TOWN of CLAREMONT

Est 1898

Biophysical Wetland Values

Appendix 2

Contents

1.0 BIOPHYSICAL ENVIRONMENT

1.1 Location

Lake Claremont is approximately 10km southwest of the Perth Central Business District. The Lake Claremont site (figure 2), including Cresswell Oval and McKenzie Bushland, are defined by Alfred Road to the north, Davies Road to the east, private property and Shenton Road to the south and Strickland Street, Lakeway Estate and Narla Road to the west.

1.2 Regional Context

Perth is Located within the Swan Coastal Plain region of the Interim Biogeographical Regionalisation of Australia (IBRA). The Swan Coastal Plain comprises of two major divisions, namely Swan Coastal Plain 1 – Dandaragan Plateau and Swan Coastal Plain 2 – Perth Coastal Plain. The site is located within the Perth subregion, which is broadly characterised as including areas of Jarrah and Banksia woodlands on sandy soils in a series of sand dunes, along with wetland areas, often within the interdunal swales (Mitchell, Williams and Desmond, 2002).

According to Mitchell, Williams and Desmond (2002) the Perth metropolitan area comprises approximately 20% of the Swan Coastal Plain Subregion and was the subject of a comprehensive assessment to determine reservation status and protection requirements as part of Bush Forever. This assessment identified regionally significant bushland areas, with Lake Claremont recognised as a Bush Forever site.

Less than 20% of the wetlands on the Swan Coastal Plain remain. In the western suburbs there are only a few protected conservation category wetlands, which include Lake Monger, Perry Lakes, Herdsman Lake, Lake Gwelup and Lake Claremont.

1.3 Linkages

The Lake Claremont site act as an ecological link between bushland areas to the east, including Kings Park and Shenton Park Bushland. The main western linkage is the coastal foreshore reserve (WALGA, 2016). Lake Claremont is an important ecological link to other sites such as Bold Park, and the Swan River. Lake Claremont meets essential criteria for consideration as a Locally Significant Natural Area (WALGA 2016) and Environmentally Sensitive Area.

1.4 Climate

The climate experiences in the area is Mediterranean, with dry, hot summers and cooler, wetter winters. The Bureau Meteorology (2021) describes the climate at Swanbourne (Station 009215) as:

- The majority of the average annual rainfall of 484.4 mm falls between May and September.

- Average daily maximum temperatures range from 18.4℃ in August to 30℃ in February, with the highest recorded maximum being 42.1℃.
- Average daily minimum temperatures range from 10.1℃ in August to 20.3℃ in February, with the lowest recorded minimum being 6.1℃.
- Wind directions are predominantly morning easterlies and afternoon southwesterly sea breezes, especially in the summer months.
- The average wind speed at 9 am is 19 km/h (10.4 knots) and at 3 pm the average wind speed is 23.0 km/h (12.4 knots) with gusts of more than 100 km/h (54.0 knots) occurring in storms event.

1.5 Geology

Lake Claremont occurs on the boundary of the Quindalup and Spearwood Dune Systems. The Quindalup Dunes are calcareous sans associated with beach ridges and parabolic dunes (Churchward and McArthur, 1980). The Spearwood Dune System consists of a limestone core overlain by yellow sand. Wind erosion has produced two different landscapes, with the shallow yellow brown sands and exposed limestone of the Cottesloe unit along the west and the deep yellow brown sands of the Karrakatta unit to the east (Churchward and McArthur, 1980).

1.6 Topography

Lake Claremont sits in the swale of a Quindalup Dune along its western side and lower Spearwood dunes to the east. The older and more weathered Spearwood Dune System to the east and south of the lake is largely flat at an elevation of 4-6 m Australian Height Datum (AHD – Above sea level). To the northwest of the lake, the land rises quickly from 4 m to 14 m AHD (Department of Environment, 2004).

1.7 Soils

Soils typically have a close association with vegetation present at a site. Natural resource information provided by the Department of Agriculture WA (2014) indicates there are five soil types in and around Lake Claremont (Figure 2 and Table 1). Variations in the soil types present, are associated with previous disturbance activities including use as a landfill and construction of the golf course.

Table 1 - Lake Claremont Soil Types

Label	Name	Description
211Qu_S2	Quindalup S2 Phase	Safety Bay Sands. Calcareous sand, white, fine to medium grained, sub-rounded quartz and shell debris, to eolian origin
211Sp_Cps	Spearwood Cps Phase	Holocene damp deposits. Peaty, clay-dark grey and black, soft, variable organic content, some quartz sand in places, of lacustrine origin
211Sp_LS1	Spearwood soils, LS1 Phase	Tamala Limestone, light yellowish brown, fine to coarse-grained, sub-angular to well rounded, quartz, trace of feldspar, shell debris, variably lithified, surface kankar, of eolian origin, some minor heavy minerals
211Sp_S7	Spearwood soils, S7 Phase	Sands derived from Tamala Limestone. Sand, pale and olive yellow, medium to coarse-grained, sub-angular to sub-rounded quartz, trace of feldspar, moderately sorted, of residual origin
211SpW_Lake	Spearwood wet, Lake Phase	Lake, open water

In 2021, the Town engaged a consultant to report on the quality and health of the soil in several sites at Lake Claremont. Multiple soil samples were collected from each site and taken to an ASPAC laboratory for analysis.

The report noted that the soil pH varied across the site from neutral to strongly acidic, which is typical of sandy Perth soils. High nutrient levels in the soil across all sampled sites which may be leaching into groundwater and potentially the lake, impacting aquatic health. Elevated levels of heavy metals were found through the site, particularly near drain location sites. The presence of heavy metals in the soil is not unexpected, given the history of the site, the runoff from external sources through the drainage channels, and the use of chemical herbicides in the bush areas at Lake Claremont (Defarge, Spiroux de Vendomis & Seralini, 2018).

Recommendations:

- Engage contractors to conduct a soil sampling and analysis report every three years to monitor any changes.
- Continue to reduce the application of chemical herbicides.

An estimated budget allocation of $7,000 (exc. GST) is required every three years to conduct soil sampling and analysis at Lake Claremont.

1.7.1 Erosion

The steeper areas of the lake banks and portions have the greatest potential for erosion. There is also the potential for erosion during storm events in steeper areas, such as the path leading from the Lakeway Estate to the lake. Revegetated and/or fenced areas have been effective in stabilising slopes. However, where there are gaps in the fence people and dogs can gain access and contribute to erosion.

The installation of rock revetments, brushing with logs, jute matting, coir logs, and replanting are the most common methods of erosion control applied within the Lake Claremont.

There is also potential for erosion on the limestone paths north of Strickland Street that run along the lakes buffer, and the limestone paths that run south of Myera Street. Heavy foot traffic, storm events, and drain outlets have led to limestone path degradation in these areas, resulting in costly and frequent limestone repair expenses.

Recommendations:

- Continue revegetation efforts in sparse areas, particularly along the slope that runs from the Lakeway Estate to the Lake.
- Install rock revetments, brushwood logs, jute matting, and/or coir logs along the slope that runs from Lakeway Estate to the Lake.
- Continue to monitor limestone tracks and steep slopes during routine inspections by Town staff for erosion after major storm events and organise repairs as required

An estimated annual expense of $5,000 (exc. GST) is required to maintain erosion sites at Lake Claremont.

1.7.2 Acid Sulphate Soils

Potential acid sulphate soils are present at Lake Claremont. These soils are presently stable and not resulting in contamination, as evidenced by pH readings from the water body of 7 to 8, and the soil sampling and analysis report of pH readings between 5.7 to 7 (2021).

Recommendations:

Currently acid sulphate soils within the Lake Claremont are stable, to minimise the potential for negative impacts from acid sulphate soils:

- Minimise disturbance of sediments within the wetland basin.
- Undertake appropriate investigations prior to any works that are likely to disturb subsurface soils.
- If required, undertake appropriate testing for acid sulphate soil chemical indicators.
- If warranted by outcome of review or investigative testing, develop and implement an Acid Sulphate Soil Management Plan for the works.
- Monitor all major excavation at the park to ensure early detection of disturbed acid sulphate material.
- Monitor pH within the water body and use as an indicator of acid sulphate soil disturbance.

1.8 Vegetation Associations

Lake Claremont is located within the Karrakatta Complex – Central and South vegetation complex, which consists of open forest of Tuart-Jarrah-Marri (Heddle, Lonergan and Havel, 1980). Other species typical of this complex include *Banksia attenuate, Baksia menziesii, Banksia grandis, Jacksonia sternbergiana, Jacksonia furcellata, Acacia cyclops, Acacia saligna, Hibbertiaa spp*, and *Calothamnus quadrifidus.*

According to the Environmental Planning Tool (WALGA, 2014), a 2.4 hectare remnant of this vegetation type is located in the western portion of the Lake Claremont site. Between 10% and 30% of this vegetation type remains within the IBRA subregion.

1.9 Fire Management Strategies

As the trees and shrubs mature within the revegetated areas in the north, the fire hazard is likely to increase. The Town's Community Safety Team regularly meet with the Department of Fire and Emergency Services to determine works required in firebreaks and to reduce the fire fuel load.

Recommendations

- Follow and implement the recommendations of the Bushfire Management and Revegetation Plan.
- Perform a bushfire threat analysis using the DEFS template, including an assessment of fire fuel loads, on a biennial basis.
- Maintain access tracks and fire control buffers in accordance with the TOC maintenance schedule and DFES Fire Management Plans.

2.0 LAKE CLAREMONT WETLAND

Wetland management considers the presence of the water body itself, the source of the water, its quality and its influences on flora and fauna. Lake Claremont is an ephemeral Conservation Category Wetland (Number 8199) that has surface water in the wetter months and dries out in summer.

2.1 Groundwater Aquifer

Lake Claremont is located on the southwestern edge of the Gnangara groundwater mound, the shallow unconfined superficial aquifer that underlies much of the northern suburbs within the Perth Metropolitan area (Government of Western Australia, 2022). Depth of groundwater around Lake Claremont varies according to the season. Levels rise in winter when infiltration from rainfall exceeds horizontal flow through the Gnangara system. Groundwater flow in the proximity of Lake Claremont is from the north-northeast, fanning out through and under the lake, before heading south where the groundwater enters the Swan River through surface springs and seepage directly into the river.

2.2 Water Body

The waterbody of Lake Claremont is a surface expression of groundwater, drying out in summer and filling in the cooler wetter winter months when the groundwater level rises, the waterbody works as a stormwater retention basin. As with almost all lakes on the Swan Coastal Plain, Lake Claremont is a 'flow-through lake' meaning that the groundwater flows from the up-gradient capture zone to the down-gradient release zone (Townly et al., 1993). The capture zone for the present-day Lake Claremont is northeast corner of the lake and the release zone is southern end of the lake, from where it ultimately flows towards the Swan River. When surface water is present in winter, the depth within the lake ranges from centimeters in the northern portion to 0.5 m and deeper in the southern end. Seasonal and topographical variation in water depth provides a variety of habitats suited to water birds with differing feeding habits, including those that forage in shallow water (e.g. Avocets and Banded Stilts) and those that dive to the bottom of a lake for food (e.g. Australian and Hoary-headed Grebe).

2.3 Water Quality

Water quality monitoring for Lake Claremont has been routinely conducted annually since 2013. Key parameters included in the water monitoring program are pH, dissolved oxygen, electrical conductivity, turbidity, nutrients (total nitrogen, ammonia/ammonium, total oxidized nitrogen, phosphorus and orthophosphate), metals and hardness, presence of macroinvertebrates and algal bloom indicators (chlorophyll-α and phaeophytin-α).

2.3.1 Ammonia

Given the direction of groundwater flow, there is the potential for contamination from waste materials, dissolved contaminants, and breakdown products such as ammonia from the old Brockway Road landfill site to the north, to be transported to Lake Claremont. The Brockway Road landfill site was decommissioned in 1991. The decomposition processes associated with the breakdown of household wastes will be their final stages, with only small amounts of landfill gas and other breakdown products generated.

Ammonium/ammonia concentrations across most sites at the Lake have been within similar ranges since 2004. However, results from 2016-2020 show a higher-than-average concentration of ammonium/ammonia when compared to results from 2004-2016. The 2019-2020 ammonium/ammonia levels of the main waterbody at Lake Claremont were between approximately 7 – 440 µg/L (WATER QUALITY REPORT, 2020). The trigger value for ammonium/ammonia is 40 µg/L based on the ANZECC 2000 water quality guidelines. Whilst the values presented in the 2019-2020 report are up to ten times the concentration, it is comparable to other coastal urban wetlands of Perth and is, mostly, below levels of 300-700 µg/L found in the groundwater linked Swan River Estuary (Thompson et al., 2001; Searle et al., 2011). Higher levels of ammonia can on occasion occur after flushing from rainfall events and other natural processes.

2.3.2 Alkalinity

The acceptable pH range for wetlands in the south-west of Australia based on the ANZECC guidelines is, 7 – 8.5. The Lakes' wetland pH values generally fall within this range, with few exceptions. The 2019-2020 water quality report show record of pH values that exceed the upper limit of 8.5 of the ANZECC guidelines value. Acidic pH valued below 6.5 or alkalinity greater than 9 are an indication of water quality issues. The 2019-2020 water quality report indicates pH levels higher than 9 in the water tested at the Lookout site. However, this is not of particular concern as the soil type of the Lake substrate (Spearwood Wet [sand over limestone]) is alkaline and it is expected that the water is more alkaline.

High alkalinities are often associated with algal blooms. Th alkaline pH readings for the lake indicate that the mobilisation of heavy metals from materials buried fill portions of Lake Claremont in the 1950s and 1960s is not likely, as that process requires acidic conditions.

Alkaline levels also indicate that actual or potential acid sulphate soils present within the site are stable and not causing contamination, as they would produce acidic conditions if mobilised.

2.3.3 Orthophosphate

Orthophosphate is the inorganic form of phosphorous that is available for uptake by plants and contributes to their growth. Monitoring of orthophosphate levels within Lake Claremont indicate that while they are higher than preferred for a water body on the Swan Coastal Plain, they are declining over time. When looked at in conjunction with the decline in chlorophyll-α readings over the same period, this indicates the lake is returning from being a eutrophic (nutrient enriched) system to a healthier low nutrient system. This improvement is also reflected in the abundance and diversity of aquatic flora and fauna found at the site (Appendix 3).

2.3.4 Sediment Sampling

Sediment sampling for metals, pesticides and hydrocarbons have not been carried out since 2007 by TOC. The samples in 2007 indicated that there are slightly elevated levels of arsenic, lead and zinc. This can also be seen in the water quality assessments carried out since 2007. The source of these contaminants is likely to be associated with stormwater runoff, with a less likely explanation being leaching from nearby landfills. Cadmium, chromium, copper, mercury and nickel were below the relevant low-level trigger values. Alkaline soils and environmental water (pH approximately 8.5) makes it unlikely that heavy metals would be mobilised and are unlikely to be negatively impacting the aquatic flora and fauna within the lake. Similarly, indicators of Organochlorine (OC) Pesticides and Poly Aromatic Hydrocarbons (PAHs) were below the detection limits of the analytical techniques. Occasional sampling will provide a review mechanism to confirm the current situation with contaminant levels.

2.3.5 Electrical Conductivity (EC)

There has been no change in the conductivity of the surface waters of the lake since water quality monitoring commenced in 2004. The EC results have always been outside the ANZECC acceptable range for wetlands of southwest Australia at all sampling sites in Lake Claremont, therefore it is expected that the biota in the waterbody have adapted to the conductivity levels.

2.3.6 Dissolved Oxygen

Dissolved oxygen provides a measure of how much oxygen there is available to aquatic organisms. In the 2021-2022, results indicated at the dissolved oxygen levels were below the ANZECC acceptable range for wetlands in all sites samples across the Lake. The lowest dissolved oxygen saturations were recorded at Alfred Road sampling site. It should be noted that dissolved oxygen does fluctuate greatly and is influenced by temperature, water level and wind conditions. Therefore, these results vary drastically between seasons and conditions.

Recommendations:

- Continue existing program of water quality monitoring and reporting as the primary indicator of wetland health.
- If any sampled parameter indicates a potential issue with water quality, the Town of Claremont consider repeat sampling or an increased frequency of sampling to determine the cause and develop an appropriate management strategy.
- Nutrient and Irrigation Management Plans (NIMP) and annual reporting of leaf and soil nutrient levels, water extraction and water quality testing of groundwater bores by the lessee are required as a condition of leasing any recreation or sporting space with the Lake Claremont.
- Liaise with managers from Scotch College to obtain historical leaf and soil nutrient levels, water extraction and water quality testing of groundwater bores data under their NIMP and establish annual reporting to LCAC as per recommendation of the 2016-2021 Lake Claremont Management Plan.
- Continue to remove weeds during the summer months or within shallow areas where practicable.
- Deciduous trees are to be uplifted in the summer months and lower branches removed.

An estimated annual expense of $20,000 (exc. GST) is required to sample and report on the water quality at Lake Claremont.

2.4 Aquatic Vegetation

Lake Claremont includes a range of aquatic and emergent vegetation. *Typha orientalis* (Bulrush) was previously removed from the lakebed and replaced with a range of native sedges including *Bolboschoenus caldwellii, Ficinia nodosa,* and *Schoenoplectus validus.* However, in 2015 *Typha orientalis* was declared native to Western Australia due to the lack of historical evidence on its listing as a weed, and the use by Noongars as a major food source (Keighery, 2016). However, *Typha orientalis* can become invasive if measures are not taken to manage its growth. *Typha orientalis* clusters are mapped out by the Towns Landcare Officer and clusters are maintained by removing the flower heads, which are highly productive. Clusters are monitored and assessed by the Towns Landcare Officer and the Friends of Lake Claremont.

2.4.1 Charophyte Flora

Charophytes are a group of multi-cellular green algae found in temporary and permanent water bodies. Ranging in height from 1-200 mm, they appear similar in structure to land plants with a 'trunk' from which multiple branches develop.

The charophytes are a pioneer species that colonise inundated areas, provide stability to sediments in the lakebed, contribute to improved water quality and provide an important food source for wetland fauna. This plant group is an indicator of good water quality, preferring low nutrient levels and moderate alkalinity (Trend n.d.). Species of Charophyte recorded at Lake Claremont in 2010, are *Lamptothamnia macropogon, Protochara inflata,* and *Chara globularis* var. *globularis*.

2.5 Algae

In the 2016-2021 Lake Claremont Management plan a NatureMap report indicates the potential for 14 species of algae. Many of these are marine species common in the nearby Swan River. Marine species may establish in Lake Claremont for a short time under specific conditions as the waterbody dries. However, algal species are ubiquitous and the possibility of their occurrence in Lake Claremont from propagules transported by water birds cannot be ruled out.

Algal blooms of Blue-Green Algae (Cyanobacteria) and unknown species of string/rope algae have occurred in Lake Claremont under nutrient rich conditions. With improvements to water quality, revegetation, and declines in the levels of orthophosphate at the site, algal blooms are less frequent and less severe than previously recorded.

2.6 Stormwater

Stormwater runoff can negatively impact wetlands through the transport of contaminants such as heavy metals, hydrocarbons and propagules of weedy plants. Historically, six drains carried stormwater from surrounding areas directly into the lake, including from an agricultural style drain along the eastern side of the Scotch College playing fields. Improvements at Lake Claremont have seen the creation of nutrient stripping basins and ponds that allow the inflow of stormwater into areas where reeds and aquatic plants act to remove nutrients and other materials from the water before it enters the main wetland area (Figure 1). These nutrient stripping basins also act to treat stormwater flowing into the Lake Claremont catchment from Claremont and Nedlands.

Figure 1 - Nutrient stripping basin at Stirling Road Park

The nutrient stripping basin adjacent to the Stirling Road playground has previously had issues with sediment runoff blocking the drain outlet. The sediment was removed, and the basin was levelled out to prevent further blockages.

Recommendations:

- Continue to monitor drain sites for blockages.
- Remove sediment build-up before major blockages.
- Vegetate the Stirling Road nutrient stripping basin with sedges to filter runoff water and enhance the aesthetic amenity of the basin.

2.7 Botulism

A botulism event occurred at Lake Claremont in 2018-2019, with the last known one before this being over 10 years ago. In 2018, 300 birds including Pacific Black Ducks, Grey Teals, Black Stilts, Spoonbill, Ibis and a White-faced Heron had died as a result of the botulism outbreak. In 2019, 47 birds including Pacific Black Ducks, Grey Teals, and one Moorhen died. It was believed that the low water levels led to an increase in water temperature and reduction in dissolved oxygen in the lake resulting in bacterial outbreak.

Town officers explored many options to combat the bacteria outbreak, including:

- Removal of deceased birdlife from the waterbody;
- Aeration of the water by installing an aerator;
- Adding/draining water to/from the lake;
- Chemical usage to reduce nutrient content;
- Harvesting plant matter.

However, after careful consideration and liaison with external authorities, the only options the Town was able to proceed with were the removal of deceased birds from the lake, and the harvesting of plant matter. There has been no record of botulism since the 2018-2019 outbreak. The Town is committed to reducing dead plant matter and weeds from the lakebed in the dry months.

2.8 Waterwise Council Program

The Town of Claremont is a member of the Waterwise Council Program run by the Department of Water and the Water Corporation with the support of the International Council for Local Environmental Initiatives (ICLEI). The aim of the waterwise program is to encourage and assist local government improve water efficiency measures.

TOC's Local Action Plan identified strategies to assess water usage and suggest areas where efficiencies were possible. Strategies implemented included auditing water use in all council buildings, review management of scheme and groundwater and reporting to the community. Additional strategies include the use of 'Waterwise' plants, with a focus on local natives and the removal of irrigation from some bushland areas. Water practices and revegetation activities within Lake Claremont are consistent with the Town's commitment to being Waterwise, as well as Lake Claremont's classification as a Conservation Category Wetland.

2.9 Nutrient and Irrigation Management Plans

Scotch College have installed a naturally vegetated nutrient-stripping swale to remove nutrients and other materials prior to it entering Lake Claremont. Scotch College has prepared and implemented a Nutrient and Irrigation Management Plan (NIMP) with the aim of minimising impacts from the campus, in particular the playing fields. Scotch College provides the Town of Claremont with a copy of the NIMP each year and has been doing so since 2017 as per the recommendation of the 2016-2021 Lake Claremont Management Plan.

Turf in the east and northeast portion of the site and at Stirling Road Park are managed as an almost closed systems to minimise the introduction of additional and/or unnecessary nutrients and trace elements to the lake environment. These areas are a mown without using a catcher, which allows grass clippings to decompose naturally in situ and return existing carbon and nutrients to the soil to maintain the turf into the future. Annual analysis of nutrient and trace elements in leaf tissue and soil samples from this turf facilitates the targeted application of the minimum amount of the most appropriate fertiliser required to maintain healthy growth. Excessive growth of turf is discouraged in these areas by the controlled application of fertiliser and water. An irrigation schedule compliant with the ICLEI and Waterwise Council Programs has been prepared and implemented for the Lake Claremont site. Townley et al. (1993) report that the contaminant capture zone of lakes on the Swan Coastal Plain is an area approximately double the width of the wetland. As a result, watering and nutrient application practices at the Lake Claremont Golf Course, Claremont Lawn Tennis Club, Claremont Aquatic Centre, Mt Claremont Oval and Cresswell Oval also have the potential to impact the lake.

Recommendations:

- Continue to liaise with Scotch College regarding the outcomes of the NIMP.
- Fertilising and irrigation of turf areas at the Lake Claremont Golf Course and Claremont Aquatic Centre occur under the regime applied in other TOC managed areas.
- For areas of the site leased to a third party (e.g. Claremont-Nedlands Cricket Club and Claremont Lawn Tennis Club) the lease conditions should include the preparation and implementation of a NIMP to ensure management of the site remains consistent with that undertaken by the Town of Claremont.
- An annual report provided by the lessee as means of demonstrating compliance with the lease condition and such reports are tabled with the Lake Claremont Advisory Committee

2.10 Regional Nutrient Surveys

The Town of Claremont participates in the nutrient surveys carried out by the South East Regional Centre for Urban Landcare (SERCUL) in association with the Swan River Trust. The survey investigates a range of management practices carried out in within local government boundaries, including those relating to the type of turf used in grassed areas, the application of fertiliser, along with soil, moisture and leaf tissue testing to determine the most appropriate type and application rate of fertiliser for a given situation.

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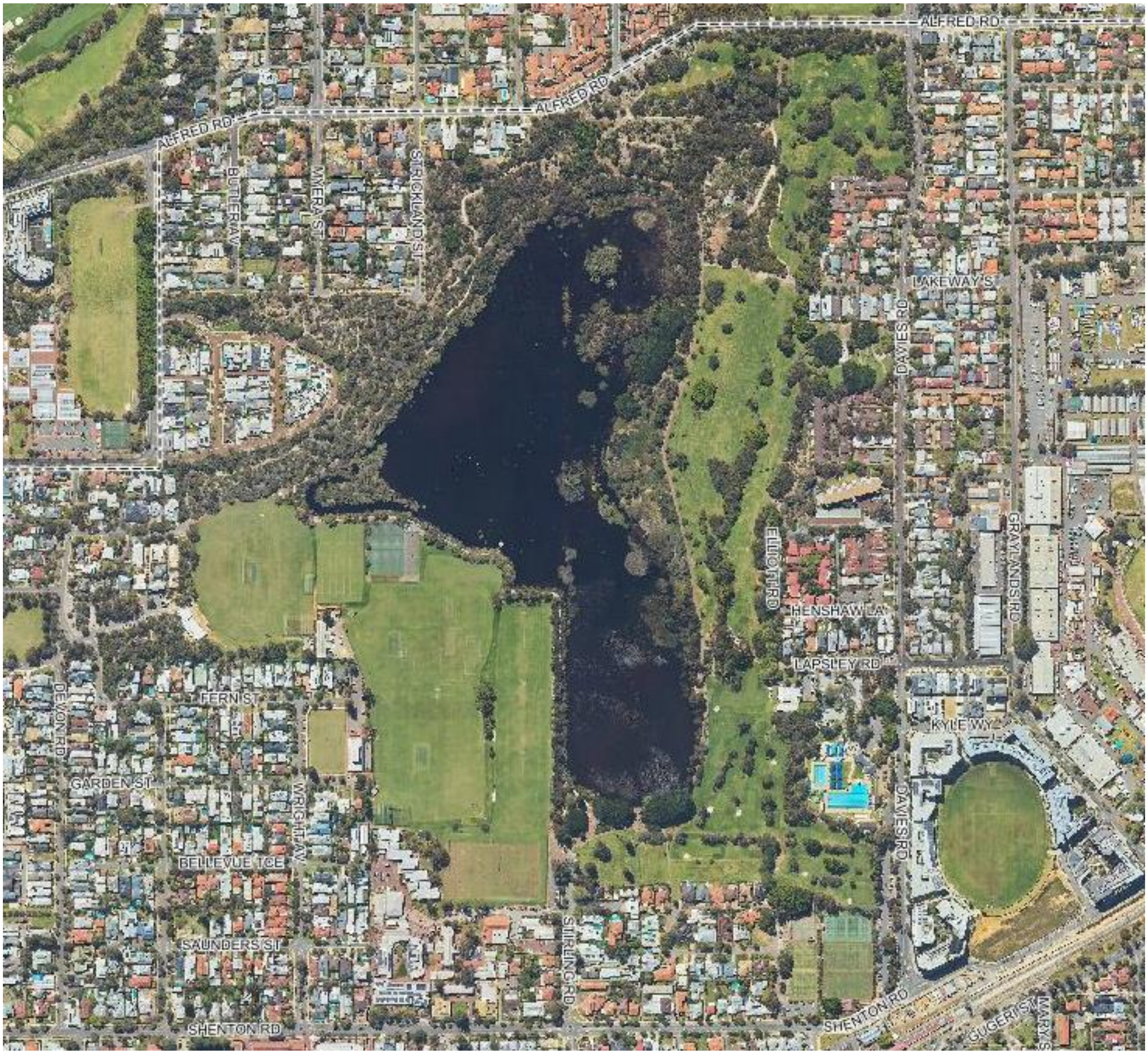

Figure 2 - Aerial image of Lake Claremont