## Detailed Feasibility Study

## Alternatives to Land Treatment for the Rotorua WWTP

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## Scope of Works

- Provide details of specific process components of each alternative option including:
  - schematics of the WWTP upgrade options
  - artistic sketches of the wastewater disposal options
- Sizing and nutrient removal performance of each alternative option
- Preparation of capital, operational and NVP for the alternative options
- A comparative analysis of the treatment plant and wastewater discharge/disposal options

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## Alternative Options Assessed

| Option | Treatment Plant | | Wastewater Disposal/Discharge Option |
|---|---|---|---|
| | Upgrade | Description | |
| 1 | Base Option | ▪ Flow balancing<br>▪ Phosphorus removal (chemical addition)<br>▪ UV disinfection | ❖ Pipe to direct discharge (with & without diffuser)<br>❖ Rock Passage to direct discharge<br>❖ Wetland<br>❖ Rapid Filtration Beds<br>❖ Gabion/Riparian<br>❖ Natural monitoring pond |
| 2 | Base Option + basic filtration | ▪ Membrane filters<br>▪ Disc filters<br>▪ Sand filters | |
| 3 | Base Option + denitrifying filtration | ▪ Carbon beds<br>▪ Denitrifying sand filters | |

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## Treatment Plant Upgrade Options

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## Effluent Quality

**Bardenpho**

| Parameter | Units | Mean | Median | 90th Percentile | No of Samples |
|---|---|---|---|---|---|
| COD | mg/L | 44 | 41 | 60.4 | 39 |
| Suspended Solids | mg/L | 23 | 20 | 40 | 39 |
| Total Phosphorus | mgP/L | 3.37 | 3.29 | 5.04 | 38 |
| DRP | mgP/L | 2.91 | 2.96 | 5.00 | 39 |
| Total Nitrogen | mgN/L | 6.61 | 6.19 | 9.00 | 36 |
| Total K Nitrogen | mgN/L | 2.43 | 2.46 | 3.03 | 36 |
| Ammonia Nitrogen | mgN/L | 0.21 | 0.06 | 0.27 | 142 |
| Nitrate | mgN/L | 3.32 | 3.14 | 5.86 | 77 |

**MBR**

| Parameter | Units | Mean | Median | 90th Percentile | No of Samples |
|---|---|---|---|---|---|
| COD | mg/L | 13.88 | 12.50 | 25.8 | 40 |
| Suspended Solids | mg/L | 1 | - | - | 5 |
| DRP | mgP/L | 1.87 | 1.99 | 3.16 | 40 |
| Total Nitrogen | mgN/L | 3.72 | 2.81 | 5.77 | 39 |
| Total K Nitrogen | mgN/L | 1.34 | 1.17 | 1.96 | 39 |
| Ammonia Nitrogen | mgN/L | 0.51 | 0.18 | 1.44 | 151 |
| Nitrate | mgN/L | 2.33 | 1.31 | 4.5 | 40 |

## Base Option

- Chemical dosing – binds P
- UV disinfection – kills pathogens
- Flow balancing:
  - Fewer peak flows
  - improvement in solids capture in clarifiers
  - control benefits for filtration and chemical dosing
  - more consistent UV dose rate
  - some reduction in size of tertiary processes

*Option (by itself) difficult to implement with TERAX*

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## Base Option + Basic Filtration

- All basic filtration options are polishing steps, all will remove TSS and subsequently reduce P in the final effluent. Less effect on N.
- Disc filters – TSS conc in final effluent from 23 mg/L to 10 mg/L
- Sand filters - TSS from 23 mg/L to 5 mg/L
  - advantages with upstream chemical dosing tank
- Membrane filters - TSS conc from 23 mg/L to 0 mg/L
  - no UV disinfection required (allowed for in costing)
  - not suitable for mixed liquor or TSS > 50 mg/L

*No additional effects from implementation of TERAX*

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## Base Option + Basic Denitrifying Filtration

- Both options, significant removal of N
- Denitrifying Sand Filtration – polishing step, required for both Bardenpho and MBR waste streams
- Carbon beds – size requirements 15 beds, 12.5m wide and 65m long (total area = 12,000m$^2$)

*No effects from implementation of TERAX*

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## Ecosystem Discharge/Disposal Options

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## Ecosystem Entry/Disposal Options

- Investigated without site being identified
- Generic layouts and costing – site specific details need to be considered (once site is known)
- Most options considered except wetland provide limited treatment
- Wetland can provide treatment but uncertainty around introducing additional nutrients, pathogens and BOD

*No additional effects from implementation of TERAX*

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## Feasibility/Constructability of Each Option

| Option | Feasibility/Constructability | Description |
|---|---|---|
| **Pipe to Direct** | Very good | Simple design. Low level of site specific background investigations reqd. Potential for diffuser dependant on location of outlet |
| **Rock Passage** | Good | Requires higher level of background investigations than other options. |
| **Wetland** | • Conveyance (1ha) - moderate<br>• Treatment (11ha – 38ha) - poor | • Simple to design<br>• Requires large area and good establishment of vegetation |
| **RIB** | Very poor | Not suitable for the likely area given high water table and poor permeability. Requires extensive investigation & modelling to prove concept. |
| **Gabion/riparian** | Good | Simple to design |
| **Monitoring Pond** | Moderate to good. | Relatively simple if use is made of the existing storage pond. |

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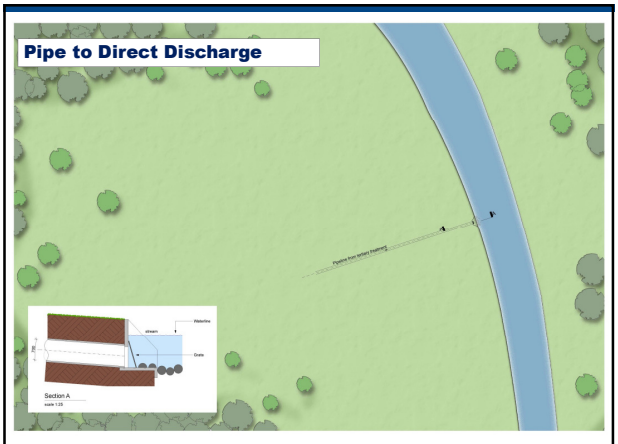
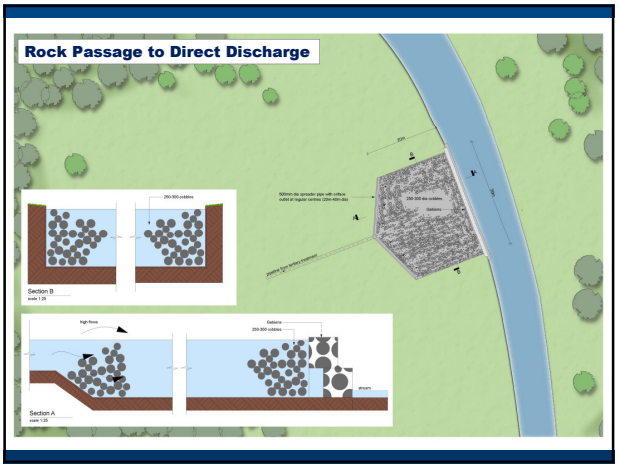
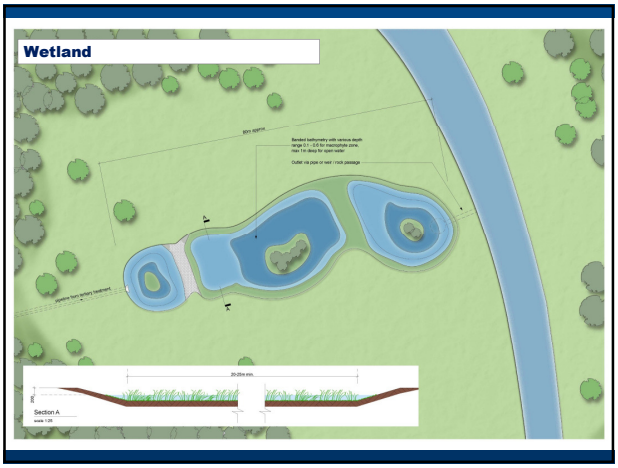
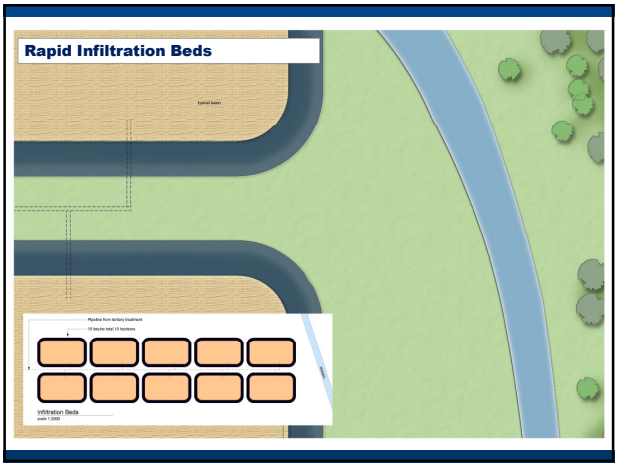
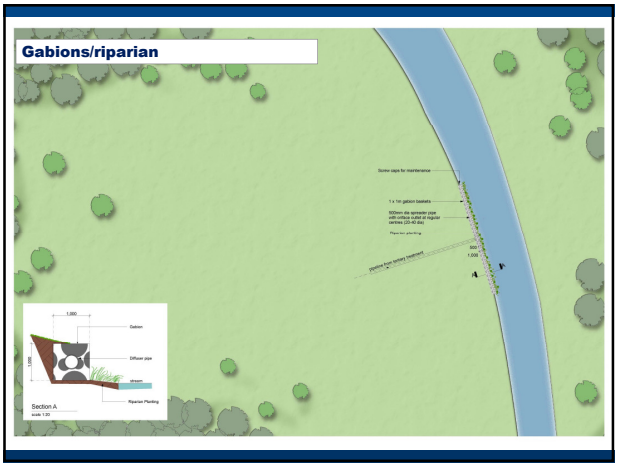


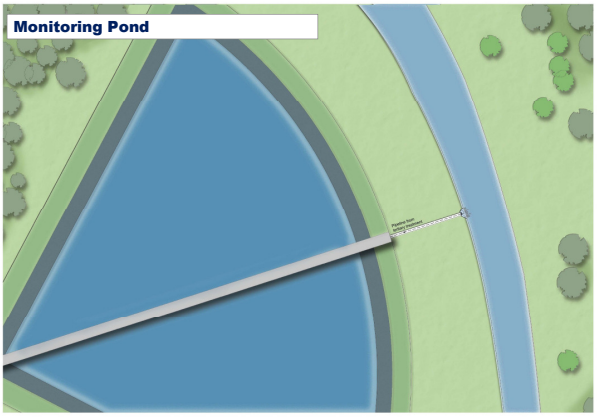

Rock Passage to Direct Discharge
Section B
Section A


Wetland
Section A


Rapid Infiltration Beds
Infiltration Beds


Gabions/riparian
Section A

## Monitoring Pond



## Summary - RSPC Options Calculation

| | Flow | DRP | Part-P | $NH_4$ | $NO_3$ | Part Org N | Sol OrgN | TP (load) | TN (load) | CAPEX | Additional OPEX |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | ML/d | g/m³ | g/m³ | g/m³ | g/m³ | g/m³ | g/m³ | t y⁻¹ | t y⁻¹ | $M | $M y⁻¹ |
| **Current Performance (@2051 flows)** | | | | | | | | | | | |
| Bardenpho + TERAX | 17 | 2.90 | 0.50 | 0.20 | 3.30 | 1.55 | 1.18 | 20.49 | 37.54 | | |
| MBR | 7 | 1.90 | 0.00 | 0.50 | 2.30 | 0.00 | 0.88 | 5.06 | 9.81 | | |
| **Combined MBR and Bardenpho** | **23.81** | **2.59** | **0.35** | **0.29** | **2.99** | **1.07** | **1.09** | **25.55** | **47.35** | | |
| **Option 1 – Base Option** | | | | | | | | | | | |
| Bardenpho+FB + Terax +UV | 17 | 0.10 | 0.90 | 0.20 | 3.30 | 1.55 | 1.18 | 6.03 | 37.54 | | |
| MBR+FB+UV | 7 | 0.10 | 0.00 | 0.50 | 2.30 | 0.00 | 0.88 | 0.27 | 9.81 | | |
| **Combined MBR and Bardenpho** | **23.81** | **0.10** | **0.62** | **0.29** | **2.99** | **1.07** | **1.09** | **6.29** | **47.35** | **$14.00** | **$0.60** |
| **Option 2 – Base + Basic Filtration** | | | | | | | | | | | |
| Bardenpho - base + disc filter | 17 | 0.10 | 0.39 | 0.20 | 3.30 | 0.71 | 1.18 | 2.95 | 32.48 | | |
| MBR – base | 7.30 | 0.10 | 0.00 | 0.50 | 2.30 | 0.00 | 0.88 | 0.27 | 9.81 | | |
| **Combined MBR and Bardenpho** | **23.81** | **0.10** | **0.27** | **0.29** | **2.99** | **0.49** | **1.09** | **3.22** | **42.29** | **$19.7** | **$0.73** |
| Bardenpho – base + sand filter | 17 | 0.10 | 0.14 | 0.20 | 3.30 | 0.36 | 1.18 | 1.45 | 30.37 | | |
| MBR – base | 7.30 | 0.10 | 0.00 | 0.50 | 2.30 | 0.00 | 0.88 | 0.27 | 9.81 | | |
| **Combined MBR and Bardenpho** | **23.81** | **0.10** | **0.10** | **0.29** | **2.99** | **0.25** | **1.09** | **1.71** | **40.18** | **$19.5** | **$0.73** |
| Bardenpho – base + membrane filters | 17 | 0.10 | 0.00 | 0.20 | 3.30 | 0.00 | 1.18 | 0.60 | 28.20 | | |
| MBR – base | 7 | 0.10 | 0.00 | 0.50 | 2.30 | 0.00 | 0.88 | 0.27 | 9.81 | | |
| **Combined MBR and Bardenpho** | **23.81** | **0.10** | **0.00** | **0.29** | **2.99** | **0.00** | **1.09** | **0.87** | **38.01** | **$22.4** | **$0.79** |
| **Option 3 – Base + Denitrifying Filtration** | | | | | | | | | | | |
| Bardenpho - base plus denit sand filter | 17 | 0.10 | 0.14 | 0.20 | 1.00 | 0.36 | 1.18 | 1.45 | 16.51 | | |
| MBR - base + denit sand filter | 7 | 0.10 | 0.00 | 0.50 | 1.00 | 0.00 | 0.88 | 0.27 | 6.34 | | |
| **Combined MBR and Bardenpho** | **23.81** | **0.10** | **0.10** | **0.29** | **1.00** | **0.25** | **1.09** | **1.71** | **22.85** | **$22.00** | **$0.85** |
| Bardenpho – base + carbon beds | 17 | 0.10 | 0.14 | 0.20 | 2.00 | 0.36 | 1.18 | 1.45 | 22.54 | | |
| MBR – base + carbon beds | 7 | 0.10 | 0.00 | 0.50 | 2.00 | 0.00 | 0.88 | 0.27 | 9.01 | | |
| **Combined MBR and Bardenpho** | **23.81** | **0.10** | **0.10** | **0.29** | **2.00** | **0.25** | **1.09** | **1.71** | **31.54** | **$28.8** | **$0.75** |

## Summary - RSPC Options Calculation cont.

| | Pros | Cons | Notes |
|---|---|---|---|
| **Current Performance (@2051 flows)** | | | |
| Bardenpho + TERAX | | | Population growth has large impact on N mass discharged. No increase in flow in catchment for 30 years. |
| MBR | | | |
| **Combined MBR and Bardenpho** | | | |
| **Option 1 – Base Option** | | | |
| Bardenpho+FB + Terax +UV | Simplest of options considered, already proven | Impact of TERAX (alum sludge) and does not reduce nutrients over that currently achieved at plant. | Flow balancing needs more investigations. |
| MBR+FB+UV | | | |
| **Combined MBR and Bardenpho** | | | |
| **Option 2 – Base + Basic Filtration** | | | |
| Bardenpho – base plus disc filter | Reasonable level of filtration, used in NZ | No additional N removal mechanism (accept filtering) and less effective treatment than other filtration methods | |
| MBR – base | | | |
| **Combined MBR and Bardenpho** | | | |
| Bardenpho - base plus sand filter | Good level of filtration, many example sites in Australia for P removal. Used at Mangere WWTP | Relatively old technology | |
| MBR – base | | | |
| **Combined MBR and Bardenpho** | | | |
| Bardenpho - base + membrane filters | Highest level of filtration and disinfection could be achieved in one step ($2Mil saving) | No additional N removal mechanism (accept filtering) | |
| MBR – base | | | |
| **Combined MBR and Bardenpho** | | | |
| **Option 3- Base + Denitrifying Filtration** | | | |
| Bardenpho - base + denit sand filter | Additional N removal mechanism for similar price for filtration only | Treatment at plant approaching or exceeding limit of technology. Uses additional carbon (Ethanol) | |
| MBR – base + denit sand filter | | | |
| **Combined MBR and Bardenpho** | | | |
| Bardenpho – base + carbon beds | Relatively in expensive | Expected that the beds will leach colour, COD and nutrients. No | |
| MBR – base + carbon beds | | | |

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## Summary – Wastewater Discharge/Disposal options

| Discharge Disposal Options | Flow | $NO_3$ (removed) | TP (load) removal | TN (load) removal | CAPEX | OPEX | Pros | Cons | Notes/ assumptions |
|---|---|---|---|---|---|---|---|---|---|
| | ML/day | g/m³ | t y⁻¹ | t y⁻¹ | $M | $My⁻¹ | | | |
| Pipe outlet[1] | 23.8 | *** | *** | *** | $0.318 | $0.0020 | Simple Design. | Potential for mixing / dispersion issues. Potentially unsightly | |
| Pipe outlet with Diffuser[2] | 23.8 | *** | *** | *** | $0.378 | $0.0025 | Potential for good dispersal, with minimal visual impact. | Potentially more investigation required. Design and cost dependant on outfall location. | |
| Rock Passage | 23.8 | *** | *** | *** | $0.461 | $0.0020 | Adaptable to meet public requirements. Required width can be decreased, potentially significantly reducing construction costs. | Subsurface flow through rocks, so difficult to flush and clean. | Nominal flow distance of 20m subsurface flow selected. Potential to decrease or increase as required. |
| Wetland (0.5ha)[3] | 23.8 | *** | *** | *** | $0.513 | $0.0073 | Potential for good nutrient Removal, especially nitrate. | Reliance on Natural system. Potential for increase in nutrient loads due to waterfowl colonisation. Relatively high maintenance requirement. Approx 15 year lifespan for plants and soil substrate. Potential for impacts due to contaminated land, particularly as a construction cost implication. | Wetland option only considered where proposed tertiary treatment does not include nitrate removal i.e. baseline and Option 1 scenarios. |
| Wetland (11.3 ha) | 23.8 | 0.91 | tbc | 8.02 | ... | ... | | | |
| Wetland (15.5 ha) | 23.8 | 1.15 | tbc | 10.16 | ... | ... | | | |
| Wetland (20.5 ha) | 23.8 | 1.39 | tbc | 12.30 | ... | ... | | | |
| Wetland (38 ha) | 23.8 | 1.97 | tbc | 17.36 | $6.950 | $0.0017 | | | |
| Rapid Infiltration | 23.8 | *** | *** | *** | $8.950 | $0.0030 | | Very unlikely to be feasible. Large footprint. Extensive investigation required. | Costs and footprints very subjective to detailed analysis. |
| Gabion Diffuser w/Riparian Planting | 23.8 | *** | *** | *** | $0.179 | $0.0026 | Simple design. Relatively small footprint. | | |
| Monitoring Pond[3] | 23.8 | *** | *** | *** | $0.100 | $0.0065 | Potential to utilise existing basin. | Potential for colonisation by waterfowls, creating nutrient issues. | |

[1] Cost includes 200m pipeline (all other options exclude pipeline
[2] Conveyance wetland only
[3] Cost based on existing storage pond

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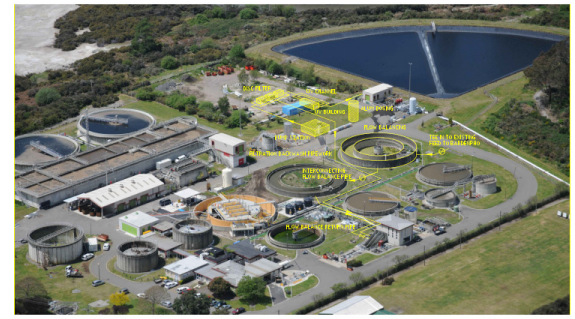

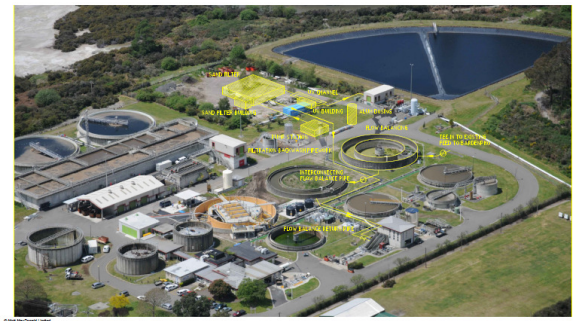




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| Rev | Date | Drawn | Description | Chkd | Appd |
|---|---|---|---|---|---|
| 0 | 21.10.14 | SC | PLANT LAYOUT | - | - |

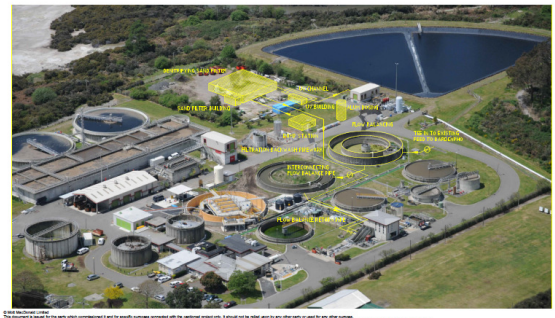
Title: OPTION 1c – BASELINE AND MEMBRANE FILTER

Drawn
Checked
Approved
Scale at A3: 1:250

Drawing Number: 94–004

Rev: 0

Status



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| Rev | Date | Drawn | Description | Chkd | Appd |
|---|---|---|---|---|---|
| 0 | 21.10.14 | SC | PLANT LAYOUT | - | - |

Title: OPTION 2e – BASELINE AND CENTRIFYING SAND FILTERS

Drawn
Checked
Approved
Scale at A3: 1:250

Drawing Number: 94–005

Rev: 0

Status