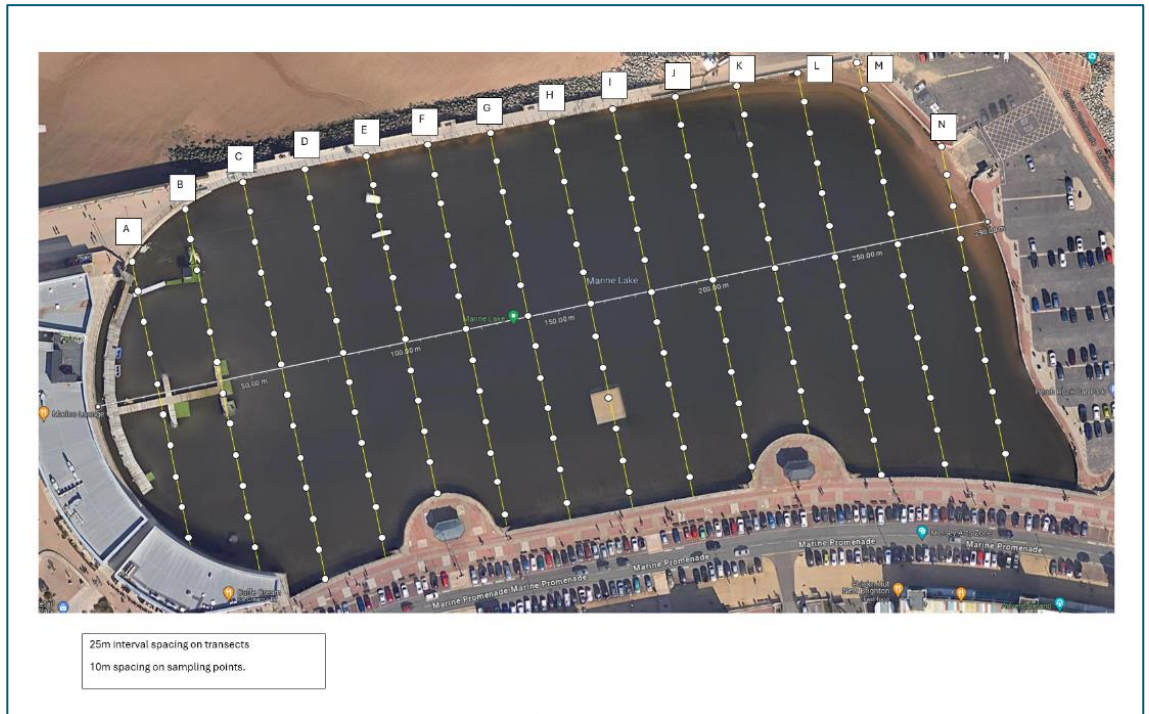


Figure 1: Locations of Water and Sediment Survey Transects and Sampling points.

### 3.1.3 Water Sample Collection and Analysis

A series of surface water samples were collected at the sampling locations shown in Figure 2

Microbiology water samples were tested for *E.coli* and Intestinal *enterococcus* which are the key indicator bacteria used to assess bathing water quality. The samples were submitted to the laboratory with a request for three ranges of dilutions to provide actual colony counts rather than greater or less than reported values.

Collected water samples were analysed for the following range of chemical determinands which are used to assess the overall general water chemistry status:

pH, Biochemical Oxygen Demand (BOD), Total Suspended Solids, Ammoniacal nitrogen, Free ammonia, Chloride, Salinity, Nitrite, Nitrate, Total Oxidised Nitrogen, Total Inorganic Nitrogen, Orthophosphate, Total Phosphorus, Dissolved Inorganic Carbon, and Dissolved Copper.

The following samples were collected:

- 4(no.) surface water samples for bathing water microbiological analysis.
- 2(no) surface water samples for chemical analysis;
- 1(no) inflow sample for microbiological analysis.; and
- 1` (no) inflow sample for chemical analysis.



**Figure 2: Locations of Water Quality Monitoring Stations**

At each sampling location a clean bucket was washed out with lake water several times prior to the collection of the sample. A clean jug was then used sub-sample the water in the bucket to fill the pre-labelled sample bottles supplied by the testing laboratories. Some samples for chemical analysis required pre-filtering on site that was undertaken using disposable syringes and filters. The sampling visit was scheduled to coincide with a period of high tides (greater than 9m height at high water at Liverpool) which allowed inflow water samples to be collected from the entry of sea water through the pipes along the north wall of the lake. These samples were collected using a clean stainless-steel bailer on a pole lowered into the inflowing water.

All collected water samples were immediately placed in a cool box with ice-packs. The samples were delivered to UKAS accredited testing laboratories on the afternoon of the same day and well within the sample stability period for requested testing.

### 3.1.4 Phytoplankton Samples

Algae samples were collected as there are certain types, such as cyanobacteria (blue-green algae) and marine dinoflagellates (red tide algae), that can present a potential risk to human health when present at high densities under bloom conditions.

2(no) 250ml bottle phytoplankton (algae) samples were collected from the locations shown in Figure 2. The collected samples were fixed and stained immediately following collection using acidified Lugol's Iodine and delivered to the testing laboratory on the same afternoon.

Analysis of the sample was carried out using a light microscope and a Sedgewick-Rafter counting cell for numeration. Algal cells were numerated from a volume of the homogenised sample totalling 1/20th ml to examine species composition and provide estimates of cell density by species.

### 3.1.5 Secchi Disc Measurements

A Secchi disc is routinely used in water quality studies as a simple method of assessing water transparency. To record the Secchi disc extinction depth, a weighted 20cm black and white quadrant disc is lowered from the surface down through the water column until it reaches the point where it is just no longer visible. If the disc disappears at a shallow depth, then this is indicative of turbid water conditions that may result from factors such as elevated suspended solids concentrations or a high abundance of phytoplankton algae. Secchi disc depth measurements were recorded at 10(no) random locations across the lake to provide a mean and range of values.

### 3.1.6 *In-situ* Water Quality Profiling

The measurement of surface dissolved oxygen concentration, temperature and salinity of an impounded marine waterbody surface is of little value in terms of assessing water quality conditions. For example, surface dissolved oxygen concentrations can show wide daily variations and are often elevated when algae blooms are present due to daytime oxygen production from photosynthesis. In addition, the majority of low oxygen concentrations problems tend to occur towards the lake bed due to bacterial oxygen demand in the sediments or the lower water column created through the decomposition of expired and settled marine biota. Therefore, it is more useful to measure the temperature and dissolved oxygen concentrations through the water column and in deepest areas of the waterbody. The measurement of salinity through the water column is also a key parameter for impounded marine waterbody management. Again measurement of salinity at the surface may be misleading as freshwater inputs will tend to accumulate in the surface layers over the denser saltwater, particularly in poorly mixed systems. Many impounded marine systems, such as NBML, tend to display an increasing range of water quality management issues as they become more brackish.

Dissolved oxygen, temperature and salinity profiles were measured at 3(no) monitoring locations as shown in Figure 2. Measurements were recorded at 0.3m depth intervals through the water column using a Hach handheld field meter with an LDO probe for oxygen and a separate probe for conductivity / salinity. Prior to measurements being recorded, the meter was calibrated for dissolved oxygen using the manufacturer's recommended 100% air saturation method and calibrated for salinity using a standard conductivity solution. Measurements were recorded from the surface to a depth of 2.1 m just above the lake bed and sediments.

## 4 RESULTS

### 4.1 Consultations

Consultations were held with Wirral Council and United Utilities to determine if plans were available on the local drainage infrastructure and its connectivity to inflows and the main outflow from NBML. Wirral Council indicated that they held no drainage plans relating to the lake.

Further enquiry was made with United Utilities who confirmed that they are responsible for sewerage infrastructure in the vicinity of the marine lake, including combined foul/surface water sewers running through Kings Parade. They further confirmed that they do not own or maintain any surface water drainage infrastructure connected to the marine lake and as such this surface water network is not mapped on their systems.

Through further consultations it is understood that a plan does exist which shows surface drainage connections and a copy of this is held by Wildshore. Enquiries are still ongoing to try and obtain a copy of this plan.

A further enquiry has also been made to the current management company for Marine Point but as yet no plan has been located or provided.

Given the above, the source of water that discharges through the two flap valves at the western end of the lake is currently unknown but is assumed to be surface drainage associated with some hardstanding areas on the Marine Point development. In addition, where the main outflow structure, in the south-west corner of the lake, discharges to is also unknown.

If further information becomes available in the near future, then this may be incorporated into the final version of this report.

### 4.2 Visual Appraisal

New Brighton Marine Lake (NGR SJ 30832 94331) is an impounded marine water body that was constructed around 1934 and forms a focal landscape feature of the New Brighton waterfront. The lake was formed with a combination of sandstone block walls and a piled concrete impounding dam wall along its northern bank. A boulder sea defence provides seaward protection of the impounding wall (see Photograph 1).



**Photograph 1: Boulder Sea Defences along the Northern Impounding Wall.**

At the eastern end of the lake is the Marine Point development, to the south the New Brighton waterfront and to the west, Perch Rock car park. Pedestrian access is available around the entire lake perimeter, behind railings, at the top of the lake marginal walls.

The lake covers an area of approximately 3.425 ha with a relatively uniform depth of around 2m. Accumulations of silt are relatively low within the lake (up to a depth of around 35cm), with the exception of the north bank and north-east corner of the lake where there are deposits of wind-blown sand from the adjacent beach. (See Photograph 2).



**Photograph 2: Accumulations of wind-blown sand in the north-east corner of the lake.**

A fine mesh fencing has been installed along the railings in the north-east corner as an attempt to reduce wind-blown sand inputs into the lake (see Photograph 3).



**Photograph 3: Mesh railing panels installed to reduce windblown sand inputs into the lake**

The water supply to the lake is from two keys sources which are freshwater surface drainage from the surrounding hard standing areas and saltwater inputs from a series of 19(no.) inflow pipes along the north wall. The extent of the surface water drainage catchment to the lake is currently unknown but is likely to include hardstanding perimeter footpaths to the south of lake (see Photograph 4), and surface water from areas of the Marine Point development that is thought to discharge into the lake via two large flap valved pipes located at its eastern end (see Photograph 5). The areas of the development at the western end of the lake that drain surface water and discharge it into the lake is unknown.



**Photograph 4: Hard standing pedestrian areas on southern surrounds that drain towards the lake.**



**Photograph 5: One of two drainage inflow pipes located at the western end of the lake.**

Some of the surface drainage from Perch Rock carpark also drains into the north-eastern corner of the lake via a gully drain (See Photograph 6). This drain is subject to frequent blockage by wind-blown sand causing localised surface water flooding at the northern end of the car park. It is not known if this drain incorporates an oil inceptor to remove hydrocarbon contamination from car park surface drainage, prior to discharge into the lake.



**Photograph 6: Sand blocked gully drain at the north end of Perch Rock car park.**

Seawater inputs into the lake are through a series of 19(no) pipes set into the northern dock wall. These pipes are fitted with a flap valve on the lake side (most of which have been fixed to open) (see Photograph 7). The pipes and also reported to have another internal valve, that in various states of disrepair, which have also been left open.



**Photograph 7: Open flap valve on inflow pipe on northern wall of lake.**

Problems frequently occur with blocking of the inflow pipes with debris and sediment and they are now routinely cleared by volunteers.

Impoundment of sea water occurs during high tide periods when the tide height is greater than 9m. For many years these inflow pipes were left closed which caused the lake to turn brackish with the associated water quality issues and decline in ecological diversity. At the time of the visit, water was observed to be discharging from the lake to the beach (see Photograph 8) as water levels will have been temporarily increased by seawater impoundment from the previous high tide which was greater than 9m. At high tide (9.8m at 13:47) during the visit, water was observed impounding into the lake through the majority of the northern wall pipes. This can



**Photograph 8: Water discharging from marine lake onto New Brighton beach during the visit.**

NBML also form part of the local coastal flooding protection system and is therefore subject to periodic inundation with large volumes of seawater during storm events. This can be through direct overtopping of the northern impounding wall. Waves overtopping the sea wall onto Harrison drive promenade can occur on spring tides under north or north-west gale force winds. The resultant seawater flows along the promenade towards and into north-western corner of the lake (see Photograph 9), excess water in the lake then either discharges through the outflow in the south-east corner (see Photograph 10) or via the slipway at the western side of lake, across Perch Rock carpark and back into the River Mersey. It is currently unknown where the in-lake outflow structure discharges to. The most recent such storm event prior to the monitoring visit was on the 9th April 2024.



Photograph 9: Storm driven seawater inundation of the marine lake.

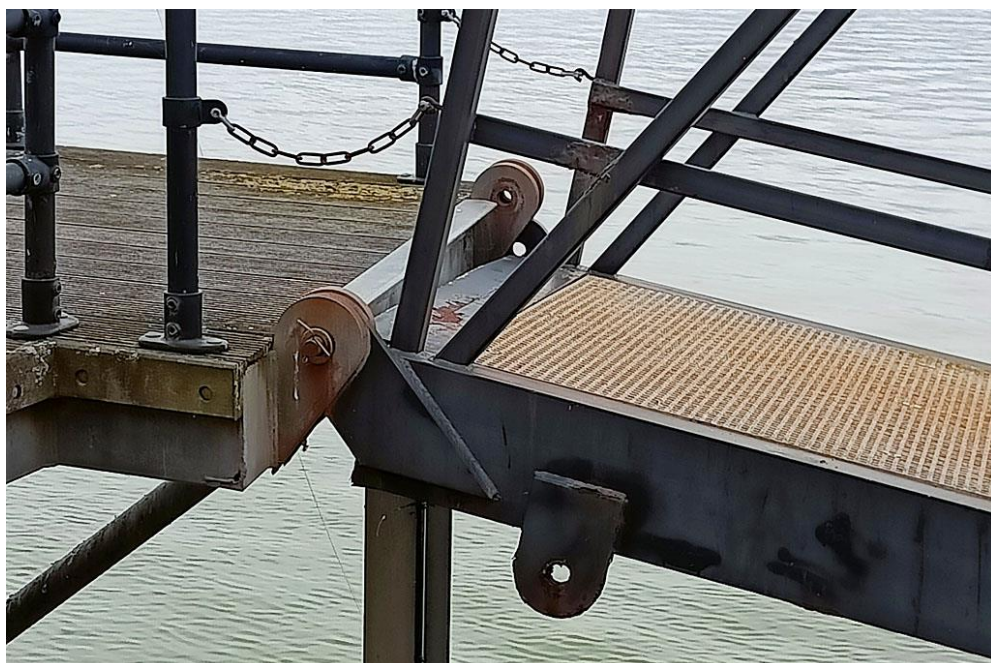


Photograph 10 overflow structure in south-east corner of the lake.

Access to the water in the marine lake is limited, given that the steps on southern bank have been sealed off, and restricted to the slipway at the eastern end and the floating pontoon structure at the western end (see Photograph 11). The pontoon is currently closed to access due to safety concerns as one of the retaining pins on the access ramp has been lost (see Photograph 12)



Photograph 11: Floating pontoon at the eastern end of the lake.



Photograph 12: Showing missing retaining pin on access ramp

At the time of the visit the visual quality of the lake was relatively low with accumulations of litter and debris (seaweed and bird feathers) along the southern and eastern lake margins under the prevailing winds. Given that the marine lake is set down below surrounding ground level, it will tend to act as a trap for wind-blown debris and litter. Litter bins are present along both the southern and eastern banks. Several life-saving rings had been removed from their holders and thrown in the lake which is a frequent problem at the site.

The red sandstone block wall that forms the southern wall of NBML showed significant terrestrial plant growth, together with hardstanding areas around the Victorian seating shelters. This weed growth reduced the overall visual quality of the site and gives the visual appearance of a general lack of maintenance (see Photograph 13). The plant growth along the southern wall is likely to further compromise the integrity of any mortar between the sandstone blocks with time.



**Photograph 13: Weed growth along the southern blockwork wall.**

There was no detectable odour from the lake at the time of the visit which is usually associated with low oxygen concentrations. Water within the lake was green and had a low transparency due to the presence of a phytoplankton (algae) bloom and suspended solids. Small quantities of filamentous algae were also noted to be growing in areas around the lake wall. There were no visible signs of gross pollution in the lake such as hydrocarbon films or unnatural foams. There was no visual evidence of sessile marine fauna (i.e. mussels, sea squirts, sponges or anemones) on the marginal walls of the lake. This lack of marine fauna is likely to be due to historically low salinity concentrations preventing a stable and diverse marine fauna from developing.

There were no gulls or other birds on the lake water at the time of the visit but the pontoon at the western end of the lake was being used as a high tide roost but around 100 Turnstone.

### 4.3 Water and Sediment Depth Survey

The surveyed transect profiles of water depth and sediment depth are presented in Appendix A. Water depth within the lake was found to be relatively uniform and shallow across the entire lake area. The average recorded water depth (based on a water level at the bottom of the inflow pipes which is the main route of lake discharge) was 1.78m and the maximum depth 2.25m. A substantial area of the lake area has a water depth of around 2m. There is some shallowing of the lake at its eastern end and along its northern bank which appears to be mainly from deposition of wind-blown sand into the lake from the adjacent beach to the north and some settlement of sediment impounded through the inflow pipes. From the water depth data, a contour map has been produced which is presented in Figure 3.



**Figure 3: Contour plot of Water Depths**

Sediment accumulations within the lake were found to be low and unevenly distributed across the lake with a maximum recorded depth of 30cms, which is not significant in relation to the retained water depth.

The main sources of sediment inputs into the lake are likely to be:

- Wind-blown sand from the beach area adjacent to the north side of the lake;
- Settlement of suspended solids from impounded seawater; and
- Settlement of suspended solids from periodic inundation of the lake with coastal floodwater.

A sample of sediment was collected for visual inspection from the lake-bed using a benthic grab sampler.. The sediment recovered was a brown-black clay/ sandy silt with finely divided organic material and was odorous with hydrogen sulphide (see Photograph 14). These features of sediment are indicative of the development of low oxygen (anoxic) conditions. The presence of anoxic sediments has implications towards water chemistry as they readily the mobilise of nutrients used for plant growth (algae), contributing to algae blooms, and release pollutants (i.e metals) from the sediment into the overlying water.



Photograph 14: Anoxic sediment sample collected from the lake-bed

## 4.4 Water Quality Results

### 4.4.1 Microbiology

The standards for the microbiological quality for coastal and transition bathing waters, set out in the EC Bathing Water Directive (2006/7/EC), which are transposed into UK legislation through the Bathing Water Regulations 2013, are presented in Table 1.

**Table 1: Microbiology Bathing Water Standards for Coastal and Transitional Waters**

Parameter	Excellent Quality	Good Quality	Sufficient Quality
Intestinal enterococci (cfu/100ml)	100 <sup>1</sup>	200 <sup>1</sup>	185 <sup>2</sup>
Escherichia coli (cfu/100ml)	250 <sup>1</sup>	500 <sup>1</sup>	500 <sup>2</sup>

<sup>1</sup> Based on 95<sup>th</sup> percentile evaluation

<sup>2</sup> Based on 90<sup>th</sup> percentile evaluation

cfu = colony forming units.

The sampling frequency requirements of the Bathing Water Directive is that a waterbody is subject to:

- one pre-bathing season sample.
- the interval between sampling dates should never exceed 35 days, provided that the next sampling is done according to the monitoring calendar.
- the yearly number of samples in the previous years should be four or three if bathing season does not exceed eight weeks or the region is subject to special geographical constraints.
- the number of samples for the assessment period should be at least 16 or 12 if season duration is less than eight weeks or the region is subject to special geographical constraints.

Assessing bathing water quality under Directive 2006/7/EC requires a data set of four consecutive years. In the UK, the bathing water season is defined as being from the 15<sup>th</sup> May through to the end of September. Therefore, the results from a single sampling visit should only be viewed as an indicative ‘snap-shot’ of conditions at the time of sampling with the concentration values presented in Table 1 being adopted as indicative threshold values. It should be noted that the EC Bathing Water Directive makes no distinction to the sources of intestinal enterococcus contamination. Intestinal enterococcus are a feature of bird droppings, such as gulls, although avian forms of the bacteria tend to present a very low risk to human health. So where large numbers of birds are present elevated concentrations of indicator bacteria may be recorded in samples although the risk to human health remains low.

Results from the laboratory testing of the collected water samples are presented in Table 2.

**Table 2: Analytical Results for Collected Water Samples**

Sampling Site	<i>E.coli</i> cfu / 100ml	Intestinal <i>enterococcus</i> cfu / 100ml
Site 1 (WS1)	170	18
Site 2 (WS2)	210	2
Site 3 (WS3)	180	15
Site 4 (WS4)	270	14
Site 5 (WS Inflow)	470	14

Notes for Table 2:

cfu = colony forming unit.

All results as presumptive colonies

To assess the results in terms of the bathing water quality there is a requirement to undertake some analysis of the data for comparison with the threshold values shown in Table 1. This analysis is presented in Tables 3 and 4.

**Table 3: Analysis of Intestinal *enterococcus* Data**

Date	Site 1	Site 2	Site 3	Site 4	Site 5 Inflow	Mean	Stand dev	90 percentile	95 percentile	Excellent classification	Good classification	Sufficient classification
22/08/2024	18	2	15	14	14							
Log <sub>10</sub> values	1.26	0.30	1.18	1.15	1.15	1.00	0.40	32.6	45.5	100*	200*	185**

**Table 4: Analysis of *E.coli* Data**

Date	Site 1	Site 2	Site 3	Site 4	Site 5 Inflow	Mean	Stand dev	90 percentile	95 percentile	Excellent classification	Good classification	Sufficient classification
22/08/2024	170	210	180	270	470							
Log <sub>10</sub> values	2.23	2.32	2.26	2.43	2.67	2.38	0.18	409.9	477.3	250*	500*	500**

Notes for Tables 3 and 4:

- \* Based upon a 95-percentile evaluation - see Bathing Water Regulations 2013, Schedule 5 para 2.
- \*\* Based upon a 90-percentile evaluation - see Bathing Water Regulations 2013, Schedule 5 para 2.

1 In order for log values to be taken and according to the guidance in the Bathing Water Regulations 2013 zero data values were replaced with the minimum detection limit i.e. 1.

Failure relative to the Bathing Water Regulations 2013.

The key points to note from the data present in Tables 2 -4 are:

The Microbiological bathing water quality at the time of sampling was of excellent status for intestinal *enterococcus* and just achieved good status for *E.coli*. The inflow results were included in the calculation as water was impounding into the lake at the time of sampling.

It should be noted that the inflow water into the lake displayed a higher concentration of *E.coli* at 470 cfu/100ml than with the lake which had concentrations ranging from 170 to 270 cfu/100ml. Therefore the impounding seawater at the time of the visit, will have been negatively impacting the microbiological status for *E.coli* in the marine lake and therefore the overall bathing water quality status of the waterbody. It is likely that the inflowing seawater, during high tides greater than 9m height, is likely to be highly variable in its microbiological quality status and dependent to a degree on operation of wastewater discharges within the tidal River Mersey.

## 4.5 Chemical Water Quality Status

The results of the analysis of collected chemical samples are presented in Table 5.

The environmental quality standards for assessing estuarine and marine waters are set out in the Water Framework Directive (WFD) Directions (2015). The quality standards for marine waters are mainly directed towards hazardous and toxic substances. Standards are set out for dissolved oxygen concentrations and inorganic dissolved nitrogen concentrations over the winter period (1<sup>st</sup> November -28<sup>th</sup> February) as a measure of the degree of nutrient enrichment. Nitrogen tends to be the limiting nutrient for algae growth in marine systems and when available in excessive concentrations can contribute to the development of algal blooms.

All the standards set out in the WFD Directions (2015) are based on a series of samples collected at monthly interval over a 12 month period against and are based on average or percentile values calculated from the time series dataset. Therefore, it is difficult to compare these WFD environmental quality standards to results from a single sampling visit. As such, the data presented in Table 5 can only be used as a general guide of water chemistry at the time of the visit.

**Table 5: Chemical Analytical Data for Collected Water Samples**

Parameter	Units	Limit of Detection	WS1 (Sampling Site 1)	WS2 (Sampling Site 4)	WS Inflow (Sampling Site 5)
pH	pH	0.01	8.74	8.83	8.38
Biochemical Oxygen Demand (BOD) 5 day settled	mg/l	1	4	6	3
Total Suspended Solids	mg/l	10	122	101	171
Ammoniacal nitrogen as N	mg/l	0.05	0.61	0.64	0.59
Ammonia (Free unionised) as NH <sub>3</sub> at 25C	mg/l	0.000036	0.16	0.20	0.09
Chloride	mg/l	1	16400	16500	17700
Salinity as NaCl	g/l	0.0016	28.9	29.2	31.2
Nitrite	mg/l	0.1	<0.1	<0.1	<0.1
Nitrate	mg/l	0.1	<0.1	<0.1	<0.1
Nitrogen Total Oxidised (TOxN)	mg/l	0.1	<0.1	<0.1	<0.1
Nitrogen, Total Inorganic	mg/l	0.1	0.6	0.6	0.6
Phosphate (orthophosphate) as PO <sub>4</sub>	mg/l	0.02	0.03	<0.02	<0.02
Phosphorus, Total (Dissolved)	µg/l	20	28	<20	26
Dissolved Organic Carbon	mg/l	2	11.9	11.4	5.9
Copper (dissolved)	µg/l	4	<80	<80	<80

The following are points of note within the chemical analytical data presented in Table 5:

1. pH was in the normal expected range for sea water i.e slightly alkaline (pH greater than 7). Slightly higher pH values were recorded in the marine lake samples than the inflow water sample and this is likely to have resulted from the daytime photosynthetic activities of the algae bloom (green water) in the lake which causes an increase in alkalinity.
2. BOD is a measure of oxygen used by microbial organisms as they break down organic matter. This was recorded to be low both within the lake and the inflow. The higher values shown in the lake are likely to be the result of breakdown of expired algae cells and other marine fauna.
3. Suspended solids concentrations in both the lake and the inflow were relatively high and would classify the waters as turbid in accordance with the WFD definition.
4. Ammonia values were found to be elevated both within the lake and the inflow. It is unionised ammonia (NH<sub>3</sub>) that is toxic to aquatic life and not the ammonium ion (NH<sub>4</sub>). Within the WFD Directions the long-term average environmental quality standard for saltwater is set at 0.021mg/l. The results recorded exceeded this significantly. Elevated concentrations within the inflow water are likely to be associated with wastewater discharges into the Mersey Estuary. The higher concentrations recorded in the lake are likely to be a function of decomposition processes i.e the breakdown of organic material and expired algae.
5. Salinity in the lake and inflow were both recorded to be slightly brackish compared to fully saline seawater being around 34-35 g/l. This is not unexpected given the proximity of the NBML to the Mersey estuary, in addition to freshwater surface drainage inputs into the lake.
6. Total inorganic nitrogen was found to be relatively high but needs to be considered in the context that nitrogen enrichment has been a historical and

ongoing issue with the Mersey catchment due to industrial and wastewater effluent discharges. Nitrogen tends to be the limiting nutrient for algae growth in marine systems and elevated concentrations may encourage the development of algae blooms, particularly in impounded systems.

7. Phosphorus concentrations were recorded to be relatively low in both the lake and the inflow.
8. Dissolved organic carbon was found to be around the typical average seawater concentration in the inflow sample at around 5-6 mg/l but elevated within the marine lake with concentrations of 11.4 and 11.9mg/l. The elevated concentrations in the marine lake are likely to result from the persistent algal bloom conditions displayed by the lake.

Overall, the chemical quality of the inflow and lake were relatively good. A range of elevated parameters were recorded in the marine lake including suspended solids, ammonia, inorganic nitrogen and dissolved organic carbon. These results are not unexpected given the lake proximity to the mouth of the Mersey estuary and the various inputs it receives in its catchment, together with the persistent algal bloom conditions (green water) displayed by the lake under nutrient enriched conditions.

## 4.6 Phytoplankton (Algae) Results

The green water conditions typically displayed by the marine lake are caused by the presence of phytoplankton blooms. Other algae present were represented by some filamentous marine algae around the lake margins. Results of analysis of the collected phytoplankton samples are presented in Table 6.

**Table 6: Phytoplankton Results**

Sample	Cell Density (cells / ml)	Algal Species Relative Abundance (%)
New Brighton Marine Lake 22/08/24 Algae Sample 1 Sampling Site 1	4800	<i>Chlamydomonas</i> sp. = 25% <i>Diatoma</i> sp. = 8.5% <i>Gyrodinium</i> sp. = 12.5% <i>Oscillatoria (Planktothrix)</i> sp. = 12.5% <i>Skeletonema</i> sp. = 33.5% <i>Synedra</i> sp. = 4% <i>Thalassiosira</i> sp. = 4%
New Brighton Marine Lake 22/08/24 Algae Sample 2 Sampling Site 4	3800	<i>Cocconeis</i> sp. = 5.25% <i>Mallomonas</i> sp. = 5.25% <i>Navicula</i> sp. = 5.25% <i>Oscillatoria (Planktothrix)</i> sp. = 21% <i>Rhodomonas</i> sp. = 16% <i>Skeletonema</i> sp. = 42% <i>Synedra</i> sp. = 5.25%

The algae density within the lake at the time of sampling was found to be moderately low with overall density of 3800 to 4800 cells/ml. A higher density of algae was recorded at sampling location 1 which reflected the prevailing wind direction blowing into the eastern end of the lake. Samples comprised of common estuarine and marine algae species including diatoms (*Bacillariophyceae*), Cryptomonads (*Cryptophyceae*), Dinoflagellates (*Dinophyceae*), Blue-green algae (*Cyanobacteria*) and Golden algae (*Chrysophyceae*).

There were two species of note within the samples that may present a potential risk to human health. *Gyrodinium* sp. belong to red dinoflagellates that, in higher densities, can

cause red tides. These are noticeable when they bloom, by a red / rust discolouration of the water. The red tides produced by some dinoflagellates are toxic and pose risks to marine and human life. The direct affects on humans tends to be irritation of the eyes, nose throat and lungs particularly when the algae forms an aerosol through wind and wave action. If filter feeding shellfish are present in a red tide bloom, then they accumulate the toxins and can cause serious illness if consumed including paralytic shellfish poisoning. However, the density present at the time of sampling was low and therefore unlikely to pose a significant risk to health during bathing or to site visitors.

It should also be noted that *Oscillatoria* sp. (now known as *Planktothrix*) are members of the Blue-green algae (Cyanobacteria) was recorded in the samples. Other blue-green algae species have been noted to be present in the lake in previous samples. Cyanobacteria can present health issues particularly when present at high densities or start forming surface scums which concentrate the toxicity. The WHO (1999) established guidelines for blue-green algae in freshwater recreational freshwater, which may be applied as guidelines for the marine lake. These guidelines are presented in Table 7.

Table 7 : WHO Guidelines for Blue-green algae in Recreational Waters

Guidance level or situation	How guidance level derived	Health risks	Typical actions
<b>Relatively low probability of adverse health effects</b> 20 000 cyanobacterial cells/ml <i>or</i> 10 ug chlorophyll-a/litre with dominance of cyanobacteria	From human bathing epidemiological study	Short-term adverse health outcomes, e.g., skin irritations, gastrointestinal illness	Post on-site risk advisory signs Inform relevant authorities
<b>Moderate probability of adverse health effects</b> 100 000 cyanobacterial cells/ml <i>or</i> 50 ug chlorophyll-a/litre with dominance, of cyanobacteria	From provisional drinking-water guideline value for microcystin-LR and data concerning other cyanotoxins	Potential for long-term illness with some cyanobacterial species health outcomes, e.g., skin irritations, gastrointestinal illness	Watch for scums or conditions conducive to scums and further investigate hazard Post on-site risk advisory signs Inform relevant authorities
<b>High probability of adverse health effects</b> Cyanobacterial scum formation in areas where whole-body contact and/or risk of ingestion/aspiration occur.	Inference from oral animal lethal poisoning. Actual human illness case histories	Potential for acute poisoning Potential for long-term illness with cyanobacterial species Short-term adverse activities health outcomes, e.g., skin irritations, gastrointestinal illness	Immediate action to control contact with scums; possible prohibition of swimming and other water contact activities Public health follow-up investigation Inform public and relevant authorities

Many blue-green algae species do not thrive in marine conditions but can develop where systems become brackish or there is a freshwater surface layer present in poorly mixed waterbodies. A dense bloom developed on the lake in 2021 requiring closure of the lake to amenity and this is likely to have resulted due to the low salinity brackish conditions that were a feature of the lake at the time.

*Oscillatoria* sp. is one species of cyanobacteria that can thrive in marine conditions and although some species do produce toxins it is not a species that typically develops scums which pose the highest potential health risk for contact water activities and animals.

*Oscillatoria* can produce a range of toxins including microcystins, anatoxins and aplysiatoxins, which can cause allergic or irritative skin reactions in people. However low numbers of cells were observed in the collected samples therefore the health risks at the time sampling of sampling are likely to have been very low.

It should be noted that algae communities can show large seasonal shifts in composition and density. Gross changes in the colour of the water, such as it going rusty red, or the appearance of floating algal scums (with the appearance of spilt paint) around the margins should be indications that potentially harmful algae blooms are developing within the lake that would warrant further investigation.

The persistent algal blooms conditions (green water) displayed by the lake are likely to result from a combination of nutrient enrichment, shallow water depths and an absence of sessile filter feeding marine organisms that reduce algae density. The absence of filter feeding organisms was confirmed by scrapes of the walls with a sampling net which showed none to be present. The lack of filter feeding animals, such as mussels (bivalve molluscs) and Sea Squirts (Ascidians) is likely due to historically low salinity conditions within the lake being unsuitable for populations of these to establish.

## 4.7 Secchi Disc Measurements

Secchi disc measurements are a simple standardised method of measuring water transparency. The average depth recorded in the lake during the site visit was 0.357m with a range of 0.34 to 0.37m. This is a low transparency and results from a combination of the elevated suspended solid concentrations and algal bloom (green water) conditions.

Within the current EC Bathing Water Directive and associated UK Bathing Water Regulations (2013), there are no standards set for water transparency. The former version of the EC Bathing Water Directive (76/160/EEC) included both guidance and mandatory Secchi disc depths for water transparency of 1.0m and 0.5m respectively. The transparency in the marine lake at the time of the visit was below the former mandatory value of 0.5m.

The low transparency of water and persistent green discolouration of the marine lake is likely to visually impact a visitors' perceptions of the lake's water quality. Generally, the public are accustomed to seeing green water conditions in freshwater lakes, such as in urban parks, but do not tend to associate turbid, green discoloured waters with marine settings.

## 4.8 *In-Situ* Water Quality Profiling

The water quality profiling data recorded are presented graphically in Appendix B for dissolved oxygen, temperature and salinity. It should be noted that the dissolved oxygen measurements have been presented for both mg/l concentrations and as % saturation to aid discussion.

### 4.8.1 Dissolved Oxygen

Standards are set under the Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015 for dissolved oxygen concentrations in coastal and transitional waters (see Table 7). These standards classify a waterbody as being of High,

Good, Moderate or Poor ecological status in relation to its dissolved oxygen concentrations. However, NBML does not classify as a defined WFD waterbody and therefore these standards are being used for guidance purposes only.

The dissolved oxygen concentration thresholds are adjusted due to the lake salinity being as it is reduced from fully saline seawater. The average salinity concentration measured, taking all points through the water column, during the visit was 29.13 psu.

**Table 6: WFD Dissolved Oxygen Standards for Transitional and Coastal Waters with Salinities of less than 35 psu**

Boundaries	Dissolved Oxygen Concentration (mg/l) boundary values as a 5th percentile
High	$7 - (0.037 \times (29.13)) = 5.92$
Good	$5 - (0.028 \times (29.13)) = 4.18$
Moderate	$3 - (0.017 \times (29.13)) = 2.50$
Poor	$2 - (0.011 \times (29.13)) = 1.67$

For comparison with these values a 5th percentile value has been calculated across all the measured profile data and combined with a mean salinity value through the water column, to provide a dissolved oxygen concentration for NBML as a whole.

**Total 5th percentile dissolved oxygen concentration = 8.68mg/l**

Taking the overall data set throughout the water column would class NBML as being of excellent ecological status at the time of the visit in respect of dissolved oxygen concentrations (i.e greater than 5.92mg/l) against the WFD standards in Table 6.

At the time of the visit, dissolved oxygen concentrations were found to be good throughout the lake and throughout the depth of the water column. The influence of phytoplankton bloom photosynthesis on increasing dissolved oxygen concentrations can also be seen from the profiles supersaturated dissolved oxygen values(i.e greater than 100% saturation) were recorded at all 3(no.) monitoring locations.

It should be considered that this is a very limited data set and dissolved oxygen concentrations in the marine were raised by the daytime photosynthetic activities of phytoplankton (algae) bloom present at the time of sampling. It is evident that there are likely to be periods when dissolved oxygen concentrations in the lake are low as it is noted to generate odour on occasions during the summer months. Low oxygen conditions may also occur in a lake where algal blooms are present at nighttime as algae switch from photosynthesis (producing oxygen) to respiration (using oxygen). There is also potential for algal bloom collapse causing a rapid and significant depletion of oxygen in the lake as bacteria breakdown the expired algae.

#### 4.8.2 Temperature

The temperature measured through the water column during the monitoring period had an average of 16.75°C and a maximum of 16.9°C. This is a relatively cool temperature for the time of sampling. Given the shallow water depths in the lake, it would be expected to show wider temperature fluctuations than a deeper system where the response warming and cooling effects of ambient temperatures are slower. The water temperature

was relatively uniform throughout the marine lake indicating a mixed system. There was no evidence of thermal stratification (water dividing into a stable warm surface layer and cold bed layer during the summer) which would not be expected in a waterbody of shallow water depths.

### 4.8.3 Salinity

Salinity had a mean concentration through the water column of 29.1 practical salinity units (psu) with a minimum recorded value of 29 psu and a maximum value of 29.5 psu. These values may be compared to full salinity seawater which around the UK has a salinity of around 34 - 35 psu. Therefore, the NBML is slightly brackish which is likely to have resulted from two key factors:

- Water in the lake system is impounded in proximity to the mouth of Mersey Estuary that will have variable salinity due to downstream freshwater flows.
- Rainfall inputs and surface drainage from developed surrounding areas into the lake.

For impounded marine systems it is important that salinity is maintained above 26 psu. This is lower threshold salinity concentration for successful reproduction by marine mussels and other sessile filter feeding organisms that may provide an important contribution to water quality maintenance and phytoplankton control within the lake.

Historically NBML, due to having the tidal inflow pipes closed, became increasing brackish with salinities as low as 18 psu recorded and a wide range of significant management issues, including closure of the lake due to severe cyanobacteria (blue-green) algal bloom. It is only recently that the inflow pipes have been reopened and maintained clear of debris to allow increases in salinity concentrations to develop within the lake through periodic tidal seawater inputs. Tidal flood inundation of NBML in April 2024 will also have contributed to raising salinity concentrations. However, salinity concentrations within the lake have not been at a suitably high concentrations (i.e. greater than 26 psu) for a sufficient period to allow beneficial marine ecosystem, including sessile filter feeding organisms, to establish within the waterbody.

## 5 DISCUSSION

### 5.1 Visual Appearance

New Brighton Marine Lake is a focal landscape feature of the New Brighton waterfront. The general impression by visitors of the condition and quality of the lake is normally based on its visual appearance. There are three key current features of the lake which negatively impact its overall visual appearance and therefore the visitor experience.

#### 5.1.1 Litter and Debris

The entry of litter and debris into the lake is likely to arise from several sources that include:

- Wind-blown litter from surrounding hardstanding areas;
- Entry of debris during tidal impoundment or coastal flood events; and
- Accumulations of feathers from moulting birds in the late summer period.

Given the low-lying aspect of the lake in relation to surrounding ground levels it will tend to act as a litter trap for wind-blown litter which then forms unsightly accumulations in the corners of the lake under prevailing winds. This is a common problem for impounded marine lakes and docks. The control of litter around the lake is a challenge given the number of visitors and presence of numerous take away food outlets along its southern side. Increasing the number of litter bins and their regular emptying, signage around litter and the lake or installing mesh on the lower perimeter railings will help but the waterbody is still likely to see quantities of litter accumulating on its surface. As future water quality and ecological conditions in the lake improve, an increase in water transparency may be expected that will also make any sub-surface litter even more evident.

Therefore, on-going regular litter collection from the lake surface will form part of the long-term lake maintenance strategy. To facilitate litter collection it is recommended that the volunteers have appropriate equipment available to them which is stored locally. This will include a boat, hand-nets and a short, and shallow seine net to encircle large accumulations of debris, together with facility for disposal of collected rubbish.

There is a system called 'Seabin' which is a floating device used to assist in collection of litter and debris from the water surface. These devices are effective but require a power supply to operate and with the given quantities of litter that accumulates in NBML any deployed unit would likely require very frequent emptying.

It is recommended that the Friends Group hold discussions with Wirral Council to see how they may be able to facilitate in reducing litter and its disposal in the vicinity of the lake.

Debris also enters lake during through the 19(no) inflow pipes along the north wall whilst in-lake litter also causes lakeside blockages of the pipes. The pipes are fitted with flap valves on the lake side of the pipe which are in various states of repair, and which are now held open. There are benefits in having the pipes open in that it allows any freshwater inputs accumulating towards the surface of the lake above the denser saltwater, to be discharged to the beach. However, it does make the pipes vulnerable to blockage by both debris and silt accumulations, that requires regular cleaning to be undertaken.

The deployment of removable marine grade stainless steel screening at both ends of each pipe may assist in reducing debris entry and blockages. The screen should not be fitted directly to the end of the pipe as this may exacerbate the problem and is likely to be more effective set as an enclosing mesh barrier set out from the lake wall. Effective screening can be difficult to implement in tidal situations. Installation of screening on the seaward end of the pipe will also present challenges and will require some rearrangement of the sea defence boulders to provide access. The screening needs to be of a highly robust design, particularly on the seaward side. It is recommended that any screening undertaken should be undertaken as a trial on several pipes before carrying out a full installation.

The maintenance of inflowing sea water on large tides is of key importance to the maintenance of water quality and marine ecology in the lake. Therefore, even if screening proves effective, cleaning of the inflow pipes should form part of the routine maintenance schedule to remove accumulated sediment and debris. Appropriate equipment should be available to volunteers undertaking this work including suitable sized pipe cleaning brushes and scrapers.

### 5.1.2 Green water

Visitors are not accustomed to seeing turbid, green water caused by algae blooms, as part of marine landscape setting, and tend to make negative assumptions about the lake's water quality. Reducing the potential for algae bloom development and improving the water transparency of the lake are discussed in more detail in Section 5.2 and 5.3.

### 5.1.3 Terrestrial plants (weeds)

Terrestrial plants (weeds) grow on the hard standing areas by the Victorian shelters and extensively along the top of block stone wall that forms the southern margin of the lake during the summer months. These have a negative impact on the visual appearance of the lake, given its formal hard-edged construction, and convey the appearance of a general lack of maintenance.

Spraying of the plants with herbicides approved for use near water may be undertaken although this is not recommended given the use of the lake for recreational bathing and possible unknown impacts on marine algae and fauna. This leaves two options, manual removal and spraying with an environmentally friendly herbicide (high concentration salt solution). The use of acetic acid which is an alternative environmentally friendly herbicide is not recommended as it will dissolve the red sandstone blocks that form the lake wall.

Manual remove and spraying with strong salt solution are likely to only to be temporary in effect and re-growth and repeat treatment would be required. A long-term solution would be to undertake repointing of the block stone southern wall to remove the cracks in which the plants are establishing. This would be a major capital works item and should form part of Wirral Councils responsibility in the overall maintenance and engineering stability of the marine lake structure.

## 5.2 Water Quality

### 5.2.1 Bathing Water Quality (Microbiology)

The microbiological water quality within the lake was found to be of overall good /excellent status at the time of the visit, with water of a reduced quality impounding on the high tide into the lake. However, it should be viewed that data from a single visit only provides a snapshot of conditions and there is potential for poorer bathing water status to be a feature of the marine lake. Routine monitoring is required to establish the lake's bathing water quality status in accordance with the sampling protocols set out in the Bathing Water Regulations (2013) to ensure the safety of users.

The key sources of microbiological contamination in the lake are likely to be:

- 1) Impoundment from the sea / Mersey estuary at high tides over 9m. Elevated concentrations of Bathing Water indicator bacteria may be present in inflowing water particularly during high rainfall events due to storm water sewer overflows discharging into the river.
- 2) Inputs from site users ('bather shed') during contact water activities.
- 3) Inputs from bird droppings, such as gulls and roosting waders on the western pontoon, and possibly low level inputs from dog waste on the hardstanding in the surface drainage catchment.

The primary source of microbiological contamination is likely through the tidal inflow water. The quality of the water entering the lake is likely to be highly variable and influenced by a range of factors including tidal conditions, wind direction, and discharges from sewerage treatment works on the Wirral side of the river. Discharges from treatment works are highly dependent on local rainfall conditions and whether storm water overflows need to be operated. Therefore, under certain conditions there is potential for poor quality water to be impounded into the lake reducing its bathing quality status and increasing health risk for recreational bathing.

The viability of bathing water bacteria in saltwater systems is typically relatively low and can be further reduced by mixing. Given the shallow water of NBML, it will be subject to some wind mixing but the effect of this will be reduced to a degree as the water level is set down around surrounding ground level, giving the waterbody a relatively sheltered aspect. Complete mixing of the lake will assist in preventing the accumulation of freshwater layers near the surface over the denser saltwater, that may potentially increase bacteria survival. If mixing of a lake is sufficient then it can further reduce bacteria concentrations through exposing the bacteria to greater amounts of neutralising UV radiation from the sun. The mixing process and beneficial effects in the lake may be significantly enhanced through deployment of a well-designed artificial aeration / mixing system.

### 5.2.2 Chemical Water Quality

The chemical water quality of a lake is important, for not only supporting a diverse and stable marine ecosystem but can have a direct effect on the visual appearance of the lake. The sampling visit recorded the lake to be slightly brackish with a number of elevated parameters including suspended solids, unionised ammonia, inorganic nitrogen and dissolved organic carbon. These results are not surprising given the primary saltwater source will be water discharging from the adjacent Mersey Estuary. Typically,

the tidal reaches of large river systems are characterised by variable salinity and a range of elevated parameters such as suspended solids and nutrients due to diffuse and point source inputs from agriculture, urban drainage, waste-water treatment and industrial plants.

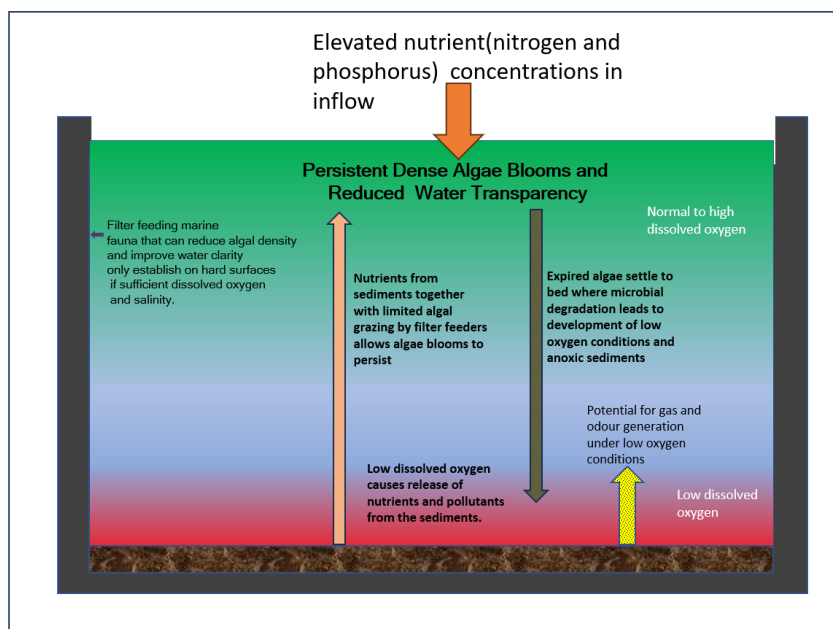
### Nutrient enrichment

Many of the common management problems seen in impounded marine systems are the result of nutrient enrichment combined with insufficient salinity. Common issues associated with nutrient enrichment include:

- Reduced water quality status for example increases in concentrations in toxic unionised ammonia.
- Fluctuations in dissolved oxygen concentrations including the development of low oxygen conditions;
- Persistent phytoplankton (algae) blooms including potentially harmful species;
- Reduced ecological diversity due to water quality impacts on sensitive species; and
- Generation of odour.

In marine systems, nitrogen tends to be the limiting nutrient for algae growth. Where elevated concentration of nitrogen are present, dense algae blooms can develop causing low transparency and cause significant fluctuations in dissolved oxygen that have numerous impacts on both water and sediment chemistry. The algae show excessive growth in the nutrient enriched conditions and expired cells settle towards the bed of the lake where they are degraded by bacteria that utilise oxygen. This can cause low oxygen conditions to develop across the lake-bed leading to gas and odour generation and also cause pollutants and nutrients, that were previously bound to sediments, to be released back in water. This is a process known as internal loading. The released nutrients then encourage further algae growth, and a cycle develops (see Figure 4).

**Figure 4: Common Processes in a Nutrient Enriched Marine Lake.**



The main source of nutrients inputs into the lake will be via the tidal inflow and this is likely to show wide seasonal variability. However, as there is no large flushing of the lake the nutrient enriched conditions will contribute to the development of persistent algal blooms (green water), particularly in the absence of filter feeding organisms and wall growing macroalgae to reduce algae density and nutrient availability.

One of the key maintenance approaches for impounded marine systems, such as NBML, is to manage the impoundment regime. This requires minimising impoundment to reduce nutrient loading and sediment accumulation (the lake effectively acts as a sediment trap) but ensuring there is sufficient saltwater inputs to maintain salinity to support a marine ecosystem. The frequency of impoundment is a unique feature of each waterbody and determine by local conditions such as the volumes of freshwater surface drainage entering the marine system.

Currently the impoundment of seawater into the lake is through a series of open pipes along the within the north wall. It is reported that these pipes had an internal valve that could be closed but the mechanism was not in marine grade steel and many ceased and were forced open. Refurbishment of the internal valves would allow control over impoundment and would also offer a safety mechanism to prevent any local pollution incidents in the sea from entering the lake on tidal heights greater than 9m. However, it is likely to be simpler for management purposes to remove these internal valves and replace with a manually operated stop valve fitted to the lake side end of the pipe. It may be found that on some high tide period (tidal height greater than 9m) suitable for impoundment, that it may be desirable to close off the inflow pipes, if the salinity is found to be at sufficient level. This would prevent additional loading of nutrients into the lake that could be used by algae for bloom development. Salinity within the lake will be the key driver for the determining the impoundment regime.

## Salinity

Salinity is one of the critical water quality parameters required for successful rehabilitation of the marine lake. The maintenance of salinity above a value of 26 psu will allow self-sustaining populations of sessile marine filter feeding organisms, such as mussels, to establish across the currently empty lake walls and other hard surfaces. Establishment of these populations will create a large grazing pressure on the phytoplankton (algae) reducing cell density and improving water transparency.

Salinity concentrations in the lake are normally determined by the balance between periodic tidal inflows and freshwater inputs into the lake through surface drainage from various sources including direct rainfall, surrounding hardstanding areas, the Marine Point Development and part of Perch Rock car park. The quality of freshwater entering the lake is likely be relatively good in its chemistry although it is suspected that the drainage from Perch Rock carpark does not include an oil interceptor which may cause some hydrocarbon contamination of water subsequently entering the lake.

As salinity reduces through inputs of freshwater (i.e. from rainfall and surface drainage inputs), the stability of the marine ecosystem reduces. This results from the fact that the majority of flora and fauna are adapted to either fully freshwater or saline conditions. The number of species that are adapted to intermediate and variable salinities is low and where an ecosystem has low diversity it generally becomes more unstable. Of particular importance, in terms of recreational water sports use is that cyanobacteria (blue-green algae) can become the dominant algae at intermediate salinities.

The salinity within the lake at the time of the visit was found to be good at around 29 psu (i.e. greater than the minimum 26 psu threshold). The good salinity levels will have been partially due to the large volume stormwater inundation into the lake during April 2024 combined with subsequent maintenance of tidal inflows.

The key question in terms of management of salinity is whether the current levels can be maintained by periodic tidal impoundment, which is essential for successful rehabilitation of the lake over the long-term. Currently the salinity appears to be holding at a relatively stable concentration given a post storm measurement undertaken by Laguna Science in April 2024 of around 28 psu. The only way to determine if salinity can be maintained is through routine and accurate monitoring of the lake salinity. If salinity cannot be maintained, then the use of a periodic temporary hire pump or a permanent pumping installation may need to be considered.

### Dissolved Oxygen

The maintenance of dissolved oxygen is another of the key water quality parameters for successful lake rehabilitation. The dissolved oxygen concentrations at the time of the visit were found to be good but there is evidence that the lake does suffer from the negative effects of low oxygen conditions that include:

These include:

- Presence of anoxic and odorous black surface sediment;
- Odour produced by the lake in warm summer periods;
- Elevated concentrations of ammonia indicating poor conversion rates to nitrite and then harmless nitrate (a process which requires oxygen and certain types of bacteria);

Fluctuations and periods of low dissolved oxygen are often a feature of dense algae blooms and their decomposition can also create a significant microbial oxygen demand. Low dissolved oxygen conditions may have several effects on both marine lake water chemistry and ecology. For example, the maintenance of dissolved oxygen concentrations in the lower water column and at the sediment / water interface allows an oxidised microzone to develop at the sediment surface. This effectively acts as a 'cap' on the sediment which inhibits the mobilisation of nutrients and pollutants from sediment deposits. However, the microzone breaks down under low oxygen conditions causing release of nutrients and pollutants.

Low dissolved oxygen in the lower water column and across the sediments can also create hostile conditions towards marine fauna leading to both a low diversity and abundance that may impact on the quality and stability of the ecosystem. Even relatively short periods of oxygen depletion can have a significant negative affect on sessile marine organisms that are unable to respond with avoidance.

There are various methods of increasing oxygen concentrations in the lower water column but the most cost effective in shallow systems is to artificially mix the water. This will be discussed in greater detail in (Section 6.2.1 - Dissolved Oxygen).

## 5.3 Aquatic Ecology

### 5.3.1 Phytoplankton (Algae) Blooms

A phytoplankton bloom was present at the time of sampling at a moderately low density that in combination with elevated suspended concentrations was causing green discolouration and a low transparency within the Marine Lake. Persistent algae blooms (green water) and low water transparency has been observed to be common feature of the lake during the Spring to Autumn period. The algae blooms result from a combination of nutrient enrichment, shallow water depths and a highly impoverished filter feeding marine fauna due to the previously unsuitable salinity regime. It is only recently the salinity in the lake has achieved concentrations that are suitable support filter feeding marine organisms and therefore as populations have not had time to establish grazing pressure on the algae remains low. If salinity and dissolved oxygen can be maintained in the lake, then it would be expected with time that filter feeding organisms would start to establish in the lake resulting in marked improvements in water clarity.

Filter feeding marine organism need a firm substrate to attach to and therefore enhancements of habitat availability can be made by substrate additions such as rocks or pipe lengths etc. For example, seeded mussel ropes may be deployed in the lake, once water quality conditions are deemed suitable and relatively stable, to accelerate the colonisation process.

Two potentially harmful algae species were recorded in the samples but at densities that did not present a risk to health. For cyanobacteria (blue-green algae), amelioration of blooms can be achieved using a relatively vigorous mixing approach. This is particularly effective on deepwater systems but has also shown to be successful in shallower system particularly if combined with lake dye to mimic the light regime of a deeper water body. Lake dye (an edible vegetable dye) offers a relatively cheap management approach to assist in reducing algal density by filtering out the wavelengths used by algae for photosynthesis. The dye is available in blue, black and 'colourless' versions from a company in the UK called Dyofix.

### 5.3.2 Other Marine Ecology

The marine ecosystem in the lake is poorly developed and impoverished. This mainly results from the historical reduced salinity concentrations being too low to allow the development and support to a flourishing marine ecosystem. Scrapes of the wall with a long-handled hand net showed no marine life to be present. In an established marine ecosystem, the walls would be expected to be covered in a diverse mix of marine macroalgae, bivalve mussels, anemones, sea squirts, sponges and prawns. If sufficient salinity is maintained in the lake, then it may be expected that such an ecosystem will start to develop on the walls and hard surfaces within the lake.

Crabs are present in the lake and the waterbody has always been popular for visitors to catch crabs with handlines during the summer months. Crabs are able to survive in the lake due to their wider tolerance of variable salinity conditions. Some flatfish (flounder) and eels are also known to be present which are again species that are tolerant of reduced salinity concentrations.

### 5.3.3 Birds

A range of birds use the marine lake with the highest numbers tending to be present during the winter months. Over the summer months the only birds present tend to be non-breeding juvenile gulls. During the winter months there can be moderate numbers of Black-headed and Herring Gull present, together with the occasional cormorant.

From late summer through to spring, the pontoon at the western end of the lake is regularly used as a high tide roost by flocks of wading birds including Turnstone, Redshank and Purple Sandpiper. High tide roosts are important for these birds for energy conservation during the winter. These birds now preferentially use the pontoon as an alternative to the sea defences along the promenade wall for roosting, as it allows them to be less prone to disturbance.

## 6 REHABILITATION AND MANAGEMENT STRATEGY

### 6.1 Introduction

New Brighton Marine Lake will require an active and long-term maintenance strategy to improve its visual appearance as a landscape feature and functioning as a facility for water based recreational amenity. It is important that the lake can provide high water quality standards to provide a safe conditions for recreational contact water-sports. It is recommended that in partnership with Wirral Council and other stakeholders that the Friends of New Brighton Marine Lake consider the adoption of the following future monitoring and maintenance regime to ensure a safe water quality environment is provided and maintained.

### 6.2 Management Objectives

The core management objectives for the lake are:

- Improve, maintain and monitor water quality in the lake;
- Establishing a diverse and stable marine ecosystem within the lake;
- Improve the visual appearance of the lake with minimum maintenance requirements.

The improvement and maintenance of water quality should always form the primary and core objective of the management strategy. If the water quality is correct, then the other management objectives may be achieved and many of the range of current management problems displayed by the lake will be ameliorated.

#### 6.2.1 Improving Water Quality Status

There are four key areas where water quality improvements should be concentrated:

- 1) Maintaining lake salinity.
- 2) Maintaining dissolved oxygen concentrations.
- 3) Achieving good or excellent bathing water quality status.
- 4) Reducing nutrient and pollutant availability

All the above may be met through management of the impoundment regime and artificial mixing / aeration of the lake combined with routine monitoring.

#### Salinity

Salinity in the lake is a balance between saltwater impoundments from the sea and freshwater inputs from the surrounding surface drainage. The minimum salinity concentration that should be maintained in the lake on all occasions is 26 psu to allow a marine ecosystem to develop and be maintained. Currently saltwater impoundment is via either the inflow pipes on the northern bank on high tides greater than 9m or from occasional coast floodwater inundation. There is insufficient data available to determine if the impoundment through the inflow pipes is sufficient to maintain salinity in the lake or whether this needs to be augmented by periodic pumping by either a temporary or permanent pumping solution. The key to management of the lake is minimising

impoundment (nutrient and sediment inputs) whilst maintaining sufficient salinity. Therefore, routine monitoring of salinity is very important.

It is recommended that a field salinity meter and probe with 5m cable is purchased and that weekly measurement of salinity in the lake is undertaken at 0.3m intervals through water column at a monitoring location on the lake. The calibration of this meter in accordance with manufacturers instructions using standard conductivity solution is important to ensure accurate readings are obtained.

These data should be used to determine if impoundment of marine water should be undertaken on tides of sufficient height, although this will require modifications to be made to the existing open inflow pipes with manually operated shut-off valves.

### Dissolved Oxygen

Mixing of the lake through artificial aeration will have a wide number of benefits in terms of function of the lake. These will include:

- Maintaining dissolved oxygen concentrations throughout the water column;
- Reducing the build up of substances that are potentially toxic to aquatic life such as ammonia;
- Reducing internal mobilisation of nutrients and pollutants from the sediment;
- Assist in the reduction of bathing water bacteria through increasing their exposure to neutralising UV light;
- Accelerate the breakdown of organic material in sediments;
- Allow marine organisms to live and flourish in all parts of the lake;
- Will make the lower water column habitable to marine organisms; and
- Improve the efficiency of bio-filtration of the water by filter feeding organisms.

The most effective way to mix a waterbody which is compatible with recreational use is through installation of a diffuser-based aeration system. This system is effectively a series of sunken hoses on the lake-bed through which compressed air is pumped and then released into the lake through a series of diffusers. The rising columns of bubbles effectively act as air lift pumps drawing water from the lake-bed and forcing it to the surface where it is oxygenated by the atmosphere. These systems are preventative in operation and typically operated on a 24/7 basis from April through to October.

To effectively mix and aerate a waterbody requires that there are sufficient mixing locations. The number of mixing locations needed is a function of water depth with shallower waterbodies requiring a greater number of mixing points (diffusers). This results from the primary area of mixing around each point being described by the relationship of a radial distance of 5 to 7 times the water depth. Therefore, on a 2m deep lake the primary area of mixing around each diffuser is a radial distance of 10 to 14m compared to a 10m deep lake where the distance is 50 to 70m. In designing systems, particularly when they are required to assist in blue-green algae control, the layout of diffuser is based around having the majority of the lake area covered with primary mixing areas that are touching or overlapping.

A provisional design layout for NBML is presented in Figure 5. It should be noted the design presented is based on the ISS Flowthrough system which is unique in that it is a self-balancing system in terms of airflow and allows the correct volume of air to be delivered to multiple diffusers on a single airline. This ensures the correct volume of air

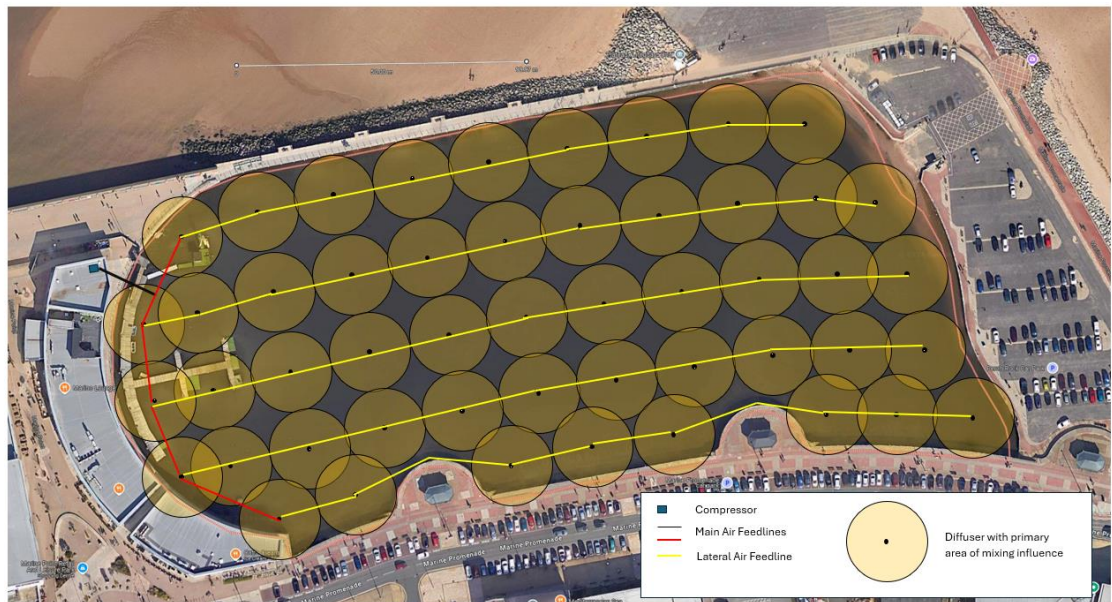
is delivered to each diffuser regardless of its position within the array or the water depth. This can be contrasted with traditional systems that require an individual airline to each diffuser, resulting in deployment of large numbers of airlines into the lake. Such systems also require the airflow to be manually balanced to each diffuser which can be very difficult to achieve when large numbers of diffusers are deployed. This system has been selected due to its proven track record in marine systems, an ease of operation and maintenance.

There are a number of considerations for developing an aeration system for the lake including:

- Location, security and noise output of the air compressor;
- Provision of a suitable electrical supply for the compressor;
- Routing of the main air line feed from the compressor to the lake;
- Deployment within a corrosive marine environment; and
- Capital and operational costs.

A provisional budget cost for the system is provided in Appendix C but a full detailed costed proposal can be provided on request from ISS Flowthrough.

**Figure 5: Design Layout for a Diffuser-based Aeration / Mixing System**

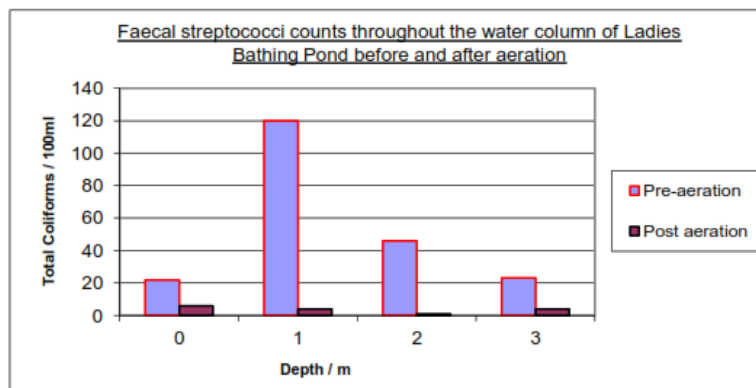
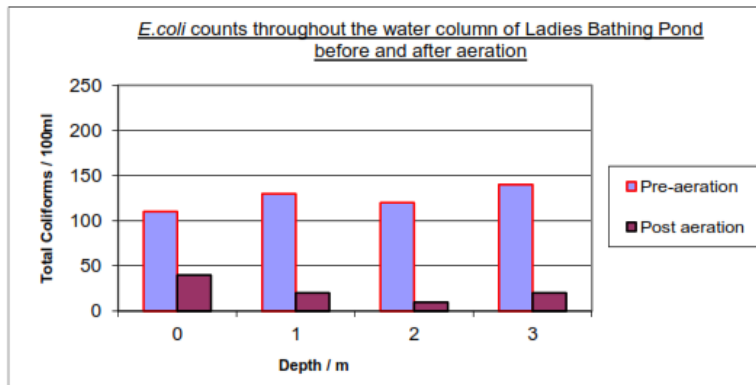


### Bathing Water Quality Status

To ensure safety of swimmers, a consistently high bathing quality status should be set as a core management objective. There is currently no control over water impounding into the lake and upstream wastewater discharges into the Mersey are likely to be the main source of this contamination in the lake for many years ahead. There are two key approaches for improving microbiological status which are:

- Maintaining high saline conditions as the indicator bathing water bacteria (*E.coli* and Intestinal enterococcus) have reduced survival in saltwater conditions; and
- Ensuring there is no distinct freshwater layer on the lake surface in which these bacteria can proliferate and show prolonged survival; and
- Increasing the exposure of the bacteria to UV radiation through mixing of the lake.

The graphs below show the effects of 24 hour of mixing on bathing water bacteria concentrations on a trial test in the Ladies swimming lake at Hampstead Heath. It was hypothesised that the significant reductions in bacteria concentrations shown were due to the mixing system allowing greater exposure of the bacteria to UV irradiation at the surface.



The key to ensuring the safety of bathers is to implement routine water quality monitoring on the lake. Therefore, although not a designated bathing water, it is recommended that routine water quality monitoring should be undertaken based on the requirements of the EC Bathing Water Directive and UK Bathing Water Regulations. It is recommended that surface samples are collected from the lake on 6 occasions each year. This will include a pre-bathing season (assumed to be mid-May to the end of September) sample combined with 5 further sample visits even spread throughout his period from two monitoring stations. Water samples should be tested for the two key bathing water indicator which are *E.coli* and *Intestinal enterococcus*. Samples should be submitted with dilution analysis such that actual colony counts are recorded.

The development of dense mats or algal scums or unusual colour changes to the water should also be a trigger to warrant additional investigation of the type of algae present to ensure blooms of harmful species are not developing.

It is recommended that training is given to a group of volunteers within the Friends of the New Brighton Marine Lake Group on how monitoring should be undertaken and results interpreted to assess bathing water safety.

### Reducing Nutrient and Pollutant Availability

The main source of inputs of nutrients and pollutants into the lake is assessed to be through tidal impoundment of water discharging from the Mersey estuary. Currently there is no control over these inputs through the open pipe system and elevated nutrients will be contributing to algal bloom conditions (green water). The ideal management approach for impounded marine systems is to ensure that there is sufficient saltwater input to maintain salinity and water level whilst minimising impoundment frequency to reduce nutrient loading that encourages algal blooms. The requirement to impound should be driven by salinity monitoring data.

Currently there is control on the pipes, that are effectively open to incoming tidal water. Therefore, it is recommended that changes are made to inflow pipes to allow a greater degree of control on water entering the lake. Manually operated marine grade shut-off valves may be fitted to the end of each pipe, to replace the existing flap valves. Fitting valves the seaward end of the pipe will prove very difficult as they are cut flush with the wall and have limited access due to boulder sea defences.

As it is known that water will only enter on tides of greater than 9m height at high water, which is predictable, salinity readings taken in the lake beforehand should inform whether the valves should be opened or kept closed over a specific period of high tides. The installation of shut-off valves also provides pollution protection to the lake in the event of a coastal pollution episode to prevent contaminated water entering the lake during tides of suitable height. Collecting monitoring data will allow refinement over time of the management impoundment regime.

A further potential source of pollutants is surface drainage from Perch Rock car park that collects in a gully drain at the northern end of the car park and discharges into the lake. Investigation should be undertaken to determine if this drain has any oil interceptor to prevent the entry of hydrocarbons into the lake.

Internal nutrient and pollutant availability will be reduced by the proposed aeration system installation by maintaining high dissolved oxygen conditions at the lake bed to reduce mobilisation of these chemicals from the sediments. In addition, by creating the correct conditions for a marine ecosystem to develop and flourish available nutrients will be directed away from algae blooms and towards other marine organisms such as macroalgae and fauna.

### 6.2.2 Marine Ecosystem Development

Through management and maintenance of the lake with a strong focus on maintaining salinity and dissolved oxygen concentrations, a marine ecosystem system may be expected to develop. Improvements in reducing algal blooms, water transparency and the overall visual appearance of the lake may take several years to achieve due to the time required for the populations of sessile filter feeding marine organisms to develop.

This establishment process may be accelerated by increasing substrate availability combined with marine fauna introductions, although such measures should only be undertaken once monitoring shows that water quality conditions are suitable and relatively stable.

The usual approach for kick starting the process is to use seeded mussel ropes. The mussel rope can be hung along walls and from the platform at the western end of the

lake. Enquires should be made to commercial mussel growers for advice and a possible source of seeded ropes. Additional empty ropes can be hung within the lake for increasing habitat availability for future colonisation.

Further improvements in habitat can be made by the introduction of any additional hard substrates, such as boulders, pipes or marine gabions within the margins of the lake. The greater the populations size of filter feeding organism the higher the grazing pressure exerted on the algae blooms and the more transparent the lake water will become.

### 6.2.3 Improving Visual Appearance and Minimising Maintenance

Given the location and aspect the marine lake, its tend to act as traps for wind-blown litter and debris. Accumulations of litter within the lake can significantly reduce its visual appearance. As such on-going routine collection of litter and debris from the lake will be required. It is recommended that equipment is purchased and made available to volunteers to facilitate surface litter collection such as hand nets, waste bags and a shallow micromesh seine net to encircle large debris accumulations. Facilities should also be made available for disposal of the collected waste.

Measures may be implemented to reduce the amount of litter entering the lake that may include:

- Installation of additional litter bins around the lake perimeter that are subject to regular emptying;
- Signage on perimeter railing to inform that litter dropped on the lakes surrounds with inevitably end up in the lake
- Installation of fine mesh panels along the lower railings.

Even with all the above control measures, litter and debris will inevitably end up in the lake and routine litter clearance will be necessary. This is even more the case if improvements in water transparency are achieved, as any litter then becomes visually more of an impact.

The main maintenance works at present revolves around the inflow pipes and clearing debris to keep them free flowing. Marine debris, litter and silt from both the sea and lake ends of the pipes tends to cause blockages that regularly require cleaning. Having appropriate equipment available to clear the pipes will facilitate this maintenance tasks. Is also further recommended that screening the pipe ends is examined to reduce the potential for pipe blockages.

Removal of weeds growing along the southern wall of the lake and spraying with high concentration salt solution should be considered to improve the visual appearance of the lake. Over the longer-term, repointing of the wall blocks may be pursued to assist in reducing plant growth.

The standard routine maintenance actions required for the lake once water quality issues have been resolved are likely to be:

- Routine monitoring of salinity and bathing water quality during the bathing season;
- Clearing debris accumulations from pipe screens and occasional cleaning of debris and silt accumulations within the inflow pipes;

- Closure and opening of the inflow pipe valves to control impoundment i.e only allow sufficient impoundment to maintain water level and salinity;
- Annual maintenance of the aeration system compressor and cleaning of the diffuser heads;
- Routine litter collection; and
- Removal and spraying of terrestrial plants growing in the lake walls and surrounds.

### 6.3 Summary of Recommendations

Implementation of the recommendations will likely require consultations to be undertaken with Wirral Council and may also involve the current owners and managers of Marine Point. A summary of the recommended rehabilitation and management actions for NBML are listed below. These works are listed in sequence of priority.

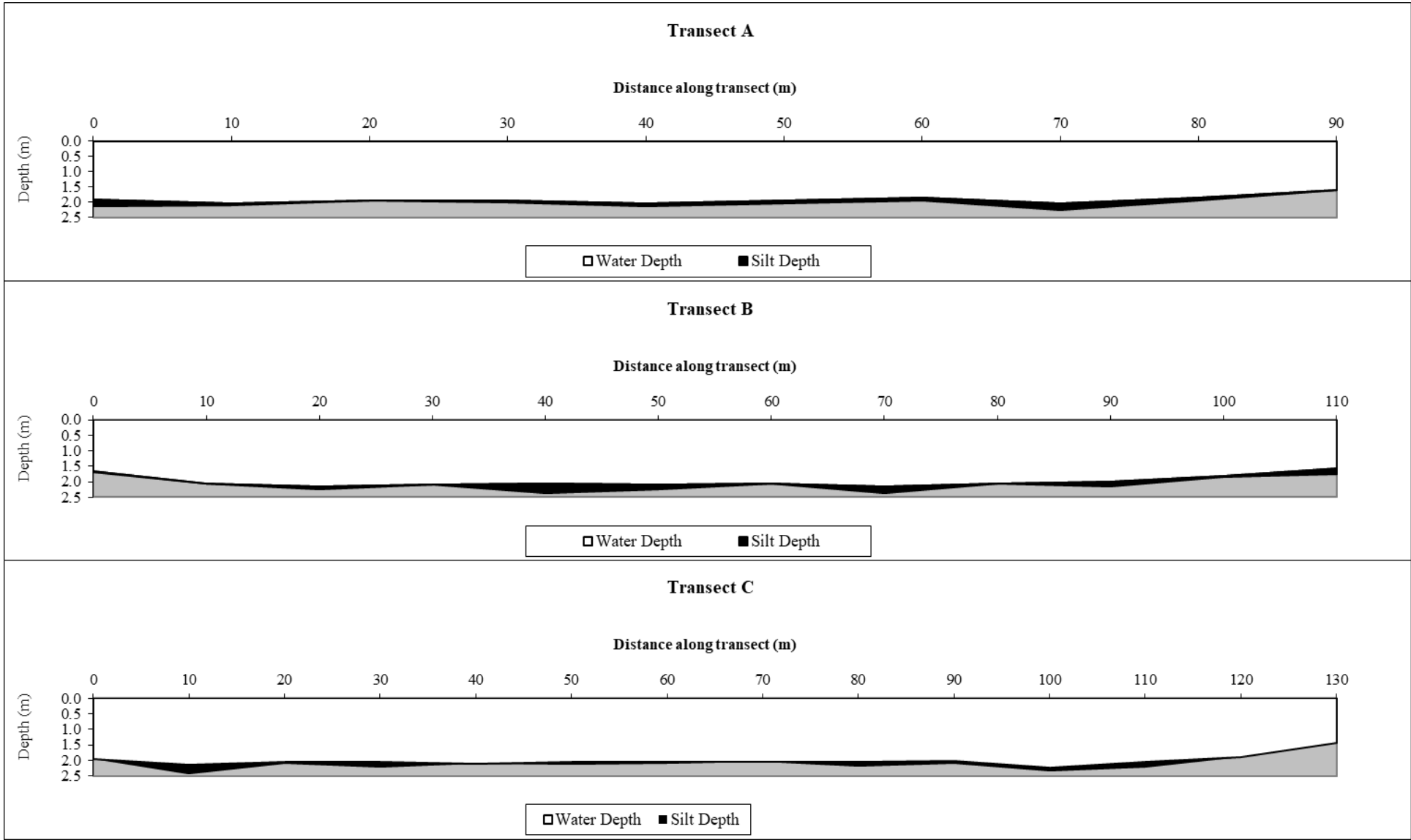
- 1) Undertake remedial works to the inflow pipes to include installation of removal stainless steel trash screens, provision of pipe cleaning equipment and installation of manual shut-off valves on the lakeside end of the pipe
- 2) Purchase a salinity meter and calibration solutions to undertake routine accurate reading of salinity through the water column to inform impoundment regime.
- 3) Provision of equipment to facilitate the collection of litter from the lake. Erect signage and discuss with Wirral Council approaches for reducing litter around and depositing into the lake.
- 4) Set-up a programme for routine bathing water quality monitoring to commence in April 2025.
- 5) Install a diffuser-based aeration system.
- 6) Once water quality looks stable and suitable, start introducing mussels, other fauna and mussel ropes into the dock. Consider enhancing availability of substrates for sessile filter feeding organisms to attach to.
- 7) Undertake routine maintenance on inflow pipes and aeration system, combined with regular litter collection and disposal.

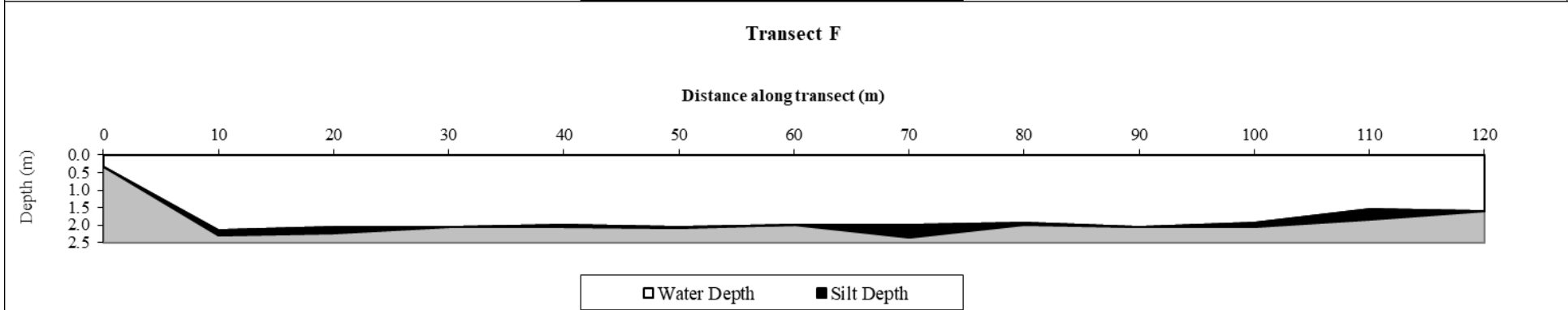
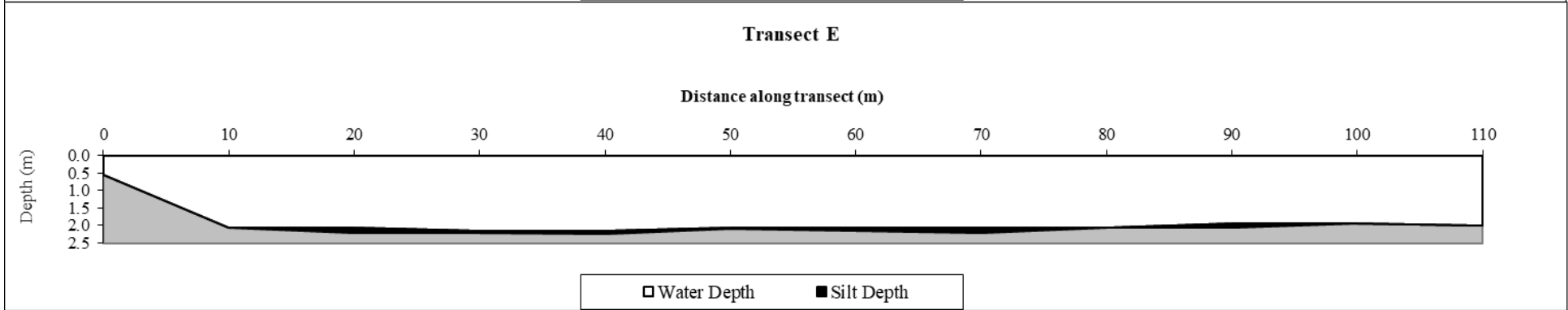
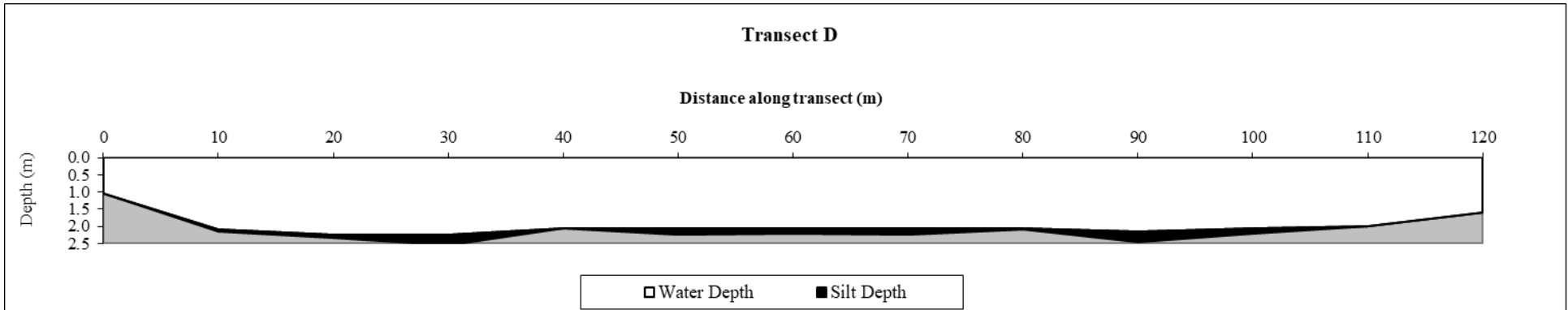
### 6.4 Cost Estimate of Works

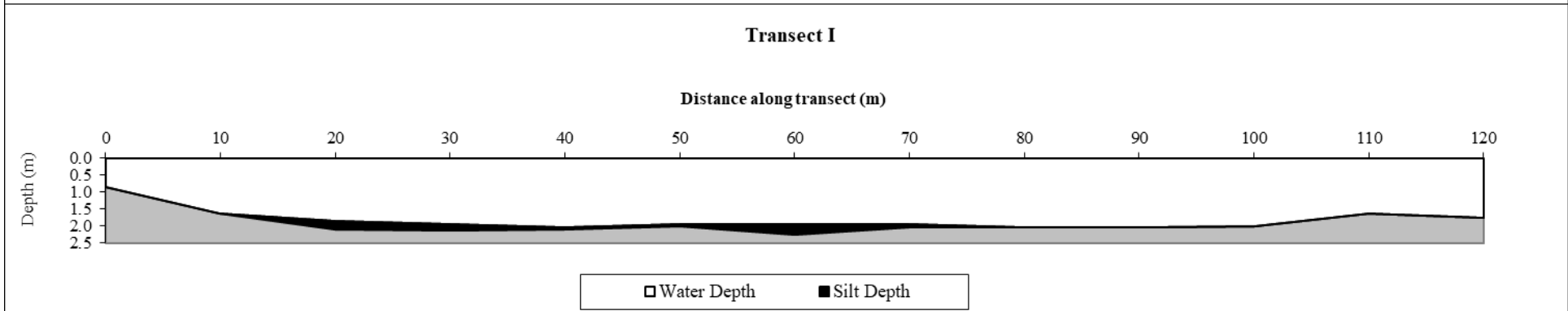
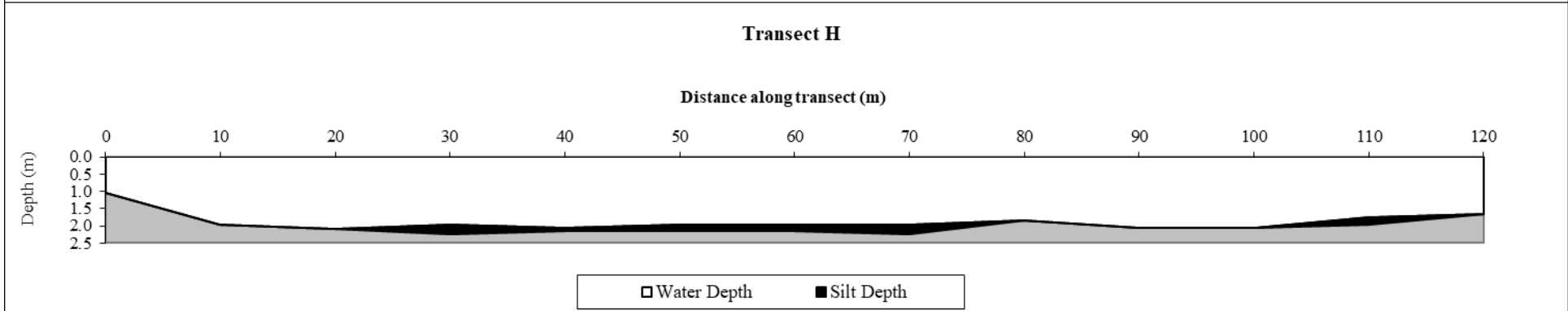
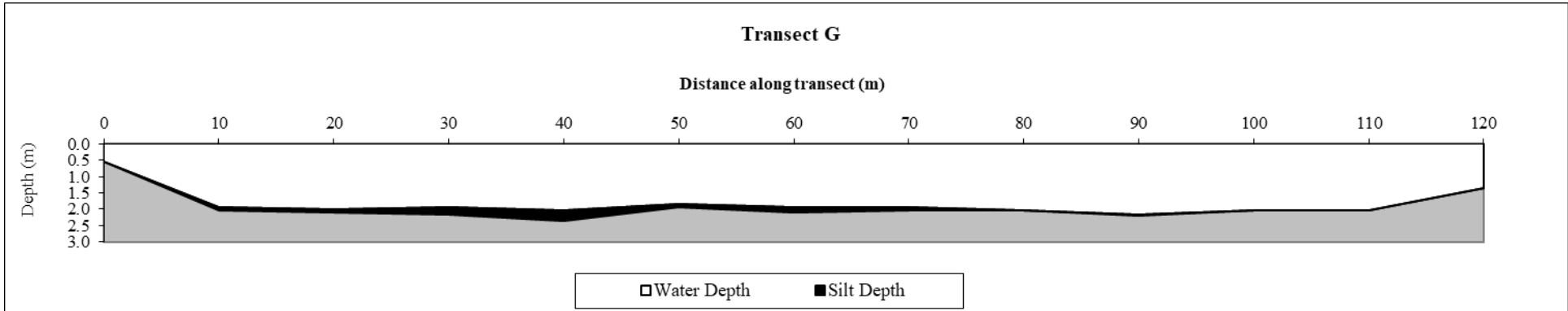
Indicative budget costs for equipment and works are provided in Appendix C. This list of costs should not be viewed as exhaustive but is provided to help focus fund raising efforts and grant applications being sought by the Friends of New Brighton Marine Lake.

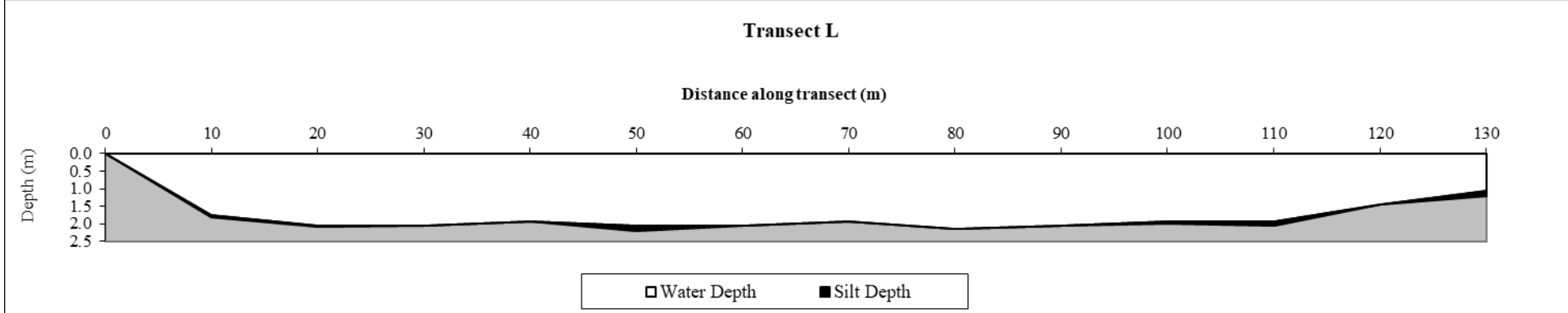
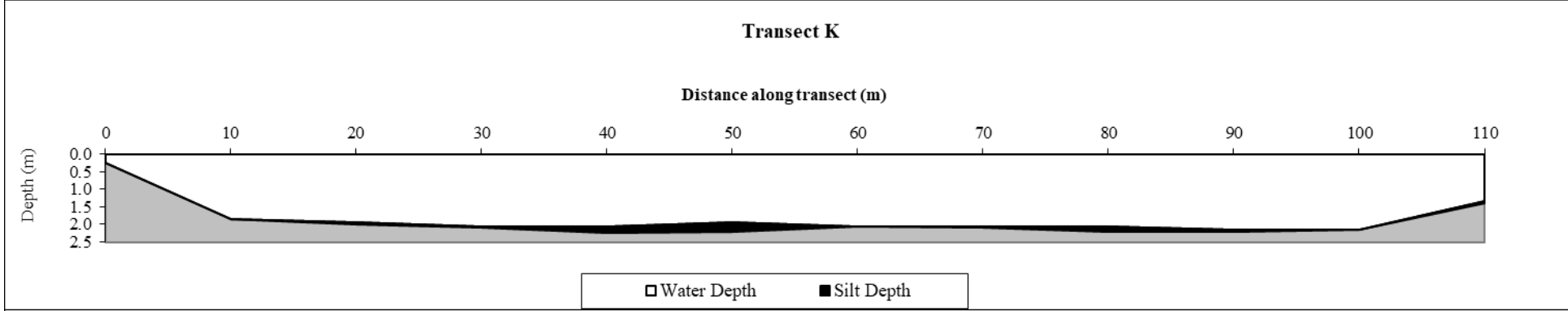
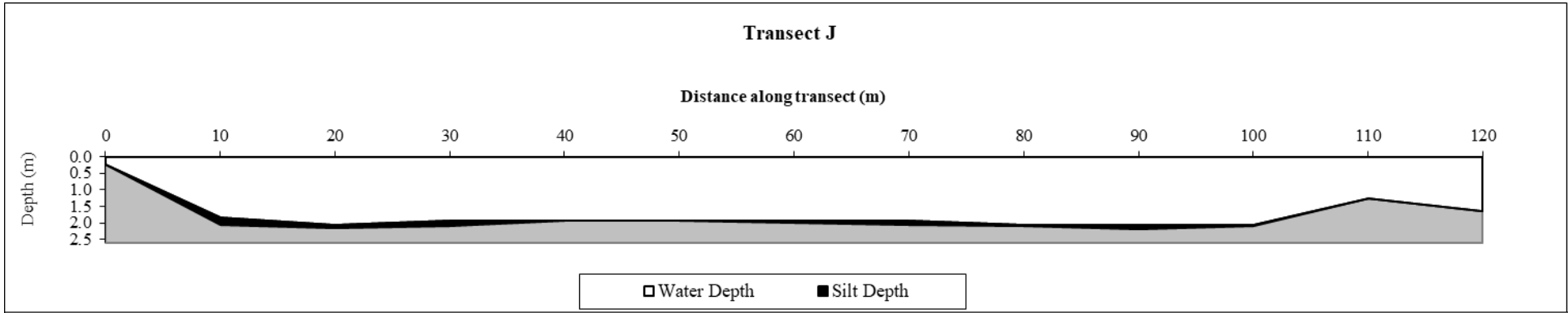
It would be worthwhile for the Friends group to obtain accurate costs on the various elements to assist providing in terms of funding bids.

## Appendix A. Water and Sediment Depth Profiles



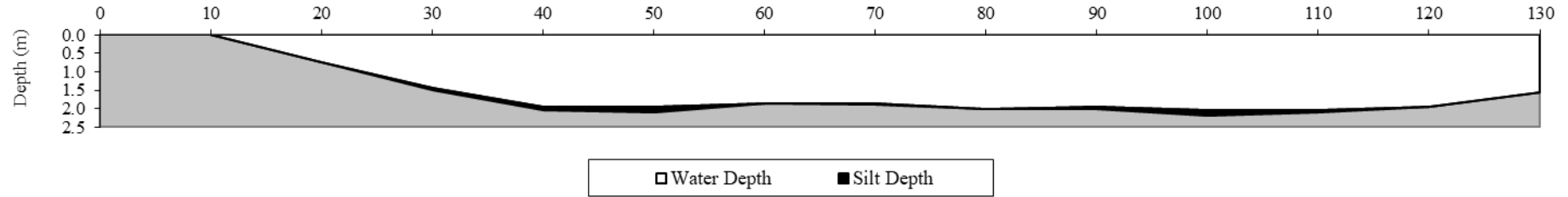






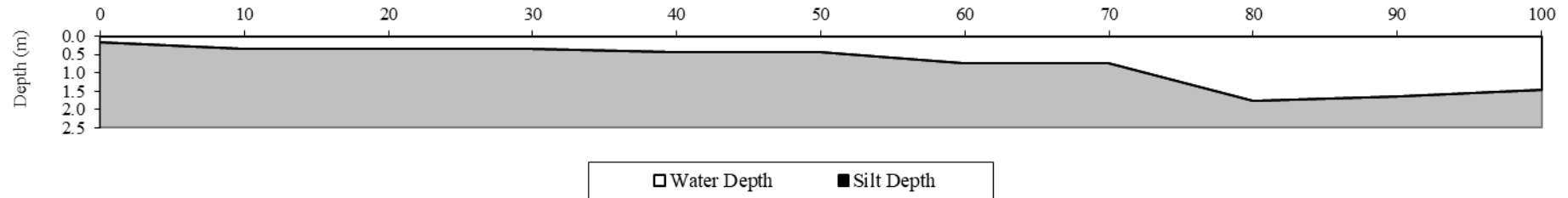
### Transect M

Distance along transect (m)



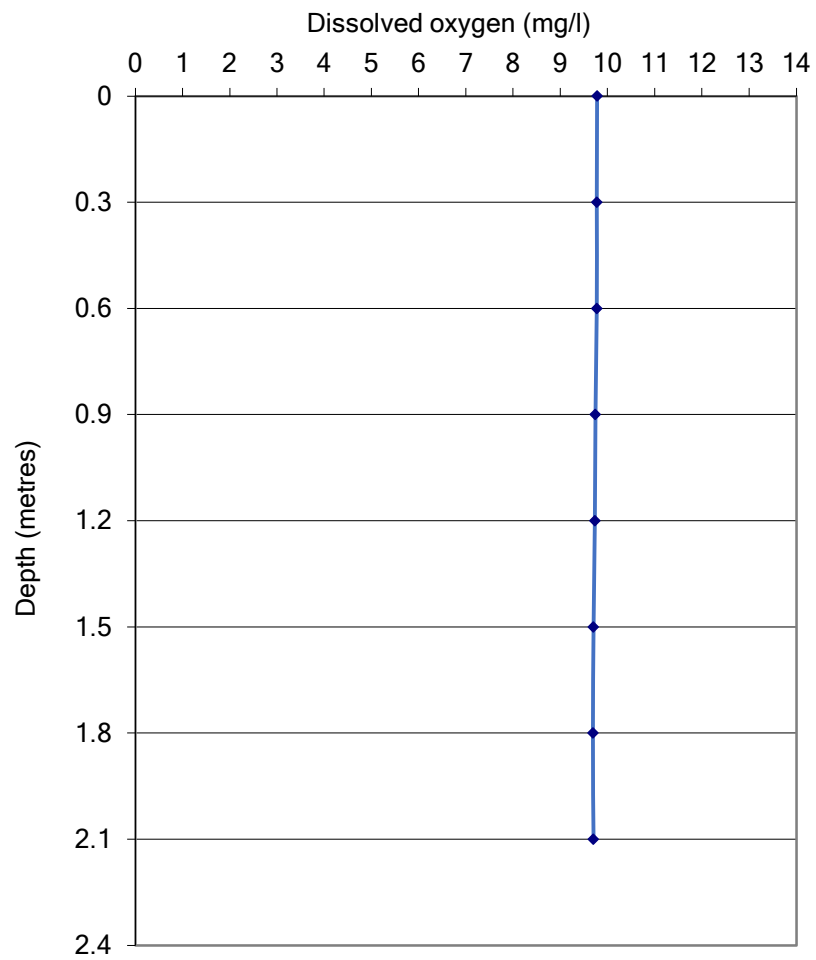
### Transect N

Distance along transect (m)

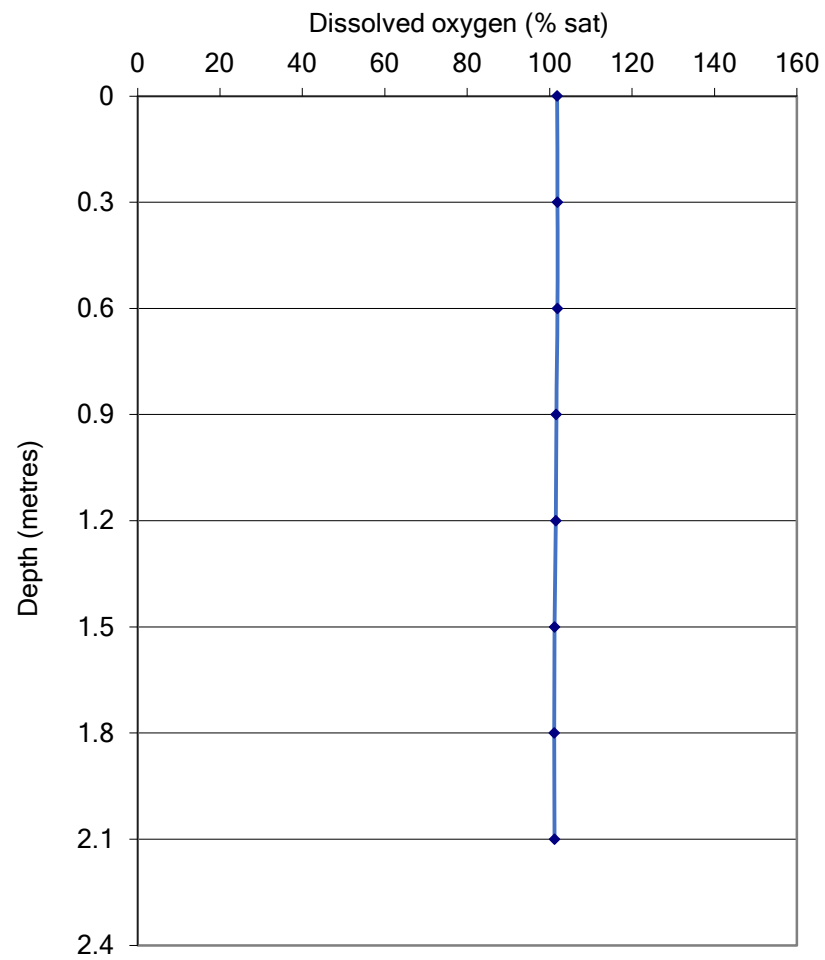


## Appendix B. Dissolved Oxygen, Temperature and Salinity Profiles

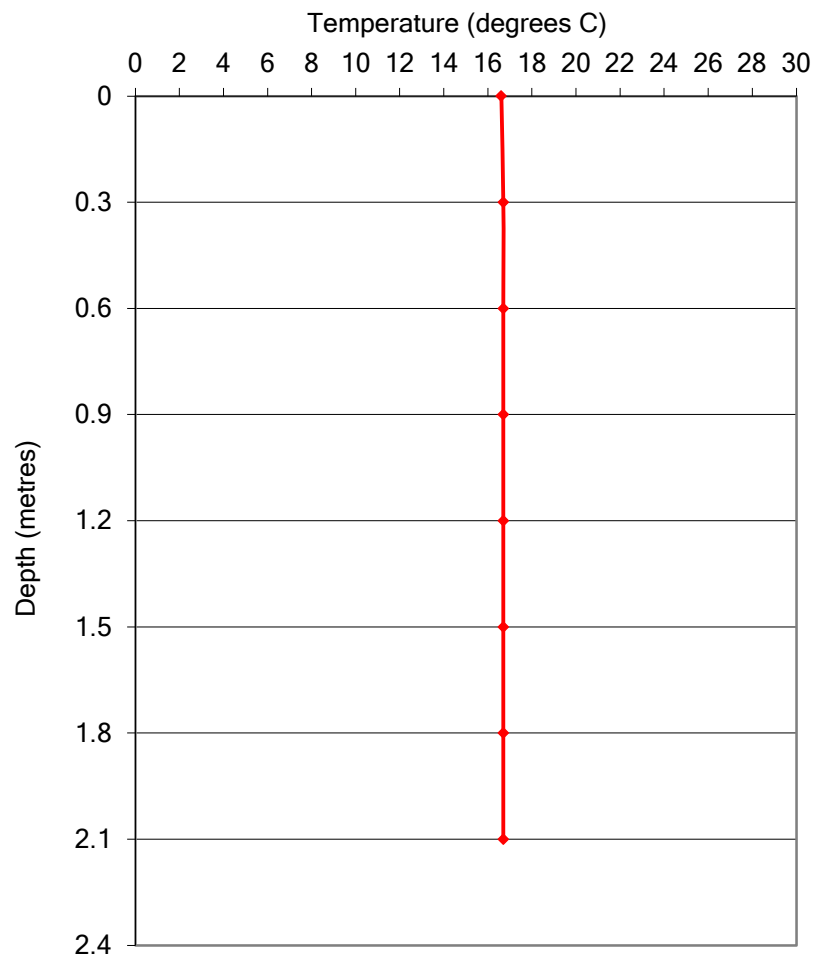
Dissolved oxygen profile for Monitoring Site 1  
(22nd August 2024)



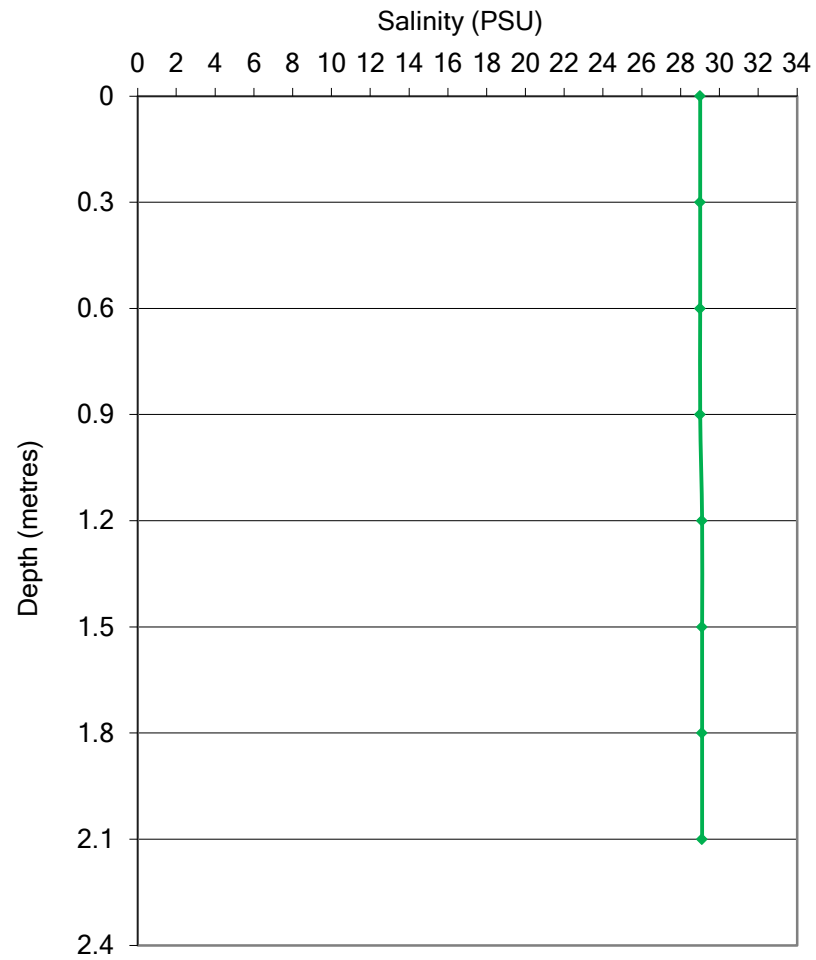
Dissolved oxygen profile for Monitoring Site 1  
(22nd August 2024)



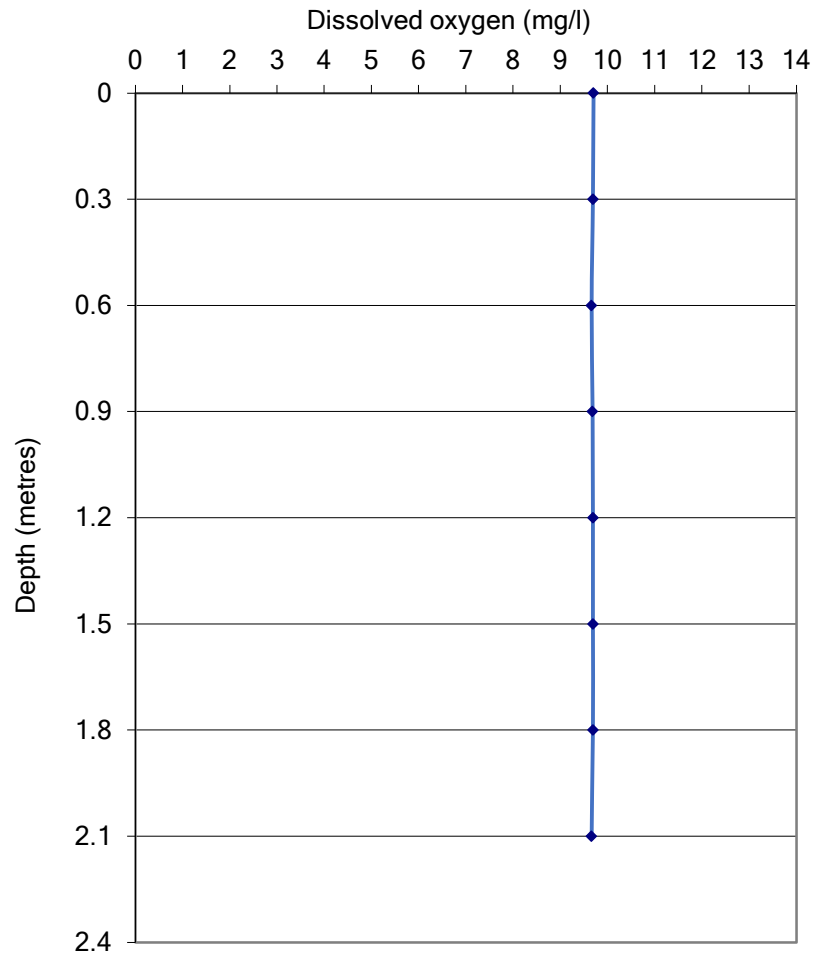
**Temperature profile for Monitoring Site 1  
(22nd August 2024)**



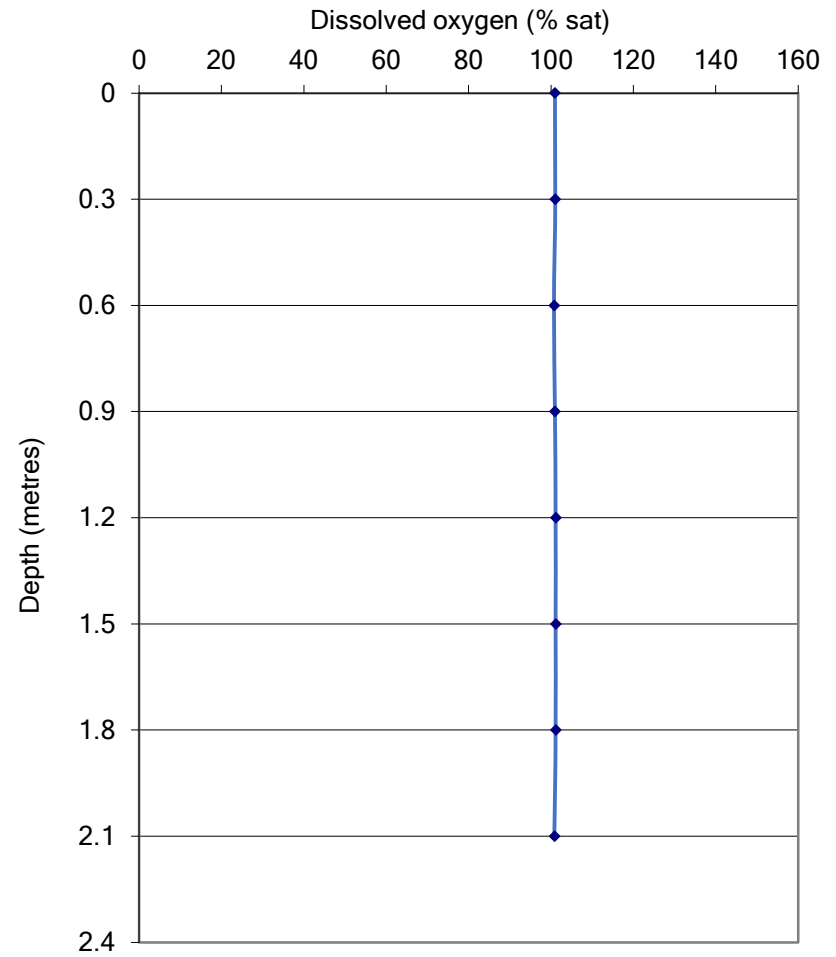
**Salinity profile for Monitoring Site 1  
(22nd August 2024)**



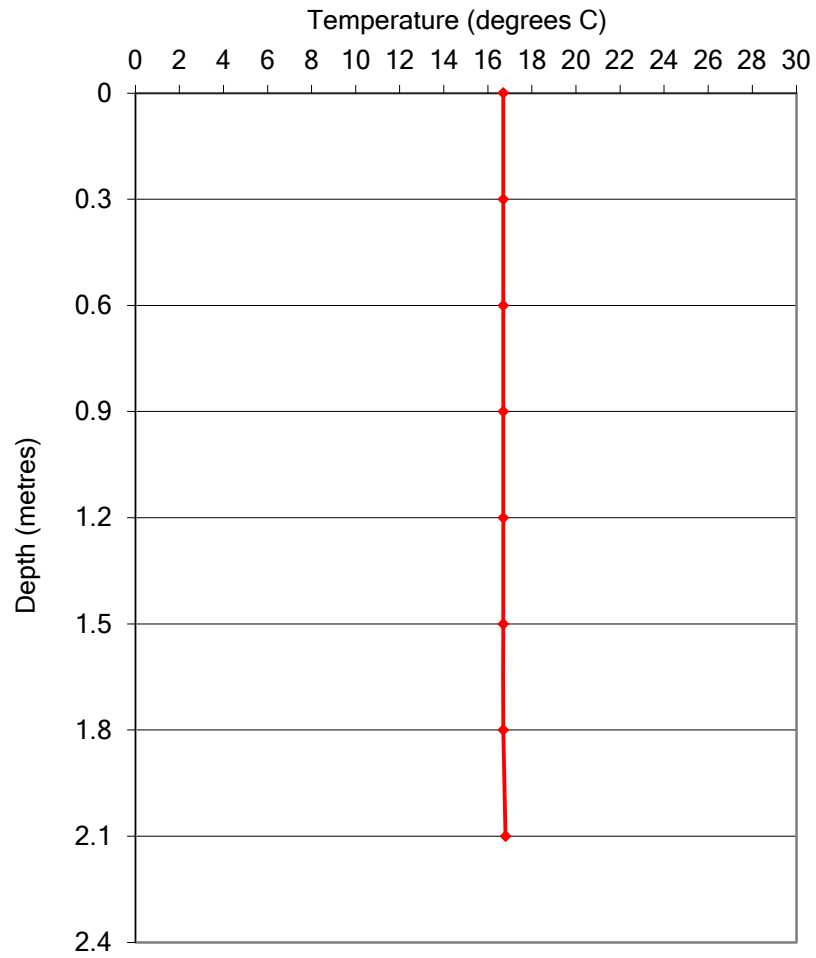
Dissolved oxygen profile for Monitoring Site 2  
(22nd August 2024)



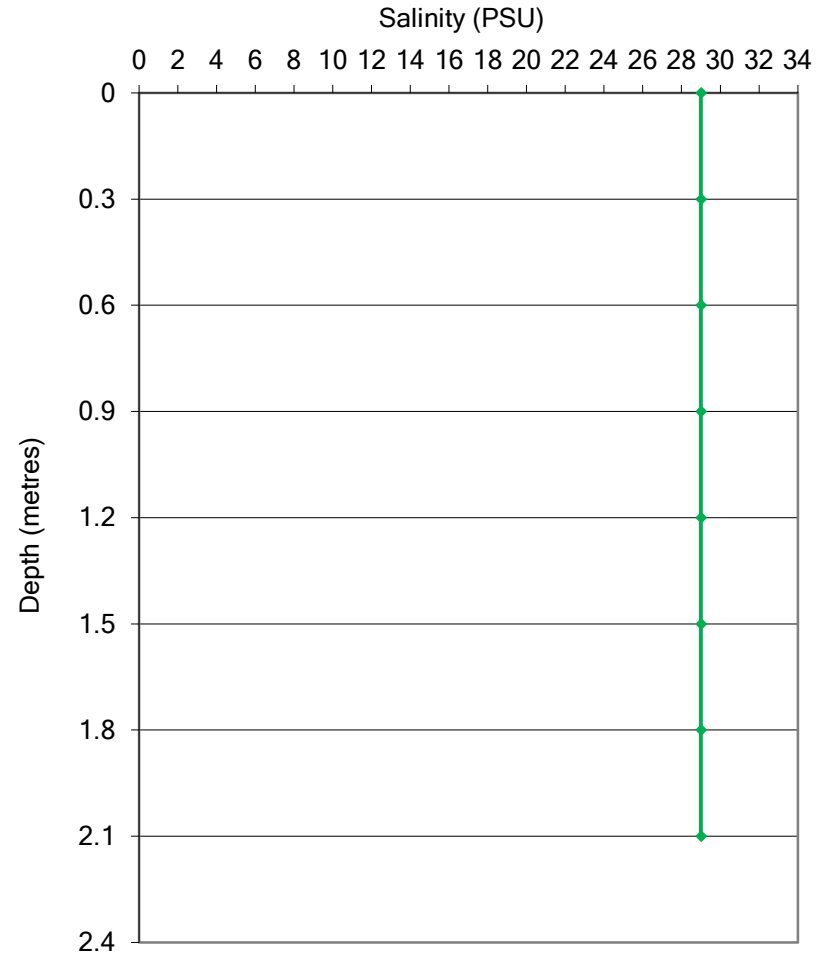
Dissolved oxygen profile for Monitoring Site 2  
(22nd August 2024)



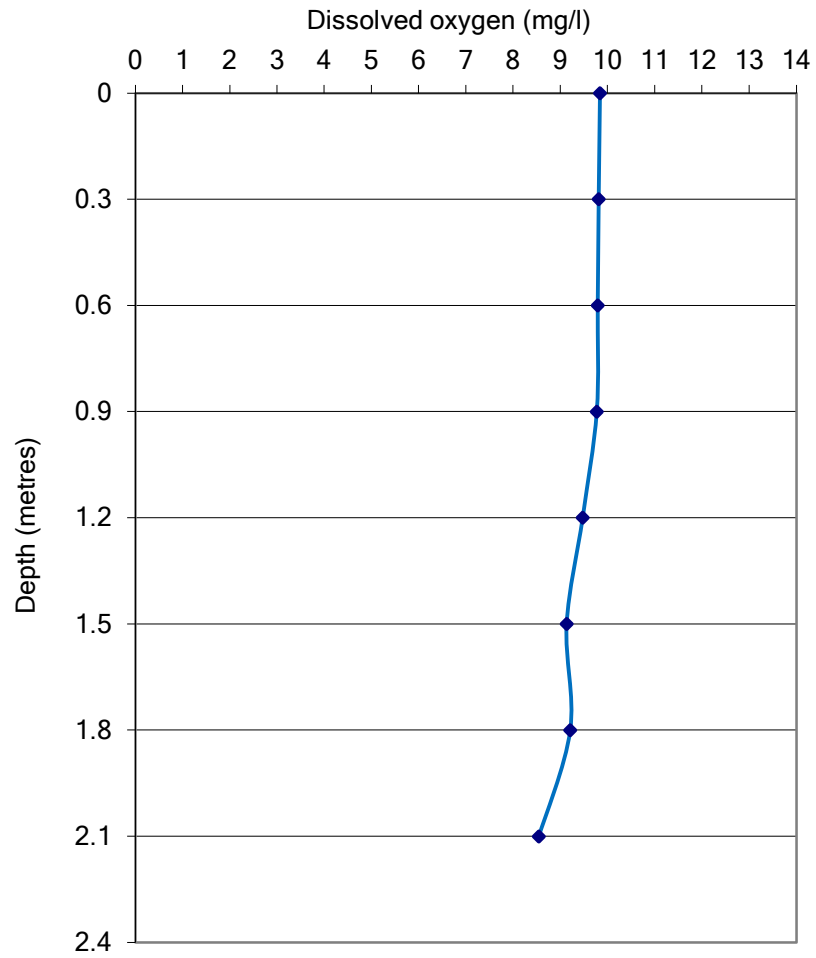
**Temperature profile for Monitoring Site 2  
(22nd August 2024)**



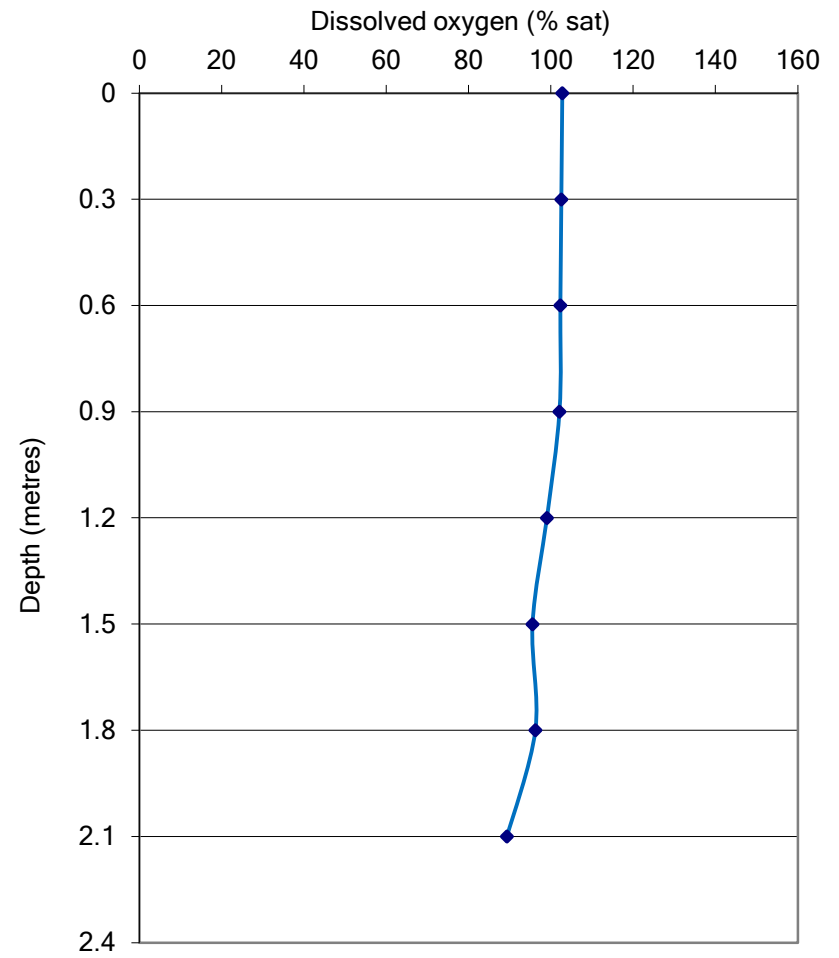
**Salinity profile for Monitoring Site 2  
(22nd August 2024)**



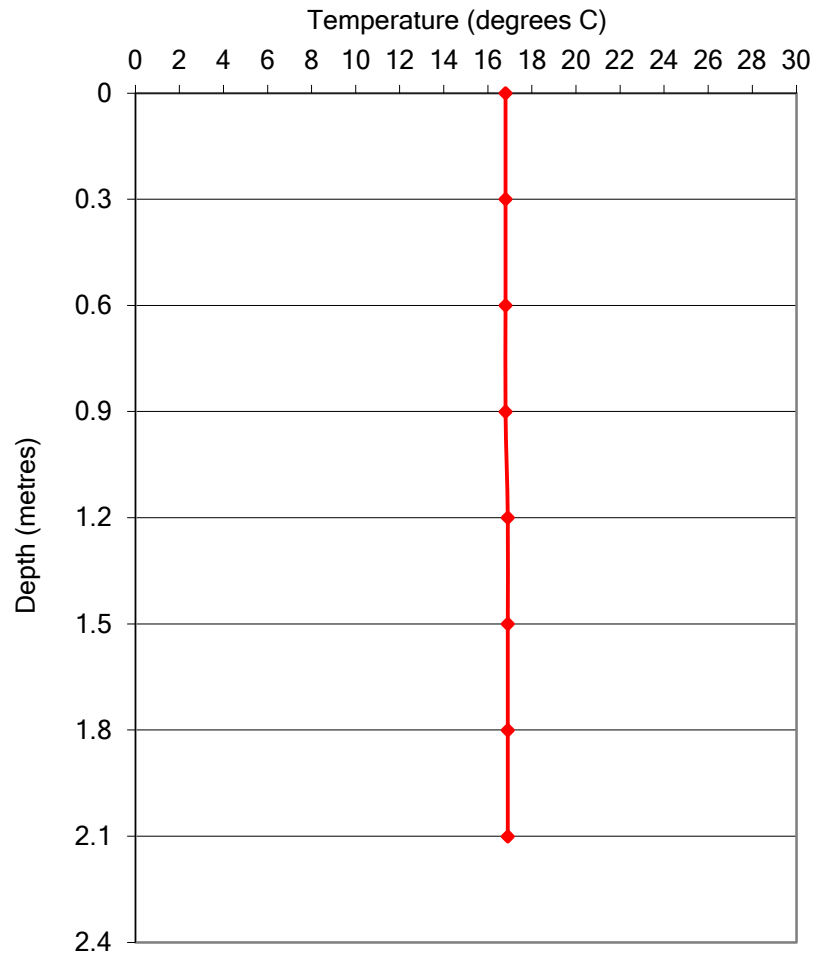
Dissolved oxygen profile for Monitoring Site 3  
(22nd August 2024)



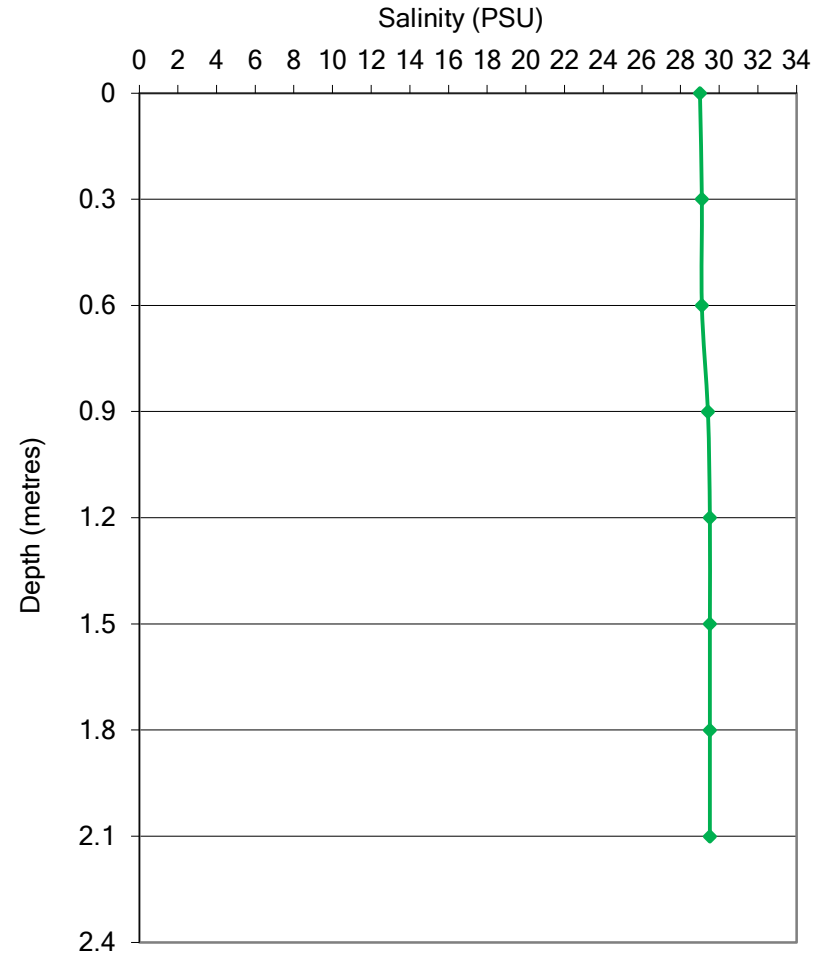
Dissolved oxygen profile for Monitoring Site 3  
(22nd August 2024)



**Temperature profile for Monitoring Site 3  
(22nd August 2024)**



**Salinity profile for Monitoring Site 3  
(22nd August 2024)**



## Appendix C. Indicative Budget Cost Estimates

