Memorandum

To:	Darren de Klerk	**Date:**	20 June 2019
From:	John Crawford	**Our Ref:**	3255239
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Subject:	**CHB Wastewater Schemes Package report: Appendix F - Description of Treatment and Conveyance Options**		

1 Introduction

Central Hawkes Bay District Council and its technical advisors and its community wastewater Reference Group have been working through a process of identifying and refining scheme options for future management of wastewater from the communities of Waipawa, Waipukurau and Otane.

The various schemes involve:

- Trunk sewers conveying raw wastewater between existing treatment plant sites;
- Wastewater treatment systems;
- Conveyance and storage of treated wastewater effluent; and
- Effluent discharge systems that include various forms of land disposal and land treatment systems.

The scheme options assessment and short-listing process has been aided by the use of a multi-criteria analysis process (MCA). Net Present Value (NPV) analysis was used to derive the financial characteristics of each short-listed option. Schemes were subsequently refined to provide more flexible, versatile schemes configured to allow the future 'form' of the scheme to be amended in response to future drivers, rather than being fixed at day one.

The levels or degrees of treatment required by different scheme options, from do-Nothing to 'Do maximum' require different levels of treatment. The levels of treatment selected are strongly influenced by:

- Potential near field acute toxicity effects of ammonium discharges to water.
- The quality needed to meet Regional Council nutrient (N&P) limits for application to land or discharge to water.
- The treatment quality required to meet Plan Change 6 (PC6) derived water quality requirements in the greater Tukituki Riverine system.
- The probability of run-off or rapid flow to ground water being able to have some acute effect on public health. This is particularly related to pathogens.
- The quality, particularly with regard to solids, required for the discharge / emitter system to work reliably over long periods of time.
- The quality (particularly with regard to pathogens) required to provide for the health and safety of discharge system operators and whatever grows on or from the discharge.
- Costs. Including total capital, calendarized capital and total cost of ownership.
- Aspirational goals of the community in terms of providing for future flexibility and opportunity in re-using the treated effluent as a resource rather than a waste product.

The purpose of this memorandum is to provide a brief description of the treatment systems and conveyance considered and assumed in subsequent development of the wastewater scheme options through to identification of a preferred scheme. This memorandum is not intended as a concept design report.

2 Treatment Levels

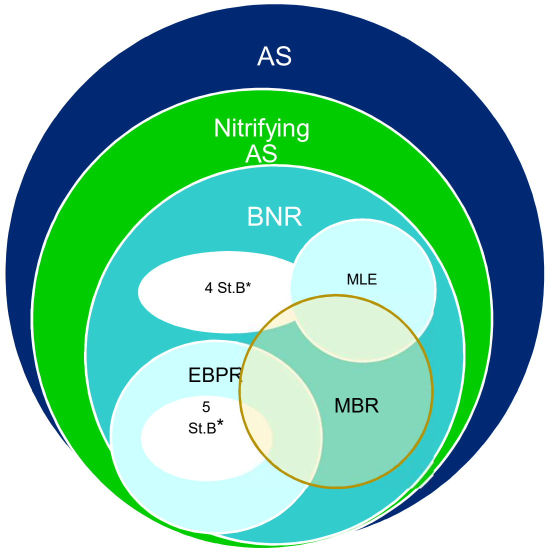
Four broad treatment levels have been considered which provide some separation between different types and configuration of treatment plant. Note that the divisions are not definite and there will be some overlap between them with regard to one or more of the key treatment analytes.

Table 1: Basic Treatment Levels Descriptions

Treatment level	Example	Comments
Level A	Advanced BNR with tertiary treatment including UV.	Nutrient and pathogen reduction to low levels. Precursors to achieving this are the removal of BOD and solids to very low levels. The new (not yet commissioned) Pukekohe WWTP is the key example of this in NZ. High level of clarity allows pathogen inactivation to very low levels.
Level B	BNR with UV disinfection	Conventional biological nutrient removal. Ammonia reduction to very low levels.
Level C	Enhanced pond systems	Typically a two or multi-pond system with enhancements such as screening, tertiary solids removal and UV disinfection. Sludge accumulates in the pond system.
Level D	Basic single pond	70 – 80% $cBOD_5$ and TSS removal. Possibly 2 x log_{10} faecal indicator bacteria inactivation or removal.

The key factor that separates the treatment levels is the ability to remove ammonia. With current technologies, high levels of ammonia nitrogen removal are generally only achieved reliably in higher intensity forced aeration systems with a high level of process control and active management of the consequent biomass. That is, the very large family of activated sludge based processes to which BNR belongs. The following Venn diagram (Figure 1) illustrates the inter-relatedness of these processes. Some progress via a pathway of conversion of organic and ammonia nitrogen to nitrite, then nitrate. A denitrification process may then follow. Other, recent evolutions of the process use nitrite shunt or anammox bacteria to create a more direct pathway for ammonia and total nitrogen reduction.

Figure 1: Interrelationship of the family of activated sludge processes



* B = Bardenpho

Thus, there is a fairly clear demarcation between Levels A and B on one side of the technology divide and levels C and D on the other. This division reflects the inability of the existing Level C plants at Waipawa and Waipukurau to fully nitrify and comply with their existing consent conditions.

The following considerations have led to Level B and C treatment plants being considered as part of the scheme development process:

- Level A or B are required to meet the current discharge requirements for nitrogen (particularly ammonium-N) and the likely future conditions if there is a discharge by rapid infiltration to the near river gravel soils.
- The levels of nutrient removal provided by Level A treatment are not required for land treatment irrigation or to meet the PC 6 quality requirements in the river.
- A Level B treatment plant can be upgraded to level A in future if required.
- Level C treatment would be satisfactory for many of the land treatment systems operating away from the river. Provided that the irrigation emitters (of the land application system) are large enough to cater for the extent and type of solids that will be present which can include issues such as filamentous algae and small aquatic snails.
- Level C treatment can be disinfected to an extent where it is safe (given appropriate work protocols are established) for irrigation scheme operators.
- It is difficult to disinfect Level D treated effluent, using UV irradiation, to any great extent.

3 Level B Treatment Description

Provision of Level B treatment at one or more of the CHB WWTP sites involves a fundamental rebuild of the system. The following are descriptions of the key plant components envisaged by the schemes that have been developed.

Specific component or process sizing has not been undertaken at this stage.

3.1 Preliminary Treatment

The high performance systems used in Level B Treatment require prior removal of screenings and grit. Screenings cause blockages and they wrap around mechanical equipment and contaminate the extracted biosolids so that it is difficult to reuse the biosolid material. The existing inlet works would be inadequate in this regard, requiring a lift pump station, at least two fine mechanical screens and a grit removal system. This latter process normally uses vortex based grit separation in these small to medium sized plants. The screens and grit removal system could sit atop elevated concrete reactor basins.

3.2 Primary Treatment

Primary treatment, which normally consists of direct physical sedimentation of the wastewater solids is normally only used where sludge digestion is employed, either with or without an energy extraction system. For plants the size of those we are considering here, primary treatment and energy extraction are not normally employed due to there being insufficient scale to make them cost effective. That would be the case here unless a large supplementary source of digestible material was available and there was an ability to replace a significant retail spend on electricity nearby.

3.3 Secondary Treatment

As figure 1 shows, there are many possible variants on the biological activated sludge process available to provide the secondary treatment. 'Batch reactor', 'membrane bioreactor' and 'flow through' activated sludge are all common and simple variants that are widely used, very successfully in New Zealand for the type and quality of service envisaged in Central Hawkes Bay.

The process includes a **reaction phase** in which the raw wastewater is mixed with existing biomass a) with the addition of oxygen to promote BOD and ammonia removal (nitrification) and b) in the absence of oxygen to eliminate the nitrate that has been formed as a result of the nitrification. This reaction will normally be carried out in a concrete tank with a water depth of between 4.0 and 5.5m. A mechanical aeration system is required. This will normally be in the form of blowers forcing air through fine bubble diffusers fixed to the bottom of the tank (e.g Queenstown and Wanaka). In some circumstances, the reactor has been built as a 4m deep pond in the ground, lined with 1.5mm thick HDPE plastic. In this situation, the aeration is normally provided by mechanical surface aerators. The plastic liners are vulnerable to mechanical damage, which can lead to severe problems once biomass has migrated behind the liner and generated gas through anaerobic decomposition. It is the concrete tank and diffused air version that has been assumed in developing the CHB schemes and costs.

Following the reaction phase, a **clarification process is** required. The purpose is twofold: i) to remove solids from the treated effluent so that it can be discharged for further treatment e.g by UV disinfection, and ii) to capture the valuable biomass, the engine of the treatment process, and return this to the reactor to continue its work. There are three principal methodologies for undertaking the clarification:

i. Using a separate, physical clarifier (flow through). Mixed liquors from the reactor enter this tank, the biomass settles, is collected and pumped back to the reactor. Floating scums are skimmed off the surface and wasted. The clarified effluent exits via overflow through a v-Notch weir system;

ii. Using a membrane separator (MBR). A physical barrier, typically in the form of a series of submerged membranes is placed in the mixed liquor. The water passed through pores in the membranes. The biomass particles (flocs) are too large to pass through the membrane pores. The rejected biomass is recycled to the main reaction tank;

iii. Using a timed settlement phase (SBR). The aeration and mixers in the reactor are turned off for a period (typically one hour) before a decanter begins to 'decant' clarified effluent from the surface of the reactor – typically for a further one hour period.

3.4 Tertiary Treatment

For level B treatment, it is likely that only UV Disinfection would be provided as tertiary treatment. The clarification step will normally render the effluent suitable for a high level of disinfection. The existing UV disinfection systems will be inadequate for future needs.

Phosphorus is currently and will continue to be a target nutrient for the Tukituki River system. The existing plants use an alum dosing system with subsequent lamella based clarification to reach the consent target of 0.25mg/l as an average. The new treatment plant or plants can be configured for enhance biological phosphorus removal but will likely still require some form of tertiary supplementary chemical dosing, albeit that this can be physically implemented by dosing into the secondary process and using the main clarification phase for the phosphorus extraction.

3.5 Biosolids Management

The high rate, activated biomass processes envisaged for level B or A treatment produce a large amount of excess biomass (due to bugs eating the incoming waste then multiplying). This excess material must be removed from the system on a daily basis to provide a healthy, stable treatment environment.

For the CHB plant/s, it has been assumed that the excess biomass will be 'wasted' to a holding tank, maintained stable by further aeration, then dewatered using a decanter centrifuge or a sludge press. This process would produce a sludge 'cake' that is typically of the order of 18 to 20% dry solids, which is a spadeable, truckable cake.

As it is expensive to cart this sludge cake significant distances and pay for its disposal at a landfill, it has been assumed that a portion of the Waipawa Oxidation pond would be reconfigured as a sludge monofill, for long term storage of the dewatered sludge. Ideally, in time, the sludge would be mined for reuse in some, as yet, unknown application.

3.6 Support Services

The following new support services and utilities would be needed to support the Level B treatment system:

- High voltage power transformer – significantly increased electrical loading;
- Electrical control and distribution system – many new electrical systems;
- Process and mechanical control system – highly automated and monitored plants;
- Recycled effluent system - Wash water, dilution and the like;
- Potable water system – Operator use and polymer make-up;
- Process air – UV system, pneumatic gates, air cleaning of instruments etc
- Odour treatment facility – Mostly from the inlet works and sludge dewatering system.

3.7 Re-Use of Assets

The ponds can perhaps be used for balancing storage prior to the main storage. They can definitely be used for storing treated effluent prior to discharge to irrigation or other system. The old ponds can also be utilized for the long term storage of dewatered, waste biomass which accumulates on a daily basis.

If easily moved and reconfigured, the existing sand filters could be considered for reuse to provide additional treatment.

The large plot of vacant (Council owned) ground immediately to the east of the existing ponds and south east of the stored geobags would be suitable real estate on which to build a new plant, either stand alone or for combined treatment of the wastewater from all three sites.

Conceivably, a portion of the ponds could be considered for conversion to a low rate sludge digester which would further decrease the amount of waste solid to be managed, and, potentially generate some useful biogas. However, the biogas yield is limited from waste activated sludge.

3.8 Anticipated Effluent Quality

Table 2 below presents a typical target average effluent quality for the Level B process in the context of likely Central Hawkes Bay Requirements.

Table 2 : Anticipated Level BTreatment Effluent Quality

$cBOD_5$	TSS	NH_4-N	TN	SRP	E.coli
mg/l	mg/l	mg/l	mg/l	mg/l	Cfu/100ml
15	15	1	8	0.25	<100

4 Level C Treatment Description

4.1 Existing

If adopted longer term, the existing level C treatment would continue to be employed at the existing sites. Treated effluent would be pumped from Otane to Waipawa for final treatment and discharge.

The existing Waipawa and Waipukurau treatment plants consist of:

- Inlet screen or screens;
- Covered anaerobic lagoon (Waipukurau only);
- One or two large oxidation pond cells with supplementary aeration;
- A zone with hanging, fixed media curtains and supplementary aeration that were intended to provide sites for nitrifying bacteria to populate;
- Floating wetlands;
- Lamella Clarifier with chemical coagulant dosing;
- Recirculating sand filters;
- UV disinfection (reactor style).

4.2 Future

The treatment plants would remain largely as they are. However some works would need to be undertaken:

4.2.1 Short Term

- The covered wetlands are causing anaerobic conditions with consequent generation of sulphides which can be a health hazard and which do lead to steel and concrete corrosion and a lack of dissolved oxygen in the discharged effluent. The wetlands should be removed in the short term;
- Improvement of the chemical dosing geometry and contact time to improve flocculation;
- Improve Lamella operational performance and required operational protocols;
- Replacement of the tiny UV reactors with systems that will perform adequately on the given effluent quality and flow.

4.2.2 Medium Term

- Provide additional supplementary aeration to cater for slowly increasing loads
- Potentially increase sand filter capacity

4.2.3 Longer Term

- Further removal of accumulated sludge

4.3 Anticipated Effluent Quality

Table 3 below presents a typical target average effluent quality for the Level C process in the context of current Central Hawkes Bay system capability (with the suggested short-term upgrades implemented).

Table 3: Expected Level C Treatment Effluent Quality - Average

$cBOD_5$	TSS	NH_4-N	TN	SRP	E.coli
mg/l	mg/l	mg/l	mg/l	mg/l	Cfu/100ml
15	20	15	20	0.25	<800

5 Conveyance

Several of the scheme options propose conveyance of raw wastewater between sites for treatment at centralised facilities. The cost estimates provide for these conveyance facilities.

Because the CHB communities experience large wet weather flow peaks, it is considered that it will not be economical to convey or to build treatment plants large enough to absorb the full flows[1].

It is therefore envisaged that the residual pond systems will be utilized to buffer wet weather flows at Waipukurau and Otane before and during pumping through to Waipawa.

CHBDC has indicated a preference for submersible transfer pump systems, rather than dry mounted progressive cavity pumps which would easily be capable to single stage pumping. With

[1] NB: Waipawa has a peaking factor of approximately 11 x dry weather flow, Waipukurau 6 times and Otane 30 – 40 times (but Otane wet weather data seems unreasonable and needs review using the new influent flow meter. Compare Hamilton whose peaking factor is 4 times and Queenstown 1.8 times.

submersible style pumps, it is highly likely that a booster pump station will be required on each conveyance rising main pipeline and the pump flow capacity will be dictated by the limited pump selections available for the head.

It is expected that the conveyance pipes will be constructed in the PE 100 polyethylene polymer and that air valves will be required at approximately 0.5km intervals. Scour chambers may be required at isolated low points in the pipelines.

The pipes will need to be designed to provide full mobilization of settled sediments, at least daily and to provide slime scouring velocities. It is envisaged that the Otane to Waipawa pipeline will be 250mm OD PE and that the Waipukurau to Waipawa pipeline will be 315 to 355mm OD PE.

Because of the geometry of the pipeline corridor, the Otane pipe will need to terminate on an elevated high point adjacent the treatment plant and gravity feed into the plant so that large negative pressures are not developed due to the pipe siphoning during pump operation.

There are several different routes that could be used for each of the raw sewage trunk mains. The cost estimating has assumed near worst case (in terms of length) for these and so there is room for refinement during the concept and preliminary design phases. For the Waipukurau pipe in particular, it has been assumed that a State Highway route will be taken. However, a significantly shorter cross country route exists, with a reasonable vertical profile. Either way two river crossings will be required, either in concrete carrier pipes beneath the scour zone of the river or via carriers on the State Highway bridges.

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