

Report

26 June 2026

To	Scott Paterson - QLDC	Contact no.	-
Copy to	-	Email	lan.Ho@ghd.com
From	Anthony Kirk, Ian Ho	Project no.	12645246
Project name	Shotover WWTP Disposal Field Alternative Discharge		
Subject	Shotover WWTP long term wastewater disposal - 30% design amendments		

Executive summary

Queenstown Lakes District Council (QLDC) is progressing a long-term treated wastewater disposal solution for the Shotover Wastewater Treatment Plant (SWWTP) in response to ongoing performance issues with the historic disposal field, enforcement action, and the need to establish a compliant and resilient discharge solution.

The developed Option A comprises enhanced treatment at the SWWTP and discharge to the Kawarau River via a new conveyance pipeline and outfall structure. Following the endorsement of Option A at the QLDC Full Council Meeting on the 19th March 2026, further investigations and design have been undertaken to support the resource consent application for long-term discharge to the Kawarau River. This work confirmed that Option A required amendments to allow compliance with water quality objectives, meet the requirements of the Kawarau Water Conservation Order (WCO), and reduce nutrient loads to the wider catchment.

Key technical investigations, including river surveys, dispersion modelling and water quality assessments, identified that the original river-edge discharge concept would result in poor mixing. This would lead to elevated concentrations of nutrients and pathogens along the river margin, increasing risks to recreational users, ecological health, and reducing confidence in meeting WCO requirements.

In response, the design has been amended to improve both in-river mixing and treatment performance:

- **Discharge structure:** The outfall has been extended approximately 10 m into the river to discharge into deeper, faster-flowing water. This significantly improves initial dilution (around 3-fold at discharge and up to 5-fold within 40 m), reducing near-field water quality risks and improving protection of river users and margins.
- **Enhanced UV disinfection:** Upgrades to the UV system are proposed to address risks from viral pathogens not captured by standard indicators. This reflects regulator feedback and provides greater confidence that bathing water requirements under the WCO can be met.
- **Phosphorus removal:** Chemical dosing has been incorporated to reduce phosphorus concentrations. While current effects are not significant locally, this addresses regulatory expectations and reduces cumulative nutrient loading within the Kawarau catchment.

These amendments align with feedback received through the Shotover short-term consent process and provide a consistent approach to managing both short-term (to 2030) and long-term discharges.

The updated design improves environmental outcomes and regulatory confidence but introduces increased capital and operational costs, along with greater construction complexity. These trade-offs have been considered necessary to support consentability and long-term compliance.

The current consent application seeks flexibility to adopt the most effective discharge configuration through detailed design. Further refinements and improvements are recommended to the discharge structure configuration (including diffuser-based options) to an alternative outfall configuration (including diffuser-based options) may be required to be progressed to further optimise improve mixing performance, cost, constructability, and visual/recreational outcomes.

1. Introduction

The purpose of this report is to summarise the key design amendments to the Option A treated wastewater discharge to the Kawarau River, following approval of Option A at the QLDC Full Council Meeting on the 19th March 2026. While the Option A concept remains technically viable, the additional assessments completed for consenting showed that changes were needed to the design to meet the required water quality objectives, provide confidence that the requirements of the Water Conservation Order (Kawarau) could be met, and that nutrient loads to the Kawarau catchment were being reduced.

These amendments are intended to provide greater support for the resource consent application for the long-term consent for discharge to the Kawarau River, with treatment improvements identified also providing benefits for the short-term discharge to the Kimiākau/Shotover River to 2030.

This letter is structured in the following manner:

- Background and timeline for Option A amendments.
- Findings of initial assessments for the long-term consent to discharge to the Kawarau River.
- Amendments to the design of the discharge to the Kawarau River, from surface flow rock outfall, to a rock-armoured outfall structure.
- Addition of enhanced UV treatment to achieve higher levels of disinfection.
- Inclusion of supplementary chemical dosing for phosphorus removal.
- Alternative Kawarau River discharge design.

1.1 Purpose of this report

The purpose of this report is to document the design changes undertaken to refine Option A following Council endorsement of the option. Additionally, this report presents any further refinements expected to occur as the design progresses.

2. Scope and limitations

2.1 Scope of work

The scope of work is to report on the investigations, assessments and design development undertaken to refine Option A during the 30% design stage to support consenting.

2.2 Limitations

This report: has been prepared by GHD for Queenstown Lakes District Council and may only be used and relied on by Queenstown Lakes District Council for the purpose agreed between GHD and Queenstown Lakes District Council as set out in section 2.1 of this report.

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The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report. GHD disclaims liability arising from any of the assumptions being incorrect.

Accessibility of documents

If this report is required to be accessible in any other format, this can be provided by GHD upon request and at an additional cost if necessary.

GHD has prepared the three-dimensional CFD model ("Model") for, and for the benefit and sole use of, Queenstown Lakes District Council to support predicted dispersion of treated wastewater when discharged at the river and must not be used for any other purpose or by any other person.

The Model is a representation only and does not reflect reality in every aspect. The Model contains simplified assumptions to derive a modelled outcome. The actual variables will inevitably be different to those used to prepare the Model. Accordingly, the outputs of the Model cannot be relied upon to represent actual conditions without due consideration of the inherent and expected inaccuracies. Such considerations are beyond GHD's scope.

The information, data and assumptions ("Inputs") used as inputs into the Model are from publicly available sources or provided by or on behalf of the Queenstown Lakes District Council, (including possibly through stakeholder engagements). GHD has not independently verified or checked Inputs beyond its agreed scope of work. GHD's scope of work does not include review or update of the Model as further Inputs becomes available.

The Model is limited by the mathematical rules and assumptions that are set out in the Report or included in the Model and by the software environment in which the Model is developed.

The Model is a customised model and not intended to be amended in any form or extracted to other software for amending. Any change made to the Model, other than by GHD, is undertaken on the express understanding that GHD is not responsible, and has no liability, for the changed Model including any outputs.

GHD has prepared the preliminary prices set out in of this report using information reasonably available to the GHD employee(s) who prepared this report; and based on assumptions and judgments made by GHD.

The Cost Estimate has been prepared for the purpose of providing a high-level cost estimate for the 30% design report issued on the 19th June and must not be used for any other purpose.

The Cost Estimate is a preliminary estimate only. Actual prices, costs and other variables may be different to those used to prepare the Cost Estimate and may change. Unless as otherwise specified in this report, no detailed quotation has been obtained for actions identified in this report. GHD does not represent, warrant or guarantee that the [works/project] can or will be undertaken at a cost which is the same or less than the Cost Estimate.

Where estimates of potential costs are provided with an indicated level of confidence, notwithstanding the conservatism of the level of confidence selected as the planning level, there remains a chance that the cost will be greater than the planning estimate, and any funding would not be adequate. The confidence level considered to be most appropriate for planning purposes will vary depending on the conservatism of the user and the nature of the project. The user should therefore select appropriate confidence levels to suit their particular risk profile.

3. Terms and definitions

The following Table 1 summarises the key terms and definitions used throughout this report.

Table 1 Terms and definitions

Terms	Definitions
Back eddy	A zone of slow or circular water flow behind structures where mixing is reduced.
Bathymetry	The measurement of river depth and underwater shape, used to understand how water moves and mixes.
Catchment effects (cumulative effects)	The combined downstream impact of nutrients and contaminants over a wider river system.
CFD	Computational Fluid Dynamics
Clarifier	A treatment unit where solids settle out from wastewater.
Consentability	The likelihood that a design will meet regulatory requirements and receive resource consent approval.
Constructability	How practical it is to build a design in real-world conditions.
Dilution factor (e.g. 3-fold, 50-fold)	A measure of how much the wastewater is diluted by river water (e.g. 5-fold dilution means the wastewater is diluted five times).
Discharge / outfall	The location and structure where treated wastewater is released into the Kawarau River.
Dispersion modelling (CFD modelling)	Computer modelling used to predict how wastewater mixes and spreads in the river. This includes flow speed, depth, and turbulence.

Terms	Definitions
E. coli	A type of bacteria used as an indicator of faecal contamination and infection risk in water.
Enhanced UV disinfection	A higher level of UV treatment designed to better remove viruses and improve public health protection.
Mixing / dilution	The process of treated wastewater blending with river water, reducing contaminant concentrations. Higher dilution means lower environmental and health risks.
Near-field	The area immediately around the discharge point where treated wastewater has not yet fully mixed with the river. Water quality effects are typically greatest here.
NPS-FM (National Policy Statement for Freshwater Management)	National regulations setting requirements for protecting freshwater quality in New Zealand.
Nutrients (nitrogen and phosphorus)	Substances in wastewater that can promote plant and algal growth in rivers and lakes if present in high concentrations.
Pathogens	Disease-causing microorganisms (e.g. bacteria or viruses) that may be present in wastewater and pose a risk to human health.
Periphyton (algae/slime)	Algal growth on riverbeds that can increase due to elevated nutrients, affecting ecology and recreation.
Phosphorus removal (chemical dosing)	The use of chemicals to remove phosphorus from wastewater before discharge, reducing nutrient impacts.
QMRA (Quantitative Microbial Risk Assessment)	A detailed method used to estimate the risk of infection from pathogens in water, particularly for recreational users.
Reasonable mixing	A regulatory concept referring to the point downstream where the discharge is considered adequately blended with the river. Water quality standards generally apply after this point.
Regional Plan: Water for Otago (RPW)	The local regulatory framework setting water quality and discharge requirements for the Otago region.
Riprap / rock armouring	Large rocks placed to protect structures from erosion by river flows.
Secondary treatment / tertiary treatment	Stages of wastewater treatment: secondary removes most organic matter and nutrients; tertiary further improves quality by removing fine solids and contaminants.
Tertiary filtration	Advanced treatment that removes fine particles to improve clarity and support effective disinfection.
Treated wastewater (effluent)	Wastewater that has been processed at the treatment plant to remove contaminants before being discharged to the environment.
Viral pathogens (e.g. norovirus)	Viruses present in wastewater that can cause illness and are more resistant to treatment than bacteria.
Water Conservation Order (WCO)	A legal protection requiring the Kawarau River to remain suitable for specific values (e.g. recreation such as swimming, and ecological health).
WEPS (Wastewater Environmental Performance Standards)	National standards that set expectations for wastewater treatment performance, including limits on contaminants and nutrient discharges.

4. Assumptions

The QLDC Full Council Meeting on March 19th 2026 approved the preparation of a resource consent application for Option A of the short list options for treated wastewater disposal, with the initial design including discharge to the Kawarau River as surface flow in a rock channel.

Subsequent investigations and assessments were undertaken to determine how the initial design would perform, to support the consent application for discharge into the Kawarau River. Amongst others, these technical assessments included:

- Detailed river bathymetry and velocity surveying.
- Three-dimensional computational fluid dynamics (CFD) modelling to predict mixing of the treated wastewater discharge with river water. This is referred to as dispersion modelling.
- Water quality and public health risk assessment, including assessment of recreational water use against the requirements of the Water Conservation (Kawarau) Order (WCO) 1997, the National Policy Statement for Freshwater Management (NPSFM), and the Regional Plan: Water for Otago (RPW).

These assessments identified elevated risk of water quality effects, resulting from poor mixing of the treated wastewater where the discharge occurred via surface flow to the river's edge (initial Option A design). This had the potential to impact upon recreational use of the river and increase the likelihood of adverse ecological effects, which in turn could result in the discharge not meeting the requirements of the WCO.

Amendment of Option A in response to these issues included changes to the discharge structure to improve mixing, and improvements to the wastewater treatment process to improve disinfection and remove greater amounts of phosphorous.

In late April 2026, at the same time as undertaking the Option A assessments, mediation was undertaken as part of the short-term resource consent process (discharge of treated wastewater to the Shotover River to December 2030) which provided ORC and submitters the opportunity to reiterate the following as issues:

1. Achieving compliance with recreational water use criteria, or national wastewater standards (WEPS), is not considered to provide sufficient demonstration that the Shotover River will remain suitable for bathing and meet the WCO requirements of suitability for bathing. Instead, a more conservative quantitative microbial risk assessment (QMRA) considering viral pathogens is required. Preliminary assessment using this approach suggests that further disinfection of treated wastewater is likely needed to demonstrate that the discharge to the Shotover River meets the WCO requirements.
2. The concentrations of phosphorous in Shotover River after reasonable mixing, while not predicted to result in excessive algal growth, are significantly greater than water quality criteria, and common treatment options exist to reduce phosphorous concentrations.

The likely amendments needed for the Option A design (discharge to the Kawarau River) and those needed to support the short-term consent application (discharge to the Shotover River) are aligned.

Collectively, they provide:

- Improved certainty of microbial disinfection and in river mixing to give confidence that the Kawarau and Shotover rivers remain suitable for bathing.
- Reduction in phosphorous concentrations in the Shotover and Kawarau River, reducing the potential for algal growth in the rivers and cumulative catchment effects on downstream environments.
- The below sections provide additional detail regarding the issues identified and design refinements introduced to address them.

5. Findings of initial assessment of effects to Kawarau River water quality

To understand how the long-term discharge of treated wastewater to the Kawarau River would perform in practice, river flow investigations and modelling were undertaken during late March and April 2026.

Kawarau River bathymetry survey

In March 2026, Earth Sciences New Zealand undertook a detailed bathymetry and two-dimensional water velocity survey of the Kawarau River, timed to coincide with a period of low river flow. Five survey transects were collected in the reach of the confluence with the Kimiākau/Shotover River, including where the discharge is proposed. These provided a high-resolution picture of water depth and the speed of the current across the river channel. Figure 1 provides an example transect survey output in the vicinity of the proposed treated wastewater discharge.

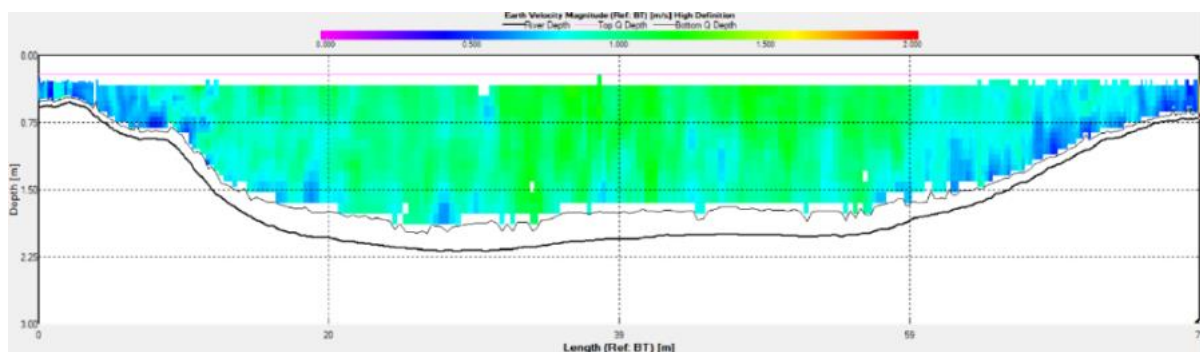


Figure 1 *Kawarau River bathymetry and water velocity survey*

A key finding was that the water along the river edge to approximately 10 metres out from the bank (at low river levels) is shallow and slow-moving. Velocities along the river edge are roughly one-third of those in the deeper, central channel. During low-flow periods these shallow margins effectively become zones of limited flow. This is significant because it means that any treated wastewater discharged at the river edge would tend to stay concentrated along the bank rather than mixing and dispersing quickly.

Dispersion modelling and water quality assessment

To quantify the mixing behaviour, three-dimensional CFD models were developed using OpenFOAM software. The models simulated the dispersion of the treated wastewater in the immediate discharge area (near-field) and the downstream transport of the treated wastewater through the Kawarau River, to the confluence with the Kimiākau/Shotover River. The scenario assessed modelled the future (2060) peak dry weather discharge of treated wastewater into the Kawarau River when under low river flow conditions and is considered to reflect a future upper bound for effects to river water quality.

Modelling of the initial Option A discharge, where treated wastewater would discharge at the river edge through a rock-filled channel, predicted that the treated wastewater would be effectively trapped along the riverbank, with minimal dilution occurring. In practical terms, this meant that concentrations of nutrients and residual pathogens close to the riverbank would remain elevated over a significant distance downstream. The key findings of the initial water quality assessment were:

1. High nutrient concentrations present near the riverbank could result in periphyton (algae) growth on the riverbed.
2. Residual pathogens concentrations in shallow river water may require bathing in the river downstream of the discharge, to be restricted, due to elevated public health risks.
3. High phosphorous concentrations persisted, even following complete mixing with the Kawarau River, increasing the potential for periphyton and algal growth in the river and Lake Dunstan.

Figure 2 illustrates the predicted dispersion of treated wastewater when discharged at the river edge, as with the initial rock channel concept design (colours reflect the percentage of treated wastewater concentration). Figure 3

illustrates the predicted dispersion when the effluent is discharged 10 m out from the bank, showing improved mixing.

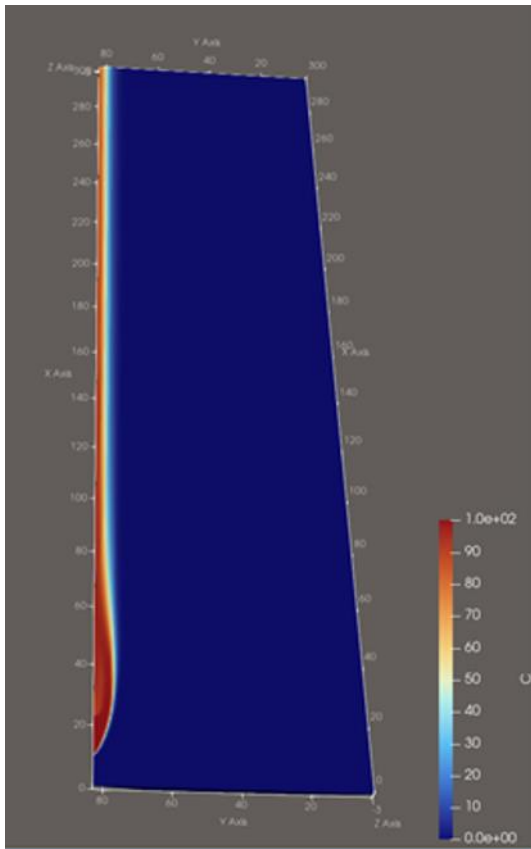


Figure 2 *Predicted dispersions of effluent when discharged at the river edge.*

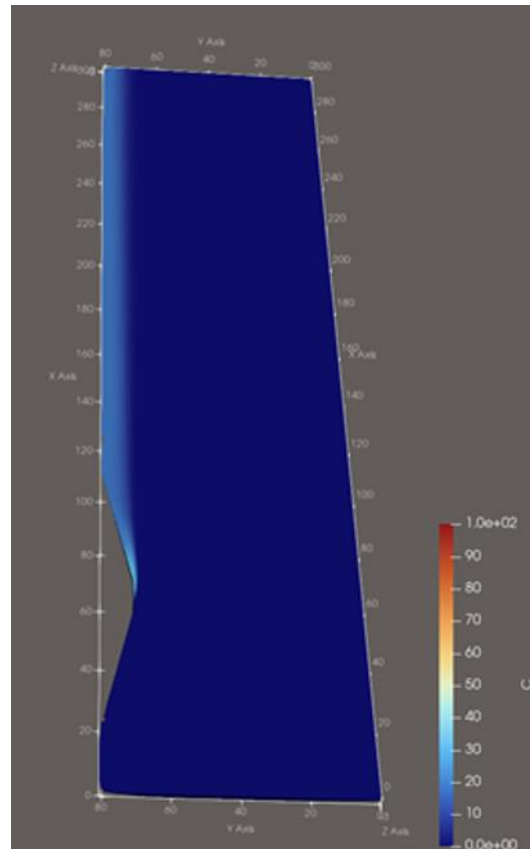


Figure 3 *Predicted dispersions of effluent when discharged 10 m out from the bank.*

From these initial assessment findings, specific amendments to the wastewater treatment process and Option A discharge design were identified and assessed as the refined Option A design.

6. Amendments to the Option A discharge design

The initial Option A outfall arrangement allowed for treated wastewater to flow through placed rocks and discharge at the river edge. When water levels increased, the zone of discharge and mixing would follow the river edge up the riverbank. In responding to the need for improved dispersion and dilution of treated wastewater, the discharge structure was amended to no longer discharge at the river edge, and instead convey the wastewater so that the point of discharge is approximately 10 metres into the river where the deeper and faster-flowing part of the channel begins. The amended design is illustrated in Figure 4 and Figure 5.

The amended design includes the following features:

- **Extended discharge point:** The outfall structure extends approximately 10 metres into the Kowarau River, with the base of the structure set approximately 1 metre below low river level. This positions the discharge at the boundary between the shallow margin and the faster main channel, ensuring that treated wastewater enters the river where current speeds are sufficient to promote rapid mixing.
- **Piped conveyance:** Treated wastewater is channelled to the end of the structure through pipes, rather than flowing loosely through placed rocks. This ensures that mixing occurs in faster-flowing water rather than seeping out along the river edge.

- **Rock armouring and erosion protection:** The conveyance pipe is covered with an approximately 10-metre-wide riprap cover to protect against erosion and to discourage public access to the outfall area.
- **Tapered rock form:** The rock structure tapers back into the riverbank, reducing the formation of back-eddies behind the structure that could otherwise trap discharged treated wastewater. The blending of the structure with the riverbank is also intended to reduce the visual impact of the structure.
- **Landscaping and planting:** Additional rockwork and planting around the outfall to help the structure blend into the surrounding delta landscape and further discourage direct public access.

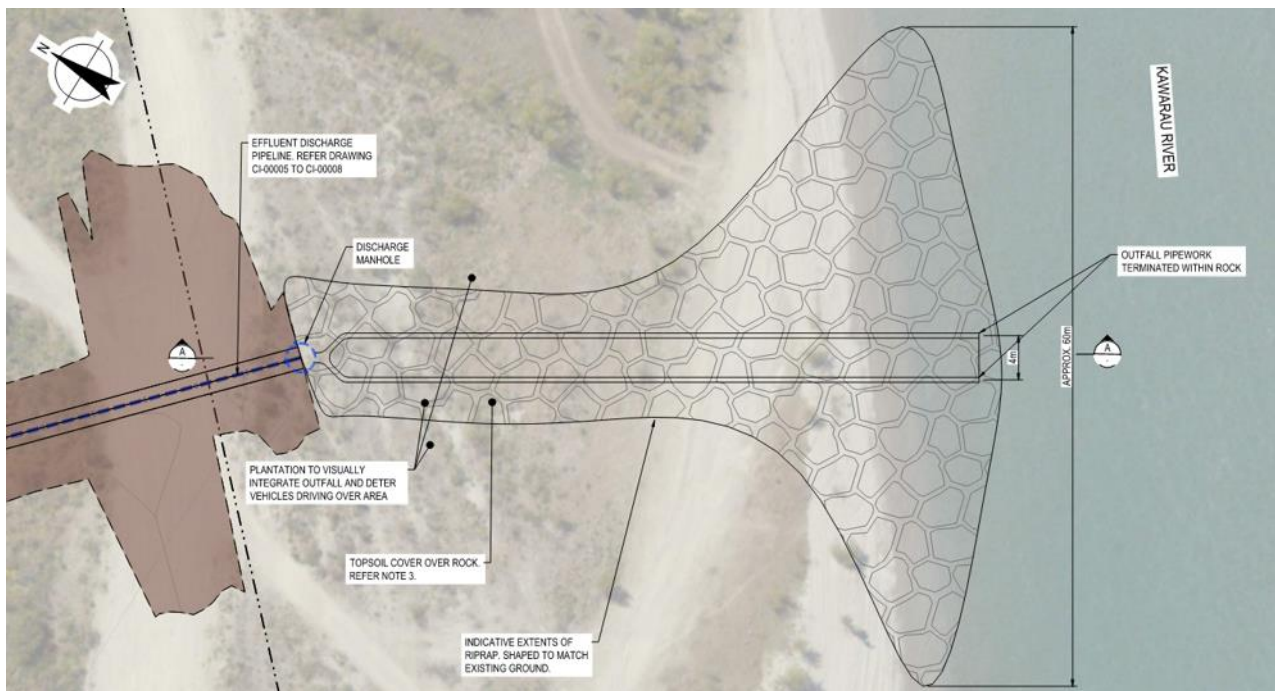


Figure 4 Option A outfall arrangement

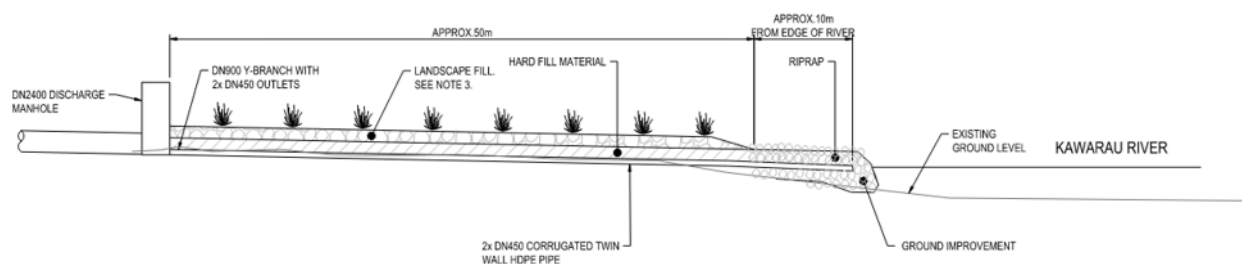


Figure 5 Option A outfall arrangement – section view

6.1 Amended discharge design benefits

CFD modelling predicted that by extending the discharge point into the faster flowing parts of the river, a substantial improvement in immediate mixing can be obtained (refer to Figures above for dispersion modelling comparison of initial Option A design (Figure 2) to the refined Option A design (Figure 3)).

Where the original river-edge design was predicted to achieve minimal dilution at the riverbank, the amended design achieves an immediate approximately 3-fold dilution at the point of discharge, and a total of approximately 5-fold dilution within 40 metres downstream of the structure. While the discharge structure and shallow, slow, flowing waters adjacent to the riverbank are still predicted to limit dispersion prior to the Shotover River confluence, the residual concentrations of nutrients and pathogens in this zone are predicted to be significantly lower than for the initial Option A design. This is important because it reduces concentrations of nutrients, and so

the potential for algal growth in the area where riverbank ecology may be affected, and pathogens in the area where people are most likely to be affected.

After confluence with the Kimiākau/Shotover River, further downstream, an additional approximately 10-fold dilution is predicted to occur, resulting in total of 50-fold dilution after reasonable mixing for the future low river flow scenario assessed.

6.2 Amended discharge design risks

While the amended rock structure design assisted in meeting the expected water quality requirements, it did introduce additional complexities and cost relative to the original rock channel design, due to the greater volume of rock required and the in-river construction works. The structure is also likely to require more maintenance due to greater exposure to river flow during flood events and risk of damage.

The structure also has the potential to influence Kawarau River flows, due to change in the river channel area. The amended structure design reduces the Kawarau River channel cross sectional area by approximately 3.5% at low flow and approximately 7% during high flow events. The river channel appears to have increased significantly since construction of the Shotover River training line, and the projected reductions in channel area due to the discharge structure are not expected to result in damming effects greater than historically experienced.

However, the influence of the structure on Kawarau River flow is likely to be greater than that of the initial rock-channel design. Further work has been recommended to be carried out to demonstrate that the amended design meets the requirements of the Water Conservation Order in regard to damming effects.

7. UV enhancement addition

The WCO outlines the requirement for the Shotover River and Kawarau River to remain suitable for bathing, after the reasonable mixing of any wastewater discharge.

Recreational water use criteria generally use E.coli as a faecal indicator bacteria, where elevated concentrations in rivers and streams suggest likely faecal contamination and a greater chance of infection by pathogens. E.coli concentrations are related to the risk of infection by the bacteria *Campylobacter*, a common pathogen associated with exposure to effluent. The Shotover WWTP provides effective treatment of such bacteria, and E.coli concentrations after mixing with river water, are predicted to be much lower than criteria for recreational water use, including bathing, and the WEPS.

However, other pathogens in wastewater, in particular viruses such as norovirus, are more resilient to treatment and are known to be highly infectious and cause illnesses, such as gastroenteritis. Viruses are difficult and expensive to measure and estimating the risk to water users from these pathogens requires detailed analysis, in the form of a QMRA. ORC have indicated that beyond the demonstration of controlling E.coli concentrations, they are concerned about the risk to water users from viruses.

Preliminary QMRA work using indicative virus concentrations in treated wastewater suggests that to achieve a low level of health risk for swimmers downstream of the discharge, the combination of in-river dilution and additional treatment targeting effective virus disinfection is likely to be required. This is a key driver of the discharge structure amendments described in Section 2 (which delivers improved in-river dilution) and also the driver for introducing enhanced UV disinfection to the treatment process.

The existing UV system capacity was assessed in the context of virus removal and found that it was unlikely to provide the required additional disinfection. Upgrading the existing unit in place is not practical, as it would require the system going offline for an extended period, and so the amended design allows for replacement of the existing unit with a new, larger, enhanced UV system, sized to deliver the higher virus-removal performance across the full range of expected future flow and water clarity conditions, with redundancy built in. The new system would be located in a new building constructed on an engineered fill platform within Pond 3, which also accommodates the tertiary filters, a new transformer and a backup generator, and includes provision for future expansion.

Figure 6 provides an outline of the platform in Pond 3 and the refined treatment infrastructure.

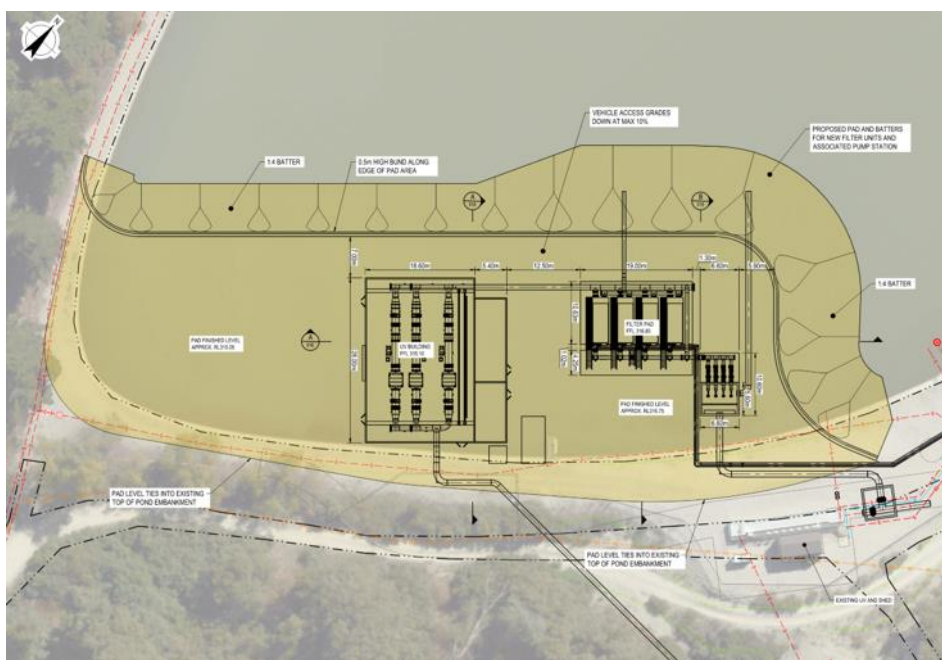


Figure 6 *Engineer filled area, located at bottom of Pond 3a, indicated in the yellow fill*

Sizing of the proposed enhanced UV system for the refined design is premised on indicative virus concentrations in treated wastewater. A comprehensive programme of virus monitoring has commenced to provide a robust understanding of the current levels of virus treatment, to allow appropriate sizing of the enhanced UV system and to provide a high level of confidence in the predicted outcomes for water quality.

7.1 Amended UV system benefit

The enhanced UV system will provide a very high level of disinfection, generally consistent with that required for recycled water use. This provides long term opportunities for how wastewater may be beneficially used. The very high level of treatment is intended to give the regulator and the community confidence that public health risks are consistently and appropriately managed, and the requirements of the WCO met both after reasonable mixing and within the mixing zone. This will effectively minimise the need for restrictions on swimming to only immediate at the discharge structure.

7.2 Amended UV system risks

The construction of the enhanced UV system, additional engineered fill, building and associated infrastructure will impact the capital works cost. The additional power needed to operate the enhanced UV system will also increase ongoing operational costs. The added capital cost is estimated to be approximately \$15M (including allowances for the engineered fill area and contingencies), and the additional annual operating cost is estimated to be approximately \$360k in 2030 and \$480k in 2060 (no cost escalation).

8. Addition of chemical dosing for phosphorus removal

The initial design of Option A assumed that the existing biological treatment process (which performs well for nitrogen removal but only moderately for phosphorus) would be sufficient to manage the potential effects to water quality. Phosphorus is the nutrient that most commonly limits the growth of periphyton (slime algae on the riverbed) and of algal blooms in lakes. Monitoring of the current discharge to the Kimiākau/Shotover River and assessment for the long-term discharge to the Kawarau River indicates that phosphorous concentrations after mixing are high relative to background water quality, national water quality criteria and the Otago Regional Plan, which sets stringent expectations for nutrient management in the Kawarau catchment. Monitoring and assessment have also demonstrated that these high phosphorous concentrations do not translate to significant algal growth in the Kimiākau/Shotover and Kawarau Rivers, due to the regular movement of riverbed gravels.

Regardless of the apparent absence of local ecological effects, the predicted concentrations are high relative to water quality expectations, and the phosphorous load from the WWTP does contribute to the cumulative downstream nutrient load. As treatment options such as chemical dosing exist and are commonly used in New Zealand, there is precedence for such improvements in treatment to be adopted in sensitive environments. This is also reflected in the prescribed low phosphorous limits of the WEPS where discharges to rivers achieve only low levels of dilution.

The amended design therefore adds supplementary chemical dosing of coagulants upstream of the secondary clarifiers to bind and remove phosphorus from the wastewater as a solid, before it reaches the discharge point. This process is a standard, well-proven technology, used at many treatment plants in New Zealand and internationally to limit phosphorus discharges.

Preliminary design indicates that chemical dosing is required to achieve dissolved reactive phosphorus rolling median limits of 1.5 mg/L (short-term consent) and 1.25 mg/L (long-term consent). The final chemical type, dose rate and dosing point will be confirmed through testing, allowing the system to be optimised for the specific characteristics of Queenstown wastewater, optimising chemical use.

8.1 Chemical dosing benefits

Introducing chemical dosing will significantly reduce the phosphorous load to the Kawarau River catchment. Additionally, the process of dosing and solids removal results in overall improved removal of suspended sediment, which in turn improves the clarity of treated wastewater and effectiveness of UV disinfection. Introduction of chemical dosing infrastructure also provides operational flexibility in how to respond to changes in influent quality or regulatory expectations.

8.2 Chemical dosing risks

The dosing system includes bulk chemical storage tanks, dosing equipment, and a bunded containment area for spill management. This carries an associated increase in costs and has footprint implications. The added capital cost is estimated to be \$700k (including contingencies), the operating cost is estimated to be approximately \$290k in 2030 and \$610k in 2060.

9. Further amendments for Option A discharge design

The original outfall concept comprised a rock outfall / land flow path discharging at the river edge. This approach provided limited land contact across the delta prior to entering the river, with mixing occurring predominantly at the margin. As previously identified, this configuration relies on passive dispersion processes and results in relatively low initial dilution, with greater interaction in near-field river edge environments.

In response to these limitations, the concept has been amended to improve mixing performance and reduce near-field effects. The current design retains the robustness of a rock outfall but incorporates piped outlets extending into deeper, higher velocity parts of the river. This shifts the discharge away from the river edge, enabling improved initial dilution and reducing adverse effects at the margin. It is recommended that further design refinement is undertaken with the expectation that further refinement of the discharge configuration may achieve greater improvements in the following areas:

- More immediate mixing and improvements to water quality.
- Minimising the visual impact and impacts to navigation of the river.
- Recreational use of the Kawarau riverbank,
- River channel's hydraulic capacity,
- Enhancement of pipe protection to reduce the risk of scour,
- Enhancement of riverbank protection against erosion from the piped discharge,
- Construction and operational costs.

To achieve these improvements, the primary disposal pathway remains discharge to the Kawarau River; however, the method of discharge can be further developed to identify the most effective approach to achieve consistent

mixing and manage near-field effects. Looking ahead, further refinements could be implemented to optimise both environmental performance and constructability. These may include (but are not limited to):

- Reducing the extent of rock armouring, to minimise construction cost and reduce visual and recreational impacts within the river corridor, while maintaining adequate structural protection and mixing.
- Lowering the pipe outlet to minimise the pipe being exposed in low flow period. This has numerous potential benefits including:
 - Allows for a lower structure, reducing cross sectional area and the corresponding potential restriction of river flow during high flow events. This may reduce the reliance on the enhanced UV system to meet water quality targets.
 - Reduces the footprint of structure, the amount of rock needed to be used, reducing and visual impact. This may also reduce ongoing maintenance requirements.
 - Allows for extending the outfall pipeline further into the river, to access higher velocity flows and improve dilution through increased jet entrainment and mixing. This may reduce the reliance on the enhanced UV system to meet water quality targets.
- Adjusting and potentially removing the rocks in front of pipe outlet to maintain exit velocity, provide better mixing and potentially reduce maintenance requirements.
- Adjustments in the configuration of pipe outlet to maximise the turbulence and mixing effects e.g., optimising the pipe size and numbers, outlet shape and further extension to the river channel.
- Transitioning to a submerged pipe or diffuser configuration, to provide greater control over discharge conditions and further enhance near-field mixing performance.

These amendments represent incremental improvements to the original concept, with a consistent focus on achieving higher dilution (targeting greater than 5-fold dilution at the end of the outfall structure and greater than 50-fold within the mixing zone) while reducing potential adverse effects on the river margin. Improvements in mixing are expected to result in less reliance on enhanced UV to manage risk to public health with recreational use of the river.

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GHD Limited

138 Victoria Street, Level 3

Christchurch Central, Canterbury 8013, New Zealand

T +64 3 378 0900 | F +64 3 377 8575 | E chcmail@ghd.com | ghd.com

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