Southern Parallel Sports Campus Limited

ASSESSMENT OF POTENTIAL ODOUR EFFECTS

COMMUNITY WASTEWATER TREATMENT PLANT

4 NOVEMBER 2022

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ASSESSMENT OF POTENTIAL ODOUR EFFECTS COMMUNITY WASTEWATER TREATMENT PLANT

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REV	DATE	DETAILS
A	04 November 2022	FINAL

	NAME	DATE	SIGNATURE
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Approved by:	Roger Cudmore	4 November 2022	

TABLE OF CONTENTS

1 INTRODUCTION

This report provides an odour impact assessment for the proposed new municipal wastewater treatment plant (WWTP) at the proposed Southern Parallel Sports Stadium Complex Limited (SPSC) recreational facility, which would be located at Stranges Road, Lake Hood, Ashburton, Canterbury. The WWTP would be a package activated sludge plant that employs a novel trickling filter type of technology, which is supplied by BioGill. The plant would be sized to treat wastewater generated at the sports facility, when hosting up to 750 people.

This report includes a description of the BioGill WWTP, its key mitigation by design features and an analysis of the receiving environment. This is followed by an assessment of the potential for the WWTP to cause any odour effects beyond the site boundary and the key odour mitigation measures (including design features and containment/treatment measures,) which aim to effectively eliminate odour occurring at the site boundary.

The general location of SPSC's proposed recreational facility is shown as the red shaded area in Figure 1-1.

LEGEND

- Southern Parallel Sports Campus site boundary
- Meteorological station

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77 Selwyn Place
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CLIENT AND PROJECT
SOUTHERN PARALLEL SPORTS CAMPUS

TITLE
SITE BOUNDARY AND LOCATION

REFERENCE SCALE: 1:50,000 (at A3)
PROJECTION: NZGD 2000 New Zealand Transverse Mercator

0 1 2
Kilometers

PROJECT NUMBER	REPORT	REV.	FIGURE
3-C2503.00	002	A	1-1

DATE	DRAWN	APPROVED
2022-11-03	ZJ	MH

NOTES
1. Aerial: LINZ Data Service, Eagle Technology.
2. Map image: OpenStreetMap and contributors, CC-BYSA.
3. Schematic only, not to be interpreted as an engineering design or construction drawing.

2 PROCESS DESCRIPTION

2.1 OVERVIEW

Wastewater that is generated from users of the SPSC facility, including discharges from the site's café and other amenities. Site generated wastewater inputs would be transferred via a local sewerage network and discharged into a wastewater sump which is located at the WWTP. This sump would be covered, enclosed and have its wastewater contents pumped out and over a static screen. Then screened wastewater would be treated by the BioGill designed system. The BioGill technology was developed in the research laboratories at ANSTO, the Australian Nuclear Science and Technology Organisation, based in southern Sydney.

The BioGill system is a type of trickling filter-based activated sludge treatment process and incorporates conventional aerobic & anoxic biological stages, settling of spent biofilm, final stage filtration, and UV disinfection treatment. The water quality of the final treated effluent is expected to be of sufficient quality for it to be discharged to an onsite wetland/pond system and to be used for irrigation of vegetated areas within the SPSC site.

At the core of the BioGill system is patented ceramic media, which provides a fine structure (for biofilms to attach) and receive nutrients and air (referred to as "Gills"). The BioGill treatment system will be housed within an enclosed building which would ventilate building air to atmosphere via carbon filters.

2.2 WWTP DESIGN INFORMATION

The WWTP is designed to accommodate wastewater generated by a maximum of 750 users of the SPSC facility (including patrons and residents). Based on this, a maximum design flow of 150 m^3/day of sewage has been allowed for in the system's design, which will include five BioGill Ultra units – three for aerobic treatment and two for anoxic treatment stages.

This allows for a conventional pre-anoxic stage, and subsequent aerobic and anoxic stages to enable the reduction in the wastewater stream's biological oxygen demand and undertake denitrification (reduction in nitrate levels in the final wastewater stream). The anticipated inlet wastewater and treated effluent flow and composition values are shown in Table 2-1

An image of two BioGill units is provided in Figure 2, Appendix A.

Table 2-1: Key design parameters for the proposed WWTP.

Parameter	Inlet flow	Treated effluent
Max. Flow (m^3/day)	150	150
Max. BOD input (mg/L)	<300	<50
TSS (mg/L)	<200	<30
TN (mg/L)	<50	<30

The incoming waste stream would be discharged from the static screen. An example of the type of screen used is provided in Figure 3, Appendix A.

Figure 2-2 provides a schematic diagram of the BioGill Ultra treatment modules and associated in-ground tanks and pumps. Note that all above ground BioGill units are supplied with wastewater flows via pumping from the in-ground tanks and returns liquor back to the tanks via gravity.

The treated discharge which exits the BioGill system (as shown in Figure 2-2) would be further treated by a water filtering system. This removes fine suspended solids from the final effluent before it is discharged to a wetland/pond system and/or irrigation to surrounding land.

The biological treatment processes (excluding the initial screening stage) are summarised as follows:

2.2.1 FIRST SETTLING TANK

Wastewater is discharged from the static screen and into the first 50 m^3 in-ground settling tank, which provides a final opportunity for settlement of any grit or sediment within incoming wastewater stream.

2.2.2 ANOXIC TANK

Wastewater overflows from the settling tank and discharges into a 50 m^3 in-ground pre-anoxic tank (the second tank in Figure 2-2). In this tank, the incoming wastewater mixes with an anoxic flow containing biosolids, which is returned (via gravity) from two above-ground anoxic BioGill treatment modules.

The anoxic BioGill modules operate in a fully submerged state and are therefore, not passively aerated. This oxygen devoid environment encourages denitrification of nitrates and subsequent release of nitrogen gas from the anoxic BioGill modules.

Wastewater is recirculated between the pre-anoxic tank and the anoxic BioGill treatment modules. It then overflows into the first recirculation tank (RT#1).

2.2.3 RECIRCULATION TANKS 1 & 2

Wastewater (ex the anoxic tank) flows into an in-ground 30 m^3 recirculation tank (i.e., RT#1), which in turn overflows into a second 30 m^3 recirculation tank (RT#2). Flows from each tank are recirculated to and from two above-ground aerobic BioGill units (i.e., BioGill Ultra #1 and #2) and at a rate of 80,000 L/hour from each recirculation tank. These two BioGill units provide a first stage aerobic trickling filter treatment. Spent biofilms from these units routinely break away and settle into the base of the recirculation tanks.

2.2.4 RECIRCULATION TANKS 3 & 4

Wastewater (ex the second recirculation tank) overflows into the third in-ground 30 m^3 recirculation tank (i.e., RT#3), which in turn overflows into a second 30 m^3 recirculation tank (RT#4). Flows from each tank are recirculated to and from a 2nd stage above ground aerobic module (i.e., BioGill Ultra #3) at a rate of 40,000L/hour from each recirculation tank. This final BioGill unit provides a second stage aerobic trickling filter treatment. Spent biofilms will also routinely break away and settle into the base of these two recirculation tanks.

2.2.5 FINAL SETTLING TANK

Partially treated waste (sewage/wastewater) from recirculation tank (RT #4) flow into a final 50 m^3 in-ground settling tank, which provides a final opportunity to settle out waste sludge. This also recycles nitrate laden treated wastewater back to the two Anoxic Bioreactors, located at the head of the treatment process. This enables denitrification and removal of nitrates from the final discharge.

2.2.6 FILTERING & UV TREATMENT

The type of in-line bag filters proposed for removing suspended solids from the effluent exiting the BioGill system, are shown in Figure 4, Appendix A. These will remove suspended flocs and other fine particulate within the final effluent and ensure the final stream is suitable for UV disinfection and discharge to a pond and then used for the irrigation of onsite vegetation.

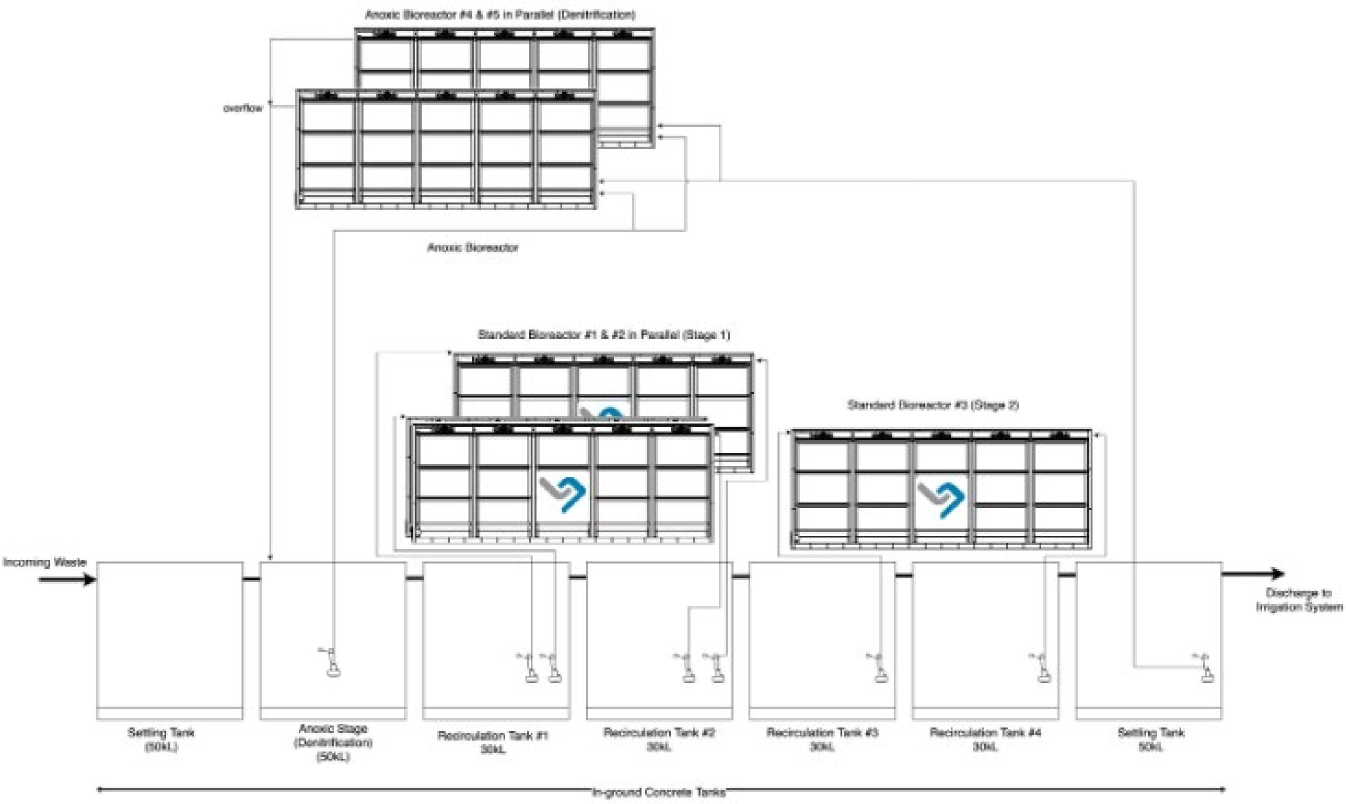

Figure 2-1: Process flow diagram (provided by BioGill, see Appendix A).

3 ENVIRONMENTAL SETTING

3.1 SITE FEATURES

The proposed SPSC site is located on Stranges Road, Huntingdon and situated adjacent to the western end of Lake Hood (itself located opposite the western bank of the Ashburton River / Hakatere. The site lies within the Canterbury Plains, approximately six km to the south of Ashburton and nine km inland from the local eastern coastline.

The WWTP is located at in the south-eastern quadrant of the site, approximately 150 m from the SPCS eastern site boundary.

Land use to the immediate south, east, and west of the site is rural farmland. To the north of the site is the Aquatic Park zone: a multi-use development consisting primarily of recreational and residential areas, per the Ashburton District Council District Plan (ADC, 2014). The plan also defines a small section of undeveloped medium to low density residential plots directly to the north of the site boundary, shown in Figure 3-1.

Figure 3-1 also shows the locations of existing nearby residential dwellings. A buffer distance of 100 m from the WWTP is shown as a green dotted line. This distance was calculated using the EPA Victoria separation distances guidance (EPA Victoria 2013)[1]. This buffer distance is located within the SPSC site boundary. The existing and potential future residential dwellings are all over 600 m from the site; to the southwest, north, and northwest of the WWTP building location.

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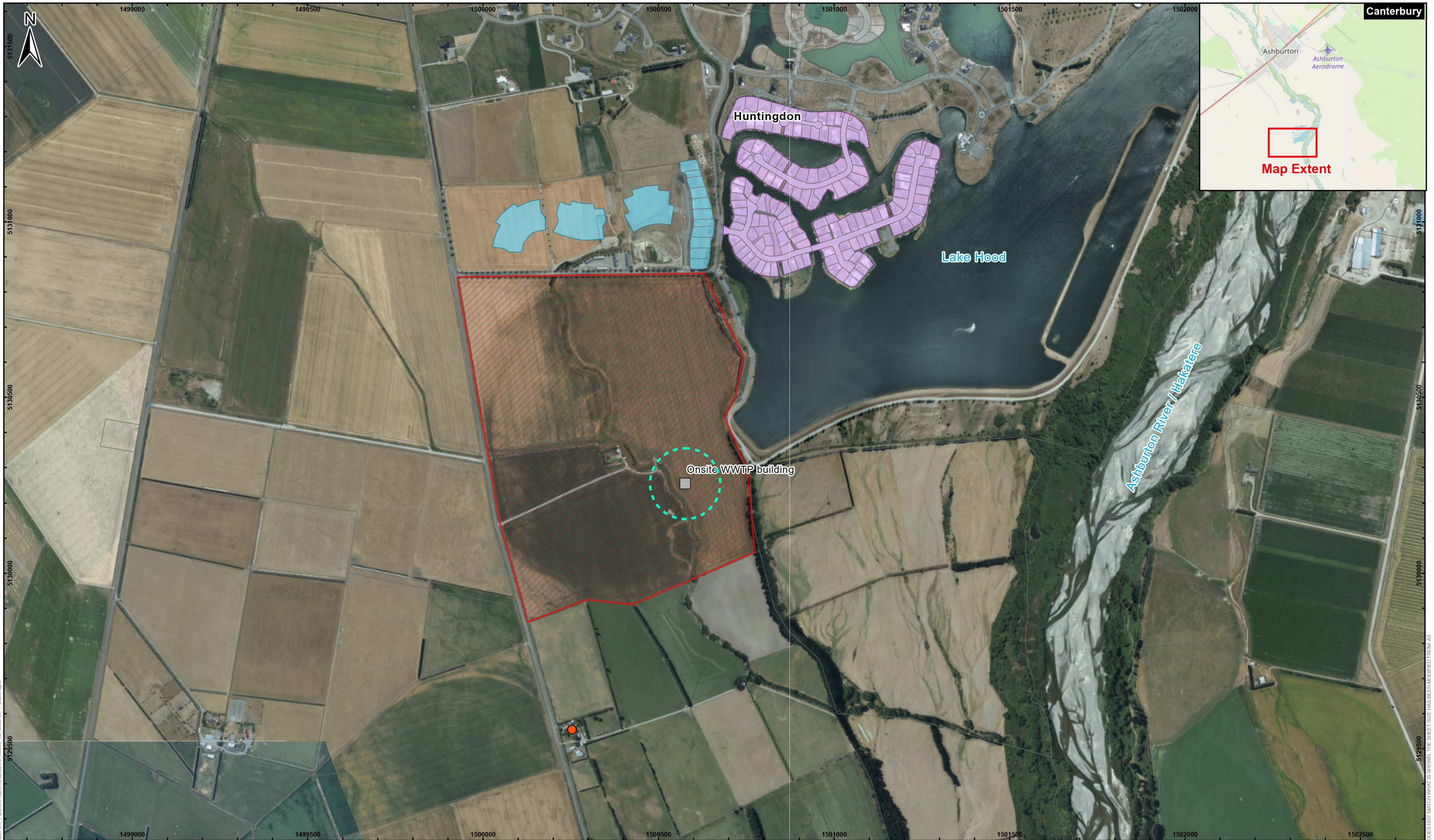
1 Separation distance for mechanical/biological WWTP = $10n^{1/3}$, n = equivalent population. This indicates approx. 70 m for this scale and type of wastewater plant.



LEGEND

- Southern Parallel Sports Campus site boundary
- Parcel boundary
- Aquatic Park Existing Residential
- Future medium / low density residential development
- Meteorological station
- Onsite WWTP building
- 100 m buffer from WWTP building
- Sensitive receptor

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CLIENT AND PROJECT
SOUTHERN PARALLEL SPORTS CAMPUS

TITLE
RECEIVING ENVIRONMENT INCLUDING POTENTIALLY SENSITIVE RECEPTORS

REFERENCE SCALE: 1:10,000 (atA3)
PROJECTION: NZGD 2000 New Zealand Transverse Mercator

0 200 400
Meters

PROJECT NUMBER	REPORT	REV.	FIGURE
3-C2503.00	002	A	3-1

DATE	DRAWN	APPROVED
2022-11-03	ZJ	MH

NOTES
1. Aerial: LINZ Data Service, Eagle Technology.
2. Map image: OpenStreetMap and contributors, CC-BYSA.
3. Schematic only, not to be interpreted as an engineering design or construction drawing.

3.2 EXISTING ODOUR SOURCES

Existing odour sources within the general area of Lake Hood include sewage treatment ponds operated by the Ashburton District Councils. They are approximately three kilometres to the north of the SPSC site, and the feedlot operated Five Star Beef, located approximately eight kilometres to the south-east of the site. These sources are sufficiently far away such that they should not cause any significant odour impacts at houses in the vicinity of the SPSC site, although may be noticeable on occasion.

The rural areas to the south, east, and west of the SPSC site and associated WWTP are used for livestock grazing and related activities. These rural activities will produce occasion low level rural character odours, which are generally acceptable to most people who live and/or work in that environment.

3.3 LOCAL METEOROLOGY AND TERRAIN

Wind speed and direction data recorded at Wakanui CWS[2] was obtained from CliFlo database. The station is approximately four km to the east of the site, and its location is shown in Figure 1-1.

Wind observations from January 2019 to December 2021 were used to produce a wind rose, as shown in Figure 3-2. Each petal in this figure provides a percentage value (%) for each wind direction (blowing from direction) and broken down into different wind speed categories. The percentage value (%) in each case, relates to the fraction of total time when winds (including all directions) which travel at wind speeds >0.5 m/s. Winds below ≤0.5 m/s in speed are classed as calms (these occur for 1.25 % of all time) and are not included in the wind-rose values shown in Figure 3-2.

Figure 3-2 shows predominant northern winds, ranging from the northeast to northwest accounting for majority of all hours and include drainage flows and most other light wind conditions (wind speeds <2 m/s). Winds blowing from south (i.e., southeast to southwest) occur for less than 20 % of time and include very few light wind speeds.

Low wind speed conditions, especially cold air drainage flows towards the local coastline, result in the poorest (worst case) odour dispersion.

Figure 3-2 shows that calm conditions, when wind speeds are less than 0.5 m/s, occur 1.3 % of the time. These will most likely be associated with drainage flows and therefore add to the prevalent light winds blowing from the northwest as shown in Figure 3-2

Light winds (wind speed less than 2 m/s) account for approximately 40 % of all winds, with winds originating in the northeast-northwest range again accounting for the majority of all light winds. As discuss, most of these winds are likely to be associated with the drainage flows that generally follow the Ashburton River / Hakatere down to the coast and occurring during still morning and evening periods. Light winds from the south and southeast are rare and "worst-case" cold air drainage flows can never occur from these directions because these only move towards the direction of decreasing terrain height.

[2] CWS = Compact Weather Station.

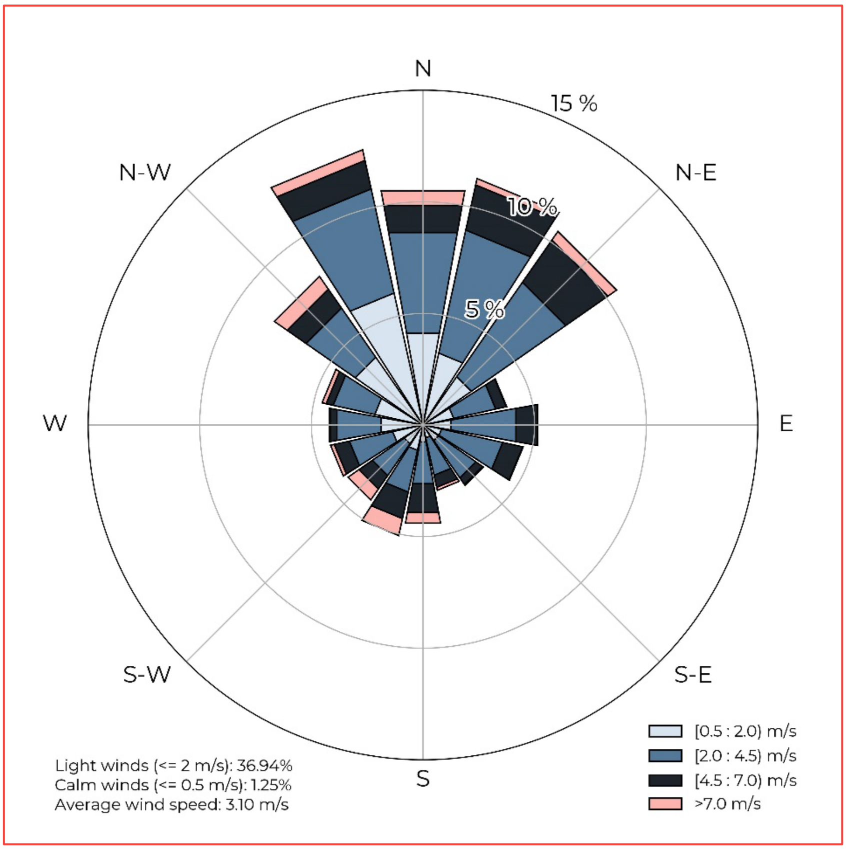


Figure 3-2: Wind rose for the period 2019 to 2021 derived from meteorological site at Wakanui operated by NIWA.

3.4 SENSITIVITY OF THE RECEIVING ENVIRONMENT

The nearest existing and future residential dwellings to the north, north-east and southwest of the SPSC site are classified as highly sensitive receptors by MfE (2016)[3]. However, these dwellings are more than 600 m away from the WWTP and would not be downwind of the WWTP during cold air drainage flow conditions. Given the scale of the WWTP, adequate separation distances, and low frequency being downwind of the WWTP, these residential dwellings would have a low sensitivity to any odour discharges from the proposed WWTP – should they occur. Likewise, the isolated rural residential dwellings within the surrounding area would also have a low sensitivity to any odour discharges from the WWTP.

[3] Ministry for the Environment, 2016. *Good Practice Guide for Assessing and Managing Odour*. Wellington: Ministry for the Environment.

4 ASSESSMENT METHODOLOGY

4.1 OVERVIEW

4.1.1 INTRODUCTION

It is considered that a technology review type of assessment of design aspects and mitigation measures is the most appropriate approach of this assessment. This is because a review process design and other mitigation measures can be used to confirm if recognisable odour at the site boundary can be effectively eliminated – therefore achieving a less than minor level of odour effects beyond the site boundary. The background to the odour assessment approach and methodology employed for this assessment are detailed in the following sections.

4.1.2 ACUTE AND CHRONIC ODOUR EXPOSURES

Odour exposures are classified as "chronic" or "acute". Chronic odour exposure refers to low to medium intensity odours occurring frequently over a long period, which can cause an accumulated level of stress in people who are exposed over the long term.

Acute odour exposure refers to a single event (typically hourly to a number of hours) of odour exposure that can be distinct or much stronger in its intensity and exhibiting an unpleasant character. The more significant acute odour exposures typically arise from abnormal or upset conditions.

Acute odour exposure could potentially give rise to an offensive or objectionable odour episode. While chronic odour exposures can cause a significant adverse effect over time, which justify further mitigation, and may also justify abatement notices and enforcement orders, the individual exposure and accumulated odour exposure events should not be considered to be objectionable or offensive. It is useful to note that all criminal prosecutions by the New Zealand Courts against individuals, or organisation for causing objectionable and/or offensive odour, have only been related to individual events/episodes of odour exposure.

4.1.3 MINISTRY FOR THE ENVIRONMENT

The significance of odour exposure effects is related to the FIDOL factors (MfE 2016) – the combination of the five factors (frequency, intensity, duration, offensiveness and location) of odour events that need to account for with the assessment. These factors need to be assessed where there is an existing odour exposure, or expectation of some level of odour exposure resulting from a proposed activity.

The MfE odour guide (MfE 2016) also describes a range of assessment techniques that can be used for assessing odour effects for new operations, which are shown in Table 5 of the MfE guide. It assigns a different priority to each technique, depending on whether the activity under consideration is an existing, expanding or a new operation. For a new operation, MfE guide assigns a high priority to community consultation, meteorology and terrain assessment, industrial experience, odour dispersion modelling and review of design and process control systems (review of Best Practicable Option).

Notwithstanding the importance of FIDOL factors for many odour assessments, for this assessment, the analysis of site wind patterns, separation distances, industrial experience and review of design and process control system are of most relevance (discussed in Section 4.2).

It is not practicable to undertake either community survey around a greenfield proposal, or odour dispersion modelling given there is no emission rate data available for the proposed WWTP system. These two tools were therefore not considered in this assessment.

4.2 ODOUR EFFECTS

4.2.1 CHRONIC AND ACUTE ODOUR EFFECTS

The assessment of potential odour effects from the proposed SPSC WWTP has been undertaken in a manner consistent with the recommendations by MfE (2016). The combination of local meteorology and terrain assessment, industrial experience and review of design system and mitigation measures is used to assess the potential chronic and acute odour effects due to the site operation.

Site-specific meteorological data was obtained from a nearby weather station (Wakanui CWS), which was used to establish the frequency of the winds that would transport odour to the nearby residential dwellings. The distances between the residential dwellings and the proposed WWTP were also established. This allows for an assessment of the risk to residential dwellings being exposed to chronic and acute odour, and their sensitivity to any odour discharge (should this occur in practice) from the proposed WWTP. This is discussed in Section 6.2.

The consideration of experience from other sites of a similar process/technology is useful for assessing the effectiveness of process design and control aspects. WSP has reviewed four case studies where BioGill technology was used to treat wastewater from recreational and food processing facilities in Australia. The review has considered the location and scale of these WWTP, complaint history, and comparison to the proposed WWTP. Detailed assessment is in Section 6.3.

4.2.2 CUMULATIVE ODOUR EFFECTS

There are no similar sources of wastewater treatment odour within the surrounding area, although odour associated with agricultural activities is likely to be present on occasion. This includes feedlot, dairy ponds, etc. Given the low potential for odour to be released from the proposed WWTP, then there would be minimal potential for any cumulative odour effects to occur with existing rural type odours.

5 ODOUR MITIGATION

5.1 DESIGN ASPECTS

The WWTP stages that could give rise to the discharge of odour, include main sewerage system and wastewater collection sump, screening plant, inground tanks, biological treatment reactors and the pumping out of sludge from inground tanks. The design features which are expected to effectively mitigate odour from these sources are discussed below.

5.1.1 SEWERAGE SYSTEM

By municipal standards, the local gravity flow sewerage system would be a small network where most wastewater sources would only need to transfer within several hundred metres of sewerage pipework before reaching the main wastewater sump located at the WWTP services building. As such the potential for sewerage type odour discharges would be minimal, as retention times of wastewater within sewerage system would be in the order of a few hours, or less. Therefore, the sewage is likely to maintain a positive dissolved oxygen (DO) level throughout its transfer from source to the site's wastewater sump.

5.1.2 MAIN WASTEWATER SUMP

The main wastewater sump which receives wastewater streams from the SPSC facilities would also have odour emissions mitigated by several design features, as follows:

Sewage arriving in a fresh state due to facilities being within 500 m or closer to the WWTP. Therefore, it is highly likely that wastewater never has an opportunity to become septic before entering the main sump.

The main sump would be sized and operated on a float level switch so to ensure wastewater retention time within the sump is less than 8 hours. To help achieve this maximum retention time (or less) consistently for a fix volume sump and the large variation in inflow rates (which would occur due to periods of heavy to light use of the facilities and different periods of the day), a variable speed pump and variable speed drive (VDS) are recommended. This would allow the pump speed to increase gradually to a maximum output (L/s) as the sump liquid level reaches >80 % of full (or other appropriate design target level) and then output down in proportion to decreasing sump level, until falling below a minimum specified low sump level (e.g., at 15 % full) at which minimum pump speed is maintained, until reaching a cut-off level (set to avoid cavitation).

The variation of pump speed in proportion to sump level, would allow for maximum sump retention times to be achieved.

The sump will be covered and located within the WWTP service building, which would be designed to allow air to be ventilated via carbon filter systems.

5.1.3 SCREENING

Wastewater which is pumped over the screen is likely to produce a weak fresh sewage odour in this instance as the wastewater from the main sump is very likely to always be fresh and contain a positive dissolved oxygen. Having the screen and associated solids skip housed within the WWTP services building is likely to ensure that odour associated with screening up to 150 m^3/day or less of fresh sewage will not be noticeable on site, and therefore at, or beyond the SPSC site boundary.

5.1.4 FIRST SETTLING TANK

Screened wastewater would be discharged into a 50 m³ in-ground settling tank which provides a final opportunity for settlement of any grit or sediment within incoming stream. For several consecutive days of low flow (e.g., when the number of people onsite is <100), then retention times for this tank would be in the order of several days. In winter periods this is not likely to cause the wastewater to become odorous, but in warmer months this could occur.

Extensive aeration of this tank is not recommended as this will produce biomass and inhibit settlement of primary sludge. However, the use of an air bubble type system is likely to be sufficient to avoid the wastewater becoming anaerobic and could be installed if found necessary.

Again, this tank would be housed within the WWTP building and so any odour emissions would be contained and treated via the carbon filter system, however this system would provide a contingency mitigation measure. However, avoiding this tank becoming anaerobic is the primary odour mitigation by design feature.

5.1.5 ANOXIC TANK

Wastewater flows from the settling tank overflows into the 50 m³ in-ground pre-anoxic tank (i.e., the second tank in Figure 2-2). The potential for this tank to become anaerobic and odorous is mitigated by its design and operation. For instance, the incoming wastewater from the first settling tank, mixes with an incoming 40 m³/hr recirculating stream, which is pumped to and from the two anoxic BioGill above ground modules and the pre-anoxic tank.

The inflow from the anoxic bioreactors, combined with the incoming wastewater flow from the first settling tank (i.e., 0 to 10 m³/hr), would result in a short hydraulic retention time of less than one hour. Furthermore, the anoxic BioGill reactors also receive an inlet stream, at 40 m³/hr, from the final settling tank, which would contain nitrates and positive DO. Therefore, the recirculating flow from the anoxic bioreactors to the pre-anoxic tank, is most likely to maintain a low odour potential because of the oxygen supply to it via (nitrates and DO) and the intensive recirculation of flow through this system and around the overall wastewater treatment system.

5.1.6 RECIRCULATION TANKS

Wastewater (exiting the anoxic tank) flows into a series of four 30 m³ in-ground recirculation tanks, which could be replaced by two larger tanks (i.e., combining RT#1 and RT#2 and likewise combining RT#3 and RT#4 as shown in Figure 2-2). These tanks receive high recirculation flows to and from an aerobic BioGill unit (40 – 80 m³/hr per tank) as well as a net inflow from the proceeding tank. The three above-ground aerobic BioGill modules would ensure the maintenance of positive DO levels in the recirculating wastewater streams. Furthermore, biofilms which routinely break away, will either settle into the base of the recirculation tanks, or else in the final settling tank, where it would form a layer, which is periodically pumped out and trucked away. These operational features would ensure that the progressively treated wastewater is likely to remain aerobic and have minimal odour.

5.1.7 FINAL SETTLING TANK

The partially treated waste (sewage/wastewater) from the last recirculation tank (RT #4) would flow into a final 50 m³ in-ground settling tank. This would arrive in an aerobic state and therefore exhibit low levels of odour. As with previous tanks, the recirculation of flow to the anoxic biological treatment units and inflow from the last recirculation tank, would ensure a low residence time within this final tank.

Unlike the first settling tank, this 50 m^3 in-ground tank will have low residence times (<1.5 hours) during the continual recirculation of its content to the anoxic bioreactors at 40 m^3/hr) and recycle of this flow to the anaerobic stage at the head of the WWTP. Therefore, can simply overflow its excess contents to the filter and receiving environment, and not cause any odour issues due to anaerobic conditions.

5.1.8 SLUDGE REMOVAL

The spent biofilms from the BioGill units will settle into the various inground tanks, or else transfer through to the final settling tank. The first settling tank will also settle out any solids within the incoming wastewater flow, which were not removed by the screening plant. The resultant sludge layers would exist in various states of mineralisation, before being sucked out to a truck/tanker and removed from the site (typically on a 3-6 monthly cycle). These sludge pump-out operations may possibly produce a localised sewage odour within 50 metres, or less of the WWTP services building. This is likely to result as much from air displacement from the truck's tanker than the removed sludge itself. Irrespectively, this odour would be temporary (e.g., ≤30 mins), occur during working hours and unlikely to be noticeable beyond the site boundary.

5.1.9 FILTERING

The filtering of the effluent as it is pumped from the final settling tank will produce a relatively small sludge stream. This has potential to become odorous during storage, therefore it is recommended that this stream is discharged near the base of the final settling tank, so it stored under a substantive water column which would be maintained in this sump. As such the odour potential associated with the collection and storage of this sludge would be negligible.

5.1.10 FINAL DISCHARGE

The water quality of the final discharge (as indicated by data in Table 2-1), suggests a negligible potential for any odour associated with this discharge an onsite pond/wetland and/or irrigation of this treated water to surrounding land.

5.1.11 WWTP BUILDING

All the above treatment stages (starting from the main sump, through to the final filtering stage) and underground tanks, would be housed within side a building which ventilates air via carbon filters. This would provide a second layer of protection against the occurrence of odour beyond the site boundary, should wastewater treatment processes failure and produce anaerobic odours.

With such a building enclosure, that any abnormal operation of the WWTP processes and release of anaerobic wastewater odour, then it is highly likely that the working environment within the building would become unsafe due to toxic gases (e.g., hydrogen sulfide, ammonia and possibly carbon monoxide) well before a significant level of odour occurred at or beyond the site boundary.

5.2 PROCESS CONTROL ASPECTS

Key WWTP process control features which may be applicable to the main wastewater sump and first in-ground settling tank could include:

- Continuous liquid level measurement and pump speed modulation for the wastewater sump.
- Continuous dissolved oxygen (DO) and air bubble system on/off control within the first in-ground settling tank.
- DO controlled to be maintained at or greater than in selected process 0.2 mg/L within the first in-ground settling tank.

5.3 KEY CONTINGENCY MEASURES

Key contingency measures proposed for the WWTP, sludge management and building air filter systems the installation of standby electricity generator for pumps and other key items where appropriate. This should include the carrying of back-ups for key components including:

- Pumps
- Water filter socks

5.4 WWTP OPERATIONAL PLAN

For this small-scale plant, the preparation of a WWTP Operational Plan (which encompasses the appropriate operational and maintenance procedures), could also provide a review of environmental performance, including water quality and ambient odour levels. The WWTP Operational Plan would list standard operational, maintenance and monitoring procedures, which impact on the potential levels of odour effects beyond the site boundary.

5.5 POTENTIAL ADDITIONAL MITIGATION MEASURES

5.5.1 DESIGN AND PROCESS CONTROL

Should further odour mitigation be required (say to avoid anaerobic conditions) then there may be some process control aspects, such as the use of DO monitoring and automatic control of aeration to maintain positive DO levels in some inground tanks. However, this is unlikely to be changes to the WWTP design itself, that would be necessary in response to any unexpected odour issues.

5.5.2 BUILDING AIR EXTRACTION AND TREATMENT

Should for any reason, the proposed carbon filters for treating building air not provide adequate control of odour discharges associated with any abnormal WWTP operating condition, or for any other reason, then SPSC would be able to consider alternative robust systems. It is considered that forced ventilation of the WWTP building and discharge of extracted air through a small soil-bark biofilter would be the most likely additional mitigation measure which could be employed for a moderate cost, if in the future, a great level of odour control was found to be necessary.

6 ASSESSMENT OF POTENTIAL ODOUR EFFECTS

6.1 OVERVIEW

The following assessment the potential for odour effects has considered the local meteorology and terrain, the location of surrounding residential dwelling (beyond the SPSC site boundary), the WWTP's odour mitigation measures, and finally the experience of odour effects associated with BioGill systems, which have been installed and operated at other sites.

6.2 SEPARATION DISTANCES AND WIND PATTERNS

The existing and future residential areas located to the north and northeast of the WWTP are more than 600 m to the WWTP. There is a low frequency (a few percent of time) of southerly and south-westerly light winds. None of these dwellings would be downwind of the WWTP during drainage flow conditions.

There is an isolated residential dwelling located 780 m to the southwest of the WWTP. This dwelling will be downwind of the WWTP during light wind conditions (wind speed less than 2 m/s) for approximately 5 % of the time in a year.

Given that these surrounding residential dwellings are sufficiently far away from the WWTP, and there are infrequent light winds blowing from the WWTP towards these dwellings, they should never notice any odour from this relatively small WWTP system when operating normally and with the proposed mitigation (discussed further below). Odour issues may only arise if the WWTP operation become abnormal and operated in an anaerobic state. Even in this instance the buffer distances and proposed enclosure of the WWTP may still avoid significant adverse odour effects beyond the site boundary.

It is considered the onsite facility users are likely to be most exposed to any odour from the WWTP system, especially if there was any system failure.

6.3 MITIGATION MEASURES

The effective mitigation of uncontrolled/abnormal discharges of odour from the WWTP is achieved via a combination of process design and control of the WWTP components, and the available separation distance between the WWTP and sensitive receptors. Additional mitigation, which is not likely to be necessary, could be achieved by installing more direct building air ventilation and discharging the extracted air to a biofilter.

In this instance, the design and small scale of the WWTP combined with its enclosure within a building (which includes passive ventilation via carbon filters) is very likely to avoid any adverse odour effects occurring beyond the SPSC site boundary.

The risk of anaerobic conditions occurring within the proposed WWTP are mostly associated with the buffering of wastewater flows at the head of the plant, which includes the main sump ahead of the screening plant and the first settling tank down-stream of the screen. Because the first settling tank is relatively large at 50 m^3, then the preceding wastewater sump's size does not need to provide any substantive buffer capacity and be in the order of 5 m^3 or less. The first settling tank is proposed to overflow to the first 30 m^3 anoxic tank. In periods of low SPSC usage the retention time within the setting tank could be in the order of several days. As such this tank provides a material risk of anaerobic conditions occurring. This can be readily avoided by installing an air bubble type system within this tank, which does not inhibit it function of enabling the settlement of grit/sediment.

Post the first setting tank, the subsequent tanks and BioGill trickling filters have significant recirculation of flows and continuous passive aeration and to an extent whereby the onset of anaerobic conditions would be very unlikely given routine maintenance/desludging of the BioGill and in-ground tank systems.

6.4 BIOGILL SITE EXPERIENCE

6.4.1 OVERVIEW

BioGill systems have been installed at recreational facilities and food processing plants in Australia. Site experiences and specific plant details some of the more relevant cases are discussed below.

6.4.2 TERREY HILLS GOLF AND COUNTRY CLUB

The Terrey Hills Golf and Country Club (the club) is located in Terry Hills near Sydney, NSW, Australia. The nearby residential dwellings are more than 150 m away from the club and its wastewater treatment plant, with nearby patrons attending the respective golf course only 20 m away. The Club's existing WWTP included anoxic tanks, a rotating biological contactor (RBC) plant including a clarifier. This upgrade included six above ground BioGill units (located in open air, which replaced the RBC). The WWTP processes 40 m^3/day wastewater, which is approximately 30% of the design flow for the proposed system for the SPSC site. The waste streams include sewage from a residential estate, restaurant kitchen and restrooms at the Club.

The wastewater from the club has a typical BOD_5 concentration of approximately 340 mg/L, and there is a BOD_5 loading of approximately 13.6 kg/day, which is 30 % of the proposed SPSC site.

It is understood that since the BioGill modules were installed in 2015, there have been no complaints associated with odour originated from the Club WWTP.

6.4.3 WANADANA BREWING

The Wanadana Brewing is located in Mullumbimby, Northern NSW, Australia. It is approximately 400 m away from the nearest residential dwellings and 30 m from dining patrons. The brewery wastewater treatment system (which is located within the brewery building) produces 2 m^3/day of wastewater with a BOD_5 concentration of more than 4,000 mg/L. The organic loading of 8 kg BOD^5/day is approximately 20 % of the design loading of 45 kg/day for the SPSC WWTP system.

The main process units consist of a balance tank, and a two staged BioGill system. The wastewater first enters a balance tank, where it is pumped to the first stage BioGill, with a proportion of flow returning into the holding tank for mixing, equalisation, and flow control. The pH is corrected in the first stage BioGill, and the wastewater passes via gravity through to the second BioGill.

It is understood that since the BioGill system was installed in 2019, there have been no complaints associated with odour originated from the brewery WTP.

6.4.4 ILLAWARRA MEAT

Illawarra Meat runs a meat processing plant in Fernhill, Sydney, NSW, Australia, and produces meat-based products. The high strength wastewater from the plant passes through a screening and cyclone before being fed into a series of three BioGill units at 20 m^3/day. The plant is surrounded by residential dwellings and commercial business units, with nearest houses within 50 m from the plant. The decision to install the BioGill plant was in part to address odour concerns and issues within the surrounding community.

The wastewater has a high concentration of organic material in the wastewater (i.e., COD) of 12,000 mg/L, and from this we estimate BOD_5 to be within the order of 6,000 mg/L. This indicates an organic loading which is approximately 2.5 to 3.0 times higher than the proposed SPSC WWTP system.

It is understood that since the BioGill bioreactors were installed in 2014, there have been no complaints associated with odour originated from the WWTP and there is very little odour generated from the WWTP.

6.4.5 SUMMARY

It is considered that the proposed design features of the WWTP and level of odour source enclosure, ventilation, and treatment for this, as well as the sludge dewatering system, means that only in rare and exceptional circumstances there might be uncontrolled releases of odour from the WWTP site. Therefore, it is concluded that uncontrolled discharges of odour to cause adverse acute odour effects can be reduced to a low risk through mitigation measures that are based on process design (to avoid and minimise odour emissions), effective process controls and operational control plans.

7 DISCUSSION

This assessment of potential odour effects associated with SPSC's proposed WWTP has essentially focused on the design, mitigation, and site-specific aspects, which would result in negligible to zero levels of ambient wastewater type odour occurring beyond the SPSC site boundary. While the 1991 Resource Management Act and relevant provisions within the Canterbury Regional Council's Regional Policy Statement and Regional Air Plan would not require a "no odour" outcome as an environmental end point in this instance, this is an appropriate goal for SPSC to aim for with respect to their proposed WWTP. This is primarily because of the nature of the recreational activities occurring within the SPSC site boundary, where patrons would have a higher level of odour exposure than residential dwellings (or any other sensitive land use activity) would potentially experience beyond the SPSC site boundary.

The analysis of process design and mitigation aspects, as well as the assessment of the separation distances to sensitive offsite locations, and local wind patterns has been the key focus of this assessment. The MfE (2016) recommended focus on FIDOL factors is less useful in this instance, as we are considering the risk of process failure and associated anaerobic conditions within the wastewater itself.

Following our assessment of the future sewerage and screening system, and the BioGill designed wastewater treatment process, we determine that site can operate reliably without generating anaerobic conditions and significant odour discharges and effects beyond the site boundary. In other words, the system can be installed and operated within an enclosed building (which has passive treatment of ventilate air via carbon filters) so there is minimal risk of anaerobic conditions in the wastewater and abnormally high odour discharge rates occurring at the site. Although this finding is based on additional mitigation feature being included into the proposed WWTP.

From our analysis of the treatment process stages, it was identified that the first 50 m^3 settling tank as a potential source of odour should there be extended periods of low input wastewater flows at the SPSC facility. While the risk that this causes adverse odour effects beyond the site boundary would be substantially reduced (by containing the WWTP within a building which features passive treatment of ventilated air via carbon filters), we recommend the use of an air bubble injection system within this tank. This would provide a further layer of protection which further ensures that the WWTP operation routinely avoids causing any odour effects beyond the site boundary.

8 CONCLUSION

It is concluded that the potential for any odour effects beyond the site boundary of SPSC due to its proposed WWTP facility are very likely be negligible given the large separation distances to sensitive locations beyond the site boundary, the scale of the BioGill design facility, its location within the site, and given the implementation of the proposed mitigation measures by SPSC and as recommended in this report.

9 REFERENCES

Boffa Miskell 2022. Draft landscape master plan. September 2022.

BioGill 2022. Southern Parallel Sports Campus Design Report. October 2022.

Ashburton District Council 2014. Ashburton District Plan. August 2014.

EPA Victoria 2013. Recommended Separation Distance for Industrial Residual Air Emission. March 2013.

MfE 2016. Good Practice Guide for Assessing and Managing Odour in New Zealand. Publication number: ME1278. Ministry for the Environment. November 2016.

APPENDIX A

WWTP DESIGN AND SPECIFICATION

Southern Parallel Sports Campus Design Report

11/10/2022

Kloud Water Co.

Powered By: BIOGILL

Table of Contents

Project Context

Catherine Stuart CEO & Project Director of Southern Parallel Sports Campus (SPSC) requires a sewage treatment plant to accommodate patrons and residents of the facility. The facility will be located in Ashburton - Canterbury, New Zealand.

Key Timelines:

- October 2022: Consent Submission.
- Q1 2023: Shovel in-ground
- Q4 2024: Facility Open.

Design

Flow (Volume):

The SPSC will have 250 participants on site 40 permanent staff and +-10 visiting consultants SPES will have +- 100 onsite at any one time. In sum, the design is specified for loading equivalent of 500 patrons on site at any one time. The design assumes 200 Litres is produced per person.

In order to accommodate a design tolerance of 50% for flow – a total of 750 patrons capacity will be used for design.

- Flow = 150 kL/day
- Concentration: detailed in table below.

Discharge Requirement:

Currently no specification for discharge requirements. Assuming a requirement of the following into the BioGill System:

	Influent	Effluent
Flow	100 kL/day	100 kL/day
BOD	<300 mgBOD/L	<20-50 mgBOD/L
TN	<50 mgTN/L	<30 mgTN/L
TSS	<150-200 mgTSS/L	<30 mgTSS/L
TP	<10 mgTP/L	<10 mgTP/L

Process Flow Design:

Five (5) BioGill Ultra Units are required.

- 3 (3) BioGill Ultra Units for secondary Biological Treatment.
- Two (2) BioGill Anoxic Ultra Unit for denitrification.

Process Flow Diagram detailed below.

Cost Estimates [Preliminary]:

The following is a guide to assist SPSC for the estimation and project management needs.

Items	Units	Price	Subtotal	Notes
Plumbing Works (5 days)	1	$ -	$ -	
Piping & other Plumbing Parts	1	$ -	$ -	
Concrete Pad	1	$ -	$ -	For placement of equipment.
Concrete In-Ground Tanks	1	$ -	$ -	Concrete Works for Settling Tank, Anoxic Tank, Recirculation Tank 1-4 and Discharge Tank
Screen (Optional)	1	$ -	$ -	Existing Brewery Setup.
Pumps	7	$ 4,000	$ 28,000	Industrial Submersible pump + 1 spare.
BioGill Ultra	5	$ 130,000	$ 650,000	BioGill Equipment.
Rails	5	$ 5,000	$ 25,000	BioGill Equipment.
Auto pH Dosing	1	$ 30,000	$ 30,000	~ sourced locally.
Provision of technical support for Owner and plumber	*1*	*$ 8,000*	$ 8,000	*Inclusive of all technical review calls with Plumber, Operator and review of site within 60 days of installation.**
Freight	*1*	*$ -*	*$ -*	*Quoted by Freight Agent at time of order.*
Project Management	*-*	*$ -*	*$ -*	*Overseen by Project Manager and owner.*
Total	**1**		**$ 713,000**	**Equipment Supply**

**Through innovative process design and method of delivery, KWC via BioGill offers a solution that empowers the end-user to project manage the installation of an Advanced Wastewater Treatment System - specifically secondary biological treatment. This allows the significant reduction in contracted engineering costs. In order to ensure technical support - it is highly recommended that the customer actively engage KWC/BioGill for engineering related support around the installation of the bioreactor. The cost allocated here will be charged regardless of total hours of client usage and thus it is encouraged that the end-user make the most of this provision in their project management.*

Note:

- Bioreactor Product Supply Only from BioGill/KWC.
- Civil Works, Pumps, in-ground tanks etc are to be procured and installed by Project Manager. BioGill will act to provide guidance throughout process but is not the Project Manager.

Process Flow Diagram

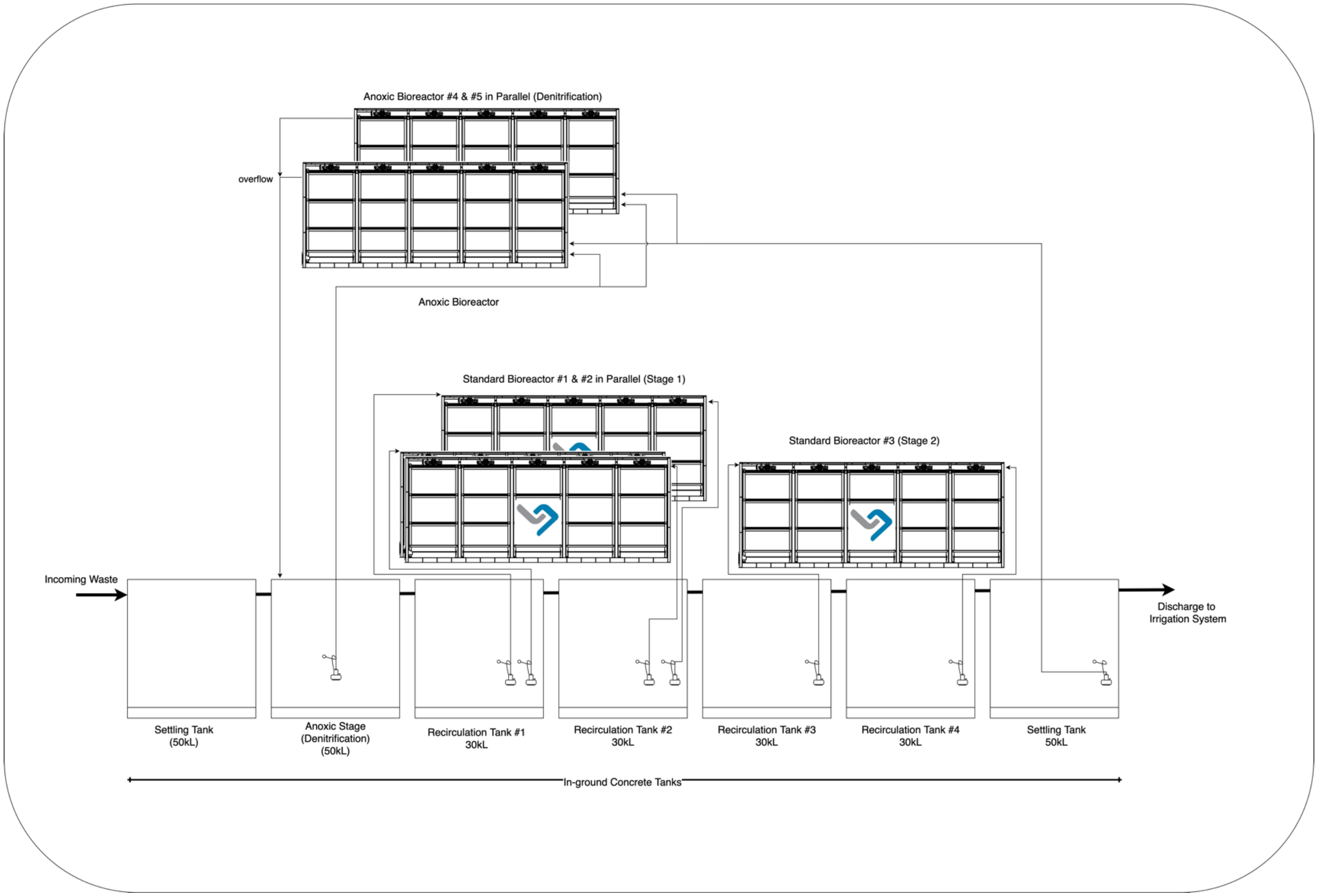


Figure 1: Process Flow Diagram

Process Description:

1. Domestic waste (sewage/wastewater) is pumped to the first Settling Tank[1].
2. Wastewater overflows to the first anoxic stage tank[2] from the settling tank. A submersible pump transfers wastewater into the anoxic bioreactor for denitrification. Wastewater overflows from the anoxic bioreactor back into the anoxic stage (tank).
3. Wastewater overflows from the anoxic tank into Recirculation Tank #1 (RT#1). A submersible pump recirculates wastewater across the 1st stage of BioGill Ultra Unit #1[3] BioGill Ultra Unit #2 at 40,000L/hour each.
4. Wastewater overflows from RT#1 into RT#2. A submersible pump recirculates wastewater across the 2nd stage of BioGill Ultra Unit #1 and Unit #2.
5. Wastewater overflows from RT#2 into RT#3. A submersible pump recirculates wastewater across the 1st stage of BioGill Ultra Unit #2.
6. Wastewater overflows from RT#3 into RT#4. A submersible pump recirculates wastewater across the 2nd stage of BioGill Ultra Unit #2.
7. Wastewater overflows from RT#4 into Settling Tank. A submersible Pump returns wastewater back into the anoxic bioreactor. Wastewater overflows[4] from the settling tank out into irrigation or into a pumping station to transfer to desired location.

[1] In-ground settling tank is baffled (walled) if possible to promote additional settling capacity. Design set by concrete tank supplier.
[2] Wastewater into the anoxic bioreactor is taken from the anoxic in-ground tank and the last settling tank to provide the nutrients required for denitrification – the biological process of removing nitrogen. The anoxic tank contains wastewater rich with a carbon source (required). The last Settling Tank contains wastewater rich with nitrates and nitrites (required).
[3] Each BioGill Ultra is compartmentalised internally/structurally into two stages – the equivalent of 5 BioGill Towers per stage.
[4] Although wastewater is pumped back into the anoxic stage from the last settling tank – the equilibrium of wastewater will lead to an overflow out to discharge. *i.e. 1,000 Litres in = 1,000 Litres out.*

Figure 2: BioGill Ultra[5]

[5] The product image demonstrates BioGill Ultra along with proprietary recirculation tank and pump skid. The bioreactor only is referred to in this project.

Design Notes

- The owner is or will employ local project manager to oversee installation. BioGill is an equipment supplier and will provide guidance to project manager throughout process. BioGill is not the project manager.

Additional/Optional ancillary equipment include (1) screens and (2) filters.

(1) Screens:

Screens will allow for removal of larger foreign material often found within domestic waste. (i.e. Rags, rocks, baby wipes etc) The benefits of a screen include the prolonged lifecycle of pumps and minimised maintenance of the bioreactors[6].
Screens are widely available and BioGill can assist (not own) in the procurement process of a suitable screen. The screen is likely installed above the first settling tank and as such may be a source of odour. Severity of odour is contingent on regular maintenance. The addition of a screen is to be weighed up with the advantages and costs of operational maintenance. Requires daily maintenance.

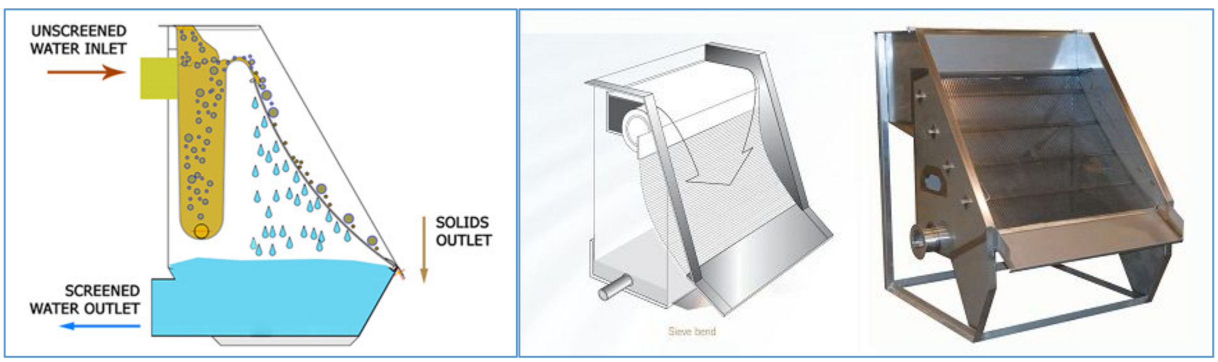


Figure 3: Examples of typical bar screens.

(2) Filters:

Depending on the irrigation[7] set up, adding bag filters at the end of the process will act to remove fine residual solids. This will assist in the maintenance of the irrigation system. Requirement for a filter depends on the real world observation of solids within final waste stream. Can be installed has a second phase within installation. Requires daily maintenance.

[6] Seeds and sticks may block up the dispersion system. Easily removed if present but can be minimised if screen is present.
[7] Irrigation system and setup is outside the scope of the wastewater treatment system.

Figure 4: Examples of typical bag filters.

(3) Odour Management

BioGill's bioreactors engage in passive aeration – a novel process that has been employed by existing clients for sewage treatment plants as well as meat processing facilities to specifically address undesirable odour. Whereby traditional technologies are at risk of anaerobic build-up of organic waste in their respective process– the BioGill bioreactor relies on (1) a recirculation process that turns over the recirculation tanks in ~20 minutes whilst engaging in (2) passive above-ground aeration. This process dramatically decreases the risk of nutrient build up leading to anaerobic decomposition of organic compounds.

In addition, the Project Managers at Southern Parallel Sports Campus will be constructing a closed building to house the bioreactors. The building will be connected to carbon filter vents to safeguard against any possibility of undesirable odour.

(4) Ecological Impact:

The discharge targets as specified on page 1 is considered as Grade A discharge and refers to New Zealand's Ministry for Environment: Wastewater Sector Report[8]. Effluent at the quality specified by the report will be discharged to the proposed pond at SPSC and further details on wider ecological impacts specific to the land and development will be within the scope of the ecological consultant for SPSC.

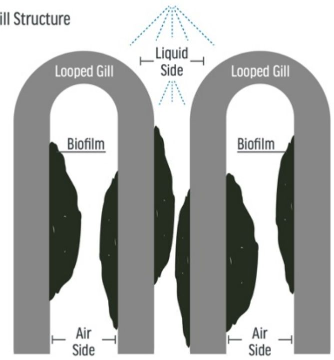
[8] https://environment.govt.nz/assets/Publications/Files/wastewater-sector-report.pdf

HOW BIOGILL WORKS

Biological wastewater treatment relies on microorganisms to consume nutrients in the wastewater. Like all living things, microorganisms need the right habitat to flourish. BioGill above-ground bioreactors use patented nano ceramic media, known as gills, to provide the ultimate air and liquid interface for the microorganisms to grow, multiply and thrive. Arranged in suspended vertical loops, each gill is folded over a support, creating two distinct sides: one in contact with the water and the other in contact with the air.

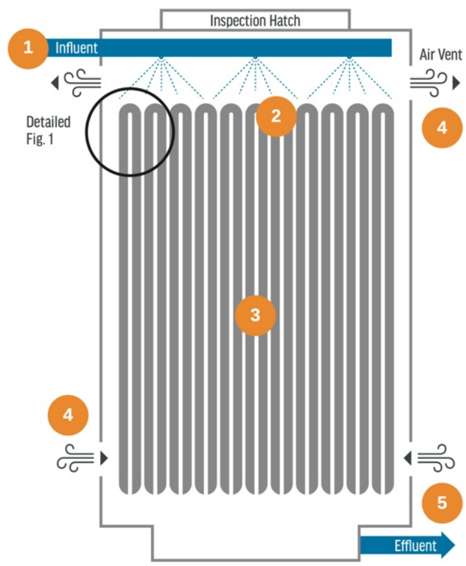
By providing the perfect oxygen rich habitat, the microbes perform at their best, protected in the biofilm and effectively removing pollutants from the wastewater. BioGill solves many of the shortfalls of other technologies by delivering effective treatment of high organic waste streams, Fat, Oil and Grease (FOG), as well as reducing odor.

Fig. 1 Gill Structure



STEP 1	Wastewater is pumped to the top of the BioGill bioreactor.
STEP 2	The wastewater is then dispersed over the looped gills and gravity fed down through the unit.
STEP 3	Biomass self-optimizes, growing the most suitable microbes to feed on a given wastewater. The result is a robust biomass that is more resilient to shock loads, FOG and high organic wastewaters.
STEP 4	Natural air convection, resulting from the heat generated by the biomass, increases the supply of oxygen.
STEP 5	Treated wastewater exits the BioGill system with reduced levels of BOD, COD and FOG.

Fig 2. BioGill Process Flow



PROJECT RESULTS

Brewery wastewater NORTH AMERICA *Up to 95% TOC mg/L removed per 24 hour cycle*	**95%**
High sugar wastewater / confectionery AUSTRALIA *Up to 96% BOD mg/L removed per cycle batch*	**96%**
Sauce / topping production JAPAN *Up to 91% soluble COD removed over a 24 hour cycle*	**91%**
Soda / soft drink AUSTRALIA *Up to 85% COD removed over a 24 hour cycle*	**85%**
Winery wastewater NORTH AMERICA *Up to 97% BOD removed per cycle batch*	**97%**
Performance boost to existing STP MIDDLE EAST *90%+ BOD reduction in 6 hour cycle*	**90%**
Reduced energy at existing STP PHILIPPINES *Reduction in energy demand by 80%. Up to 89% BOD reduction*	**89%**

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*Case studies and technical reports are available at **biogill.com***