Appendix 8.5

LAKE WATER COLUMN PROFILES

Appendix 8.5 Lake Water Quality Profiles 23/01/2023

A Hanna HI9829 Multiparameter Water Quality Meter was used to record a number of parameters at ten locations and at 1m intervals in the water column, around Broadwater Lake in January 2023, as shown on Figure 1. The parameters measured were: pH, Dissolved Oxygen, Electrical Conductivity, Turbidity, Pressure and Total Dissolved Solids. This was supported by the use of a Secchi disk to assess the clarity of the water.

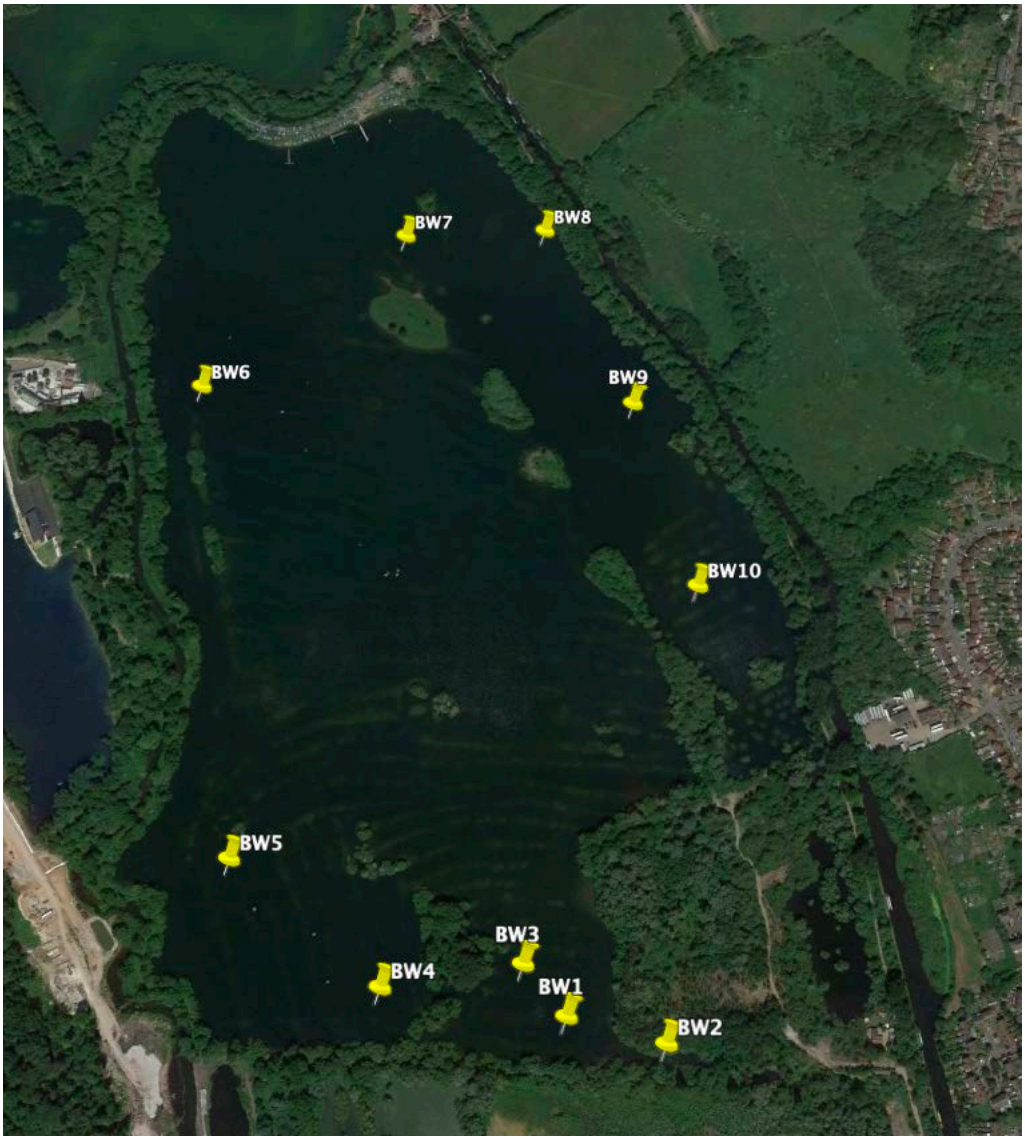


Figure 1. Sampling Locations

Temperature

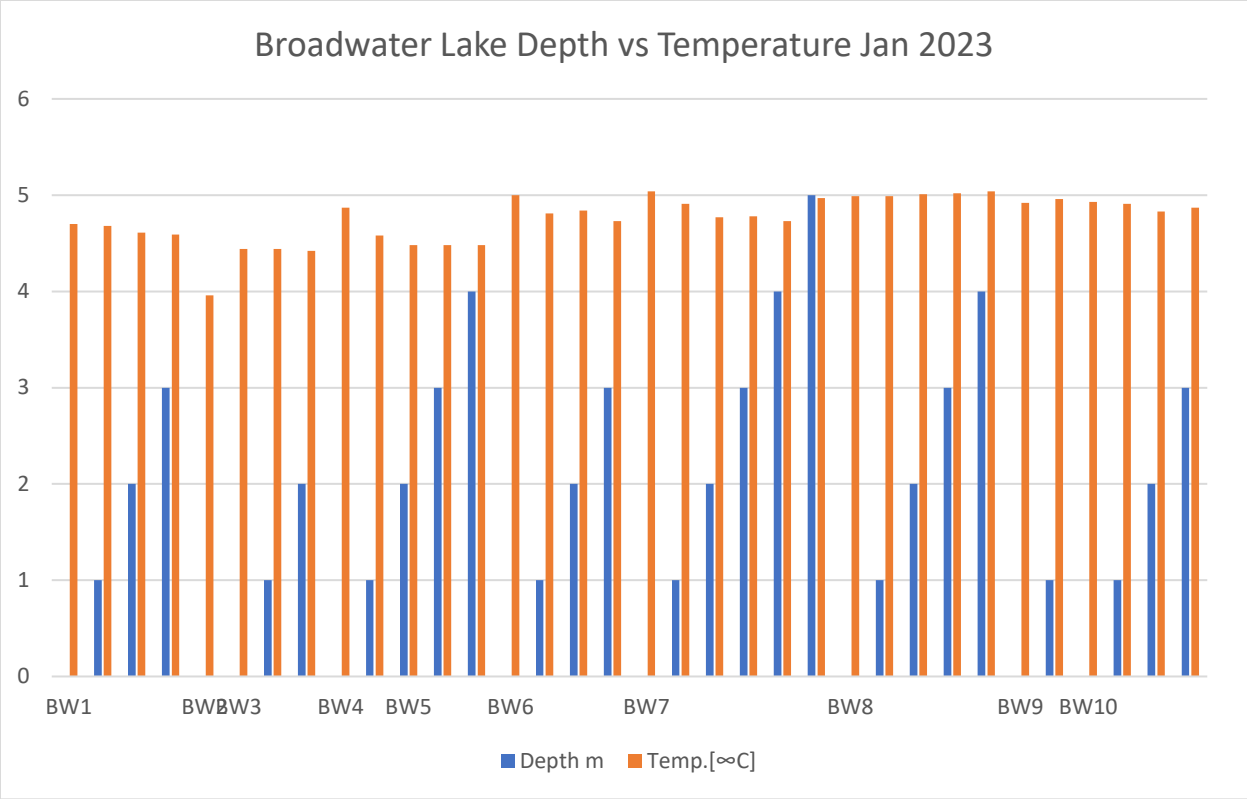
Water temperature influences the majority of physical, biological, chemical, and ecosystem processes in aquatic environments. Altered stream temperature is a significant cause of water quality impairment and influences other water quality parameters. Measuring temperature

helps to understand the magnitude and variability of temperature fluctuations and anticipate the consequences for water quality and ecosystem health.

In general, increased water temperature can result in:

- Decreased dissolved oxygen (DO) available to aquatic life.
- Increased solubility of metals and other toxins in water.
- Possible increased toxicity of some substances to aquatic organisms.
- Algal blooms, which typically occur during the summer season or periods of unusually warm temperatures.

Location	Depth m	Temp.[°C]
BW1	0	4.70
	1	4.68
	2	4.61
	3	4.59
BW2	0	3.96
BW3	0	4.44
	1	4.44
	2	4.42
BW4	0	4.87
	1	4.58
BW5	2	4.48
	3	4.48
	4	4.48
BW6	0	5.00
	1	4.81
	2	4.84
	3	4.73
BW7	0	5.04
	1	4.91
	2	4.77
	3	4.78
	4	4.73
	5	4.97
BW8	0	4.99
	1	4.99
	2	5.01
	3	5.02
	4	5.04
BW9	0	4.92
	1	4.96
BW10	0	4.93
	1	4.91
	2	4.83
	3	4.87



Water temperature in January 2023 were low (typically below 5 degrees Celsius and well mixed throughout the lake and vertically throughout the water column). The colder water temperatures will have supported an elevated oxygen concentration.

Dissolved Oxygen

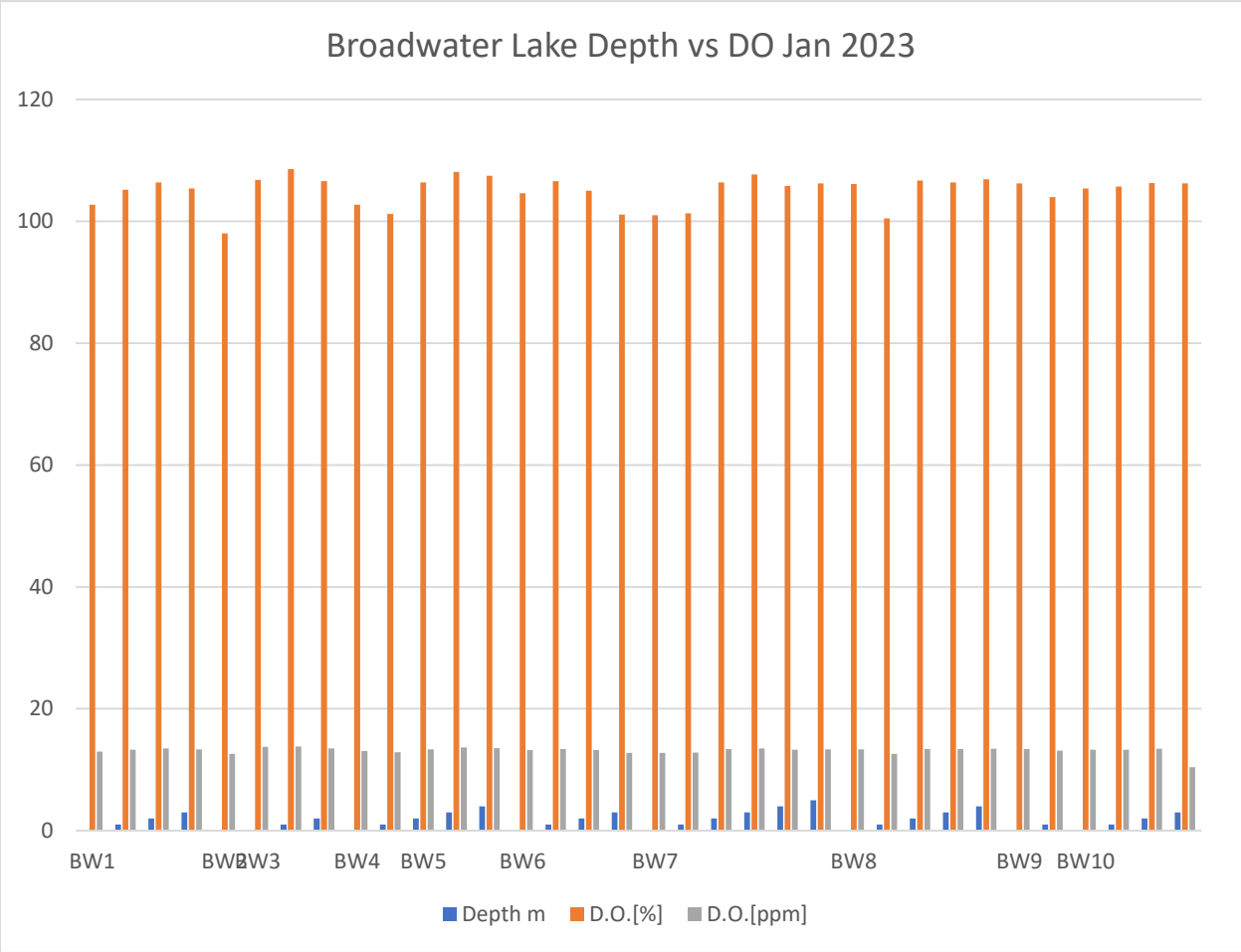
Dissolved oxygen is a particularly important water quality parameter for biological communities and varies according to rates of atmospheric dissolution, photosynthesis, and respiration. It also a function of water temperature, salinity and pressure. Cold water absorbs more oxygen than warm water, salinity decreases solubility, and pressure increases it.

Low oxygen levels in water are caused mainly by organic pollution i.e., discharge of poorly treated or untreated wastewater, and high inputs of nutrients that increase microbiological activity. Low oxygen results low species abundance and diversity.

Concentrations of over 9 mg O2/l (9 ppm) or 90 % oxygen saturation are indicative of good quality waters in terms of oxygen. For example, the EC Directive on Fresh water for Fish (78/659/EEC) gives a guideline level of 9 mg O2/l for waters that are suitable for salmon and trout. At concentrations below 5 mg O2/l or 50 % saturation, some effects on biological communities are expected.

Location	Depth m	D.O.[%]	D.O.[ppm]
BW1	0	102.7	12.98
	1	105.2	13.31
	2	106.4	13.48
	3	105.4	13.36
BW2	0	98.0	12.63
BW3	0	106.8	13.77
	1	108.6	13.81
	2	106.6	13.47
BW4	0	102.7	13.06
	1	101.2	12.88
BW5	2	106.4	13.34
	3	108.1	13.64
	4	107.5	13.55
BW6	0	104.6	13.22
	1	106.6	13.37
	2	105.0	13.21
	3	101.1	12.76
BW7	0	101.0	12.75
	1	101.3	12.80
	2	106.4	13.37
	3	107.7	13.52
	4	105.8	13.29
	5	106.2	13.33
BW8	0	106.1	13.32
	1	100.5	12.60
	2	106.7	13.41
	3	106.4	13.37

Location	Depth m	D.O.[%]	D.O.[ppm]
	4	106.9	13.44
BW9	0	106.2	13.37
	1	104.0	13.11
BW10	0	105.4	13.27
	1	105.7	13.28
	2	106.3	13.46
	3	106.2	10.41



Dissolved oxygen levels in January 2023 were good, being at least 100% saturation and influenced by the colder water temperatures.

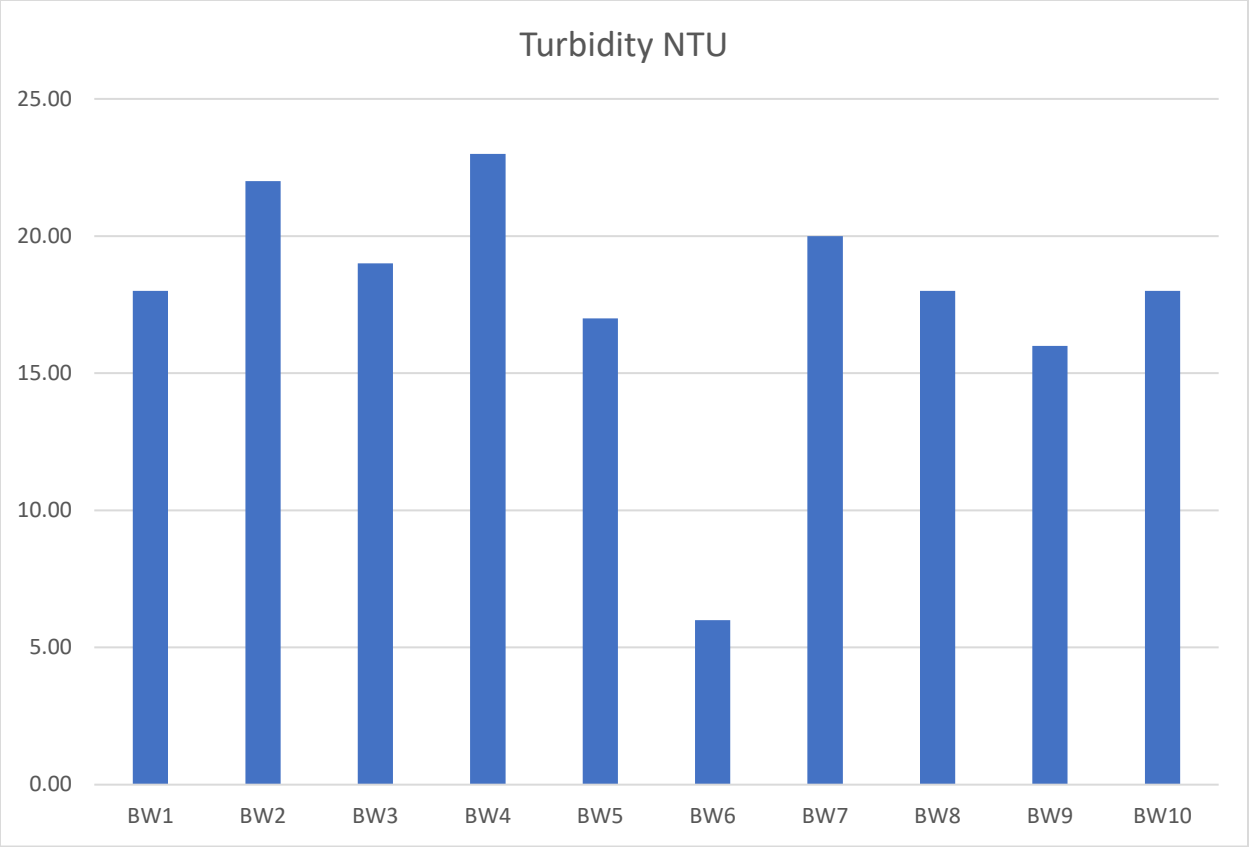
Turbidity

Turbidity is an indication of how clear the water is – the greater the amount of total suspended solids (or sediments) in the water, the cloudier it appears and the higher the measured turbidity. Common suspended solids in lakes and other standing waterbodies include clay, silt, and sand from soils, phytoplankton, particles of decaying vegetation, industrial waste and sewage. Usually turbidity is measured with a Turbidimeter, however for this survey the multiparameter probe that was used is able to measure turbidity. High turbidity and suspended solids in streams and lakes may be caused by a number of factors, such as:

- Soil erosion
- Domestic and industrial wastewater discharge
- Urban run-off from roads, car parks and other impermeable surfaces
- Flooding and increased flow rates
- Algal growth arising from nutrient enrichment
- Dredging or de-silting operations
- Removal of riparian vegetation and other bank disturbances
- An excess of bottom-feeding fish (such as carp) that stir up sediment

NTU stands for Nephelometric Turbidity Unit and signifies that the instrument is measuring scattered light from the sample at a 90-degree angle from the incident light. NTU is most often used when referencing the USEPA Method 180.1 or Standard Methods For the Examination of Water and Wastewater.

Location	Turbidity NTU
BW1	18.00
BW2	22.00
BW3	19.00
BW4	23.00
BW5	17.00
BW6	6.00
BW7	20.00
BW8	18.00
BW9	16.00
BW10	18.00



Turbidity levels at the surface of Broadwater Lake in January 2023 were relatively low, below 25 NTU, likely to be influence by the levels of zooplankton and algae observed. These levels are unlikely to result in long terms impacts to fish and invertebrates.

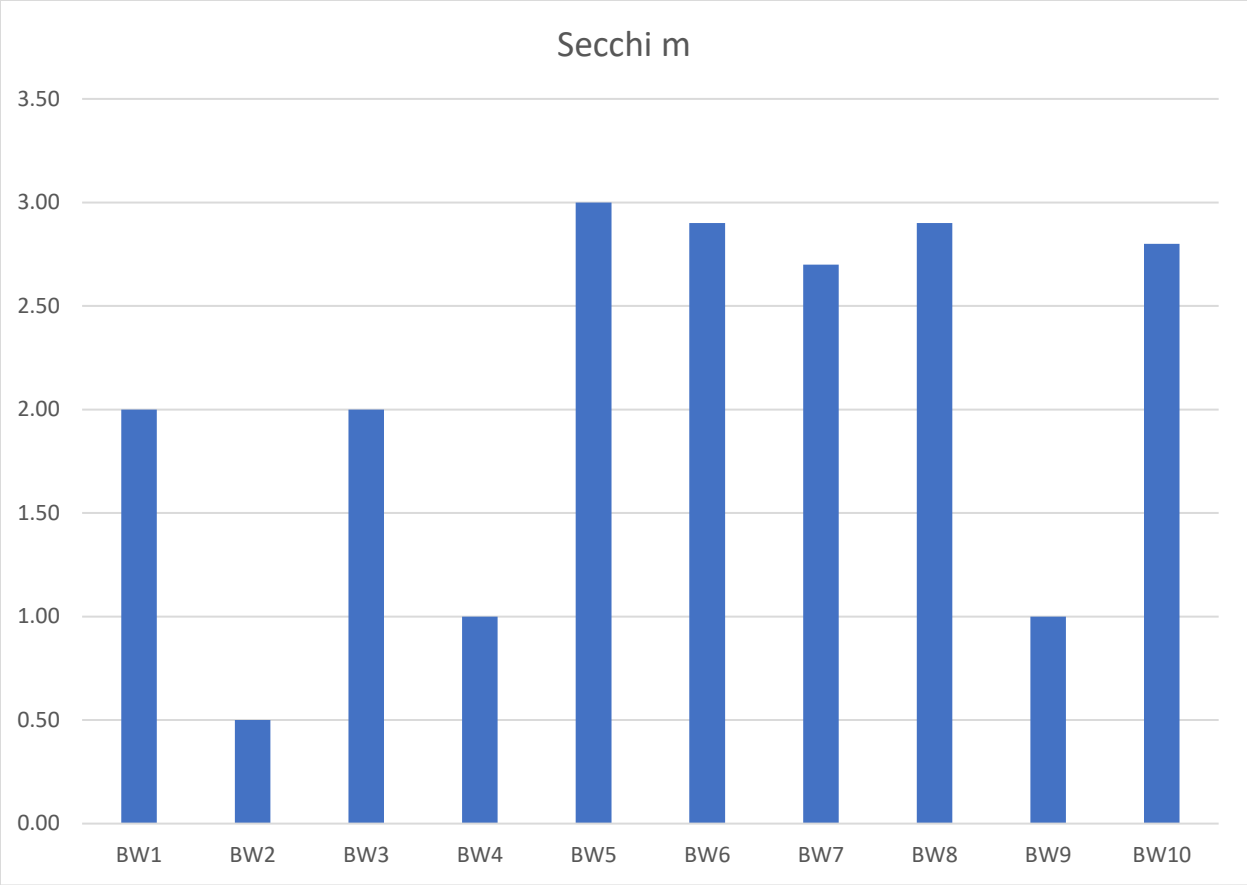
Secchi Depth

Secchi depth refers to the depth at which a disk lowered into the water can no longer be seen from the surface. Secchi depth is related to water clarity and is a measure of how deep light can penetrate into the water and is related to the 'photic depth' the maximum depth light penetrates and plants can photosynthesize.

This depth can range from a few centimetres to several metres and is influenced by the amount of suspended solids (e.g., silt, algae) or if the water has a lot of colour (e.g. from soils).

Depths in Broadwater Lake are encouraging, highlighting the potential for aquatic macrophyte growth at depths at least that measured by the Secchi depth.

Location	Secci m
BW1	2.00
BW2	0.50
BW3	2.00
BW4	1.00
BW5	3.00
BW6	2.90
BW7	2.70
BW8	2.90
BW9	1.00
BW10	2.80



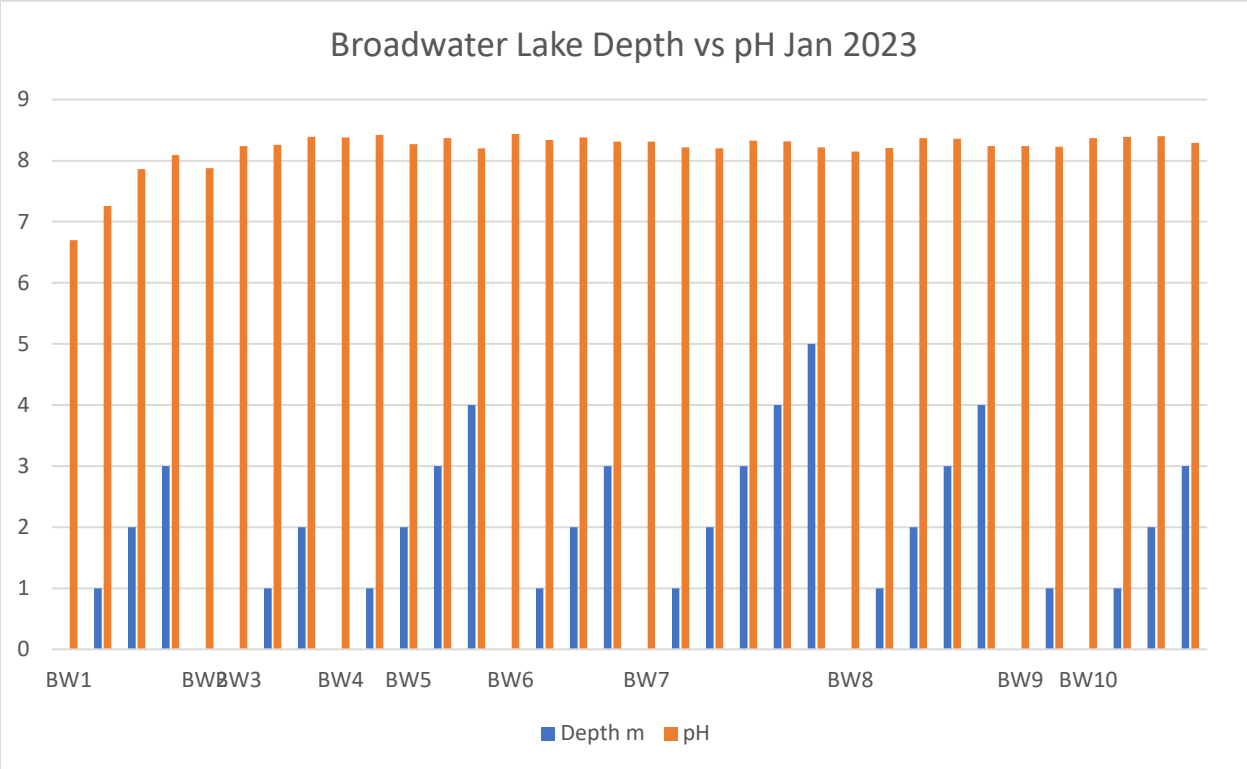
pH

The pH scale ranges from 0 to 14, a measurement of 7 is considered to be neutral, with substances up to 7 acidic, and over 7 to be alkaline. Typical lake water ranges between pH 6.5 and pH 8.5, lower values can occur in dilute waters high in organic content, and higher values in eutrophic water, groundwater brines and salt lakes. The pH sample is a measure of the concentration of hydrogen ions.

Broadwater lake is typically alkaline in character – associated with the underlying chalk geology. Localised areas of neutral and slightly acidic water is associated with BW1, located adjacent to the southern shore.

Location	Depth m	pH
BW1	0	6.70
	1	7.26
	2	7.86
	3	8.09
BW2	0	7.88
BW3	0	8.24
	1	8.26
	2	8.39
BW4	0	8.38

	1	8.42
BW5	2	8.27
	3	8.37
	4	8.20
BW6	0	8.44
	1	8.34
	2	8.38
	3	8.31
BW7	0	8.31
	1	8.22
	2	8.20
	3	8.33
	4	8.32
	5	8.22
BW8	0	8.15
	1	8.21
	2	8.37
	3	8.36
	4	8.24
BW9	0	8.24
	1	8.23
BW10	0	8.37
	1	8.39
	2	8.40
	3	8.29



Electrical Conductivity and Total Dissolved Solids

Conductivity is a measure of the ability of water to conduct an electric current. It is sensitive to variations in dissolved solids – the degree to which these dissociate into ions, the amount of electrical charge on each ion, ion mobility and the temperature all have an influence on conductivity. Conductivity of freshwaters can range from 10 to 1000 µS cm^{-1}, however in polluted water or those that receive large amounts of land run-off the measurement may exceed 1000 µS cm^{-1}. As water moves through a catchment it picks up a variety of dissolved and particulate materials from the substrate, rocks and soils.

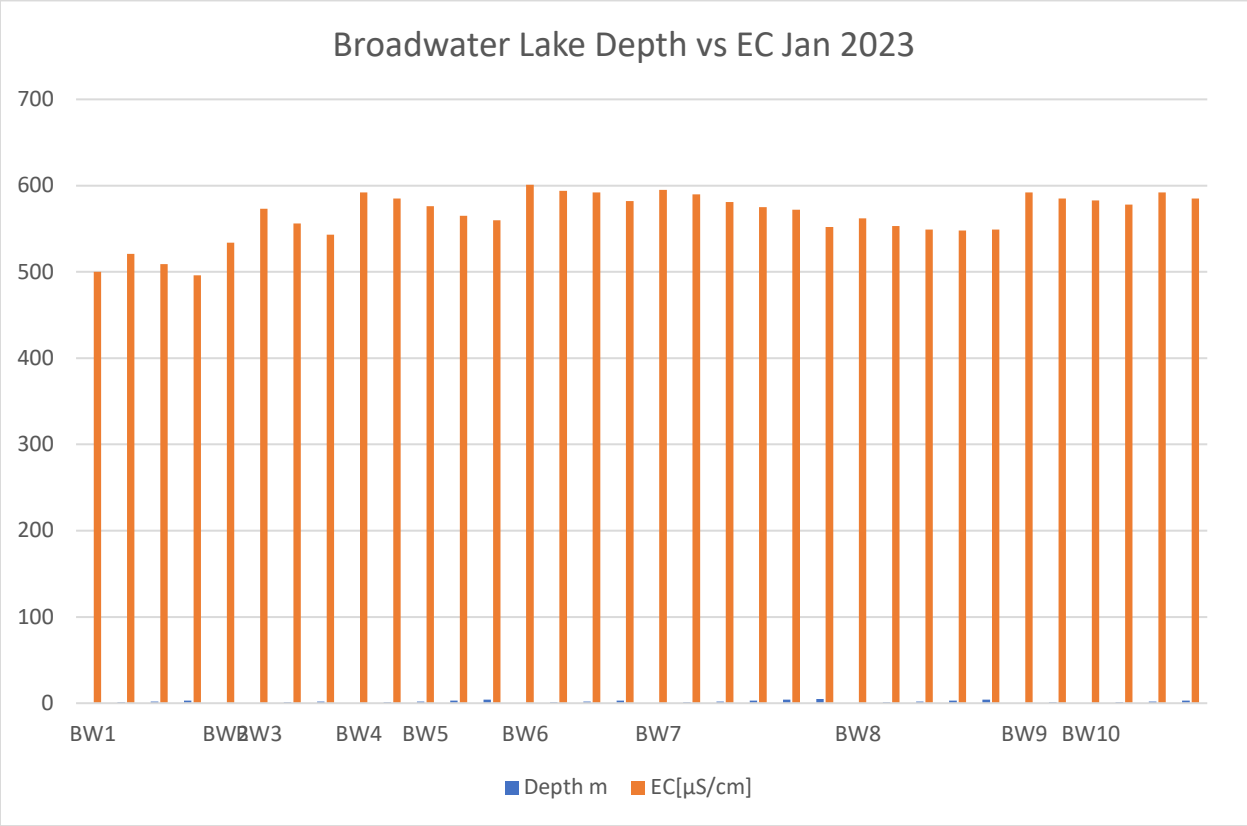
Conductivity is a measure of the waters ability to conduct and is directly related to the total dissolved salt content of the water. It is temperature sensitive and increases with temperature. Variations in conductivity may indicate sources of pollution such as: wastewater from sewage works, industrial discharges, urban runoff from roads, and agricultural runoff.

There is a general consistency of conductivity at Broadwater Lake, likely to reflect the mixed water column with the solute concentration reflecting the underlying chalk and groundwater as well as localised surface runoff.

Electrical Conductivity

Location	Depth m	EC[µS/cm]
BW1	0	500
	1	521
	2	509
	3	496
BW2	0	534
BW3	0	573
	1	556
	2	543
BW4	0	592
	1	585
BW5	2	576
	3	565
	4	560
BW6	0	601
	1	594
	2	592
	3	582
BW7	0	595
	1	590
	2	581
	3	575
	4	572
	5	552
BW8	0	562
	1	553

	2	549
	3	548
	4	549
BW9	0	592
	1	585
BW10	0	583
	1	578
	2	592
	3	585

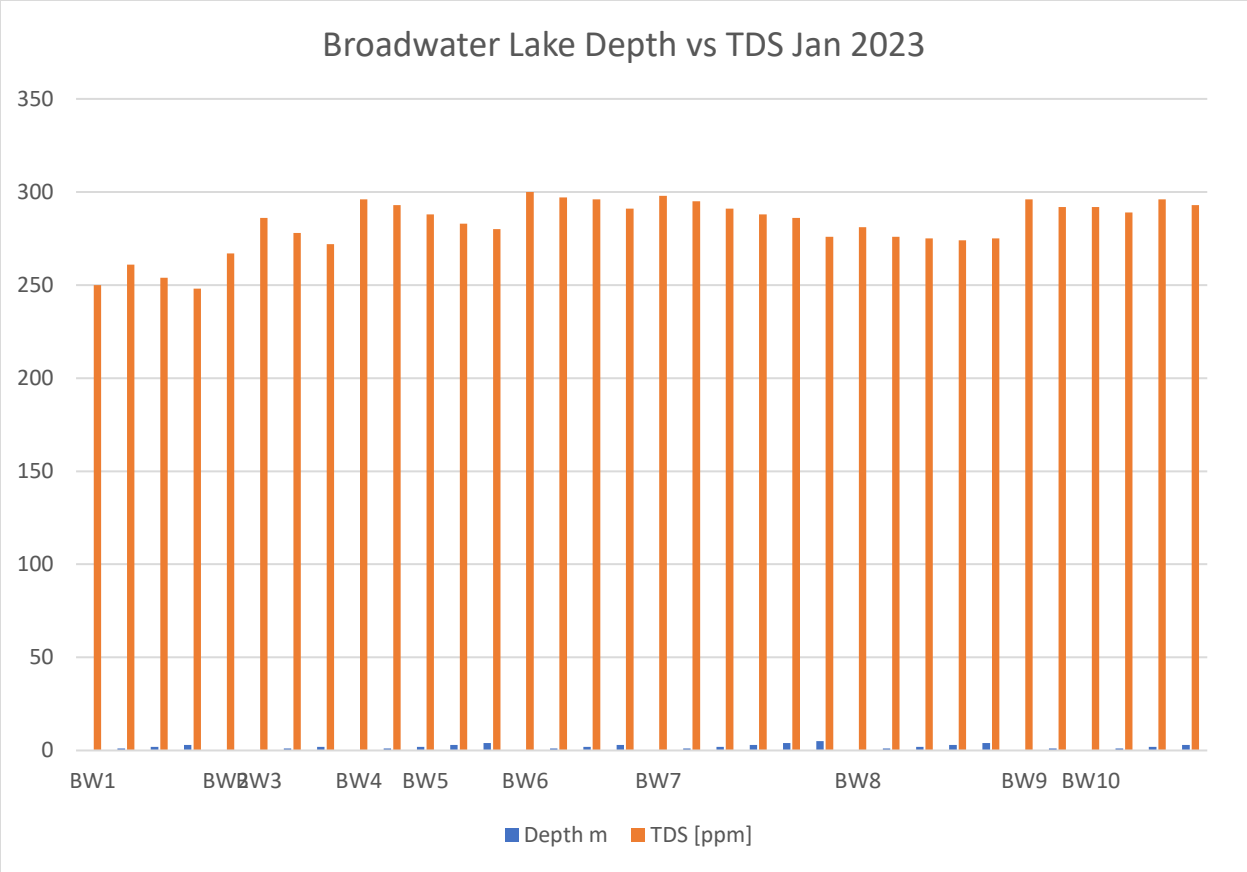


Total Dissolved Solids

The dissolved, or soluble fraction of the waters total solid load is referred to as total dissolved solids (TDS). The electrical conductivity of water provides a simple measure of TDS.

There is a general consistency of total dissolved solids at Broadwater Lake, likely to reflect the mixed water column with the concentration reflecting the underlying chalk and groundwater.

Location	Depth m	TDS [ppm]
BW1	0	250
	1	261
	2	254
	3	248
BW2	0	267
BW3	0	286
	1	278
	2	272
BW4	0	296
	1	293
BW5	2	288
	3	283
	4	280
BW6	0	300
	1	297
	2	296
	3	291
BW7	0	298
	1	295
	2	291
	3	288
	4	286
	5	276
BW8	0	281
	1	276
	2	275
	3	274
	4	275
BW9	0	296
	1	292
BW10	0	292
	1	289
	2	296
	3	293


Broadwater Lake Depth vs TDS Jan 2023
350
300
250
200
150
100
50
0
BW1
BW2
BW3
BW4
BW5
BW6
BW7
BW8
BW9
BW10
Depth m
TDS [ppm]