Nelson Wastewater Treatment Plant

Process Capability Assessment

PREPARED FOR Nelson City Council | June 2023

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Revision schedule

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Executive summary

The Nelson Wastewater Treatment Plant (NWWTP) is owned by Nelson City Council (NCC) and has been operated by Nelmac since 2011. The NWWTP receives primarily domestic wastewater from the northern catchment of Nelson City, treats the wastewater via an oxidation pond-based system, and discharges treated wastewater to Tasman Bay via an ocean outfall.

Stantec has been engaged by Nelson City Council (NCC) to undertake a Process Capability Assessment (PCA) of the NWWTP to inform the reconsenting process. The design horizon adopted for this PCA is 2059, which is based on a reconsenting horizon of 35 years.

The report has been prepared to document the findings of the PCA for NWWTP and includes:

- An overview of current plant operation
- Definition of design horizons and appropriate flow and loads
- Review of current plant performance against current consent and potential future requirements
- Review of treatment capacity over design horizon
- Review of the condition of existing infrastructure
- An identification of information gaps, risks and improvement recommendations.

The key conclusions from the PCA are:

- Treated wastewater discharge has typically complied with consent limits over last ten years. Total suspended solids were elevated in 2020, but ongoing wetland cycling trials since then have been successful in controlling algal solids below the consent limit since.
- Plant hydraulic and process capacity is generally suitable, however additional monitoring and some optimisation would be beneficial to understand and potentially improve pre-treatment process, which is currently used intermittently.
- Plant condition, particularly mechanical plant which requires extensive renewals.

A list of improvements recommendations for short and longer term is provided in Section 10. These are related to improved flow and load management, optimisation of the pre-treatment system, increase in flow buffer capacity, resilience of pond system, and outflow hydraulic constraints in periods of sustained peak flows.

It is recommended that NCC:

- Consider outputs of the PCA findings
- Develop a plan to execute the actions recommended in the PCA.

Contents

List of appendices

List of tables

List of figures

Abbreviations

Abbreviation	Full Name
ADF	Average Daily Flow
ADWF	Average Dry Weather Flow
BOD_5	5-day Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
EBCT	Empty Bed Contact Time
FDR	Final Design Report
HLR	Hydraulic Loading Rate
HRT	Hydraulic Retention Time
I&I	Infiltration and Inflow
IF	Instantaneous Flow
NCC	Nelson City Council
NH_3	Ammonia
NWWTP	Nelson Wastewater Treatment Plant
NRMP	Nelson Regional Management Plan
PCA	Process Capability Assessment
PDWF	Peak Dry Weather Flow
PE	Population Equivalent
PIF	Peak Instantaneous Flow
PFD	Process Flow Diagram
PMT	Pond Management Team
PWWF	Peak Wet Weather Flow
RC	Resource Consent
SOR	Surface Overflow Rate
SRT	Solids Retention Time
TDH	Total Dynamic Head
TKN	Total Kjeldahl Nitrogen
TN	Total Nitrogen
TP	Total Phosphorus
TSS	Total Suspended Solids

Abbreviation	Full Name
UVT	Ultraviolet Transmittance
VFD	Variable Frequency Drive
VSS	Volatile Suspended Solids
WWTP	Wastewater Treatment Plant

1 Introduction

1.1 Background

The Nelson Wastewater Treatment Plant (NWWTP) located at Boulder Bank Drive, Nelson is owned by Nelson City Council (NCC) and has been operated by Nelmac since 2011. Due to its location, NWWTP is sometimes referred to as the North Nelson Wastewater Treatment Plant or Nelson North.

The NWWTP receives wastewater from the northern catchment of Nelson City, which is primarily residential with a small percentage of commercial/industrial discharges. The NWWTP is an oxidation pond-based treatment system, comprising preliminary treatment (grit removal and screening), pre-treatment (clarification and trickling filter used as required), facultative pond, maturation pond and wetland system. Treated wastewater is discharged via an ocean outfall into Tasman Bay.

The current resource consents for NNWTP expire on 1 December 2024. Stantec has been engaged by NCC to undertake a Process Capability Assessment (PCA) of the NWWTP to inform the reconsenting process.

1.2 Plant History

Historically wastewater from Nelson was discharged without treatment into Boat Harbour. In the 1960s, new pumping stations and an ocean outfall were constructed to convey the wastewater to North Nelson, with untreated wastewater discharged into Tasman Bay at the current location from 1970.

The current oxidation pond was established in 1979 to treat wastewater prior to discharge into Tasman Bay. In 1996, the oxidation pond was sub-divided into two interlinked ponds to improve the treated wastewater discharge quality, however, the resulting organic loading on the primary pond (14 ha) was too high, so the pond system reverted to one pond (26 ha) in 2000. The pond system was originally installed without upfront pre-treatment.

The NWWTP underwent its most recent upgrade in 2007-2009 to comply with the current resource consents and increase the plant capacity to accommodate the anticipated population increase. The upgrade included a new pre-treatment facility (i.e., primary clarifier, trickling filter, flow buffer), partitioning of the existing oxidation pond into 16ha facultative and 10ha maturation areas, and a new downstream wetland.

Minor modifications at NWWTP have occurred since, including addition of aerators and monitoring probes (for dissolved oxygen, DO, and oxidation-reduction potential, ORP) in the facultative pond and covering the trickling filter. The facultative pond was desludged in 2014, with sludge initially stored on-site in geobags in the flow buffer area and then disposed off-site at the landfill. The flow buffer area was taken offline while used to store sludge and then returned to its original purpose of providing flow buffering when all the stored sludge had been removed.

There have also been upgrades to the wastewater network. Recent upgrades include pipe relining to reduce inflow and infiltration and addition of screening at one of the main pump stations (Neale Park).

1.3 PCA Objectives

The objectives of this PCA are as follows:

- Assess NWWTP's design hydraulic capacity against its current and future flows at both dry and wet weather conditions.
- Analyse capacity of each process unit to treat wastewater to a specified quality parameter (e.g., TSS, BOD, pathogen concentration) by comparing NWWTP's process design capacity against its current and future flows and loads.
- Summarise the current condition of civil, mechanical, and electrical process equipment based on existing information provided by NCC.
- Review the process data that has currently been collected, and outline data monitoring gaps in conjunction with the work that is being undertaken through the consent renewal process.
- Assess the performance of the NWWTP against the current and expected Nelson Resource Management Plan (NRMP) as well as the current Resource Consent (RC).
- Assess the levels of risk associated with the different processes with respect to technical or compliance criteria.

The design horizon adopted for this PCA is 2059, which is based on a reconsenting horizon of 35 years.

1.4 Report Purpose

The purpose of this report is to document the findings of the NWWTP Process Capability Assessment (PCA) to inform the reconsenting process, assess plant performance from a treatment process perspective, and identify any information or data gaps that may be required for reconsenting.

1.5 Input Information

Stantec has carried out this PCA as a desk-top exercise only and has relied on information provided by NCC and Nelmac. Stantec has not carried out any site inspections or other investigations to verify the accuracy of this information.

Several documents and data sources were provided by NCC and Nelmac to inform the PCA. These documents included:

- Resource consents and permits
- Nelson Wastewater Treatment Plant Upgrade – Final Design Report (OPUS, 2006)
- Drawings (OPUS, 2006)
- Operation and Maintenance Manual (OPUS, 2007)
- Pond Management Plan (Nelmac, 2021)
- Odour Management Plan (Nelmac, 2022)
- Operation records (log sheets)
- Data including compliance (monthly consent sampling) and plant monitoring data
- Population projections
- Asset registries and condition assessments (Nelmac, 2021).

2 Description of Existing WWTP

2.1 Overview

The NWWTP receives wastewater from the northern catchment of Nelson City. The plant was designed to:

- Remove gross solids at the inlet works.
- Buffer peak flow at the inlet works (diurnal peaks) and flow buffer pond (wet weather flows)
- Pre-treat raw wastewater for Biochemical Oxygen Demand (BOD) and Total Suspended Solids (TSS) removal, as and when required for pond health.
- Pond-based treatment for BOD and TSS removal.
- Disinfection using the maturation pond and wetland system.

The preliminary treatment at the inlet works is provided by a horizontal grit trap and a 3 mm step screen. All flows are passed through the inlet works. The inlet pump station downstream of the inlet works can divert flow to three different streams: flow buffer storage, pre-treatment, or bypass to the facultative pond.

Flow buffer storage is used during periods of high influent flows, which typically occur during rainfall events. Once the high inflows end, the flow buffer storage is drained to the Interstage Pump Station No. 2. The downstream ponds and wetland system also provide flow buffering.

The pre-treatment plant consists of a clarifier and trickling filter and can be used or bypassed depending on the needs of the facultative pond with respect to pond health. The clarifier removes readily settleable solids and a portion of the influent BOD load, whilst the trickling filter is a fixed film treatment process designed to further reduce the BOD of the wastewater. The trickling filter also reduce sulphide loads to the ponds. Primary sludge from the clarifier can be thickened for disposal off-site to Bell Island WWTP, however it is typically directed to the facultative pond via Interstage Pump Station No. 2. Sloughed biomass from the trickling filter is also directed to the facultative pond via the same pump station. Supernatant from the sludge thickening system is typically returned to the head of the inlet works.

The facultative pond (or P1), maturation pond (or P2) and wetland system collectively provide the final treatment prior to discharge to Tasman Bay via an ocean outfall. Sludge accumulates in the facultative pond as well as the maturation pond and wetland system, albeit to a much lesser degree. If required, the relocatable seeding system can be used to transfer algal from another pond or wetland and sodium nitrate can be dosed upstream of the facultative pond.

Malodorous air extracted from the covered process units (inlet works, trickling filter, interstage pump station No.2, and sludge handling) is treated via a biofilter.

The overall layout of NWWTP is shown in Figure 1, with the pre-treatment plant layout shown in Figure 2.

Figure 1 Aerial photograph showing key components of NWWTP

Figure 2: Aerial photograph showing key components of NWWTP Pre-treatment Plant (P1 in background)

2.2 Process Flow Diagram

Figure 3 presents a process flow diagram (PFD) of the NWWTP from the final design report (2006), updated to reflect the current situation as at June 2023.

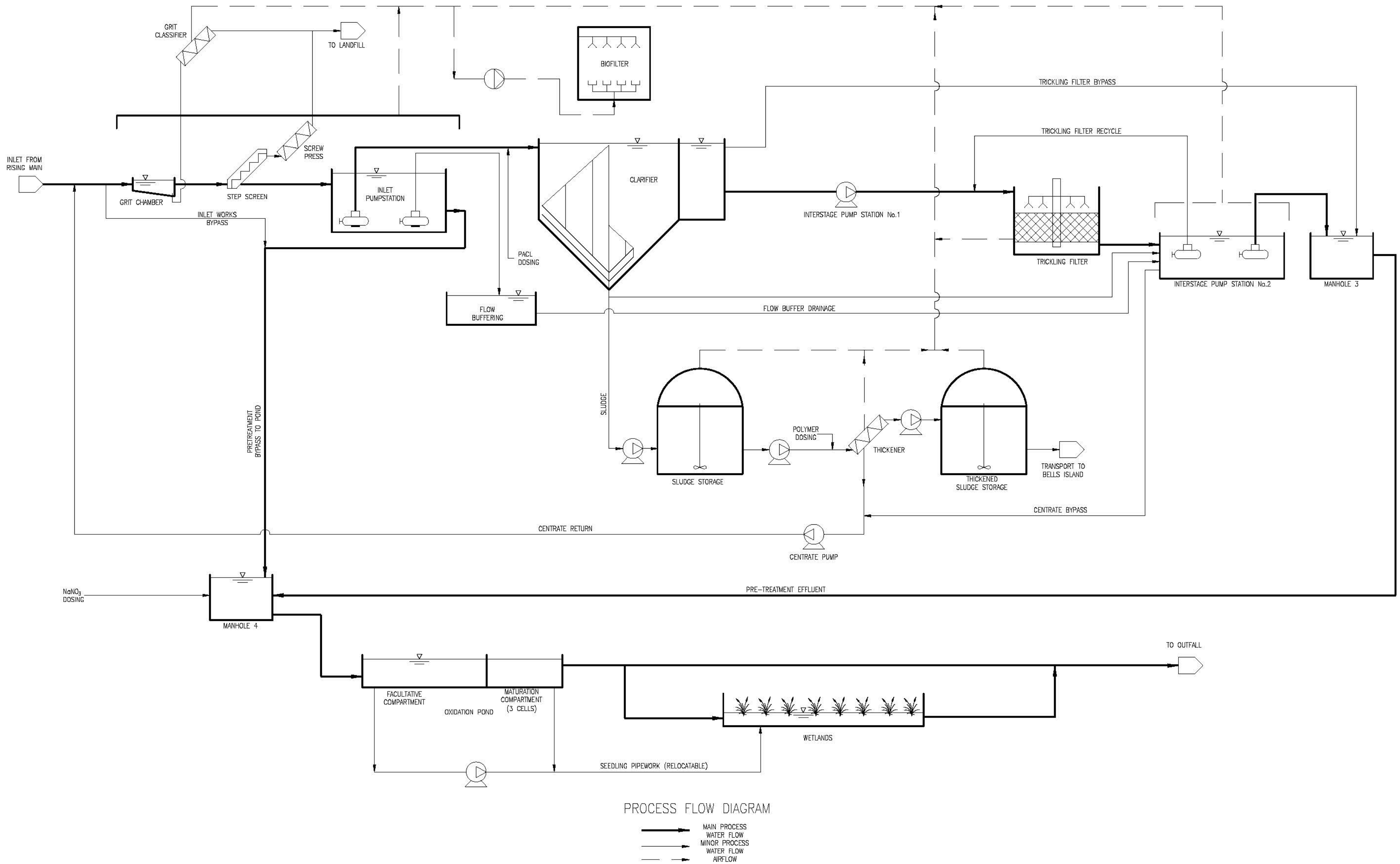

Figure 3: North Nelson WWTP process flow diagram (Stantec 2023)

2.3 Process Unit Summary

A summary of the process units at the NWWTP including their characteristic size is presented in Table 1. The information included in Table 1 was sourced from manuals and design information provided by NCC. It has not been verified by Stantec, either by on-site inspection or other investigations. Some plant and equipment may have been replaced or substituted either at or after time of original installation.

Table 1: Process unit summary and design capacity

Process Unit	No.	Characteristic Size	Comments
Influent Flow Meter	1	900 mm	ABB magnetic flow meter
Grit Chamber	1	2 mm particle removal at 700 L/s	Concrete
Grit Chamber Submersible Pump	1	10 L/s @ 3.5 mH_2O TDH	Flygt DF6068 MT472
Grit Classifier	1	12 L/s, 350 kg/d	Huber Tech
Inlet Step Screen	1	3 mm, 700 L/s	Hydropress: Sindico SSL2000X1165X3 Refurbished in August 2020
Screw Press	1	2 m^3/h Minimum solids concentration: 25 wt%	Screen press: Sindico SP200/1200
Bypass Channel	1		EWM
Inlet Pump Station	1	42 m^3	
Clarifier Feed Submersible Pump	2	382 L/s @ 10.6 mH_2O TDH	Flygt NP3301 LT620
Clarifier Inlet Flow Transmitter & Sensor	1	350 mm	ABB
Flow Buffer Feed Submersible Pump	2	139 L/s @ 8.3 mH_2O TDH	Flygt NP3202 MT641
Flow Buffer Storage	1	16,000 m^3	Earth embankment pond
Primary Clarifier	1	20 m dia Maximum SOR: 95 $m^3/m^2/d$ HRT: 1.1 h	Peripheral drive scraper arm 30,000 m^3/d
Desludge Pump	2	12 L/s @ 4.8 mH_2O TDH	Flygt NT3085 MT461
Interstage Pump Station No. 1	1	20 m^3	Concrete cast into Primary Clarifier wall
Trickling Filter Feed Pump	2	382 L/s @ 5.8 nH_2O TDH	Flygt NT3301 LT812
Trickling Filter Inflow Flow Transmitter	1	350 mm	ABB
Trickling Filter		7,600-30,000 m^3/d 2-30 revs / h 15m diameter 3.5m depth structured plastic media	Covered, concrete tank with underdrain Rotary distributor with four arms Ecomachine EM46 distributor AccuPAC VF5000 media AccuGrid WG 2424 surface grating Fan forced ventilation

Process Unit	No.	Characteristic Size	Comments
Interstage Pump Station No. 2	1	65 m^3	Concrete
Trickling Filter Recycle Submersible Pump	1	88 L/s @ 8.9 mH_2O TDH	Flygt NT3153 MT432
Trickling Filter Recycle Flow Transmitter	1	150 mm	ABB
Facultative Pond Feed Pump	2	388 L/s @ 5.2 mH_2O TDH	Flygt NT3301 LT814
Facultative Pond	1	16 ha, 1.5 m deep	Earth embankment pond
Facultative Pond Aerator	4		Sindico S & N 1600
Maturation Pond	1	10 ha, 1.5 m deep	Earth embankment pond Partitioned to give 3 zones
Maturation Pond Bar Screen	1		
Wetland	2	13 ha in total 40% shallow area, 60% deep area	Wetland 1 & 2 Each wetland has three deep cells about 800mm deep and two shallower cells about 300mm deep.
Algae Reseeding System	1		Relocatable pump and above ground pipework, mobile diesel generator
Final Effluent Channel	1	9 m wide, 3 m deep	Earth embankment channel
Effluent Channel Flow Transmitter	1		ChannelMag
Ocean Outfall	1	900 mm diameter concrete lined steel, about 430m long with diffuser at tip[1]	Perpendicular to shoreline, discharges approx. 350m offshore
Unthickened Sludge Storage Tank	1	144 m^3	Circular, mild steel with a polyethylene liner, and concrete base
Unthickened Sludge Storage Tank Mixer	1	1.5 kW	Propeller type mixer Sulzer ABS RW3021
Unthickened Sludge Transfer Pump	2	8 L/s @ 2 mH_2O TDH	Flygt TF551
Flocculation Chamber	1		Concrete
Flocculation Chamber Mixer	1	0.75 kW	Smith & Loveless
Polymer Makeup & Dosing System	1	Hopper, screw feeder, wetting head, makeup tank, storage tank, aging tank, duty diaphragm dosing pump	Smith & Loveless EM P20C/3/3
Rotary Drum Thickener	1	21 m^3/h, 8.5 wt% solids output 9 rpm	Smith & Loveless Eccomachine Model EM 139SM1A

[1] Diffuser structure: 9 outlet holes on the top half of the pipe, each 0.3mx0.3m with alternating opening angles, equally spaced over 20m from outlet tip. 1 outlet hole at the end of the pipe parallel to the seabed and fitted with a 0.3m diameter conical reducer.

Process Unit	No.	Characteristic Size	Comments
Thickened Sludge Storage Tank	1	72 m^3	Circular, mild steel with a polyethylene liner, and concrete base
Thickened Sludge Storage Tank Mixer	1	3 kW	Top propeller type mixer Sulzer ABS
Thickened Sludge Transfer Pump	1	3 L/s @ 4 mH_2O TDH	Flygt TF381
Biofilter Fan	2	15 kW	Hartzell
Biofilter	2	Slotted pipe, 100 mm pea gravel, biofilter media (bark mulch, loam topsoil, crushed shell), water spray, underdrain pipework	Earthen bund with 1.5 mm HDPE liner
Potable Water Tank	4	100m^3 total storage	25m^3 for fire fighting storage
Potable Water Pump	2	8.7 L/s @ 8 bar TDH	Brown Brothers VFDs maintain pressure in on-site potable water network

3 Current Plant Operation

This section provides a high-level summary of the current plant operations. It is based on the final design report (2006), updated to reflect Stantec's understanding from its involvement in the NWWTP Pond Management Team (PMT). The current plant operations reflect the relatively low influent loads typically received at NWWTP. As a result, the pre-treatment facility is usually offline and, despite this, the Facultative Pond is typically underloaded most of the year. Underloading poses different operational risks to a higher loaded pond-based system; bringing the pre-treatment facility online is one tool the PMT uses to manage these risks.

Inlet Works

Raw wastewater flows from the Nelson City northern catchment to the Neale Park Pump Station by a variety of gravity and pressure mains. The wastewater is screened and then pumped to the Inlet Works of the NWWTP via the nine-kilometre long, underground Atawhai rising main alongside SH6. A magnetic flow meter measures the inflow to the Inlet Works (FIT0101).

Grit is removed by the horizontal grit chamber installed in the inlet channel to protect downstream equipment from damage. The grit is collected in the grit sump and pumped to the grit classifier. The grit classifier consolidates the grit material and resulting water is returned to the inlet channel, upstream of the Screen. The grit extraction system is operated automatically on time intervals.

The 3 mm step screen removes gross pollutants (e.g., rags, plastic, personal care products) which may damage downstream equipment or reduce treatment efficiency. The step screen consists of a set of stationary and moving laminates; the moving laminates transport the screenings up the stationary laminates to the discharge point at the top of the screen. The screen runs automatically for set period when the differential pressure (measured by water level) setpoint across it is reached. The screenings are discharged to the screw press for washing and dewatering and collected at the bagging system for off-site disposal. The screw press runs automatically for a set period after the step screen has run for a set number of cycles.

A passive bypass channel was constructed as part of the Inlet Works. During high flow events or when the step screen becomes blocked, influent wastewater will automatically flow over the bypass weir and into the bypass channel. The bypass channel has stop logs to alter its discharge point to divert flow to either the facultative pond (normal bypass operation) or the Inlet Pump Station.

Inlet Pump Station

During normal operation, all wastewater flows from the Inlet Works to the Inlet Pump Station. The Inlet Pump Station buffers out peaks in plant inflow and directs flow to the flow buffer, pre-treatment, or the facultative pond.

The Inlet Pump Station contains four submersible pumps; two Clarifier Feed Pumps that feed the pre-treatment facility, and two Flow Buffer Pumps. A fixed overflow weir within the pump station controls the flow to the facultative pond. Under normal operation, all flows less than 30,000 m^3/d are directed to the facultative pond.

The two Clarifier Feed Pumps operate in a duty / standby configuration and convey flow to the pre-treatment facility. The pumps are equipped with a variable frequency drive (VFD) which allow for flow adjustment to the pre-treatment facility. Flow to the Clarifier is measured by a magnetic flow meter (FIT0108). The pre-treatment facility is currently only used if pond health conditions require the loading to the Facultative Pond to be reduced; in this situation all flows up to 30,000 m^3/d are directed to the pre-treatment facility.

The two Flow Buffer Pumps operate in a duty / standby configuration and can pump up to 12,000 m^3/day to the Flow Buffer. The flow buffer pumps operate when the influent flow is greater than 33,700 m^3/day. There is a pump recycle to the Inlet Pump Station so the pumps can be exercised without pumping wastewater to the Flow Buffer.

The fixed overflow weir controls the flow to the Facultative Pond; wastewater from the Inlet Pump Station flows over the weir and into the pre-treatment bypass channel discharging to the facultative pond. This means influent wastewater can flow by gravity to the facultative pond regardless of the availability of power. The plant was designed so that approximately 3,700 m^3/day will flow over the weir when the influent flow is equal or exceeds 33,700 m^3/day and 30,000 m^3/day is being passed to the pre-treatment facility.

Flow Buffer

The flow buffer storage is an earth embankment pond with a capacity of 16,000 m^3. Screened wastewater is automatically pumped to the flow buffer storage during high flow events. After the high flow event has ended, the flow buffer storage volume is discharged by gravity to Interstage Pump Station No. 2 using a manual knife gate valve. To minimise the odour risk, the flow buffer is emptied as soon as possible after the high flow event and, if required, the flow buffer is flushed down using treated wastewater from the Final Effluent Channel and a portable pump.

Pre-Treatment Facility

The pre-treatment facility comprises a primary clarifier and a trickling filter. The pre-treatment facility is currently only used if pond health conditions require the loading to the Facultative Pond to be reduced. Initially inflow is passed through the pre-treatment facility and sludge generated is discharged into the Facultative Pond (first operation mode). If further load reduction is required, sludge generated is thickened and tankered off-site (second operation mode).

The Primary Clarifier removes readily settleable solids, reducing solids and organic loads prior to secondary treatment by the Trickling Filter or the ponds. The Primary Clarifier is a circular concrete structure with an internal diameter of 20 m and a sidewall depth of 4 m. Flows up to 30,000 m^3 can be passed through the clarifier. Flows enter through a stilling well and clarified water flows over a V-notched weir at the perimeter of the clarifier to Interstage Pump Station 1. Settled sludge in the Primary Clarifier is raked to its central sump and then either discharged into the facultative pond via Interstage Pump Station 2 (first operation mode) or pumped to the Unthickened Sludge Storage Tank (second operation mode). The two Desludge Pumps at the Primary Clarifier operate in a duty / standby configuration and run based on a time setpoint. This is automatically controlled based on the inflow volumes to the Primary Clarifier.

Interstage Pump Station No. 1 was designed to split the flow from the Primary Clarifier between the Trickling Filter and the Facultative Pond. The pump station has a wet well with two dry mounted centrifugal Trickling Filter Feed Pumps that operate in a duty / standby configuration with VFDs for flow control. During normal operation, a portion of the flow is pumped to the Trickling Filter by the duty pump based on flow to the Primary Clarifier and the remainder flows over a weir to the Facultative Pond by gravity via manhole 3. A flow meter measures the trickling filter feed flow, excluding recycle[2] (FIT0205).

[2] Called ‘Interstage Pump Station No. 1 effluent’ in the Final Design Report (2006)

The Trickling Filter was designed to reduce the BOD load prior to further treatment in the ponds. It was designed as a roughing filter, which is a high-rate filter suitable for high organic and hydraulic loading rates. The Trickling Filter is a 15 m diameter, covered concrete tank with an underdrain system that supports 3.5 m depth of structured, plastic media. The rotating distributor, equipped with a VFD, sprays the clarified wastewater over the filter media, and it is treated by the attached biofilm as it passes down through the media. A minimum wetting rate and ventilation rate must be maintained to achieve effective BOD reduction. The treated flow, bypass flow, recycle rate, dosing rate and rotation speed can all be adjusted to optimise the trickling filter performance. Filter effluent collected in the underdrain gravity flows to Interstage Pump Station No. 2 and is then pumped to the Facultative Pond via manhole 3.

The Trickling Filter was designed to be flushed one to two times per day to prevent the build-up of excess biomass, increase the aerobic surface area and improve overall treatment. A daily flushing cycle was intended to be carried out automatically during a low flow period (12am to 4am), with a second flushing cycle to be carried out during the day if required. Supernatant from the primary clarifier and recycled trickling filter effluent was intended to be used for flushing, with trickling filter feed pumps ramped up to design flushing flow rate, trickling filter recycle pumps ramped up to maximum flow rate to reduce volume removed from the primary clarifier, and valve opened to minimise the risk of disturbing the sludge blanket in the clarifier and introducing sludge into the trickling filter. The flushing regime may need optimising – primary sludge is currently returned to Interstage Pump Station No. 2 (first operation mode) and the flushing flow rate, duration, frequency is dependent on the trickling filter organic loading rate. Sloughed biomass from the Trickling Filter is discharged with the filter effluent to Interstage Pump Station No. 2 and ultimately settles in the Facultative Pond.

Interstage Pump Station No. 2 receives flows from the Trickling Filter, Flow Buffer Storage, Biofilter Drain, Unthickened Sludge Storage Tank Supernatant, Sludge Thickener Filtrate, pump containment pads, control building facilities, and the Polymer Dosing System drains. Sludge Thickener Filtrate can be directed to the Interstage Pump Station No. 2, however is typically returned to the head of the inlet works. The pump station has a wet well with a Trickling Filter Recycle Pump and two submersible Facultative Pond Feed Pumps. The Trickling Filter Recycle pump is operated in a duty configuration with a VFD, and was designed to maintain the minimum trickling filter wetting rate at 43 $m^3/m^2/d$ (i.e., trickling filter feed flow plus trickling filter recycle flow). A flow meter measures the trickling filter recycle flow (FIT0206). The Facultative Pond Feed Pumps are operated in a duty / assist configuration with VFDs. The pond feed pumps discharge to Manhole 3 which gravity flows to the Facultative Pond.

Facultative Pond, Maturation Pond and Wetlands

Wastewater flows via gravity through the Facultative Pond (also called P1), then the Maturation Pond (also called P2) and then, typically, the wetlands. A brief overview of the current operation of each follows.

The Facultative Pond (or P1) has a surface area of 16ha, an average depth of 1.5 m, and four surface aerators positioned to minimise hydraulic short-circuiting. The primary function of P1 is to reduce organic and suspended solids concentrations, however it will also provide some initial pathogen reduction. Treatment is provided 'naturally', through the interaction of sunlight, wind, algae and bacteria. The level of treatment depends on several factors including organic loading, hydraulic retention time (accounting for short-circuiting), climate and season (both temperature, sunlight and wind), mixing/stratification, algal population (algae concentration, species type and health as well as algal grazers), wastewater physical characteristics (temperature, pH, dissolved oxygen), and sludge inventory. Effluent from the Facultative Pond gravitates to the Maturation Pond via a pond transfer structure, designed to minimise algae and sludge carry over to the maturation pond.

The Maturation Pond (or P2) has a surface area of 10ha, an average depth of 1.5 m, and is partitioned into three zones to promote plug-flow. The primary function of P2 is to reduce pathogens. Treatment is provided 'naturally' through various mechanisms including sunlight exposure, grazing by protozoans and invertebrates, and retention time. A manual bar screen is located at the outlet of the Maturation Pond. The effluent from the Maturation Pond flows by gravity to the flow splitter box, where effluent is typically directed to the wetlands but can be diverted to the Final Effluent Channel, bypassing the wetlands.

The wetland system consists of two surface flow wetlands (Wetland 1 and Wetland 2), with a combined surface area of 13 ha. The wetlands typically operate in parallel, with the flow split equally to the two wetlands. Wetland cycling has been trialled successfully for past two summers to reduce algal solids, with all flow directed to one wetland for a period to allow solids to reduce in the other wetland, and then all flow is directed to the other wetland. Each wetland is made up of three deep cells (about 800 mm deep) and two shallower cells (about 300 mm deep). The shallow areas were designed to be planted with appropriate wetland plants, however the plants have all but died. The wetlands essentially now act as an extension of the Maturation Pond, further polishing the effluent. The effluent from the Wetlands flows by gravity to the Final Effluent Channel.

Overflow weirs are used to control the water level in the pond and wetlands. They can be used to balance flows within the pond-wetland system.

The health of the pond and wetland systems is monitored daily. Several mechanisms can be used if needed to maintain pond health, including using the pre-treatment facility to de-load the Facultative Pond (either with sludge discharged to the Facultative Pond or sludge thickened and tankered off-site), dosing sodium nitrate[3] to the Facultative Pond inlet (manhole 2) to minimise risk of anaerobic conditions, and reseeding algae from another pond or wetland using relocatable pipework and seeding pump.

Discharge System

Treated wastewater from the wetlands (or maturation ponds if the wetlands are bypassed) gravitates via the Final Effluent Channel and then a 900 mm pipe under the pre-treatment works to 'Manhole Y' and the offshore ocean outfall, discharging into Tasman Bay.

The Final Effluent Channel is an open, earthen embankment channel that is approximately 9 m wide and 3 m deep.

At the end of this channel, the treated wastewater discharge flows are measured by an open channel magnetic flow meter in the Effluent Flow Measurement Channel (FIT0405).

The offshore ocean outfall is a concrete pipe that runs perpendicular to the shoreline and extends approximately 430 m from 'Manhole Y'. At the end of the outfall, there are 10 outlet holes; nine located on the top half of the pipe equally spaced over 20 m, and one at the end of the pipe parallel to the seabed and fitted with a 0.3 m diameter conical reducer.

Solids Treatment

The solids treatment comprises an unthickened storage tank, a rotary drum thickener and a thickened storage tank. Solids treatment is not frequently used (once in last two years for a period of less than a month). Typically, when the pre-treatment system is required to be operated, the primary sludge from the clarifier is directed back to the facultative pond via Interstage Pump Station No. 2 (first operation mode). However, if the loading to the facultative pond is required to be further reduced, the solids treatment system is operated as outlined below, with thickened sludge tankered off-site (second operation mode).

When operating, the sludge treatment system operates on a batch basis. It was designed to thicken primary sludge from 2.5-4% dry solids concentration to 6-8.5% dry solids concentration, however this has not been achieved recently.

Primary sludge is pumped (duty/standby) to the Unthickened Sludge Storage Tank, which has a volume of 144 m^3, equivalent to three days of storage during normal operation. The tank is equipped with manual decant valves at various depths which allows for a degree of in-tank sludge thickening for use during maintenance or the thickening plant if offline; the supernatant flows by gravity to Interstage Pump Station No. 2.

The Unthickened Sludge Transfer pumps operate in a duty / standby configuration with VFDs and are positive displacement type. They transfer unthickened sludge to the Flocculation Chamber where a polymer is added and mixed to promote polymer bridging. The sludge and polymer mixture flows over a weir to the Rotary Drum Thickener. A flow meter measures the unthickened sludge flow to the rotary drum thickener (FIT0308).

The duty Rotary Drum Thickener is equipped with a polyester filter cloth to separate the flocculated sludge from free water. The sludge moves along the length of the drum to the sludge discharge point. The rotary drum is equipped with a spray bar for continuous cleaning of the filter media. The wash water and sludge filtrate is typically returned to the head of the inlet works, however can also flow by gravity to Interstage Pump Station No. 2. The thickened sludge is discharged to an intermediate hopper then pumped to the Thickened Sludge Storage Tank using the duty positive displacement Thickened Sludge Transfer Pump equipped with a VFD.

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[3] Sodium nitrate was used as required during and prior to 2021. It is not made in NZ and, since the global covid pandemic, it has been difficult to obtain sodium nitrate in NZ. NCC have recently replenished its sodium nitrate stocks, however are exploring alternative dosing options to mitigate this supply risk.

The Thickened Sludge Storage Tank is equipped with a mixer and has a volume of 72 m^3, which is equivalent to two to five days storage during normal operation. When the sludge treatment system is operating, the thickened sludge is tankered off-site five to six times per week. The thickened sludge is transported to the Bell Island WWTP, where it is treated to Grade A biosolids, pumped to Rabbit Island and then sprayed to a Pine Plantation.

Odour Control

The Odour Control System was designed to extract and treat air from equipment and areas that may emit malodours or require ventilation. The duty / standby odour extraction fans extract air from the following process areas: Inlet Channel, Inlet Pump Station, Trickling Filter, Unthickened Sludge Storage Tank, Rotary Drum Thickener, Thickener Room, and Thickened Sludge Storage Tank. The highest demand of the Odour Control System is the Trickling Filter when it is in operation; it requires a minimum air supply to meet the process requirements. The extracted air is then passed through a bark biofilter, where it is treated via a combination of adsorption and microbial action. An irrigation system is used to maintain optimal humidity/saturation within the biofilter.

Water Supply

Water is taken from a NCC water main on SH6 to NWWTP via a backflow preventer and a 2 km long water main. The water is stored on-site in four tanks giving a total of 100 m^3 of water storage, of which 25 m^3 is reserved for fire-fighting use. Water is drawn from the tanks as required, with duty/standby pumps operated with VFDs to maintain pressure in the on-site water network. After the pumps, the water supply is split into two separate systems: the potable water system, which supplies the staff facilities, eyewash and safety shower in the administration building, and the service water system, which supplies plant equipment (Grit Classifier, Screw Press, Biofilter, Sludge Thickener, Polymer makeup) and washdown hoses. A backflow preventer is used to prevent contamination of the potable water system.

4 Influent Flows and Loads

4.1 Historic Flow and Loads

Wastewater monitoring data was provided by Nelmac from 1 July 2012 to 9 March 2022, with data to 30 June 2020 provided for an assessment of flow and load projections in 2021[4] and data from 1 July 2020 to 14 May 2023 provided for this PCA. The data included:

- Daily inflow and discharge volumes
- Daily chemical oxygen demand (cod) and total suspended solids (tss) concentration, typically weekdays[5]
- Monthly bod concentration.

Daily rainfall data was obtained from the NIWA Cliflo website for Nelson Aero (Station Number 4241) for the same period for the 2021 assessment and this PCA (i.e., 2012 to 2023 in total), and used to estimate historic dry weather flows. A daily rainfall of 0 mm/day was assumed for this PCA on 5/1/2023 and 22/1/2023 as no rainfall data is available.

A key event in the past few years that has influenced wastewater generation nationally is the New Zealand response to the global Covid pandemic[6]. The period from the start of the 4-tiered Alert Level system (21 March 2020) to the end of the traffic light system (12 September 2022) is shaded yellow in graphs in this section, with relevant trends discussed.

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[4] North Nelson WWTP Consent Renewal Project, Project Technical Memorandum No. 7 - Flow and Load Projections, Stantec, 2021
[5] Daily samples are collected Monday to Friday. Weekend sampling has also been carried out from time to time.
[6] 21 March 2020, the Government introduced the 4-tiered Alert Level system, with all of New Zealand at Alert Level 2, then on 23 March moved to Alert Level 3 (‘restricted’ movements), then on 25 March moved to Alert Level 4 (‘lockdown’, only nominated essential services able to remain open). All of New Zealand then moved on 27 April to Alert Level 3, on 13 May 2020 to Alert Level 2, and on 8 June 2020 to Alert Level 1. Rest of New Zealand (including Nelson) moved to Alert Level 2 on 12 August 2020 and Alert Level 1 on 21 September 2020; then to Alert Level 2 on 14 February 2021 and back to Alert Level 1 on 17 February 2021; then to Alert Level 2 on 28 February 2021 and back to Alert Level 1 on 7 March 2021; then to Alert Level 4 on 17 August 2021, back to Alert Level 3 on 31 August 2021, and Alert Level 2 on 21 September 2021. Alert Level system ends and all of New Zealand moved to Traffic Light system on 2

Figure 4 shows the temporal variation in total daily inflow volume (m^3/day) and trend lines for the monthly (30-day) and annual (365-day) average daily flow (ADF) alongside daily rainfall (mm/day). The variation in daily dry weather inflow, where daily inflow on days with 5mm/day or more of rainfall has been excluded, is provided in Appendix B .

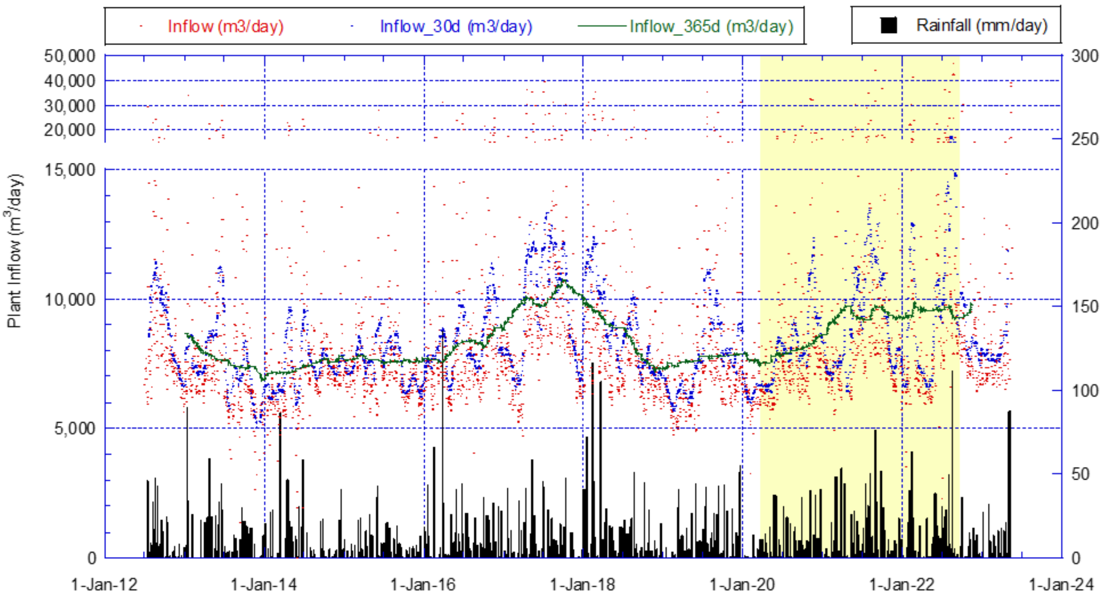

Figure 4: Temporal Variation in Total Daily Inflow and Daily Rainfall. Period influenced by Covid response (yellow).

There is a marked difference in annual average inflows from year to year, which generally corresponds with daily rainfall. Annual average inflows were lower in 2014-2016 and 2019 (in the order of 7,000 to 8,000 m^3/day) but higher in 2017, 2021 and 2022 (in the order of 9,000 to 11,000 m^3/day). Some drop in inflow observed with an increase in Covid restrictions.

Figure 5 shows the variation in influent TSS, COD and BOD loads (kg/day) and trend lines for the monthly (30-day) and annual (365-day) average loads. 24-hour composite influent samples are typically analysed for TSS and COD each weekday and for BOD once a month; hence monthly trend lines are only provided for TSS and COD. The annual trend line for BOD excludes the daily sampling carried out from 1-25 July 2013 as the calculated BOD loads in this period were significantly lower than typically seen. Influent TSS, COD and BOD concentrations are provided in Appendix B .

Overall influent TSS and COD loads have not markedly increased over the 10-year period from 2012 to 2022, with annual average loads ranging from 1,600 kg/day to 2,200 kg/day for TSS and from 2,800 kg/day to 4,000 kg/day for COD. Higher average influent COD loads were seen in 2015 and 2017, coinciding with higher average TSS loads and, in the case of 2017 but not 2015, higher average influent flows.

The New Zealand response to the global Covid pandemic appears to have influenced loading to NWWTP. Monthly average influent loads, particularly TSS, were more generally more variable. Local changes in Alert Level or traffic light setting influenced influent loads, with a drop in loads seen when a setting increased to the most restrictive setting. There were also periods of increased loads but, unlike other plants with a large industrial component where large spikes were seen as trade waste was discharged as processes were shutdown or started up, the periods were not correlated to changes in settings.

The dataset for TSS and COD is far larger than for BOD (about 20 days/month vs 1 day/month) and so is expected to be more representative of loads. However, the BOD load trends are largely consistent with TSS and COD load trends.

December 2021, with 'rest of New Zealand' (including Nelson) at Orange, moved to Red on 23 January 2022, moved to Orange on 13 April 2022. Traffic Light system ends on 12 September 2022

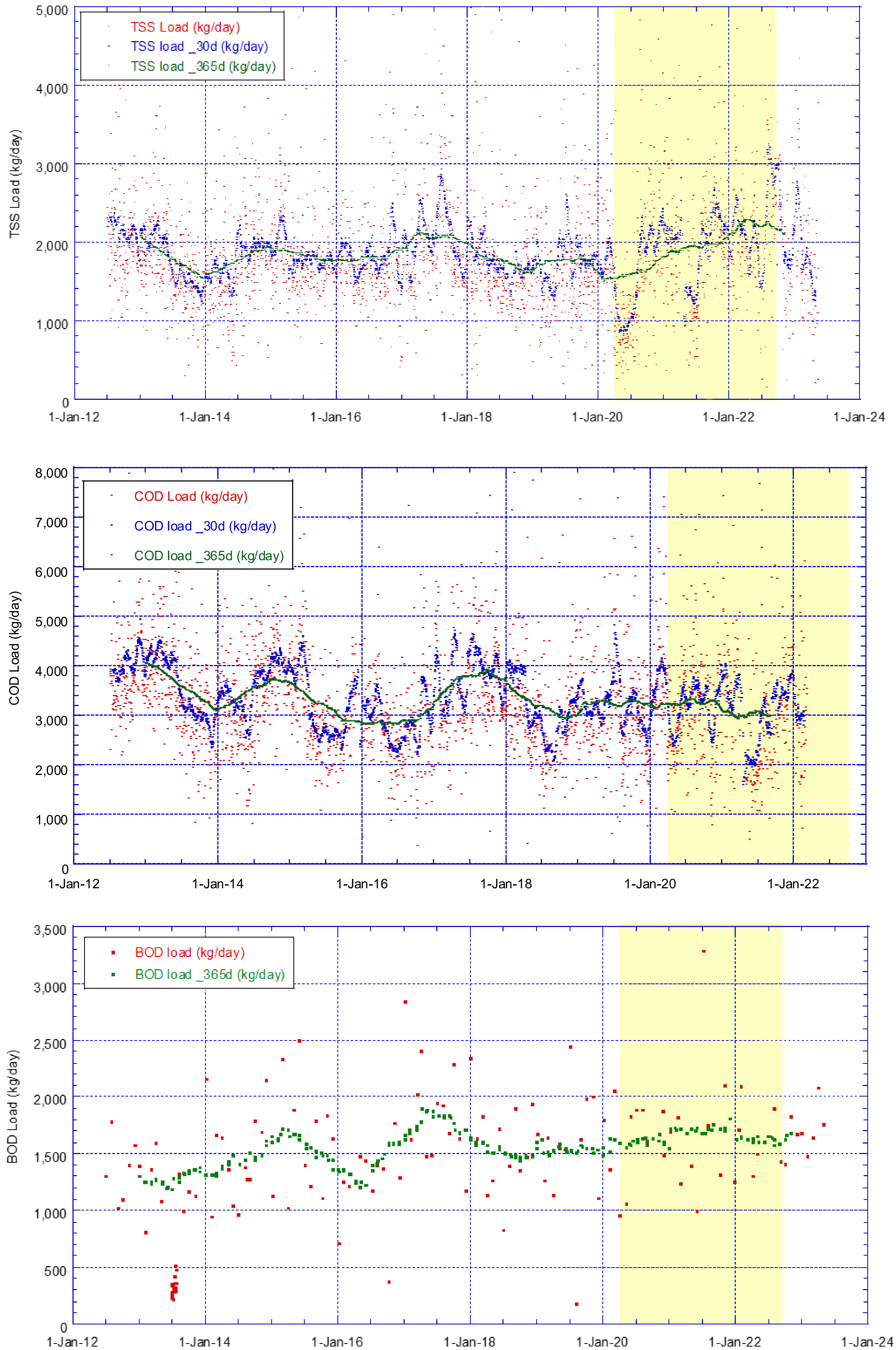

Figure 5: Temporal Variation in Influent Load: TSS (upper graph), COD (middle graph) and BOD (lower graph). Period influenced by Covid response (yellow).

4.2 Projected Flow and Loads

In early 2021, to inform the NWWTP reconsenting process, Stantec carried out an assessment of wastewater flow and load projections to 2059[7] as follows:

- NWWTP influent monitoring data from Nelmac and daily rainfall data from the NIWA Cliflo website for Nelson Aero (Station Number 4241) for the period from 1 July 2012 to 30 June 2020 was used to determine historic dry weather flow and 'base' annual average per capita flow and load factors. 2019 was adopted as the 'base' year
- Current and projected connected household numbers and household occupancy (people per household) were provided by NCC to 2050[8]. As agreed by NCC at that time, the population projection to 2059 was extrapolated from this dataset
- The 2059 projected flow and loads were then calculated by multiplying the adopted per capita factor for each parameter (flow, TSS, COD, and BOD) by the 2059 projected population.

The projections were reviewed as part of this PCA as follows:

- The influent monitoring and rainfall dataset used for the 2021 assessment was updated to include data from July 2020 to May 2023 for this PCA (see Section 4.1). On review of this data, influent loads from 2020 to 2022 appeared to be impacted to some degree by the local response to the global covid pandemic and 2023 is a part year. Hence the 'base' annual average per capita flow and load factors from the 2021 assessment were adopted for this PCA, adjusted for a minor amendment in 2019 population estimate[9,]. The adopted ratio of BOD:COD is higher than typical for primarily domestic wastewater and the observed ratio of BOD:COD varied more than expected; it is recommended that influent organic concentration and loads are reviewed once online influent monitoring is operational to better understand extent of commercial/industrial wastewater inflows
- The population projections from the 2021 assessment were reviewed. Minor amendments were made[10], with the updated populations projections adopted for this PCA provided in Appendix A
- The projected flow and loads were calculated as previously, with projections provided in 10 year increments over the 35 year design horizon for this PCA, from 2022 to 2059.

A summary of the flow and load projection to 2059 is presented in Table 2.

Table 2: NWWTP Flow and Load Projection

Parameter	Unit	2022	2032	2042	2050	2059
Population	PE	27,540	28,805	31,935	34,320	37,230
Average Dry Weather Flow	m^3/day	7,400	7,800	8,600	9,300	10,100
Average Daily Flow	m^3/day	8,200	8,600	9,500	10,200	11,100
Peak Wet Weather Flow	m^3/day	36,800	38,500	42,700	45,900	49,800
Peak Instantaneous Flow	L/s	850	890	990	1,060	1,150
BOD Load	kg/day	1,800	1,900	2,100	2,200	2,400
COD Load	kg/day	3,300	3,500	3,800	4,100	4,500
TSS Load	kg/day	1,700	1,700	1,900	2,100	2,200

[7] North Nelson WWTP Consent Renewal Project, Project Technical Memorandum No. 7 - Flow and Load Projections, Stantec, 2021
[8] Long Term Plan and Activity Management Plans 2021 – Population Growth and Demographics, Nelson City Council
[9] The 2019 population used to determine the per capita factor for flow and load projections was re-estimated assuming the same change in household numbers for each meshblock between 2019 and 2020 as forecast between 2020 and 2021. Revised per capita rates were 270L/person.day for average dry weather flow, 65g/person/.day for BOD, 120g/person/day for COD and 60 g/person.day fpr TSS. See also footnote 10.
[10] Household numbers were unchanged, however the Nelson Central – Trafalgar meshblock was added and the population projection after 2028 was updated to be based on 2.3 for households existing in 2028 and 2.2 for additional households after 2028.

4.3 Comparison of Projections with NWWTP Design Basis

Table 3 compares the current flow and load projections for 2022 and 2059 (Section 4.2) with those developed for 2020 and 2050 to inform the original plant design in 2006. Current projections that exceed the 2020 NWWTP design basis are in bold, while those that exceed both the 2020 and 2050 NWWTP design basis are in bold and underline.

Table 3: NWWTP Flow and Load Projection

		NWWTP Design Basis		Projections	
Parameter	Unit	2020	2050	2022	2059
Population	PE	28,190	33,750	27,540	<u>**37,230**</u>
Average Dry Weather Flow	m^3/day	10,200	12,100	7,400	10,100
Peak Wet Weather Flow	m^3/day	41,700	49,600	36,800	<u>**49,800**</u>
Peak Instantaneous Flow	L/s	640	760	<u>**850**</u>	<u>**1,150**</u>
Average BOD Load	kg/day	2,100	2,500	1,800	**2,400**
Average COD Load	kg/day	4,900	5,700	3,300	4,500
Average TSS Load	kg/day	2,600	3,000	1,700	2,200

The current population projections for 2022 are of a similar order as originally projected for 2020, and are about 10% higher for 2059 than originally projected for 2050. Despite this, the current average dry weather flow and TSS and COD load projections for 2059 are of a similar order or less than the original projections for 2020, and markedly less than the original projections for 2050. This is due to slightly lower per capita rates being adopted based on recent influent monitoring data. Conversely, the current projected peak wet weather flow (peak day and instantaneous) are higher than original projections; again this is due to higher ratios being adopted for peak flows based on recent monitoring data and maximum daily instantaneous flow data being available.

The original 2006 design considered the 2050 projections. All process units were designed for 2020 projections as a minimum and, for those not designed for 2050 projections, there was an allowance for an 'easy upgrade' to meet 2050 projections. The future upgrades identified in the 2006 design report included additional 6,000 m^3 flow buffer storage, additional 2.5 m trickling filter media depth (3.5 m to 6 m), upgrade to effluent channel (for high flows >45,000 m^3/day and high tide conditions), addition of wetland pump station and/or increase in weir width to pass required flow, increase in odour control system in terms of airflow and biofilter capacity (increased depth, additional biofilter or both).

5 Plant Performance and Consent Limits

5.1 Resource Consent Requirements

NCC holds following six consents associated with the NWWTP (RM025169), which all expire on 1 December 2024:

- Coastal permit to discharge treated wastewater to Tasman Bay via ocean outfall
- Coastal permit to deposit in or on the seabed substances from the outfall pipe
- Coastal permit to use, maintain, and renew a pipeline and outfall structure and to occupy the seabed
- Discharge permit to discharge wastewater onto or into land from the oxidation pond, wetlands, and flow buffer storage pond
- Discharge permit to discharge contaminants to air from the wastewater treatment plant
- Land use consent to carry out vegetation clearance, soil disturbance, and earthworks during construction.

Under the coastal permit, the treated wastewater discharge from NWWTP is required to comply with the criteria summarised in Table 4. The consented limits for flow, BOD, TSS and faecal coliforms are of particular interest when assessing current plant performance and capacity.

Table 4: Consented Treated Wastewater Discharge Criteria

Parameter	Consent Criteria	Notes	Monitoring Frequency
Flow	38,000 m^3/d 21,000 m^3/d	Peak daily flow in 2-year rainfall period shall not exceed Peak 28 day average flow shall not exceed	Daily
BOD_5	40 mg/L 50 mg/L	Annual median shall not exceed No more than 1 of 12 monthly samples shall exceed	Monthly
TSS	100 mg/L 150 mg/L	Annual median shall not exceed No more than 1 of 12 monthly samples shall exceed	Monthly
Faecal Coliform	10,000 cfu/100mL 80,000 cfu/100mL	Annual median shall not exceed No more than 1 of 12 monthly samples shall exceed	Monthly
Cadmium	0.275 mg/L	Shall not exceed	Annual
Copper	0.065 mg/L	Shall not exceed	Annual
Nickel	3.5 mg/L	Shall not exceed	Annual
Zinc	0.75 mg/L	Shall not exceed	Annual
Chromium	1.37 mg/L	Shall not exceed	Annual
Lead	0.22 mg/L	Shall not exceed	Annual
Cyanide	0.2 mg/L	Shall not exceed	Annual
Phenols	20 mg/L	Shall not exceed	Annual
Mercury	0.02 mg/L	Shall not exceed	Annual

5.2 Treated Wastewater Discharge and Compliance

Figure 6 shows the variation in treated wastewater discharge flow and concentration of of BOD5, TSS and faecal coliforms from 1 July 2012 to 14 May 2023 and compares the observed values with consent limits. Due to the nature of the consent limits, the treated wastewater discharge flow is shown as a time series plot whereas as treated wastewater is shown as a dot plot, with data for an annual compliance period shown separately. The temporal variation in treated wastewater concentrations from 2010 to 2022 are shown alongside discharge flow in Appendix C.

For flow, the total daily discharge flow (red), trend lines for the rolling 28-day average flow monthly (blue) and consent limits (black solid horizontal lines) are shown alongside daily rainfall (black). All daily discharge flow data is shown; whilst the peak 28-day average flow limit (21,000 $m^{3/}$day) applies in all scenarios, the peak daily flow limit (38,000 m3/day) only applies in a 2 year rainfall return period.

For quality parameters, monthly sample results are shown as “dots” and the median for each annual compliance period shown as a coloured, solid horizonal line, with a different marker type used for each compliance period. The year shown refers to the annual compliance period from 1 July of that year to 30 June of the following year (eg ‘2012’ means 1 July 2012 to 30 June 2013). 2022 is only a part year (11 months); data for June 2023 was not available at the time of writing this report. The annual consent limits (median and upper) are shown as black solid horizontal lines. As the purpose is to compare with consent limits, only consent compliance sampling results have been shown for clarity.

Overall, the treated wastewater discharge from NWWTP has complied with the consent limits for the last eleven years. The exception is for BOD during the period while the Facultative Pond was being desludged in 2014, when the upper consent limit for was exceeded more than allowed.

Key observations from the monitoring data are:

- Discharge volume has consistently been less than the consent limits, with the highest rolling 28-day average reaching 18,400 m^3/day (vs limit of 21,000 $m^{3/}$day) and maximum daily discharge volume reaching 36,900 m3/day for all observed rainfall return periods (vs limit of 38,000 m^3/day for 2 year return period)
- Treated wastewater BOD, TSS and faecal coliform concentrations have consistently been less than consent limits for all annual compliance periods in the last eleven years, with the annual median each year being well below the consented median limit and no occasions when the monthly compliance sample exceeded the consented upper limit more than allowed (ie once) in an annual compliance period. The only exception is for BOD.in 2014 (see below)
- In 2014, the annual median BOD concentration in the treated wastewater was well below the consented limit, but four monthly samples were above the limited (ie three more than allowed). The TSS and faecal coliform results remained compliant in 2014. The reasons for the high BOD results in 2014, and whether they were linked to the pond desludging that occurred in that year, are not known. In future, when the ponds are being desludged, care should be taken to ensure that disturbance of the pond is kept to a minimum and that there is no short circuiting.
- Whilst complying with annual compliance limits, higher treated wastewater TSS concentrations were observed in 2020 (annual maximum of 143 mg/L and median of 85 mg/L). This was attributed to the algae in the pond-wetland system at that time, rather than a reduction in pond treatment as there was no material increase in concentration of BOD or faecal coliforms. Since then the PMT has trialled wetland cycling to mitigate this; the trial is ongoing but has been successful to date in keeping TSS concentrations below the consent limits since early 2021
- Lower treated wastewater BOD and TSS concentrations were observed in 2016 (ie mid 2016 to mid 2017) and are attributed to prolonged high plant inflows (and hence discharge flows) diluting concentrations, rather than improved plant performance. The consequential reduction in hydraulic retention time through the pond system did not appear to have materially impacted pathogen reduction as faecal coliform concentrations during this period were similar to other years.

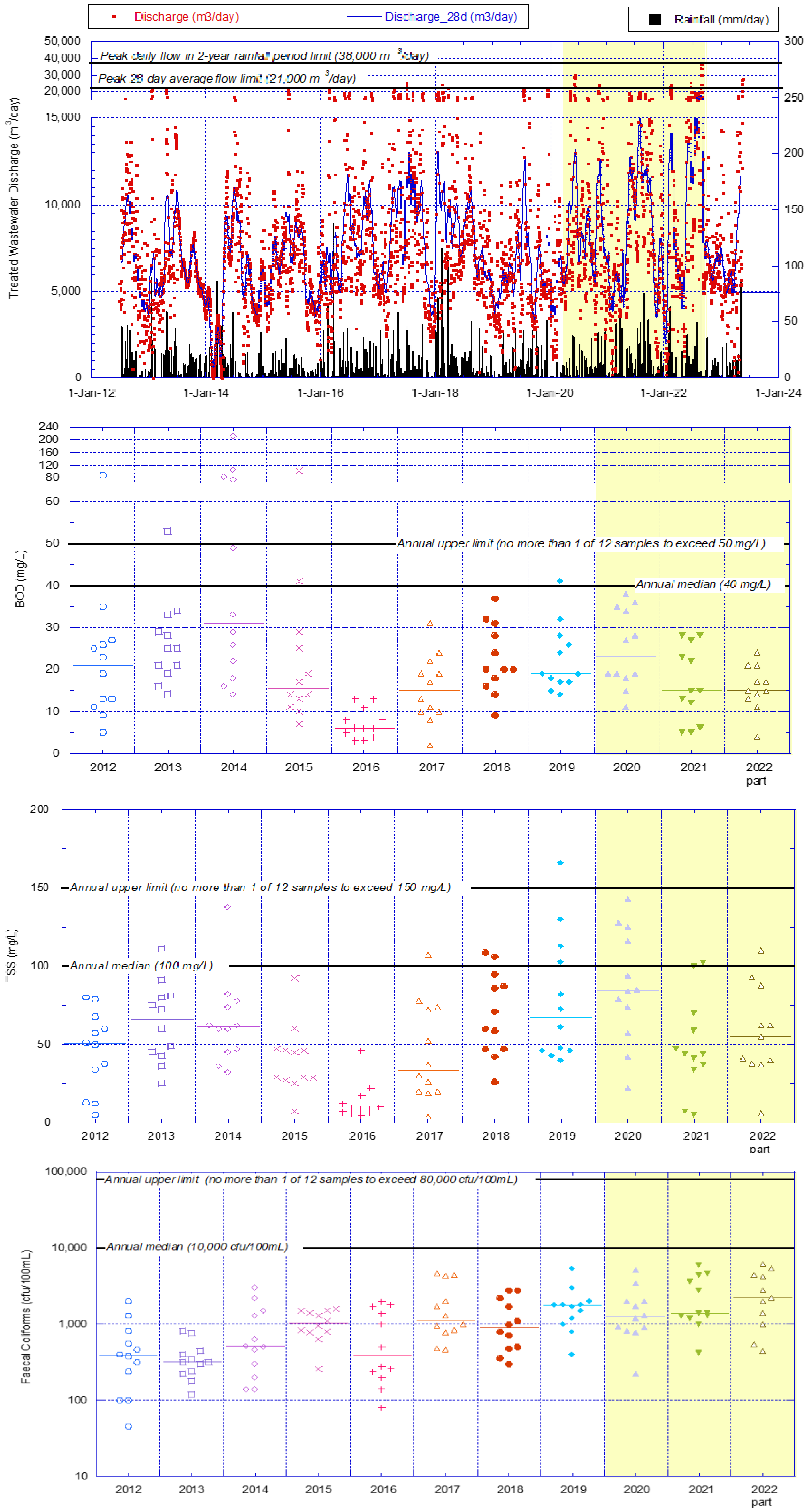

Figure 6: Variation in treated wastewater discharge flow, BOD₅, TSS and faecal coliforms. Compliance period influenced by Covid response shaded yellow.

5.3 Future Requirements

5.3.1 Microbiological Standards

The Nelson Resource Management Plan (NRMP) and the draft Nelson Plan (dNP) provide a perspective on future requirements for a treated wastewater discharge from NWWTP via an ocean outfall to Tasman Bay. The NRMP and the dNP do not specify treated wastewater discharge standards, rather provide receiving water quality standards for different locations based on human recreational activities (contact recreation, shellfish gathering, fishing).

The receiving water standards in the NRMP and dNP of relevance for a coastal discharge from NWWTP are given in Table 5.

Table 5: Receiving Water Standards in NRMP and dNP

Plan	Activity	Parameter	Unit	Median	Upper Limit	Comments
NRMP	Contact Recreation	Enterococci	no./100mL	35	104-275 (site specific)	Median: 1Nov-31Mar. Upper limit is max.
	Shellfish gathering	Faecal coliforms	MPN/100mL	14	43	Median: gathering season. Upper limit is 90%ile
dNP	Contact Recreation	Faecal coliforms	MPN/100mL	35	140	Median: 1Nov-31Mar. Upper limit is max.
	Fishing & shellfish gathering	Faecal coliforms	MPN/100mL	14	43	Annual median. Upper limit is 90%ile

The scope of this PCA is limited to on-site NWWTP performance; others are assessing the effects on the receiving environment, including Tasman Bay. However, to provide an initial perspective on the ability to comply with the NRMP and dNP, the receiving water standards in Table 5 have been considered in the context of observed treated wastewater discharge concentrations and potential dilution from the outfall. Further work is required by others to confirm this.

MetOcean Solutions recently carried out hydrodynamic modelling of the existing ocean outfall discharge in Tasman Bay. One of the outputs of this work was a series of dilution contours of the treated wastewater discharge plume under a range of representative conditions. Under these scenarios a 1000-fold dilution was achieved near the ocean outfall. Based on the observed concentrations of faecal coliforms in the treated wastewater data (<10,000 cfu/100mL), a dilution of 1000 would be sufficient to achieve the required water quality standard for faecal coliforms under the NRMP and dNP (14 to 140 MPN/100mL) if there was no background contamination in the receiving water. Enterococci concentrations are typically of a similar or lesser order as faecal coliforms, and so a dilution of 1000 would also be sufficient to achieve the required water quality standard for enterococci under the NRMP, again if there was no background contamination.

5.3.2 Emerging Organic Contaminants

Emerging organic contaminants (EOCs) cover a wide range of compounds that are present in domestic wastewater and are resilient to degradation and hence can accumulate in the environment and potentially lead to environmental and human health issues. The major groups of EOCs include:

- Endocrine disrupting compounds (EDCs)
- Pharmaceuticals and personal care products
- Veterinary medicines
- Fire retardants and other industrial products
- New generation pesticides

In general, secondary biological treatment, particularly activated sludge processes, provide substantial removal of some EOCs through either biodegradation or adsorption onto the activated sludge floc (Salverson *et al*., 2012). To date no monitoring of EOC's in the WWTP influent or effluent has been undertaken. It is recommended that a round of sampling be undertaken on an annual basis to build up a database and understand if there is an issue.

5.3.3 Microplastics

Microplastics are typically characterised as plastic particles from 1 nm to 5mm in size. They can result from the degradation and weathering of larger plastic items or from the direct discharge of materials originally manufactured at that size, for example microbeads used in facial scrub cleansers. The durability and resilience of plastics are major reasons why they pose a hazard to aquatic ecosystems.

The New Zealand Government introduced regulations in June 2018 that prohibit the sale and manufacture of wash-off products that contain plastic microbeads, including wash-off cosmetics, exfoliants, toothpastes, hand cleansers and abrasive cleaning products.

While sewage treatment plants are not designed to remove microplastics, an average removal value of 88% for WWTP's applying preliminary/primary plus secondary treatment, and 94% for WWTPs applying tertiary treatment, was calculated in a recent study (Iyare et al, 2020). The primary removal mechanism for microplastics is adsorption onto larger solids and removal in either the dewatered sludge or grit.

As with microplastics, it is recommended that a round of sampling be undertaken on an annual basis to build up a database and understand if there is an issue.

6 Process Unit Capability Assessment

The capacity assessment was undertaken to assess the suitability of the NWWTP to treat the projected flow and loads from 2022 to 2059. A comparison of the current projected flow and loads for 2022 to 2059 and those developed to inform the overall NWWTP design in 2006 are presented in Section 4.3.

The assessment presented in this section considers each process unit separately. It is based on a review of the process unit design and operating information from the Final Design Report (FDR) (OPUS, 2006) and the Operation and Maintenance Manual (OPUS, 2007).

6.1 Inlet Works

The Inlet Works include the Inlet Works structure, Grit Chamber, Step Screen, and Inlet Pump Station. Interstage Pump Station No. 1 can direct flow to the Flow Buffer, Pre-treatment system, or the Facultative Pond.

6.1.1 Grit Chamber

The horizontal grit chamber structure is formed in concrete and sloped to a cross channel where grit accumulates. The cross channel is sloped and equipped with a spray header to push the grit along it and into the grit sump, where it is pumped to the grit classifier. The grit classifier consolidates the collected material which is discharged to a bin and disposed offsite. Water that is removed by the grit classifier drains back to the inlet channel.

Based on the FDR (OPUS, 2006), the grit chamber has a design capacity of 700 L/s and can remove particles of a minimum size of 2 mm. Since the grit chamber is a passive system, it can theoretically receive flows greater than 700 L/s but would be less effective at removing grit (i.e., minimum particle cutoff >2 mm). Flow through the inlet channel is limited by the downstream Inlet Step Screen at 700 L/s; flow greater than 700 L/s is automatically bypassed to the passive bypass channel.

The design of the grit chamber was reviewed against standard design criteria (Metcalf & Eddy, 2003) and summarised in Table 6. Based on the Metcalf & Eddy design criteria, the maximum capacity is less than outlined in the FDR. Consideration should be given to derating of the grit chamber if the grit capture at the NWWTP is observed to be limited. Girt settling at 0.4 m/s would be variable, but, if less than 0.6m/s, reasonable. At 0.4 m/s negligible, if any, organics should be captured.

Table 6: NWWTP grit chamber design criteria comparison

Parameter	Units	Final Design Report (OPUS, 2006)	Metcalf & Eddy (2003) Design Criteria
Max Design Flow	L/s	700	156
Velocity	m/s	0.39	0.30
Grit Chamber Volume	m^3	9.4	9.4
HRT	s	13.4	60

Based on the design presented in the FDR (OPUS, 2006), the Grit Chamber has sufficient capacity to treat the projected 2059 design horizon ADF and PWWF. However, there is insufficient capacity to treat either the current or future the Peak Instantaneous Flow (PIF). Allowing a flow bypass during a PIF event is typical since they are expected to last for short periods of time.

Using the standard design criteria (Metcalf & Eddy, 2003), the Grit Chamber has sufficient capacity to treat the current and future ADF. However, it does not have capacity to treat either PWWF or PIF.

Grit capture data (e.g., settleable solids) at various flow rates would allow the Grit Chamber's treatment design capacity to be validated. Given that the Grit Chamber is a constructed channel, its hydraulics are not anticipated to be a limiting design factor.

6.1.2 Inlet Step Screen

The Inlet Step Screen (duty only) consists of step profile plates of stainless steel arranged to form a strainer with 3mm spacing. The walking motion lifts screenings from one step to the next until it reaches the top, where screenings are discharged into the hydropress hopper. The hopper is fitted with sprayers to rinse the screenings. Water that is pressed out of the screenings drains back to the inlet channel. Dewatered screenings are discharged into a bin and disposed offsite.

The screen has a design capacity of 700 L/s and therefore does not have sufficient capacity to treat the current and future PIF. During such events, the screen is automatically bypassed; surplus unscreened flows overflow into the passive bypass channel. From the bypass channel, the flow is diverted to either the Interstage Pump Station No. 1 or the Facultative Pond. In addition, a single screen is provided and there is no redundancy. No redundancy implies loss of screenings at times into the ponds, primarily the Facultative Pond, which means needs to be consider when planning desludging operations.

It is recommended that the Inlet Works be upgraded to provide sufficient capacity for the future PIF (1,130 L/s) with duty / duty redundancy. No redundancy is necessary for the screenings press.

6.1.3 Inlet Pump Station

The Inlet Pump Station has an approximate capacity of 42 m^3 and constructed of concrete. At the peak design flow of the upstream Step Screen of 700 L/s, it has a filling time of 60s from empty and is noted to be adequate to buffer most peak inflows caused by reticulation pump stations cycling on and off. The pump station has four pumps, two clarifier feed pumps that feed the pre-treatment facility and two flow buffer feed pumps; both sets of pumps are operated in duty / standby configuration. The capacities of the pumps are summarised in Table 7.

Under normal operating conditions outlined in the FDR, the pump station has a hydraulic capacity of 45,671 m^3/d. However, the flow to the Buffer Storage Pond is reduced to zero when it is filled to 16,000 m^3.

Table 7: Inlet Pump Station hydraulic capacity

	Units	Final Design Report without Flow Buffering (OPUS, 2006)	Max Hydraulic Capacity with Flow Buffering	Notes
Clarifier Feed Pump	L/s	347	347	Duty / Standby
Overflow to Pond	L/s	42.5	42.5	Stated design maximum flow of 3,671m^3/d
Flow Buffer Feed Pump	L/s	-	92.6	Capacity of 12,000m^3/d per day, with limit of 16,000m^3/d in two consecutive days
Total	L/s	390	482	
	m^3/d	33,671	41,671	

The current operation of the NWWTP differs from the Process Operation Strategy outlined in the FDR (OPUS, 2006). Instead of primarily conveying the screened and degritted wastewater to the Pre-Treatment system, it is conveyed to the ponds (Nelmac, 2021). A maximum 30,000m^3/day (347 L/s) is conveyed to the ponds and surplus flow up to 12,000 m3/d (maximum of 16,000 m^3/day over two days) is pumped to the Flow Buffer Storage. The Pre-Treatment system is used on an as-needed basis depending on the loading requirements and performance of the ponds.

The Inlet Pump Station and pipework has sufficient hydraulic capacity to convey the current and 2059 design horizon ADF to the Pre-Treatment system. The combined pumping capacity of the Inlet Pump Station is insufficient to convey the current or future PWWF and PIF to Pre-Treatment and Flow Buffer Storage. However, this was not the design intent as flows above this will gravitate to the Facultative Pond. The current PIF is above the design basis, without sites noted on site; peak hydraulic capacity should be confirmed.

The plant was designed with operational flexibility to split flows less than 30,000 m^3/d between the pre-treatment facility and the facultative pond to achieve a specific pond loading. However, current influent loads are such that all flows less than 30,000 m3/d are normally directed to the facultative pond, unless there are pond health concerns when these flows are all directed to the pre-treatment facility.

A pressure transducer monitors the pre-treatment sump water level. Setpoints are programmed to increase or decrease pump speeds. The high-high level indicates with the overflow weir is in use.

6.2 Pre-Treatment System

The Pre-Treatment System includes a Primary Clarifier, Trickling Filter, and Interstage Pump Station No. 1. Interstage Pump Station No. 2 can direct flow from the Primary Clarifier to the Trickling Filter and Facultative Pond. The pre-treatment facility is currently only used if pond health conditions require the loading to the Facultative Pond to be reduced. Initially inflow is passed through the pre-treatment facility and sludge generated is discharged into the Facultative Pond (first operation mode). If further load reduction is required, sludge generated is thickened and tankered off-site (second operation mode), however is infrequent (once in last two years for a period of less than a month).

6.2.1 Primary Clarifier

The Primary Clarifier removes settleable inorganic and organic solids, reducing the load to the downstream Trickling Filter and ponds. It has a sidewall depth of 4 m and an inner diameter of 20 m; this corresponds to a surface area of 314m2. The Primary Clarifier was designed to a maximum design flow rate of 30,000 m^3/d, which equates to a Surface Overflow Rate (SOR) of 95 m^3/m^2/d (3.9 m/h) and a Hydraulic Retention Time (HRT) of 1.1 hours. The Primary Clarifier has been sized appropriately based on a maximum design flow rate of 30,000 m^3/d. The FDR has a graph of anticipated (theoretical) BOD and TSS removal rates from the primary clarifier at different HRTs, however a plant-specific graph is not available and limited monitoring data is available to verify on-site performance.

The performance of the Primary Clarifier at various design horizons is summarised in Table 8.

Table 8: Primary Clarifier performance comparison at various design horizons

Parameter	Units	2022	2059	Notes
Average Dry Weather Flow				
Surface overflow rate	m/d	24	31	
Hydraulic retention time	Hours	4.5	3.4	
Effluent BOD load	kg/d	1,130	1,560	Estimated
Effluent TSS load	kg/d	600	840	Estimated
Average Daily Flow				
Surface overflow rate	m/d	26	34	Textbook range: 36 - 48
Hydraulic retention time	Hours	4.1	3.1	Textbook range: >2
Effluent BOD load	kg/d	1,130	1,560	Estimated
Effluent TSS load	kg/d	600	880	Estimated
Peak Wet Weather Flow (30,000 m^3/d)				
Surface overflow rate	m/d	95	95	Textbook range: 79 - 120
Hydraulic retention time	Hours	1.1	1.1	
Effluent BOD load	kg/d	1,400	1,870	Estimated
Effluent TSS load	kg/d	990	1,280	Estimated

Based on the typical industry standard, the Primary Clarifier has capacity to treat the full ADWF and ADF to the 2059 design horizon. The theoretical percent removal of BOD and TSS at the projected ADF at the 2059 design horizon is estimated to be 35% and 62%, respectively. No monitoring is carried out to confirm the removal.

The 2021 and 2059 PWWF flows are 36,800 m^3/d and 49,800 m^3/d, respectively. If the full PWWF was pumped through the Primary Clarifier the 2021 and 2059 SOR would be 117 m^3/m^2/d and 158m^3/m^2/d, respectively, with an HRT of less than 1.0 h. Some reduction in TSS removal in the Primary Clarifier could be expected however this would still be within the capacity of the Trickling Filter.

6.2.2 Interstage Pump Station 1 (Trickling Filter Feed)

Interstage Pump Station No. 1 is used to split the flow from the Primary Clarifier between the Trickling Filter and Facultative Pond. The purpose of splitting the flow is to control the BOD loading of the Facultative Pond. Flow splitting control is achieved by using the duty / standby Trickling Filter Feed Pump. Flow that is not pumped to the Trickling Filter overflows a weir in the wet well and gravitates to the Facultative Pond via Manhole 3.

The operation of the Trickling Filter Feed Pump is controlled using the pond loading curve, which determines the Trickling Filter feed rate based on the desired average BOD loading of 65-80 kg/ha/d on the Facultative Pond. Both pumps are equipped with a VFD that adjust the pump speed based on water level in the wet well.

The duty Trickling Filter Feed Pump has a normal operating capacity of 12,600 m^3/d. If both pumps are run simultaneously, the maximum design flow of 30,000 m^3/d could be pumped to the Trickling Filter.

Table 9: Interstage Pump Station No. 1 hydraulic capacity

Parameter	Units	Final Design Report Normal Operation (OPUS, 2006)	Theoretical Max Hydraulic Capacity	Notes
Interstage PS 1 capacity	L/s	146	347	Duty / Standby Normal max flow of 12,600 m^3/d

The flow to Interstage Pump Station No. 1 depends on the flow from the Inlet Pump Station delivered to the Primary Clarifier. This flow rate is limited to 30,000 m^3/d (347.2 L/s), but the Trickling Filter design flow rate is limited to 12,600 m^3/d (145.8 L/s). All excess flow that is not pumped to the Trickling Filter, up to 30,000 m^3/d, flows by gravity to the ponds. On this basis, Interstage Pump Station No. 1 is not anticipated to be a hydraulic bottleneck for the plant during normal operation.

6.2.3 Trickling Filter

The Trickling Filter is a fixed film attached growth biological process, and generally produces less sludge with greater process stability. The Trickling Filter is primarily used to reduce the BOD on the pond, but can also reduce the solids load. It is intended to be a roughing filter with high organic and hydraulic loading rates. Depending on the organic loading, it is estimated to provide 42-98% organic removal at a temperature of 8°C.

The Trickling Filter has a diameter of 15 m with an underdrain system that supports a depth of 3.5 m of plastic filter media. A distributor arm operates above the filter media surface to evenly distribute the flow across the entire filter. The treated flow, bypass flow, recycle flow, and dosing rate can all be adjusted to optimize its performance. A minimum hydraulic loading rate (minimum wetting rate) is maintained to maintain the biofilm, minimise the biofilm thickness, and maximise the aerobic surface area. The optimal dosing rate depends on the organic and hydraulic loading rate; the influent flow rate and distributor arm rotation speed can be varied based on the desired BOD load at the Facultative Pond. The Trickling Filter is flushed regularly to prevent excess accumulation of biomass on the filter media and increase the aerobic surface area. The flushing step is completed automatically during periods of low flow (12 am – 4 am). Effluent solids from the Trickling Filter are discharged to the ponds.

The Trickling Filter was not designed to receive the full flow from the primary clarifier, and is intended to be used to reduce the BOD load on the ponds to either 65kg/ha/d or 80 kg/ha/d. It was designed for a hydraulic loading rate of 43-170 $m^3/m^2/d$, and an organic loading rate of 0.1-4.0 $kg/m^3/d$. The organic load to the Trickling Filter depends on the influent organic load and the desired pond organic load. A minimum organic loading rate is required to maintain the biofilm. Treatment efficiency decreases with increasing BOD loading rate.

Maintaining adequate air flow to the biofilm attached to the filter media is fundamental to maintaining aerobic conditions and minimising odour production. Forced air ventilation is provided by the odour control system fans at a design air flow rate of 104 m^3/min.

6.2.4 Interstage Pump Station 2 (Trickling Filter Recycle / Pond Feed)

Interstage Pump Station No. 2 consists of a 65m^3 wet well with a duty only Trickling Filter Recycle Pump and two Facultative Pond Feed Pumps that operate in a duty / standby or duty / assist configuration with VFDs. The pump station receives flows from the following process areas: Trickling Filter, Flow Buffer Storage, Biofilter Leachate, Thickener Filtrate, Unthickened Sludge Storage Tank Supernatant, Pump Containment Pads, Administration Building Facilities, and polymer dosing system drains.

The Trickling Filter Recycle Pump is used to maintain the minimum wetting rate of 43 $m^3/m^2/d$ (when combined with the Trickling Filter Feed Flow). The Trickling Filter Recycle Pump has a capacity of 88 L/s. During normal operation, the Facultative Pond Feed Pumps operate in duty / standby configuration. But during Flow Buffer Storage draining operations, the pumps operate in a duty / assist configuration with a combined capacity of 42,000 m^3/d.

Table 10: Interstage Pump Station No. 2 Hydraulic Capacity

Parameter	Units	Normal Operation	Max Hydraulic Capacity	Notes
Trickling Filter Recycle Pump capacity	L/s		88	Normal operation used to maintain minimum wetting rate when combined with Trickling Filter feed flow rate. Duty only
Facultative Pond Feed Pump capacity	L/s	146	486	Normal operation matches Trickling Filter feed flow rate Maximum capacity with pumps in duty / assist mode

The flow to Interstage Pump Station No. 2 depends on the flow from Interstage Pump Station No. 1 delivered to the Trickling Filter. This flow rate is limited to 12,600 m^3/d (145.8 L/s). Interstage Pump Station No. 2 was designed to match this flow at normal operating conditions. Its maximum hydraulic capacity is only required during Flow Buffer Storage emptying operations flowing a wet weather event. On this basis, Interstage Pump Station No. 2 is not anticipated to be a hydraulic bottleneck for the plant during normal operation.

6.3 Ponds

6.3.1 Facultative Pond

The Facultative Pond (or P1) has a surface area of 16ha, an average depth of 1.5m, and four surface aerators positioned to minimise hydraulic short-circuiting. The primary function of P1 is to reduce organic and suspended solids concentrations, however it will also provide some initial pathogen reduction.

Treatment in the Facultative Pond is provided ‘naturally’, through the interaction of sunlight, wind, algae and bacteria. The level of treatment depends on several factors including organic loading, hydraulic retention time (accounting for short-circuiting), climate and season (both temperature, sunlight and wind), mixing/stratification, algal population (algae concentration, species type and health as well as algal grazers), wastewater physical characteristics (temperature, pH, dissolved oxygen), and sludge inventory.

The plant was designed to be operated based on a pond loading curve, with higher loads (kg/ha/day) applied during warmer summer months and lower loads applied during cooler winter months. Relatively low influent loads are typically received at NWWTP. As a result, the pre-treatment facility is usually offline, with raw wastewater (after grit removal and screening) passing directly to the Facultative Pond. Despite not routinely operating the pre-treatment facility, the Facultative Pond is typically organically underloaded most of the year. Underloading poses different operational risks to a higher loaded pond-based system (including rotifier grazing of algae); bringing the pre-treatment facility online is one tool the PMT uses to manage these risks.

The broad range of risks to pond health and associated performance are outlined in the Pond Management Plan (PMP). These include organic underloading and overloading, hydraulic overloading, sludge over accumulation, algal parasitism, algal grazing, and development of algal monocultures. The PMP outlines the range of mitigation measures available to the PMT, including using the pre-treatment facility, algal reseeding (interpond transfer) and nitrate dosing.

The pond normal operating level is RL 15.1 and the maximum pond water level is RL15.4. The weir is designed so the water level automatically increases during high flow events, thereby increasing the total volume of the ponds and allowing for the minimum design HRTs in the facultative and maturation ponds to be maintained.

Effluent from the Facultative Pond gravitates to the Maturation Pond via a pond transfer structure, designed to minimise algae and sludge carry over to the maturation pond. The Facultative Pond was last desludged in 2014.

Table 13 summarises the hydraulic retention time through the Facultative Pond at various design horizons. It based on inflow, which provides a conservative estimate as there is attenuation and reduction of flow through the pond system. Normal operating depth has been used to assess hydraulic retention time during average flows; the high operating depth (normal operating depth + 0.3m) has been during peak flows.

Table 11: Facultative Pond Hydraulic Retention Time

Parameter	Units	2022	2059	Notes
Average Dry Weather Flow				
Flow	m^3/day	7,400	10,100	No attenuation of inflow
Hydraulic retention time	days	22	16	Normal operating depth
Average Daily Flow				
Flow	m^3/day	8,200	11,100	No attenuation of inflow
Hydraulic retention time	days	20	15	Normal operating depth
Peak Wet Weather Flow				
Flow	m^3/day	36,800	49,800	No attenuation of inflow
Hydraulic retention time	days	11	8	High operating depth

Given the projected 2059 design horizon influent organic and solids loads, the Facultative Ponds are not expected to be a process bottleneck, however expect the pre-treatment facility to be utilized more frequently. The capacity of the pre-treatment facility may need to be augmented close towards the end of the design horizon considered.

Given the projected 2059 design horizon ADWF and PWWF and observed attenuation through the pond-wetland system, the Maturation Ponds are not expected to be a hydraulic bottleneck.

There are typically few odour complaints related to the ponds. The notable exception in recent years is the significant pond odour event in October 2018 (labour weekend). Prior to the event, the Facultative pond largely contained a monoculture of Euglena with a low level of infection (1% to 6% of population infected). Over the course of three days, the level of infection increased exponentially, ultimately wiping out the *Euglena* population. The sudden loss of the main oxygen producing algae in the pond saw a marked drop in pond dissolved oxygen and Oxidation-Reduction Potential (ORP), a change in pond colour, and a production of strong odours which drifted well beyond the site boundary, with odour complaints received from 23 October to 1 November. The PMT responded by algae seeding (from the wetlands as well as tankering of algae from Bell Island WWTP), sodium nitrate dosing, and 'full' pond deloading by running the pre-treatment facility with sludge treatment and thickened sludge tankered off-site. These measures saw the ponds recover quickly, with a marked improvement in pond health seen within two weeks such that algal seeding was ceased and then about a week later pond loadings were returned to normal. Following this event, the PMT reviewed its procedures and have taken a more proactive approach to minimise the risks of a similar event occurring.

6.3.2 Maturation Pond

The Maturation Pond (or P2) has a surface area of 10 ha, an average depth of 1.5 m, and is partitioned into three zones to promote plug-flow. The primary function of P2 is to reduce pathogens but is also used as a potential source for algal seeding of the Facultative Pond, when required to address pond health issues.

Treatment in the Maturation Pond is provided 'naturally' through various mechanisms including sun light exposure, grazing by protozoans and invertebrates, and hydraulic retention time. The partitioning of the pond to promote plug-flow through three zones is a key aspect of the design to ensure adequate inactivation of micro-organisms.

The pond normal operating level is RL 15.1 and the maximum pond water level is RL15.4. The weir is designed so the water level automatically increases during high flow events, thereby increasing the total volume of the ponds and allowing for the minimum design HRTs in the facultative and maturation ponds to be maintained.

A manual bar screen is located at the outlet of the Maturation Pond. The effluent from the Maturation Pond flows by gravity to the flow splitter box, where effluent is typically directed to the wetlands but can be diverted to the Final Effluent Channel, bypassing the wetlands.

Table 13 summarises the hydraulic retention time through the Maturation Pond at various design horizons. It based on inflow, which provides a conservative estimate as there is attenuation and reduction of flow through the pond system. Normal operating depth has been used to assess hydraulic retention time during average flows; the high operating depth (normal operating depth + 0.3 m) has been during peak flows.

Table 12: Maturation Pond Hydraulic Retention Time

Parameter	Units	2022	2059	Notes
Average Dry Weather Flow				
Flow	m^3/day	7,400	10,100	No attenuation of inflow
Hydraulic retention time	days	20	15	Normal operating depth
Average Daily Flow				
Flow	m^3/day	8,200	11,100	No attenuation of inflow
Hydraulic retention time	days	18	14	Normal operating depth
Peak Wet Weather Flow				
Flow	m^3/day	36,800	49,800	No attenuation of inflow
Hydraulic retention time	days	7	5	High operating depth

The FDR estimated the concentration of faecal coliforms in the treated wastewater from the entire pond system (i.e., Facultative Pond and Maturation Pond, excluding the wetlands) using the Marais design equation (first-order removal) and compared these to observed concentrations. Influent faecal coliform concentrations, pond hydraulic retention time based on pond outflow (rather than inflow) and pond water temperatures were key parameters considered. At that time the observed concentrations were more conservative even without the 2006 pond modifications to improve performance (i.e., separation of 26ha pond into two ponds and then partitioning of the Maturation Pond into three zones), and have been in the order of 1 log (or more) less than the consented limited over the last ten years. The combined pond-wetland system is expected to reduce faecal coliforms to current consent requirements over projected 2059 design horizon for ADWF and PWWF.

Given the projected 2059 design horizon ADWF and PWWF and observed attenuation through the pond-wetland system, the Maturation Ponds are not expected to be a hydraulic bottleneck.

6.4 Wetlands

The wetland system consists of two surface flow wetlands (Wetland 1 and Wetland 2), with a combined surface area of 13 ha. The wetlands were designed to maintain the maturation pond effluent quality. They are also used as a potential source for algal seeding of the pond system, when required to address pond health issues.

The maturation pond outlet flow is typically split evenly between the two wetlands. Flow is piped to Wetland 1 and is conveyed via an open channel to Wetland 2, with each wetland having a simple distribution system; a single inlet consisting of piped flow to an upflow weir chamber, relying on the deep area of the wetland to provide even flow distribution to the shallower sections.

Each wetland is made up of three deep cells (about 60% of total area) and two shallower cells (about 40% of total area), with normal operating depths of 1000 mm and 300 mm, respectively. During peak flows, the normal operating depth can increase by 300mm, providing a storage volume of 39,000 m^3 above the normal operating level. There is also a free board of 600 mm above the maximum operating level. The shallow areas were designed to be planted with appropriate wetland plants and operating water depths controlled to enable plants to thrive, however the plants have all but died[11], with the wetland essentially becoming an extension of the Maturation Pond. The deep areas were not planted but left as open water.

Each wetland has three effluent structures, each consisting of an open ended pipe protected by a circular rock filter bund, that feed to a single effluent pipe as well as an emergency overflow. Flap valves are provided on pipe outlets to prevent backflow during very high tides. Level control is achieved using sharp crested weirs, which allows for the wetland storage capacity to be utilised during periods of peak flows.

Table 13 summarises the hydraulic retention time through the wetlands at various design horizons. It based on inflow, which provides a conservative estimate as there is attenuation and reduction of flow through the pond-wetland system. Normal operating depth has been used to assess hydraulic retention time during average flows; the high operating depth (normal operating depth + 0.3 m) has been during peak flows.

Table 13: Wetland Hydraulic Retention Time

Parameter	Units	2022	2059	Notes
Average Dry Weather Flow				
Flow	m^3/day	7,400	10,100	No attenuation of inflow
Hydraulic retention time	days	13	10	Normal operating depth
Average Daily Flow				
Flow	m^3/day	8,200	11,100	No attenuation of inflow
Hydraulic retention time	days	12	9	Normal operating depth
Peak Wet Weather Flow				
Flow	m^3/day	36,800	49,800	No attenuation of inflow
Hydraulic retention time	days	3.8	2.9	High operating depth

[11] See “Nelson Wastewater Treatment Plant (NWWTP) Wetlands Review” (Stantec, 2019)

Given the projected 2059 design horizon ADWF and PWWF and observed attenuation through the pond-wetland system, the wetlands are not expected to be a hydraulic bottleneck during short periods of high inflows. However, the ability to discharge from the outlet is a bottleneck during prolonged periods of extreme high inflows (e.g. 2022 flooding event). This is discussed in Section 6.5.

The wetlands have historically improved treated wastewater quality, however elevated algal solids were observed in 2020. Hence, in recent summers wetland ‘cycling’ has been trialled to reduce algal solids In the treated wastewater discharge. During the summer trials, all flow from the Maturation Pond has been directed to one wetland and the other has been taken offline. When algal solids reduce, this wetland is returned to service and the other wetland is taken offline. The trial is ongoing but has been successful to date.

In terms of faecal coliform requirements, the additional hydraulic retention time provided by the wetlands provide greater confidence of compliance.

6.5 Outlet

The effluent from the Maturation Pond flows by gravity to the Flow Splitter Box, which contains three weirs – one leading to the Final Effluent Channel and the other two leading to the wetlands. All three weirs are manually adjustable to allow the water level in the pond to be varied as required. The pond normal operating level is RL 15.1 and the maximum pond water level is RL15.4. The weir is designed so the water level automatically increases during high flow events, thereby increasing the total volume of the ponds and allowing for the minimum design HRTs in the facultative and maturation ponds to be maintained. The weirs leading to the wetlands are used to divide the flow evenly between the two wetlands or to isolate a wetland, and the weir within each wetlands used for level control.

Flow passed to the wetlands currently gravitates to the Final Effluent Channel. The original design allowed for a wetland pump station[12], which received flows from the two wetlands and discharged the flow to the Final Effluent Channel though a combination of gravity flow and pump discharge, however this pump station was not constructed.

The Final Effluent Channel is an open, V-shaped, earthen embankment channel that is approximately 9 m wide and 3 m deep. It has been sized to convey peak flows and to minimise scour along the base of the channel. Under high-tide conditions, saltwater backs up into the effluent pipe and channel.

At the end of the channel, the treated wastewater discharge flows are measured by an open channel magnetic flow meter in the Effluent Flow Measurement Channel (FIT0405). Flows then gravitate through a 900mm pipe under the pre-treatment works to ‘Manhole Y' and then the offshore ocean outfall, discharging into Tasman Bay.

The offshore ocean outfall is a concrete pipe that runs perpendicular to the shoreline and extends approximately 430 m from ‘Manhole Y’. At the end of the outfall, there are 10 outlet holes; 9 located on the top half of the pipe equally spaced over 20m, and 1 at the end of the pipe parallel to the seabed and fitted with a 0.3m diameter conical reducer.

The following hydraulic constraints were noted in the FDR:

- Effluent channel may not be suitable for use during high outflows (greater than 45,000 m^3/day) and high tide conditions
- The maturation pond outlet weirs may require and increase in weir width to pass the required flow without increasing the pond water level beyond rl 15.4

Given the projected 2059 design horizon PWWF and observed attenuation through the pond-wetland system, the outlet is not expected to be a hydraulic bottleneck during short periods of high inflows. However, it is a bottleneck during prolonged periods of extreme high inflows (e.g., 2022 flooding event), where constrained discharge flows result in increasing pond water levels. These events are more likely to occur with climate change, and so it is recommended that NCC consider reviewing hydraulic constraints and determine best approach to mitigate (e.g., installing a pump station, modifying weir). Impact of predicted sea level risk, high tides and storm surge conditions on outlet hydraulics should also be reviewed.

[12] The Final Design Report (2006) included a Wetland Pumping Station that was not constructed. The designed pumping station was intended to have three pumps configured duty/assist/assist. For Wetland 1, flows were intended to discharge to the Final Effluent Channel during low tide but the Wetland Pumping Station during high tide. For Wetland 2, flows were intended to discharge to the Wetland Pumping Station at all tidal conditions.

6.6 Sludge Handling System

The Sludge handling system includes raw sludge storage, a rotary drum thickener and a thickened sludge storage. Thickened sludge is then tankered off-site.

The sludge handling system is not frequently used (once in last two years for a period of less than a month). Typically, when the pre-treatment system is required to be operated, the primary sludge from the clarifier is directed back to the facultative pond via Interstage Pump Station No. 2 (first operation mode). However, if the loading to the facultative pond is required to be further reduced, the solids treatment system is operated as outlined below, with thickened sludge tankered off-site (second operation mode).

The sludge treatment system was designed to remove settled sludge from the Primary Clarifier at a solids concentration of 2-5 wt%, and thicken it to 6-8.5 wt% using the Rotary Drum Thickener, however these dry solids contents have not been achieved recently when the sludge treatment system has been operated. The thickened sludge is transported to the Bell Island WWTP for further treatment.

6.6.1 Primary Sludge Management

Table 14 summarises the current and 2059 design horizon sludge flow rates and loads based on ADWF and average load conditions. It was assumed that the solids concentration of the sludge drawn from the Primary Clarifier is 3 wt%. There is limited monitoring data available to assess the removal efficiency of the Primary Clarifier.

The mass of sludge withdrawn from the Primary Clarifier is expected to be consistent, but dependent on the desludging procedure. Desludging of the Primary Clarifier is based on an operator adjustable timer (frequency and duration). If too much sludge is removed, the sludge blanket depth becomes too shallow which negatively impacts performance by reducing the Solids Retention Time (SRT). The sludge removed will also have a lower solids concentration which negatively impacts the performance of the downstream Rotary Drum Thickener.

Table 14: Primary Clarifier sludge flow rates at various design horizons

Parameter	Units	2022	2059
Average Dry Weather Flow*	m^3/day	7,400	10,100
Influent TSS Load	kg/d	1,700	2,200
Primary Clarifier HRT	h	4.5	3.4
Percent of TSS Removed by Primary Clarifier	%	65	63
Waste Sludge Load	kg/d	1,100	1,390
Sludge Flow Rate at 3 wt% solids concentration	m^3/day	37	46
* Assuming all influent flow is directed to the Primary Clarifier			

The centrifugal Primary Clarifier Desludge Sludge Pumps are operated in a duty / standby configuration at a fixed speed. Each pump has a capacity of 12 L/s, and corresponds to a flow rate of 1,037 m^3/d. The duty Desludge Pump has surplus capacity at the 2059 design horizon.

The Unthickened Sludge Tank has a capacity of 144 m^3, and provides three days of storage during average conditions at the 2059 design horizon. The Unthickened Sludge Tank was designed to store sludge until it can be processed by the Rotary Drum Thickener at a constant rate and solids concentration.

6.6.2 Rotary Drum Thickener

The sludge from the Primary Clarifier is drawn from the Unthickened Sludge Tank by the duty / standby Unthickened Sludge Transfer Pumps, each equipped with a VFD. The thickening process employs a polymer feed system, flocculation tank, and Rotary Drum Thickener designed to increase the solids concentration the sludge to 6-8.5 wt%, however these dry solids contents have not been achieved recently when the sludge treatment system has been operated. There is limited monitoring data available to assess the performance of the rotary drum thickener.

The polymer is added to the sludge to improve its dewatering characteristics. The polymer dosing system includes and polymer hopper, screw feeder, wetting head, make-up tank, storage tank, aging tank, and diaphragm dosing pump. The polymer is injected into the sludge pipe before entering the flocculation tank. The flocculated sludge overflows into the Rotary Drum Thickener for dewatering.

The flocculated sludge traverses the length of the Rotary Drum Thickener as it rotates, separating the flocculated sludge from the free water. The drum thickener is equipped with a polyester filter cloth and rotates at 9 rpm. It has a design flow range of 5-21 m^3/h. The average sludge feed rate, thickened sludge concentration, and thickened sludge truck capacity are assumed to be 9 m^3/h, 6 wt%, and 25 m^3, respectively. A summary of the rotary drum thickener capacity is presented in Table 15.

Table 15: Rotary Drum Thickener capacity summary

	Units	2022			2059		
Waste Sludge Load at ADWF	kg/d	1,100			1,390		
Unthickened Sludge Concentration	wt%	2	3	4	2	3	4
Unthickened Sludge Flow Rate	m^3/day	55	37	28	70	46	35
Drum Thickener Feed Rate	m^3/h	9					
Drum Thickener Run Time – 7-day basis	h/d	6	4	3	8	5	4
Drum Thickener Run Time – 5-day basis	h/d	9	6	4	11	7	5
Thickened Sludge Concentration	wt%	6					
Thickened Sludge Flow Rate – 7-day basis	m^3/day	18			23		
Thickened Sludge Flow Rate	m^3/h	3	4.5	6	3	4.5	6
Sludge Truck Movements	No. per week	5			6		
* Assuming all influent flow is directed to the Primary Clarifier							

At the average sludge loading, the Rotary Drum Thickener has sufficient capacity to the 2059 design horizon. It has the capacity to treated higher sludge loading rates if it were operated for a longer period of time.

The Thickened Sludge Tank has a capacity of 72 m^3, and has retention time of three days at average sludge loading. If sludge is removed from the Thickened Sludge Tank using a 25 m^3 truck, sludge transfer to Bell Island WWTP would need to be done six to seven times per week at the 2059 design horizon. The bottleneck for the sludge treatment system may be the scheduling of the truck to transfer sludge to Bell Island WWTP.

6.7 Odour Control System

The NWWTP is equipped with an odour control system with extraction points at following process areas throughout the plant: Inlet Works, Grit Classifier, Inlet Pump Station, Trickling Filter, Interstage Pump Station No. 2, Rotary Drum Thickener, Unthickened Sludge Storage Tank, Thickened Sludge Storage Tank, and Plant Room.

The biofilter is contained in an earthen bund with a 1.5 mm thick HDPE liner, and has a surface area of 210 m^2. The gas delivery system consists of slotted pipework connected to a distribution pipe embedded in 100 mm of pea gravel to distribute the foul air. The biofilter media is a uniform mixture of 75% screened bark mulch, 20% loam topsoil, and 5% crushed shell to a 1m depth. The typical life span of the filter media ranges from 2-7 years depending on the odour loading rate. The moisture content of the media is maintained at 60% using a water spray in the influent duct and an irrigation spray system at the top of the media. The leachate is collected at the bottom of the biofilter and pumped to the Inlet Pump Station for treatment.

The total design air flow through the odour control system biofilter delivered by the duty / standby odour extraction fans is noted to be 2.7 m^3/s. The design air flow through the Trickling Filter is makes up approximately 65% of the air demand at 1.7 m^3/s (104 m^3/min).

The design of the biofilter at the NWWTP is compared to industry standard design criteria ((Metcalf & Eddy, 2003) (Quigley, Easter, Burrowes, & Witherspoon, 2004)) and summarised in Table 16.

Table 16: NWWTP odour control biofilter design criteria comparison

Parameter	Units	Final Design Report (OPUS, 2006)	Metcalf & Eddy (2003) Design Criteria	Quigley, et al. (2004) Design Criteria
Empty bed contact time	s	78s	30 - 60	30 - 120
Surface loading rate	m/h	46	10 - 100	35 - 90
Volume loading rate	h^{-1}	46	10 - 100	
Media depth	m	1	1.0 - 1.25	

Based on the typical design criteria, the existing odour control biofilter was appropriately sized. However, the performance of the odour control biofilter cannot be assessed because no flow rate, differential pressure, inlet and outlet odour concentration, or irrigation rate data were made available.

It is recommended that an investigation be undertaken into the actual loading rate, pressure drop and performance of the biofilter.

Odour complaints logs have not reviewed as part of this assessment.

6.8 Summary of Plant Capability

A traffic light summary of the plant hydraulic and process capability at various design horizons is summarised in Table 17 and Table 18, respectively. A green circle indicates within plant design capability, an amber circle indicates at or near design capability, and a red circle indicates outside design capability. This assessment is primarily based on the design capability stated in the Final Design Report (2006).

For flow, the PIF is not shown on the table. The current PIF (2022) is greater than design capacity for all plant items (i.e., a ‘red’ rating), however comments from site indicate that these flows are able to be conveyed through the inlet works to the ponds/wetlands without over-topping or overflows occurring on-site. Overloading of the inlet screens during peak wet weather events will lead to screenings entering the facultative pond. Therefore an upgrade of the inlet screens with Duty/Duty redundancy is recommended.

Further assessment of peak hydraulic capacity would be beneficial.

Table 17: NWWTP hydraulic capability traffic light summary

	2022	2032	2042	2052	2059	Notes
ADF						
NWWTP	🟢	🟢	🟢	🟢	🟢	ADF less than design capacity for main plant components
PWWF						
Inlet works	🔴	🔴	🔴	🔴	🔴	Screen upgrade needed
Flow buffer	🟢	🟢	🟠	🟠	🟠	Increase volume
Primary clarifier	🟢	🟢	🟢	🟢	🟢	Limited to 30,000 m^3/day
Trickling filter	🟢	🟢	🟢	🟢	🟢	Limited to 30,000 m^3/day
Ponds (P1 & P2)	🟢	🟢	🟢	🟢	🟢	
Wetlands	🟢	🟢	🟢	🟢	🟢	
Outfall	🟢	🟢	🟠	🔴	🔴	Add pump station/change effluent channel

Table 18: NWWTP process capability traffic light summary

	2022	2032	2042	2052	2059	Notes
Solids load						
Primary clarifier	🟢	🟢	🟢	🟢	🟢	
Trickling filter	🟢	🟢	🟢	🟢	🟢	
Ponds (P1 & P2)	🟢	🟢	🟢	🟢	🟢	Pre-treatment required for pond health & 2059 load. If wetland cycling not successful, may need TSS removal
Organic load						
Primary clarifier	🟢	🟢	🟢	🟢	🟢	
Trickling filter	🟢	🟢	🟢	🟢	🟠	May need additional media by increasing height of filter
Ponds (P1 & P2)	🟢	🟢	🟢	🟢	🟢	Ok if pre-treatment adequate

7 Condition Assessment

A condition assessment of all mechanical equipment was completed by Nelmac in 2021 and 2022. A summary of these findings is presented herein. This condition assessment did not include a civil structure condition assessment. A civil structure condition assessment is planned for 2023.

A traffic light summary of the anticipated equipment condition at various design horizons is summarised in Table 19.

A green circle indicates good condition, an amber circle indicates short-term (< 5 years), or minor equipment replacement required, a red circle indicates immediate or major equipment replacement is required. This assessment assumes that the existing equipment is retained and maintained with no major upgrades up to 2059.

All equipment has an expected serviceable life span at which point it will require replacement or a significant refurbishment. A proactive maintenance programme will either allow for the operation of equipment to its expected life span, or extend it by one to two years. The point in time when major pieces of equipment within each process area will reach the end of its expected life is indicated with a red circle. The operation of the plant and the ability to meet the discharge consent requirements may be compromised if the equipment is not replaced or refurbished in time.

The expected operating life spans that have been applied (e.g., 10-15 years for instruments / electrical equipment, 25 years for mechanical equipment and motors, 50 years for civil works) are based on typical industry standards. However, these life spans depend on the operating environment (e.g., corrosive / marine environments have shorted operating life spans).

Table 19: NWWTP mechanical equipment condition assessment traffic light summary

Process Area	2022	2032	2042	2052	2059	Notes
Inlet Channel	🟢	🟡	🟡	🟡	🟡	Replace instruments
Grit Chamber and Classifier	🟢	🟡	🔴	🔴	🔴	2033 Replace / refurbish grit classifier
Step Screen	🟢	🟡	🔴	🔴	🔴	2033 Replace / refurbish screen
Inlet Pump Station	🟢	🟡	🔴	🔴	🔴	2035 replace instruments, refurb pumps, replace VFDs
Primary Clarifier	🟢	🟡	🔴	🔴	🔴	2035 replace instruments, refurb pumps, replace drives
Interstage Pump Station No. 1	🟢	🟡	🔴	🔴	🔴	2027 replace drives 2035 replace valves refurb pumps
Interstage Pump Station No. 2	🟡	🟡	🔴	🔴	🔴	2027 replace drives, instruments 2035 refurb pumps 2040 FRP covers
Trickling Filter	🟡	🟡	🔴	🔴	🔴	2027 replace drives, 2035 replace valves, refurb pumps 2040 replace media

Process Area	2022	2032	2042	2052	2059	Notes
Odour Control Biofilter	🟡	🟡	🔴	🔴	🔴	Verify biofilter media condition 2027 refurb fans and replace instruments 2035 refurb pipework and structure, replace dampers
Sludge Treatment	🟡	🔴	🔴	🔴	🔴	2025 replace sludge valves, pumps, drives, mixers, instruments 2035 inspect / refurb pipework, polymer, drum thickener 2045 inspect / refurb structure
Flow Buffer	🟢	🟢	🟢	🟡	🟡	2035 replace instrument 2040 inspect structure
Ponds	🟢	🟢	🟡	🟡	🟡	2035 replace / refurb aerators 2040 inspect structure
Wetlands	🟢	🟢	🟡	🟡	🟡	2027 inspect piping 2035 replace piping 2040 inspect structures
Potable and Service Water	🟢	🟡	🟡	🟡	🟡	2027 replace instruments 2035 replace / refurb drives, pumps, and valves
Outlet Channel and Outfall	🟢	🟢	🟢	🟡	🟡	2030 and 2040 inspect structures

Additional detail of the condition assessment and the current overall condition score for the respective process area is provided in Table 20. The condition score is ranked from 1 to 5, where 1 is new and 5 requires immediate replacement. Estimates for the year to complete repairs or replacements have been assumed based on typical service for the respective equipment.

Table 20: Mechanical condition assessment summary notes

Process Area	Condition Score (1-5)	Year of Installation	Notes
Inlet Channel	3	2008 – Interceptor Box, Weir, Inflow Sensor and Transmitter 2016 – Hi-Hi Level Switch, Level Transmitter	Instruments require replacement 2023-2026
Grit Chamber and Classifier	3	2008 – Grit Chamber (recoated 2019/20), valves, Grit Classifier 2020 – Grit Classifier Motor	2033 end of grit classifier service life
Step Screen	3	2008 – Step screen, stop boards, pipe work	2022/23 replace step screen laminates 2033 end of screen service life
Inlet Pump Station	2	2008 – Pump chamber, pipework, valves 2015 – Clarifier Feed Pump VFD repaired 2019-2021 – Chamber relined, level instruments replaced, clarifier feed & flow buffer pump refurbished	2035 replace instruments, refurbish pumps, replace VFDs
Primary Clarifier	3	2008 – Clarifier and pipework 2017/18 – Clarifier drive replaced 2019/20 – instruments replaced, pumps refurbished	2035 replace instruments, refurbish pumps, replace drives
Interstage Pump Station No. 1	3	2008 – Wet well and pipework 2019/20 – pump refurbishment	2027 replace drives 2035 replace valves, refurbish pumps
Interstage Pump Station No. 2	3	2008 – wet well and pipework 2020 – Flow Buffer actuator replaced 2021 – FRP covers recoated	2027 replace drives 2035 replace valves, refurbish pumps 2040 replace FRP covers
Trickling Filter	3	2008 – Trickling Filter and Pipework 2012 – Structure relined 2021 – Pump refurbished	2027 replace drives 2035 replace valves, refurbish pumps 2040 replace media
Odour Control Biofilter	3	2008 – Odour control system 2020/21 – leachate irrigation valves replaced	Verify biofilter media condition and effectiveness. 2-7 year lifespan. 2027 refurbish extractor fans 2035 inspect / refurbish pipework, replace damper valves
Sludge Treatment	4	2008 – sludge treatment system 2021 – sludge storage mixer replaced	2025 replace sludge valves, pumps, drives, mixers, instruments 2035 inspect / refurbish pipework and polymer system, drum thickener 2045 inspect / refurbish structure (corrosive environment)

Process Area	Condition Score (1-5)	Year of Installation	Notes
Flow Buffer	2	2008 – Flow Buffer Storage 2020 – level transmitter replaced	2035 replace level transmitter 2040 inspect structure
Ponds	2	2008 – Pond upgrade 2015 – Manhole repairs	2035 replace / refurbish aerator 2040 inspect structure
Wetlands	3	2008 – Constructed	2027 inspect piping 2035 replace piping 2040 inspect structures
Potable Water and Service Water	3	2008 – Installed 2020 – Hose reels and associated valves replaced	2027 replace instruments / switches 2035 replace / refurbish drives, pumps, and process valves 2040 inspect structure
Outlet Channel and Outfall	3	1970 – Outfall 2008 – Outlet Channel	2030 and 2040 inspect structures for refurbishment

8 Information Gaps

Table 21 summarises key information gaps identified and their respective impact on the scope of this PCA.

Table 21: Information gap summary

Information Gap	Description and Impact
Grit Chamber capture data	• No grit capture efficiency data is available. • Data would be used to confirm its actual capacity given the FDR design criteria conflicts with standard design criteria.
Pre-Treatment process performance data	• Pre-treatment system is typically used infrequently, for short periods of time. • Some data available for pre-treatment facility, but no interstage data available to assess performance of individual units. In addition, primary sludge is not routine processed but returned to the system, with at least some partially recycled through the pre-treatment system. • Unable to assess the BOD and TSS removal performance of the Primary Clarifier • Unable to assess BOD removal performance of the Trickling Filter and minimum start-up period to achieve reliable removal rates when brough back online • Unable to assess effectiveness of trickling filter flush regime
Sludge Treatment system performance data	• Solids treatment system is rarely used (once in 2020 and once in 2022). • Limited solids capture data available due to limited use. • Unable to assess effectiveness.
Pond & Wetland process performance data	• This scope has considered treatment performance provided by the pond and wetland system collectively. Treatment performance across the individual components, effective of wetland cycling and extent of ongoing monitoring required is being assessed separately.
Outlet capacity	• The current PIF exceeds the design capacity in the FDR. • Hydraulic constraints should be reviewed, and appropriate modifications identified (eg install pump station as per FDR, modify weirs) to enable greater flow to be discharged during prolonged periods of sustained high inflows
Odour system performance data	• No data collected. • Odour complaints log not reviewed as part of this PCA • Final Design Report provides limited information. • Unable to determine if additional capacity is required. • Important consideration with increased development around the NWWTP.

In addition, it is recommended that the following issues be reviewed as part of the 2023 resource consent application to capture any new information not available at the time of writing this PCA::

- Assessment of effects and any impact on effluent discharge standards
- Recent plant upgrades, renewals, and condition assessments
- Trends from online influent monitoring, when data is available, and comparison to results from traditional sampling
- Influent flow and loads to assess if returned to “pre-Covid” levels
- PMT review findings.

9 Risks

A traffic light summary of key risks identified in terms of technical or compliance criteria is summarised in Table 22, along with potential mitigation. A green circle indicates low risk, an amber circle indicates moderate risk, and a red circle indicates high risk.

Table 22: Technical or Compliance Risks

Item	Sub-item	Risk	Comment / Potential mitigation
Capacity – Growth	Flow	🟡	Higher peak inflows, mitigate if possible
	Load	🟢	Pre-treatment appears sufficient
Compliance – Higher Standard Required	Organics	🔴	Add-on process / new plant
	Solids	🔴	Add-on process / new plant; pond heath related aspects
	Micro-organisms	🔴	Add-on process / new plant; impacts of other discharges
	Nutrients	🔴	Add-on process / new plant; impacts of other discharges
	Odour	🟡	Reduced acceptance; reduced buffer zones
Condition	Life	🟡	Complete required renewals over 35 years
Resilience	Climate change	🟡	Increased storms, droughts, inundation, increasing pond/wetland water temperatures.
	Redundancy	🟡	Site-wide philosophy for upgrades

10 Recommendations

Table 23 summarises NWWTP recommendations.

Table 23: NWWTP PCA Recommendations

1.	**Network**
1.1	Consider further inflow and infiltration improvements to reduce PWWF and PIF
1.2	Consider ability to combine/split load with adjacent catchments
2.	**Influent Sampling**
2.1	Take flow proportional composite samples of screened influent daily and test at an external laboratory for the following: • COD • BOD • TSS • VSS • TKN Compare with the data from the online influent quality sensor to better understand extent of commercial/industrial wastewater inputs.
2.2	Sample and test influent and final effluent for emerging organic contaminants (EOC's) and microplastics on an annual basis, to build up a database and understand if there are any issues needing further attention.
3.	**Inlet Works**
3.1	Upgrade inlet screens to provide the required peak wet weather flow capacity and duty / duty redundancy.
3.2	Consider use of alarms / auto-start based on influent quality when online influent monitoring / flow.
3.3	Sample grit chamber influent and effluent to measure grit capture efficiency.
4.	**Primary Clarifier**
4.1	Sample primary clarifier influent and effluent to measure TSS removal performance and, if required, optimise operation.
5.	**Trickling Filter**
5.1	Undertake a trickling filter performance investigation including: • Sample trickling filter influent and effluent for BOD and TSS at regular intervals time following start up • Sample trickling filter effluent for TSS to measure effectiveness of flushing regime
5.2	Optimise Trickling Filter operation – including start-up, recycle (for minimum wetting), flushing regime, and possible "standby" mode"
5.3	Increase Trickling Filter media height if projected organic loads are realized. This will also require an increase in the biofilter capacity (eg increase media depth and/or new filter)

6.	**Sludge Handling System**
6.1	Improve sludge handling, so primary sludge solids are not recycled over Trickling Filter media.
6.2	Periodically operate sludge treatment system to ensure it is available when required
6.3	If transport of thickened sludge to Bell Island approaches 7 truck movements per week, investigate methods to increase the sludge solids concentration to reduce truck movements.
7.	**Odour Management**
7.1	Undertake an odour system investigation to determine improvements needed: • Measure extraction rates from the various locations • Measure biofilter the loading rate, pressure drop and odour reduction performance • Assess biofilter media condition, • Review odour logs
8.	**Flow storage**
8.1	Consider increasing flow buffer capacity. FDR recommended upgrading to 22,000 m^3 beyond 2020 flows. This could be done by increasing the side wall height of existing flow buffer lagoon. There is limited room to expand pond laterally. Deepening the flow buffer would require a pump to empty.
9.	**Ponds**
9.1	Consider alternatives to nitrate dosing (eg peroxide) to provide increased resilience.
9.2	Consider options to mitigate underloading of the facultative pond.
9.3	When the ponds are being desludged take care to ensure that disturbance of the pond is kept to a minimum and that there is no short circuiting in order to reduce the risk of effluent non-compliances during desludging operations.
10.	**Wetlands**
10.1	Repeat the wetland cycling trials
10.2	Consider installing additional seeding infrastructure
10.3	Consider installing protected zones for nitrification, recirculation
11.	**Effluent Discharge**
11.1	Review hydraulics of outflow system and upgrade as required (eg install pump station, change weirs) to accommodate sustained periods of peak flows.
12.	**General**
12.1	Consider future peak flows, where appropriate, when carrying out upgrades/renewals

11 Conclusions

The key conclusions from the PCA are:

- Treated wastewater discharge has typically complied with consent limits over last ten years. Total suspended solids were elevated in 2020, but ongoing wetland cycling trials since then have been successful in controlling algal solids below the consent limit since.
- Plant hydraulic and process capacity is generally suitable, however additional monitoring and some optimisation would be beneficial to understand and potentially improve pre-treatment process, which is currently used intermittently.
- Plant condition, particularly mechanical plant which requires extensive renewals.

A list of improvements recommendations for short and longer term is provided in Section 10. These are related to improved flow and load management, optimisation of the pre-treatment system, increase in flow buffer capacity, resilience of pond system, and outflow hydraulic constraints in periods of sustained peak flows.

It is recommended that NCC:

- Consider outputs of the PCA findings
- Develop a plan to execute the actions recommended in the PCA.

12 References

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Appendices

We design with community in mind

Appendix A NWWTP Population Projections

Revised population projections used for flow and load forecast presented in Section 4.2.

Year ending 30 June	Total projected households per SA2 in NWWTP Catchment															Population connected to NWWTP
	Nelson Central-Trafalgar	Rutherford	Toi Toi	Britannia	Maitai	The Wood	Nelson Rural	Washington	The Brook	Victory	Grampians	Atawhai	Port Nelson	Marybank	Inlets Nelson city	
2019	**378**	**1178**	**785**	**826**	**617**	**1326**	**883**	**1361**	**917**	**757**	**1122**	**1274**	**22**	**483**	**26**	**27,497**
2020	378	1178	791	826	617	1326	883	1361	917	757	1122	1274	22	483	26	27,510
2021	378	1178	797	826	617	1326	883	1361	917	757	1122	1274	22	483	26	27,524
2022	**378**	**1178**	**803**	**826**	**617**	**1326**	**883**	**1361**	**917**	**757**	**1122**	**1274**	**22**	**484**	**26**	**27,540**
2023	378	1178	815	826	617	1326	883	1361	917	757	1122	1274	22	486	26	27,572
2024	378	1178	824	826	617	1326	883	1361	917	757	1122	1274	22	487	26	27,595
2025	378	1178	832	826	617	1326	883	1361	917	757	1122	1274	22	488	26	27,616
2026	378	1178	855	826	617	1326	883	1361	917	757	1122	1274	22	488	26	27,669
2027	378	1178	922	826	617	1326	883	1361	917	757	1122	1274	22	488	26	27,823
2028	378	1178	991	826	617	1326	883	1361	917	757	1122	1274	22	488	26	27,982
2029	378	1178	1055	826	617	1326	883	1361	917	757	1122	1274	22	488	26	28,123
2030	378	1178	1121	826	617	1326	883	1361	917	757	1122	1274	22	488	26	28,268
2031	397	1190	1134	826	621	1326	899	1367	924	767	1129	1302	22	488	26	28,536
2032	**416**	**1202**	**1147**	**826**	**625**	**1326**	**914**	**1373**	**930**	**778**	**1136**	**1331**	**22**	**488**	**26**	**28,805**
2033	434	1214	1160	826	628	1326	930	1380	936	788	1144	1360	22	488	26	29,073
2034	452	1225	1172	826	632	1326	944	1386	942	798	1150	1386	22	488	26	29,322
2035	469	1236	1183	826	635	1326	958	1391	948	808	1157	1413	22	488	26	29,566
2036	499	1255	1204	826	635	1326	983	1392	958	825	1169	1448	22	488	26	29,940
2037	529	1274	1225	826	636	1326	1007	1393	968	842	1181	1483	22	488	26	30,314
2038	559	1293	1245	826	637	1326	1031	1394	978	860	1192	1519	22	488	26	30,688
2039	586	1310	1263	826	637	1326	1052	1395	987	875	1203	1550	22	488	26	31,018
2040	612	1327	1282	826	638	1326	1073	1396	995	890	1213	1581	22	488	26	31,346
2041	642	1343	1282	827	641	1347	1099	1398	1003	903	1222	1588	22	488	26	31,645
2042	**671**	**1358**	**1282**	**827**	**644**	**1368**	**1124**	**1400**	**1011**	**917**	**1231**	**1594**	**22**	**488**	**26**	**31,935**
2043	700	1374	1282	828	648	1389	1149	1402	1019	930	1241	1601	22	488	26	32,234
2044	729	1390	1283	829	651	1410	1175	1405	1027	943	1250	1608	22	488	26	32,536
2045	758	1406	1283	830	654	1431	1200	1407	1035	957	1259	1615	22	488	26	32,833
2046	787	1422	1283	830	658	1453	1225	1409	1042	970	1268	1622	22	488	26	33,128
2047	817	1438	1284	831	661	1474	1250	1411	1050	983	1277	1628	22	488	26	33,425
2048	846	1454	1284	832	664	1495	1276	1413	1058	997	1287	1635	22	488	26	33,726
2049	875	1469	1284	832	667	1516	1301	1415	1066	1010	1296	1642	22	488	26	34,016
2050	**904**	**1485**	**1285**	**833**	**671**	**1537**	**1326**	**1418**	**1074**	**1024**	**1305**	**1649**	**22**	**488**	**26**	**34,320**
2059															extrapolated from 2050 population	**37,230**

Notes:

1. 2020-2050 population estimated from projected household number and an occupancy of 2.3 people per household up to 2028 (shaded green) and 2.2 people per household after that for additional households
2. 2019 population extrapolated from 2020, assuming same growth rate as between 2020 and 2021 on a meshblock basis.
3. 2059 population extrapolated from 2020-2050 dataset (line of best fit for 2040-2050).

Appendix B Inflow and Inlet Concentrations

Figure B1 shows the daily dry weather inflow (DWF, red) volume and trend lines for the monthly (30-day, blue) and annual (365-day, green) average DWF. Daily inflow on days where there was 5mm/day or more of rainfall were excluded.

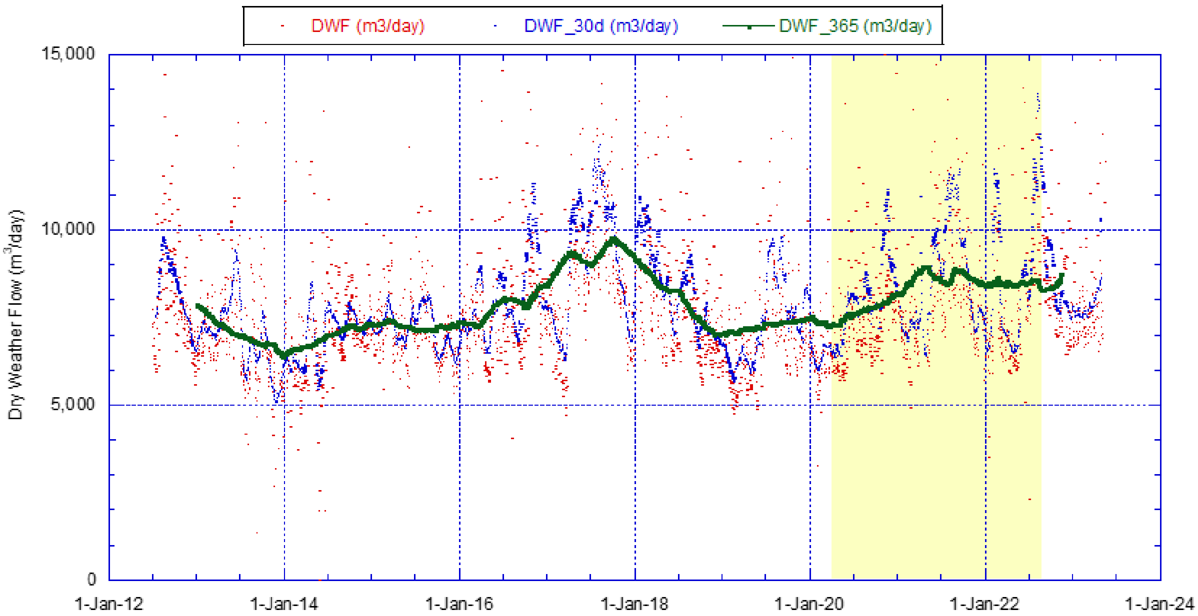

Figure B1: NWWTP Dry Weather Daily Inflow Volume. Period influenced by Covid response shaded yellow.

Figure B2 shows the daily influent TSS, COD and BOD concentrations, based on 24-hour composite samples. BOD is routinely measured once a month. BOD was measured daily for three weeks in mid 2013, however the BOD concentrations measured during this period were lower than that typically observed from 2012 to 2022.

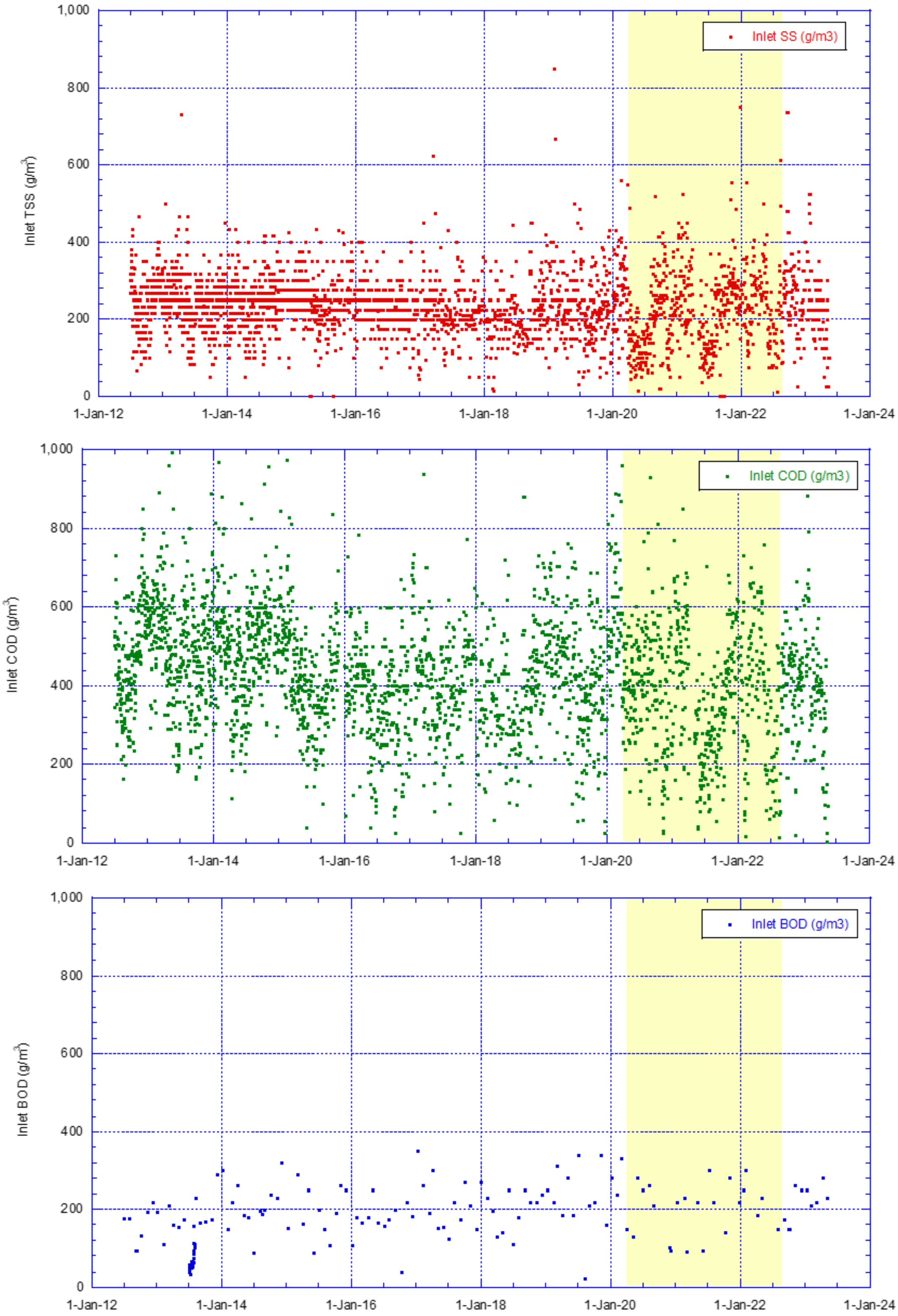

Figure B2 Influent Wastewater Concentrations: TSS (red), COD (green), BOD (blue). Period influenced by Covid response shaded yellow.

Appendix C Treated Wastewater Data from 2010

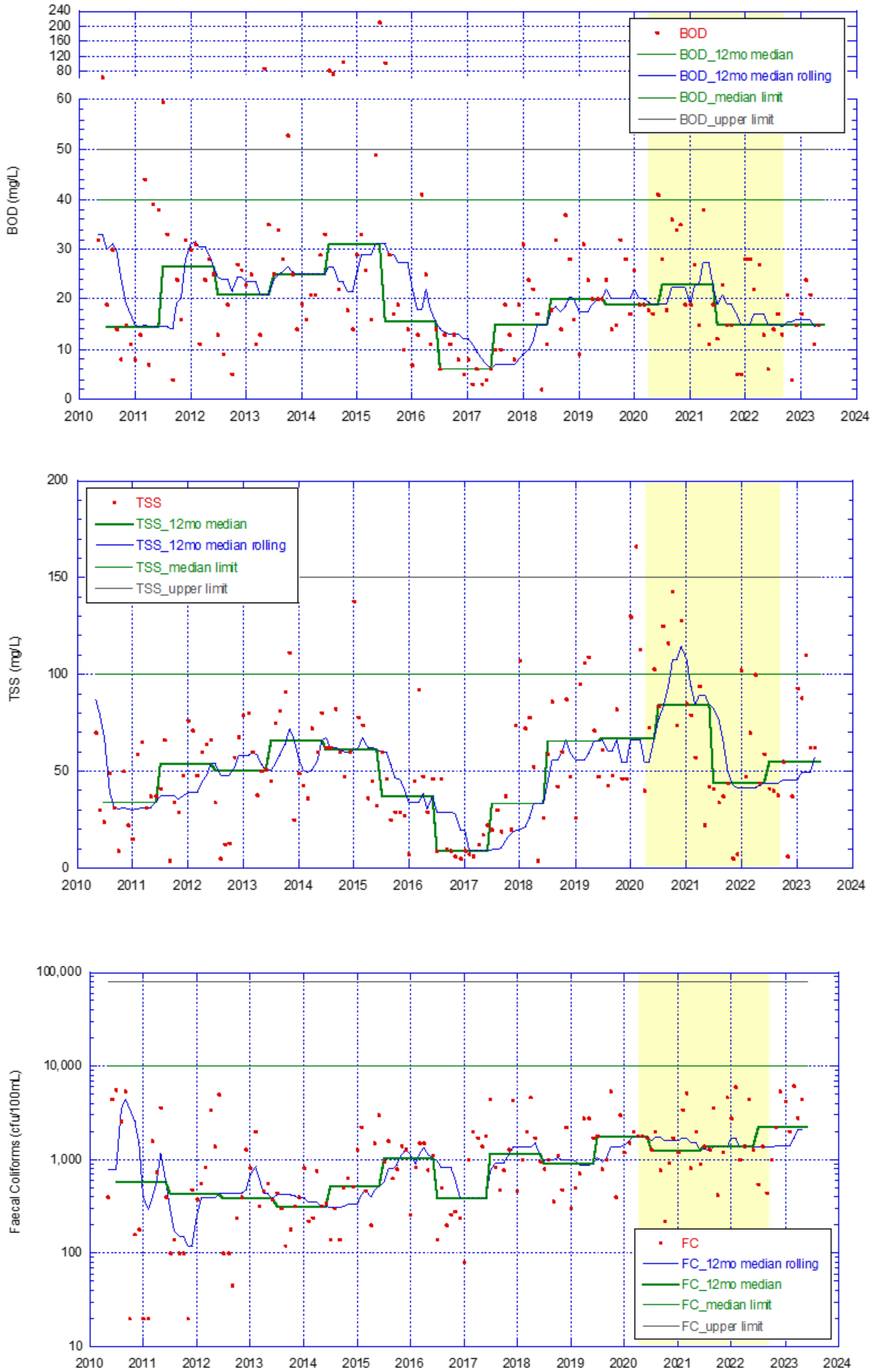

Figure C1: Variation in treated wastewater discharge BOD_5, TSS and faecal coliforms from 1 May 2010 to 9 March 2023. Period influenced by Covid response shaded yellow.

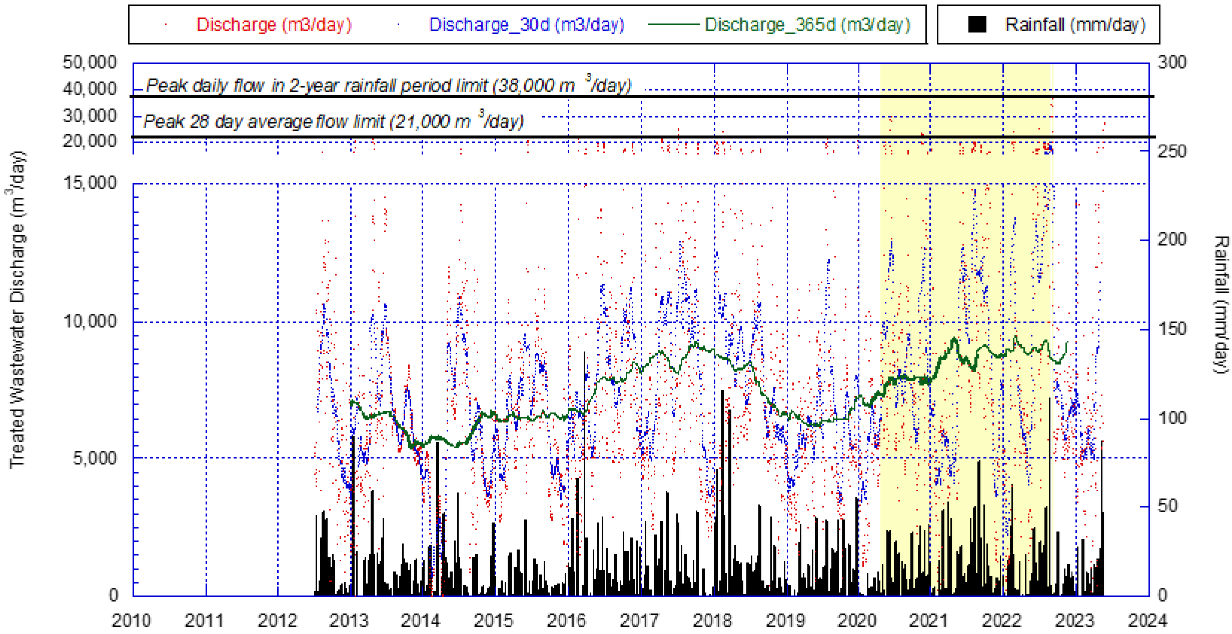

Figure C2: Variation in treated wastewater discharge flow and rainfall. Period influenced by Covid response shaded yellow.

CREATING COMMUNITIES

Communities are fundamental. Whether around the corner or across the globe, they provide a foundation, a sense of belonging. That's why at Stantec, we always **design with community in mind**.

We care about the communities we serve—because they're our communities too. We're designers, engineers, scientists, and project managers, innovating together at the intersection of community, creativity, and client relationships. Balancing these priorities results in projects that advance the quality of life in communities across the globe.

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