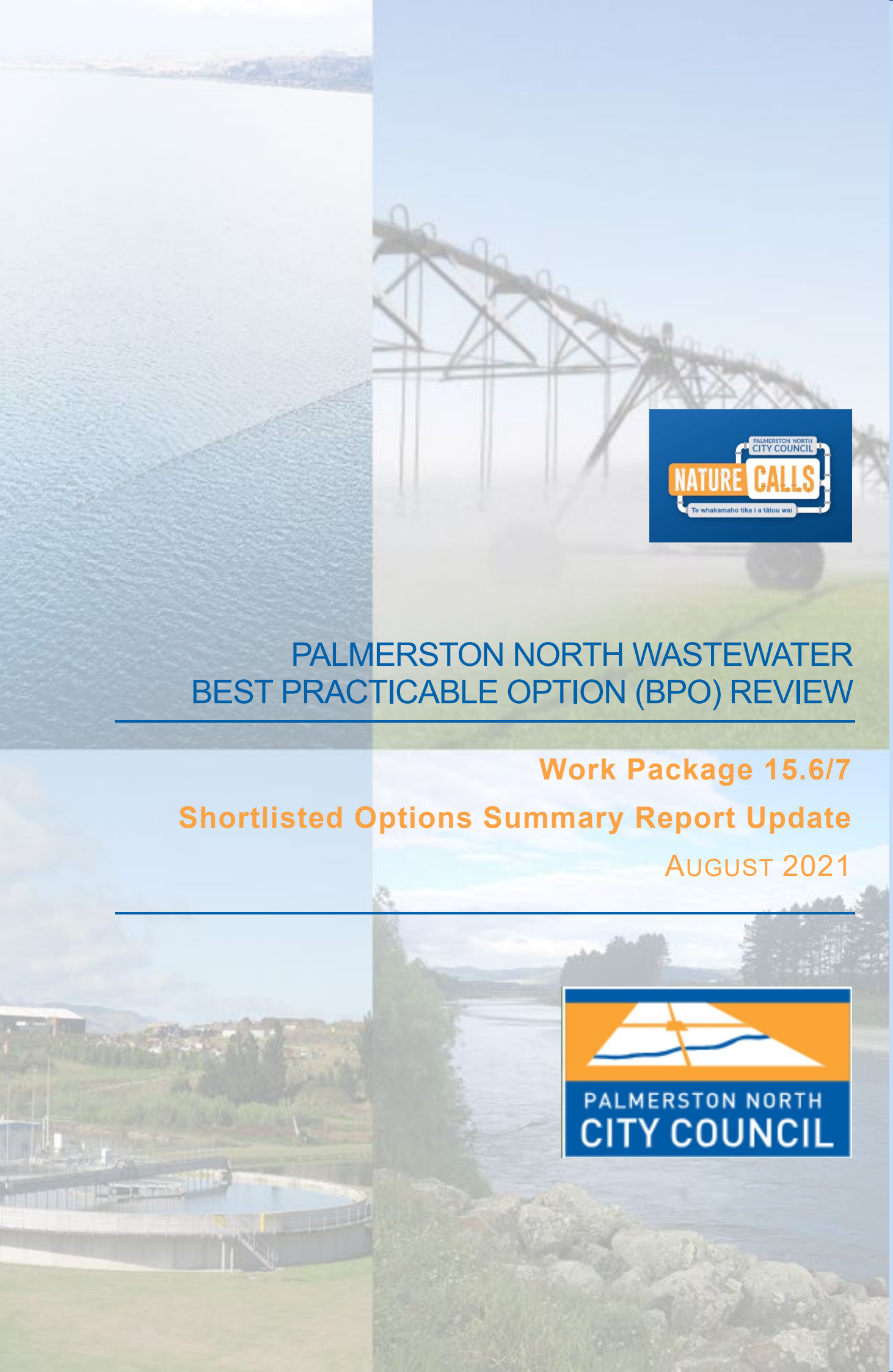

PALMERSTON NORTH WASTEWATER BEST PRACTICABLE OPTION (BPO) REVIEW

Work Package 15.6/7

Shortlisted Options Summary Report Update

AUGUST 2021

Prepared for Palmerston North City Council by:

QUALITY STATEMENT

Project Details

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Report Details

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Approved & Issued by:	Roger Hulme	15/10/2020

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Version:	Description	Prepared	Checked	Reviewed	Date
1	Original Release	Anna Bridgman	Richard Peterson	Jim Bradley	October 2020
2	February 2021 – Treatment & shortlist upgrades	Rita Whitfield	Anna Bridgman	Jim Bradley	February 2021
3	May 2021 - edits	Anna Bridgman	-	Jim Bradley	June 2021

4	July 2021 – edits	Ashleigh Dick/ Rita Whitfield	Anna Bridgman	Jim Bradley	July 2021
5	Aug 2021 – edits	Anna Bridgman	-	Jim Bradley	August 2021

Executive Summary

What does this report cover?

PNCC identified the shortlist for the Best Practicable Option (BPO) in July 2019. Since then, work has been undertaken to further develop the different elements of each option. This option development work has resulted in the identification of option variants. This report describes the refined options and summarises their "key matters". This summary reports takes in to account that previous work, and work identified in the comparative assessment workshop.

BPO short list of options

For the BPO review six options were shortlisted in July 2019. However it is recommended that the groundwater option not proceed through the shortlist assessment phase. The five remaining options are:

R2(b) All treated wastewater is discharged, via a wetland and land passage system to the Manawatū River at/near the existing Tōtara Road site with improved removal of phosphorus and nitrogen

L + R (a) & (b) Treated wastewater applied to land, with discharge to the Manawatū River in exceptional circumstances.

L + R (d) & (e) Treated wastewater applied to land, with some discharges to the Manawatū River

Dual R+L Manawatū River discharge at Tōtara Road and below Oroua confluence with some land application in drier months

O+L Most of the treated wastewater discharged to the ocean and some applied to land in drier months

It is proposed to carry forward 11 variants of these five options to the further shortlist assessment phase.

For the BPO assessment short listed options names have been used that are more description of the options. The previous and new names are listed in the table below together with the previous and new option numbers. The new names and Option numbers 1 to 11 are used for the briefing materials and the BPO assessment. The previous (shorter) names may also be used throughout the text of this report.

Option No.	New Name	Previous Option No.	Previous Name
1	R2(b) River discharge with enhanced treatment	1	R2 (b)
2	R2(b) River discharge with Enhanced treatment, 75% ADWF to Land at low River flow	1	R2 (b) (75% ADWF to land at low River flows)
3	Dual R+L(b) Two River discharge points with 75% ADWF to Land at low River flow	2	Dual R+L (b) (75% ADWF to land at low River flows)
4	L+R (a) 97% of the time to Land (inland)	3	L+R(a)
5	L+R (b) 97% of the time to Land (coastal)	3	L+R(b)
6	L+R (d-1) to Land <80m^3/s / 53% of the time to Land (inland)	4	L+R(d-1) 80m^3/s River flow trigger
7	L+R (d-2) to Land <62m^3/s / 43% of the time to Land (inland)	4	L+R(d-2) 62m^3/s River flow trigger

Option No.	New Name	Previous Option No.	Previous Name
8	L+R (e-1) to Land <80m^3/s / 53% of the time to Land (coastal) TN = 35 mg/L	4	L+R(e-1) 80m^3/s River flow trigger
9	L+R (e-2) to land <62m^3/s / 43% of the time to Land (coastal) TN = 35 mg/L	4	L+R(e-2) 62m^3/s River flow trigger
10	O+L / Ocean with Land (coastal)	6	O+L
11	Ocean discharge	-	O no land

What work was undertaken?

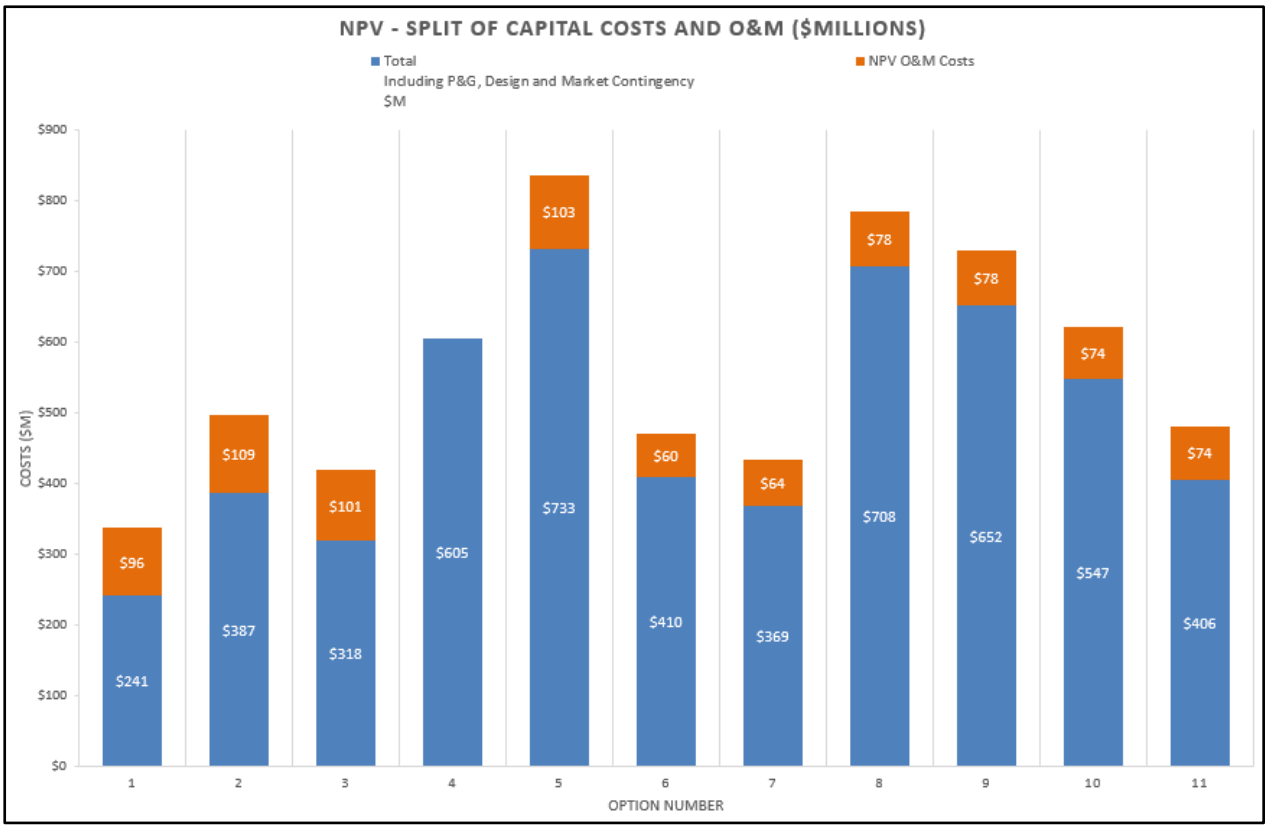
For this report we outline the key considerations of the wastewater schemes. We discuss the development of the options from previous stages of the shortlist to as they are now. This is followed by summaries of each option with more detail on each component part of the total option scheme.

We also updated the indicative comparative cost estimates for each option. The capital cost for a full scheme (without staging) and lifecycle net present value (NPV) of each of these options is covered below. The NPV is based on a 35 year (maximum resource consent duration) operating period. The cost estimates included in this version of the report use updated land values (compensation assessments) prepared by The Property Group in March 2021, higher percentage contingencies advised by Alta Consulting, updated population forecasts, review of land application infrastructure, and review of capital costs items.

The updated population forecast has a 17% increase for projected population at 2073 from what was previously forecast. The higher population at 2051 (covering a 35 year resource consent duration) results in higher domestic wastewater flows and loads as compared to the previous 2018 projections.

The increased flows resulted in an increase in the land areas required for land application and associated infrastructure costs, some of the treatment elements not based on peak flows, and overall operations and maintenance costs.

Option		Capital Cost $M	NPV $M
1	R2(b) River discharge with enhanced treatment	$241	$337
2	R2(b) River discharge with Enhanced treatment, 75% ADWF to Land at low River flow	$387	$496
3	Dual R+L(b) Two River discharge points with 75% ADWF to Land at low River flow	$318	$419
4	L+R (a) 97% of the time to Land (inland)	$605	$604
5	L+R (b) 97% of the time to Land (coastal)	$733	$836
6	L+R (d-1) to Land <80m^3/s / 53% of the time to Land (inland)	$410	$470
7	L+R (d-2) to Land <62m^3/s / 43% of the time to Land (inland)	$369	$433
8	L+R (e-1) to Land <80m^3/s / 53% of the time to Land (coastal) TN = 35 mg/L	$708	$786
9	L+R (e-2) to Land <62m^3/s / 43% of the time to Land (coastal) TN = 35 mg/L	$652	$730
10	O+L / Ocean with Land (coastal)	$547	$621
11	Ocean discharge	$406	$480



The chart above shows the net present value (NPV) of each option, and the split between the capital cost and the NPV of the operations & maintenance costs over the proposed 35-year consent duration.

The option of 50% (rather than the 75% above) of average dry weather flow (ADWF) being applied to land when the Manawatū River is less than half median flow was also looked at, resulting in a lower indicative cost estimate, but would have a greater effect on the River quality.

The option of 100% of ADWF being applied to land for the Dual R+L option was also looked at, but did not provide a material improvement on 75% application to land at low River flows, and was more expensive. It has been removed from the options list.

For the coastal land application options (L+R(e) and O+L), the initial assessment identified that a Total Nitrogen (TN) of 10mg/L was required to control the nitrogen leaching rate. An assessment was completed to determine the land areas required if the current level of treatment (i.e. TN of 35mg/L) was allowed for, with a larger land application area, due to the land values used initially. Whilst this option (larger land area, lower level of treatment) has a higher level comparative indicative cost estimate with the reviewed costs, for continuity it has been included in the summary tables. The costs of the alternative (higher level of treatment, smaller land area) are included in Table 3-1 of this report for completeness, but not the option summaries.

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APPENDICES

1 Introduction

In 2018 and early 2019 Palmerston North City Council (PNCC) identified and assessed a long list of options as part of its wastewater treatment and discharge Best Practicable Option (BPO) Review. This process is outlined in the Longlist Assessment Report (22 July 2019). This phase of the project culminated within the identification of a shortlist of options.

Since PNCC identified the shortlist, work has been undertaken to further develop the different elements of each option. This option development work has resulted in the identification of option variants. As a result, it was decided to carry forward six options and eleven option variants to the shortlist assessment phase. These are listed in Table 1-1.

In developing the shortlisted options a conservative approach has been taken to the inclusion of measures which might otherwise mitigate the cost or adverse effect of an option. That is, mitigation measures have only been included where these are well understood and where there is relative certainty that they can be delivered. It is recognised that there are other potential mitigation measures which might increase an option's likelihood of being identified as the BPO. However, given uncertainty regarding these measures they have not been included for the purpose of the short list assessment. Examples of such potential mitigation measures are:

- The inclusion of an adaptive management regime in Option 1: R2(b) and R2(b-2) (now Option 1 and 2 respectively). Such a regime might improve the environmental performance of the option and increase the option's level of 'compliance' with One Plan requirements. However, the form such a regime would take is uncertain at this point and, therefore, is very difficult to incorporate into the cost estimates for the option
- Negotiation of land lease or partnership arrangements associated with the land application elements of options. Such arrangements may reduce the cost of an option over time. However, the form of such arrangements and whether they can be negotiated remains uncertain. Therefore it has been decided to assume that land application areas need to be acquired, as this can be achieved through powers under the Resource Management Act and the Public Works Act.

The option development work has also identified that one option, former Option 5 (GW2) should be removed from the shortlist. The reasons for this are covered in more detail in Section 3.1. The option of Ocean (O) with no land has been added to the shortlist. This is covered further in Section 2.7.5.

Table 1-1 Short List Options & Option Variants

Option No.	Previous Option No.	Title	Description
1	1	R2 (b)	All treated wastewater is discharged, via a wetland and / or land passage system to the Manawatū River with improved removal of phosphorus and nitrogen
2	1	R2 (b) (75% ADWF land at low river flows)	All treated wastewater is discharged, via a wetland and / or land passage system to the Manawatū River with improved removal of phosphorus and nitrogen, with removal of 75% ADWF to land when the River is below half median flow (37.5m^3/s).

Option No.	Previous Option No.	Title	Description
3	2	Dual R+L (b)	Manawatū River discharge near Tōtara Road and below Opiki Bridge with, with removal of 75% ADWF to land when the River is below 37.5m^3/s)
4	3	L + R (a)	Treated wastewater applied to inland land, with discharge to the Manawatū River in exceptional circumstances (approximately 3% of the time)
5	3	L + R (b)	Treated wastewater applied to coastal land, with discharge to the Manawatū River in exceptional circumstances (approximately 3% of the time)
6	4	L + R (d-1)	Treated wastewater applied to inland land, with discharges to the Manawatū River (when River flow is above 80m^3/s)
7	4	L + R (d-2)	Treated wastewater applied to inland land, with greater discharges to the Manawatū River (when River flow is above 62m^3/s)
8	4	L + R (e-1) (TN = 35mg/L)	Treated wastewater applied to coastal land, with discharges to the Manawatū River (when River flow is above 80m^3/s)
9	4	L + R (e-2) (TN = 35mg/L)	Treated wastewater applied to coastal land, with greater discharges to the Manawatū River (when River flow is above 62m^3/s)
8b*	-	L + R (e-1) (TN = 10mg/L)	Treated wastewater applied to coastal land, with discharges to the Manawatū River (when River flow is above 80m^3/s)
9b*	-	L + R (e-2) (TN = 10mg/L)	Treated wastewater applied to coastal land, with greater discharges to the Manawatū River (when River flow is above 62m^3/s)
10	6	O + L	Most of the treated wastewater discharged to the ocean and 50% ADWF applied to land in drier months, with discharge to the Manawatū River in exceptional circumstances (approximately 3% of the time)
11	-	O	Treated wastewater discharged to the ocean, with discharge to the Manawatū River in exceptional circumstances – **Added to Shortlist**

Code:
R River
L Land
GW Groundwater
O Ocean

* Options 8b and 9b have not been carried forward into the arms of the BPO assessment. While they require a higher degree of treatment for nitrogen removal and result in smaller land areas required, with a lower NPV (but in the BPO assessment fall in the same (highest) cost band), for the purposes

of continuity in the BPO evaluation Option 8 and 9 have remained with the larger land areas and lower level of treatment. Options 8b and 9b are included in the above for completeness. If Option 8 or 9 did become the Preferred/BPO solution they would probably be further considered as a potential variance as the option was developed.

For the BPO assessment short listed options names have been used that are more descriptive of the options. The previous and new names are listed in the table below together with the previous and new option numbers. The previous and new names are listed in the table below, and in the summary tables in Section 4. The previous names are also used in the text throughout this report.

Table 1-2 Option Updated Names

Option No.	Previous Option No.	New Name	Previous Name
1	1	R2(b) River discharge with enhanced treatment	R2 (b)
2	1	R2(b) River discharge with Enhanced treatment, 75% ADWF to Land at low River flow	R2 (b-2) (75% ADWF to land) 37.5m^3/s River flow trigger
3	2	Dual R+L(b) Two River discharge points with 75% ADWF to Land at low River flow	Dual R+L (b) (75% ADWF to land, 37.5m^3/s River trigger)
4	3	L+R (a) 97% of the time to Land (inland)	L+R(a)
5	3	L+R (b) 97% of the time to Land (coastal)	L+R(b)
6	4	L+R (d-1) to Land <80m^3/s / 53% of the time to Land (inland)	L+R(d-1) 80m^3/s River flow trigger
7	4	L+R (d-2) to Land <62m^3/s / 43% of the time to Land (inland)	L+R(d-2) 62m^3/s River flow trigger
8	4	L+R (e-1) to Land <80m^3/s / 53% of the time to Land (coastal) TN = 35 mg/L	L+R(e-1) 80m^3/s River flow trigger (TN = 35mg/L)
9	4	L+R (e-2) to Land <62m^3/s / 43% of the time to Land (coastal) TN = 35 mg/L	L+R(e-2) 62m^3/s River flow trigger (TN = 35mg/L)
8b	-	L+R (e-2) to Land <62m^3/s / 43% of the time to Land (coastal) TN = 10 mg/L	L+R(e-1) 80m^3/s River flow trigger (TN = 10mg/L)
9b	-	L+R (e-2) to Land <62m^3/s / 43% of the time to Land (coastal) TN = 10 mg/L	L+R(e-2) 62m^3/s River flow trigger (TN = 10mg/L)
10	6	O+L / Ocean with Land (coastal)	O+L
11	6	Ocean discharge	O no land

1.1 Purpose of this work package and structure of this report

Since the shortlist was confirmed by PNCC in mid-2019, elements of each option have been further developed through the work packages listed in Table 1-3. Consequently, the objective of this work

package is to prepare a report which describes the refined options and summarises their “key matters”. This summary will be used as the basis for the shortlist assessment, and in particular, the comparative assessments and any further MCA.

The first iteration of this report was prepared in March 2020. A discussion on the development of the options since that time is included in this report.

Table 1-3 List of work packages

Work Package	Name	Date
7.3	Flow and Loads Summary Report Update	May 2021
15.1	Preliminary Assessment of Land Application Site Alternatives	December 2019 & June 2020
15.2	Short List Treatment Assessment Short List Treatment Assessment Rev1	September 2020 February 2021
15.4	Coastal Outfall Constraints	December 2019
	Cawthorn - Assessment of Coastal Ecological Effects of Ocean Outfall	January 2021
15.5	Wetland and Land Passage Elements	April 2020
	River Impact Modelling Report (Aquanet)	September 2020
15.7	Development of Options	September 2020
15.9	Short List Treatment Addendum	March 2021

2 Key Considerations

A number of key considerations relating to the key components of a total scheme need to be considered to arrive at a complete option. This section summarises these considerations.

2.1 River Flows Triggers

The Manawatū River flow trigger levels for the treatment upgrades and discharge elements are outlined in the individual option summaries. These have been refined by Stantec and Aquanet during the shortlist option development stage, as a greater understanding of the effects of discharge to the River has been gained through modelling scenarios.

2.2 Treatment Upgrades

WP15.2 (Shortlist Treatment Assessment) identified the "most appropriate" treatment alternative to deliver the treated wastewater quality required for each of the shortlisted options. The assessment was made against the following factors:

1. Process Reliability
2. Process Flexibility
3. Process Constructability (including space requirements)
4. Process Affordability (capital, operating and net present value)
5. Other Process Impacts (odour and noise; chemical consumption and energy demand; health and safety

WP15.2 also involved:

- A comparative high-level assessment of the WWTP operating effects.
- A review of planning aspects of the existing Totora Rd WWTP site.
- An assessment of the current WWTP site, infrastructure and treatment processes and suitability for future developments.

An update of the WP15.2 report was completed in March 2021, and the indicative comparative capital, operating cost estimates and net present value (NPV) are included in that report and carried forward to the shortlist options. This July 2021 report further updates those costs bringing in a range of factors as set out in Section 3.

An addendum to the WP15.2 report was completed in February 2021 to align the treatment to the shortlist options taken to the MCA in November 2020. This is WP15.9. The treatment levels discussed in this report relate to WP15.9.

For each shortlisted option it has been identified a level of additional storage at the WWTP would benefit those options with a discharge to the River. An optimum volume has not yet been identified, and so is identified in each schematic as "storage optimisation". A provisional sum ($3M) is included in the capital cost estimate for storage at the WWTP.

2.3 Wetlands and Land Passage Options

A work package (WP15.5) was completed in April 2020 to identify an appropriate wetland and / or land passage for all river discharge elements of each short list option. These wetlands / land passages, agreed in a workshop in May 2020, are included in the option summaries in Section 4.

2.4 Land Application Sites and Land Use

WP15.1 identified a number of potential site locations for each option. For the development of options to take to the MCA workshop, a single site location was identified to be used. For the coastal sites it was agreed to use Coastal Site 2, the middle land parcel on the coast, closest to Himatangi Beach. This is not to be read as the site that may be the preferred land discharge location if an option is selected. A robust site selection process will be undertaken should an option that includes a land application element be selected as the BPO. The potential land application areas used for the development of the options are shown in Figure 2-1.

Land use categorisation is referenced from WP15.1 "Assessment of land use alternatives, December 2019", including Appendix 7 – Land Use Options Assessment, PDP, December 2019.

The WP15.1 evaluation has developed a preferred/recommended type of land use for each of the Short List Options at each possible land application site location. This recommendation is based on the technical suitability and favourability, based only on aspects covered in the assessment. For the inland sites it was agreed to use Site Location 1, the land parcels closest to Palmerston North.

Generally, the recommendations for each land application site location correlates with the soil types which dominate each site. In summary:

- The Inland LA sites (L+Ra, L+Rd, GW-2, and Dual R+L) are typically dominated by High Productivity Soils being fluvial and loam soils. The recommended land use is Cut and Carry (Lucerne or Barley).
- The Coastal LA sites (L+Rb, L+Re, and O+L) are typically dominated by raw sandy soils. Exotic Forestry is the recommended land use for these regions.

The land application infrastructure is based on the summary provided as part of WP15.1, and updated as part of WP15.7 and following the revision of the population forecasts (refer A03109212_PDP_UpdatedPopulation_OptionsSummary_STRev.xlsx, PDP, June 2021). The areas and volume of storage and rapid infiltration basins are based on the indicative preferred site, and the assumed split between irrigation/storage and rapid infiltration.

Some rapid infiltration has been included with each of the land options to provide buffering from above average wastewater treatment plant flow, and to bridge wet periods where land application is not suitable or practicable. The benefit of installing rapid infiltration infrastructure, versus greater discharge to the river for these days, will need to reviewed if one of these options is selected as the BPO.

2.5 Conveyance Updates

Conveyance upgrade requirements were initially updated as part of WP15.1, based on the land locations identified, and River and ocean outfall locations, and following the same rationale as in the Long List Traffic Light Briefing Report. The range of pipeline lengths and number of pump stations required is based on the potential land application sites identified. These have been updated for this report based on the site selected that was taken into the MCA process.

For sites identified with multiple land parcels, the location for discharge has been taken at the centroid of the land parcel (or multiple land parcels), as per WP15.1.

2.6 Regional Scheme

The May 2021 Options Summary Report included this additional assessment not included in the earlier report. This July 2021 report similarly includes this assessment of the additional works that would be required for this option with regards to a regional scheme, or sub-regional scheme. There are many options available if a regional scheme was to be considered. This section outlines at a high level how the scheme would have to be adapted (post construction or pre-construction) to allow for the additional flows should such a scheme not be implemented from the outset.

A regional scheme includes picking up the wastewater from communities such as Fielding, Marton, Bulls, Halcombe etc.

This does assume the additional flows are treated at the wastewater treatment plant. An alternative would be to treat locally and look at regional discharge (most likely suitable for the ocean outfall options).

As outlined in the Shortlist Treatment Addendum Report it is expected there is sufficient room at the treatment plant for additional treatment processes to be added if required for growth.

2.7 Staging Possibilities

Following on from the May 2021 Options Summary Report, this July 2021 report also outlines at a high level whether there are possibilities of staging the options. This is only to give an indication at this stage, and does not complete a full assessment of staging alternatives for each option.

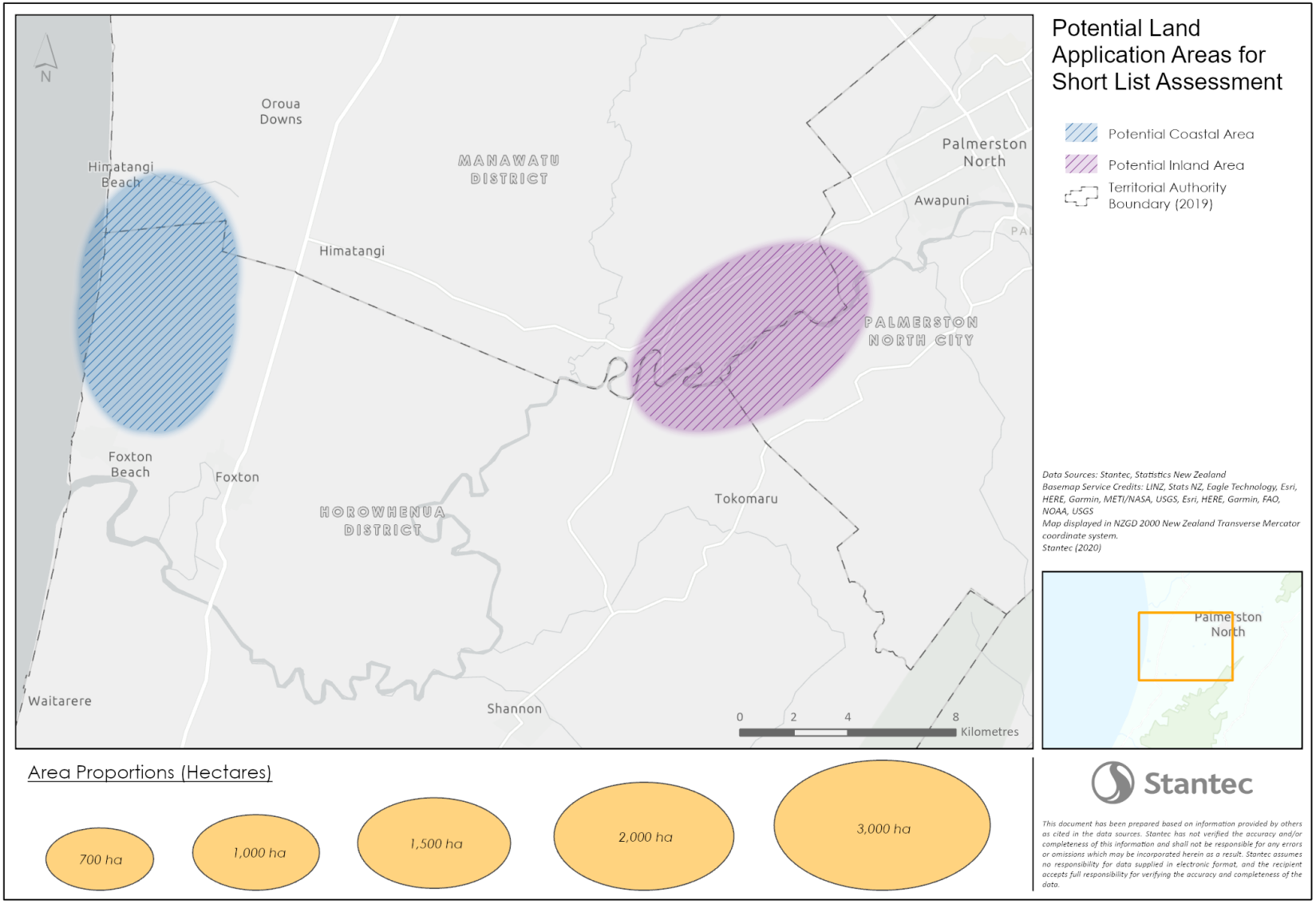


Figure 2-1 Potential Land Application Areas for Short List Assessment

3 Indicative Comparative Cost Estimates

Initial indicative comparative cost estimates were prepared for the long list workshop and comparative traffic light assessment. These indicative, comparative cost estimates have been updated through work packages listed in Table 1-3, and again recently following a review of the capital costs. The updated indicative comparative cost estimates are included here. These estimates were compiled to the same level of accuracy as used for the traffic light assessment of the long list options. They cover capital, annual operation and maintenance and Net Present Value (NPV).

Key assumptions made in the development of these cost estimates, and the breakdown of the cost estimates into their key components is covered in each of the work packages listed in Table 1-3.

For this version of the shortlist summary report (August 2021) the costs include the following:

1. Review of capital costs including higher percentage contingencies by Alta Consulting
2. Review of land purchase costs by the Property Group following feedback at the comparative assessment workshops that the land values used did not reflect the current market situation.
3. Revised population forecasts used by Palmerston North City Council (PNCC) in its 10-year plan process which required– re-calculation of capital and operational costs due to the dependency of option scope and particularly land area on projected populations
4. Review of land application infrastructure construction cost rates
5. Review of capital cost estimate completeness leading to identification of some work items not previously included
6. Review of electricity supply requirements for specific options leading some additional allowance for electrical network upgrades

The Flows and Loads Summary report (WP 7.3) was updated in May 2021 to include the updated population forecast based on Infometric's high growth rate projections from 2021 through to 2051. The higher population at 2051 (covering a 35 year resource consent duration) results in higher domestic wastewater flows and loads as compared to the previous 2018 projections. This increase results in the revised 2073 (50 year projections) rising from 120,000 population equivalent to 140,000 population equivalents, a 17% increase.

The increased flows resulted in an increase in the land areas required for land application and associated infrastructure costs, some of the treatment elements not based on peak flows, and overall operations and maintenance costs.

The Assessment of Land Use Alternatives, December 2019 report includes a high-level estimate of incomes from an assumed commercial crop on the land application options. The land use values that were included in this report were challenged at the MCA workshop. As noted above updated land values have been sought and the comparative cost estimates have been updated with these new values.

The Preliminary & General, Professional Services Fees PNCC costs, and contingencies have been included as a total for each option.

The NPV shown is based on the P50 estimate. The P50 estimate represents a cost that likely to be exceeded in half of the outcomes. It is estimated that the project cost has equal chances of being under or over this value. The P95 estimate represents a cost that is likely to be exceeded in only 5% of the outcomes. The P95 is therefore a conservative estimate at this stage of the project. A cost estimate summary table is included in Appendix 2 (not rounded to the nearest million).

Operating & Maintenance (O&M) Costs presented are based on the O&M costs in Year 1 and do not include net income from land use activities. O&M varies through growth, and includes renewal works for infrastructure in the year estimated to be required. Net Annual Income is assumed to happen annually from Year 1 (Y1) for inland cut and carry sites, and for the coastal forestry sites it has been assumed they will be harvested and replanted through Y26-30. Income from carbon credits has not been included in the annual income.

The updated indicative comparative cost estimates, with the projected population increase allowed for, are summarised in Table 3-1, rounded to the nearest million.

Table 3-1: Summary of updated indicative comparative cost estimates (in millions) – June 2021

Option		Capital Cost[1]	Land Cost[2]	Y1 Operating & Maintenance Costs (O&M)[3]	Net Present Value (NPV)
1	R2(b) River discharge with enhanced treatment [4]	$241	$3	$6	$337
2	R2(b) River discharge with Enhanced treatment, 75% ADWF to Land at low River flow	$387	$55	$7	$496
3	Dual R+L(b) Two River discharge points with 75% ADWF to Land at low River flow	$318	$61	$6	$419
4	L+R (a) 97% of the time to Land (inland)	$605	$249	$4	$604
5	L+R (b) 97% of the time to Land (coastal)	$733	$81	$7	$836
6	L+R (d-1) to land <80m^3/s / 53% of the time to Land (inland)	$410	$136	$5	$470
7	L+R (d-2) to Land <62m^3/s / 43% of the time to Land (inland)	$369	$112	$5	$433
8	L+R (e-1) to Land <80m^3/s / 53% of the time to Land (coastal) TN = 35 mg/L	$708	$115	$5	$786
9	L+R (e-2) to Land <62m^3/s / 43% of the time to Land (coastal) TN = 35 mg/L	$652	$95	$5	$730
8b	L+R (e-1) to Land <80m^3/s / 53% of the time to Land (coastal) TN = 10 mg/L	$614	$42	$6	$712

[1] Total Capital Cost with P50 contingencies.
[2] Land purchase with P50 contingencies, inclusive of wetland and land parcel.
[3] This does not include estimate income from land application schemes and is the estimate for Y1 of operation. The individual Option Summaries include estimates of incomes.
[4] This option is for SIN = 2mg/L, Treatment Option 1.4 outlined in WP15.2 Report, September 2020 and the WP15.9 Addendum Report, February 2021.

Option		Capital Cost[1]	Land Cost[2]	Y1 Operating & Maintenance Costs (O&M)[3]	Net Present Value (NPV)
9b	L+R (e-2) to land <62m^3/s / 43% of the time to land (coastal) TN = 10 mg/L [4]	$599	$38	$6	$697
10	O+L / ocean with land (coastal)	$547	$49	$5	$621
11	Ocean discharge	$406	$1	$5	$480

As discussed in Section 1 two variations were considered for the L+R(e) options – Options 8 & 9 with lower (Level 2) levels of treatment and larger land areas, and Options 8b and 9b with higher (Level 3) levels of treatment and smaller land areas. The costs for both are included in Table 3-1 above for completeness, but for consistency only Option 8 and 9 are included in the Option Summaries in Section 4.

Chart 3-1 below shows the split of the NPV between capital costs (P50) and the NPV of the Operations and Maintenance costs over the proposed 35 year duration of the consent.

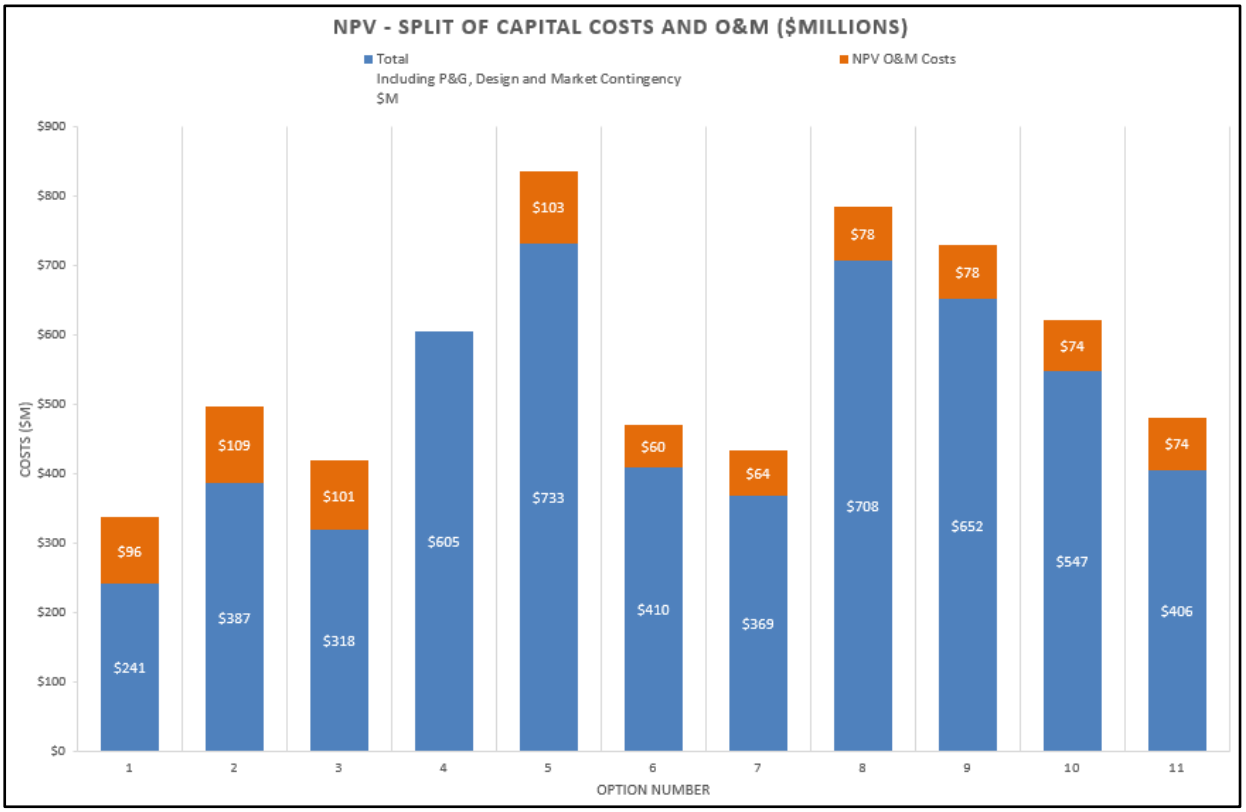


Chart 3-1 NPV - Split between Capital Costs (P50) and NPV of Operations & Maintenance Costs (35 year duration)

3.1 Options Development

As discussed in the sections above the shortlist options have been further developed and refined as further information was available, and assessment and modelling work completed. This has led to the following changes to the shortlist options from the longlist assessment report, and previous reports.

3.1.1 R2(b) River discharge with Enhanced treatment, 75% ADWF to Land at low River flow

The Aquanet modelling of the effects on the Manawatū River of full discharge at Tōtara Rd showed that the level of treatment required to meet the One Plan targets (Soluble Inorganic Nitrogen (SIN) = 0.3mg/L in dry flow conditions) would be equivalent to treating the wastewater with technology that is more regularly used for drinking water, i.e., using a Reverse Osmosis (RO) plant. A RO plant has a very high capital cost, as well as high annual operating and maintenance costs, and the treatment process results in a brine byproduct which could be difficult to dispose of. Workpackage 15.2 discusses the practicalities and issues associated with a RO plant and highlights how globally it would amongst few (if any) examples.

It was agreed by the Project Technical Group to include a wastewater treatment plant upgrade option that could provide a significant improvement in the level of treatment for the discharge (although not to the level required to meet all One Plan standards) and which is more feasible from an operational and cost perspective than an RO plant. Option R2(b) outlines this option for a 5-Stage Bardenpho Biological Nutrient Removal with membrane treatment (MBR) and UV disinfection. The RO treatment upgrade option is not included in the Options for assessment because its anticipated cost would render the option 'fatally flawed' based on criteria used in the long list phase of the project.

A variant of R2(b), included in the Options for short list assessment, is removing 50-75% of the average dry weather flow (ADWF) for discharge to land. This results in a gross land area of 430 ha to 670 ha being required, as well as the treatment upgrades. R2(b) 75% to land is included in the Option Summaries and costing.

3.1.2 Dual R+L(b) Two River discharge points with 75% ADWF to Land at low River flow

Initial assessment of this option undertaken as part of Aquanet's river modelling work, showed that as described for the long list assessment phase, this option was unlikely to get consent granted if it was selected as the BPO due to the adverse effects on the River.

This option has therefore been refined to have discharge to the Manawatū River at the Tōtara Rd outlet when river flow is greater than 62m^3/s, discharge to the Manawatū River downstream of the Opiki Bridge and Oroua confluence when the river flow is between 62m^3/s and 37.5m^3/s, and partial to full discharge to land when the river flow is less than 37.5m^3/s (two variants included in the options summary – 75% and 100% discharge to land). Only Dual R+L 75% to Land has been included in the options to go forward to the MCA at this stage as there was not a material benefit for the 100% to land option for the additional cost.

A further refinement that could be undertaken, if this option is selected as the BPO, increasing the trigger level for discharge at Tōtara Rd (i.e. discharge at Opiki/Oroua confluence more often) and keeping the Tōtara Rd discharge for very high flows only. A discussion could be had on the suitable level of wetland/land passage at Tōtara Rd weighed up against the quantity of flow pumped to

Opiki/Oroua for discharge. The primary requirement of this option is removal of the discharge from the Tōtara Rd location when the River flow is less than 62m^3/s.

3.1.3 L+R (d) and (e)

The initial intent of the L+R (d) and (e) options was removal of at least 50% of the flow to land. The flow triggers for these options have changed, and two trigger levels (discharge to river at flows >62m^3/s and >80m^3/s, which equate to removing the flow from the river 43% and 53% of the time respectively) have been included in the assessment.

The Pattle Delamore Partner (PDP) assessment of the land discharge requirements for coastal land (L+R (e) and O+L) initially identified that a Total Nitrogen (TN) of 10mg/L was required for discharge on coastal land environments, due to assumption of leaching rates of <20kg N/ha/yr maximum[5]. An assessment was also completed to determine the land areas required if a lower level of treatment (i.e. a higher TN level in the treated wastewater) was allowed for. WP15.9 Shortlist Treatment Addendum identifies the higher level of treatment as being required for the L+R (e) options as this is what the receiving environment can handle.

There is a trade-off in the coastal land application areas between a higher level of treatment and less land, and a lower level of treatment and greater land areas for application. Though the value of the land areas is still under consideration, for the basis of this report this has resulted in a selection of an option of a TN treatment level of 35mg/L, with a gross land area of 3,110 ha for assessment.

Due to the dual trigger levels (discharge to river at flows >62m^3/s and >80m^3/s, which equate to removing the flow from the river 43% and 53% of the time respectively) , and inland and coastal land locations, there are four variants for assessment under this option.

3.1.4 GW2

This option was identified as needing the same level of treatment as for R2(b) as it discharges to shallow aquifers, from which it is assumed will enter the River. This resulted in high capital and operating costs due to the high level of treatment required, combined with land purchase, conveyance and discharge infrastructure. It was proposed by the Project Technical Group that this option did not offer anything of value over the other options and coupled with its very high cost should be removed from the list of options for assessment.

This was endorsed in Principal by the Project Steering Group. No description of this option has been included in the summaries below and it will not be carried through the short list assessment phase.

3.1.5 O+L / Ocean with Land (coastal)

As discussed in Section 3.1.3 above, the PDP assessment identified a land treatment level for TN of 10 mg/L. As a large portion of flow under this option is to be discharged to the ocean, approximately 2km off shore, into approximately 20m of water, it was questioned whether upgrading the WWTP to treat to this level was required. The options of treating to a lower level of TN, and discharging to a

[5] Note: these proposed leaching rates are higher than those required in Table 14.2 of the Horizons One Plan. As part of WP 15.1 it has been assumed that achieving the One Plan table 14.2 requirements would require either unfeasibly large areas of land or unfeasibly high levels of treatment. Further conversations with Horizons are recommended in relation to this point, and in line with PNCC's submission on One Plan PC 2.

greater area of land, were compared, and it was proposed to go with a TN treatment level of 35mg/L, with a gross land area of 1,470 ha for assessment.

It was also agreed to include an alternative option, brought back from the long list, of an ocean discharge with no land application (Option O). This was re-included given the increases in the cost of O+L. Based on these cost increases it was considered appropriate to re-assess the appropriateness of an ocean discharge (only) option as part of the short list assessment.

3.2 River Discharge Mixing

One significant improvement that could be made to any option that includes River discharge would be to design and install a discharge system that allows for a higher level of mixing than is currently achieved. This will have significant positive effect in low flow situations in River. The current diffuse bankside discharge only achieves partial mixing as defined under the One Plan.

In order to maximise the fusion of the treated wastewater flow in low River flow situations (in high flow there should be enough flow/turbulence), the discharge location and discharge arrangements is important. Narrowing of rivers and river bends are good places to place discharges as any turbulence created by the river bends lasts a while before returning to a more laminar flow. Figure 3-1 below highlights some areas within relative close proximity to the WWTP current site where modifications could potentially be made for improved mixing.

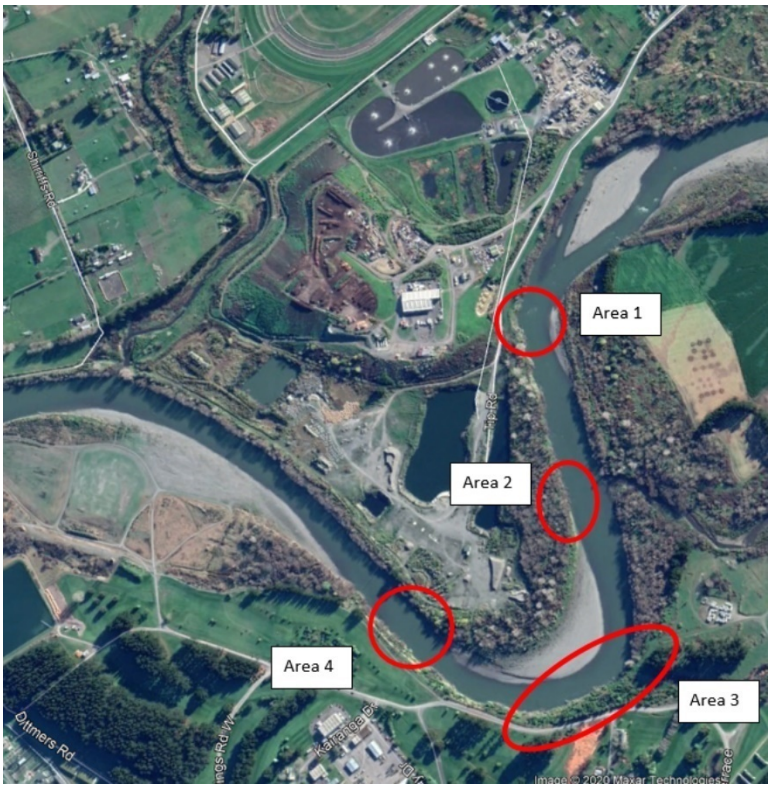


Figure 3-1 Totora Rd River Discharge Options for Mixing

- Area 1 is a place of conference which could allow for more complete mixing.
- Area 2 is the inside of a of a beginning bend, which will be slower moving initially but flow discharged there is likely to be pulled across the River in natural diffusion process. Area 4 is where the discharge at Area 2 will be mixed as the turbulence from the bend is reduced.

- It's also important to identify the material on the outer edge of the bend. For example ideally at Area 3 it will be rocks or willows as these strengthen the riverbank and create rough surfaces which are areas of higher turbulence. If the Area 2 discharge position was chosen, further investigation on the bank composition would be required and likely recommend armament (if not already in place), to protect surrounding infrastructure and add turbulence.

Another approach that could be investigated is the discharge mechanism. Some potential options that could be investigated are discussed below.

- The treated wastewater could be diffused across the width of the river by using a multi-point diffuser pipe (similar to Hamilton City Council discharge into Waikato River). This would not fulfil the cultural preferences that have been expressed by Rangitāne representatives so far in the project.
- The treated wastewater could be discharged from a single discharge through a length of bankside rock wall and diffuse below river level.
- Could spread the flow in long perforated pipe and allow for ground soakage/diffusion through rock wall into the river. This spreads the entry point into the river to aid with mixing.
- The flow could be divided into smaller channels/pipes close to the point of discharge to achieve similar dispersion by discharging at multiple points.
- A proportion of the river flow could be diverted into a bank side mixing pond to which treated wastewater is discharged.
- In River turbulent mixers could be strategically placed to aid mixing.

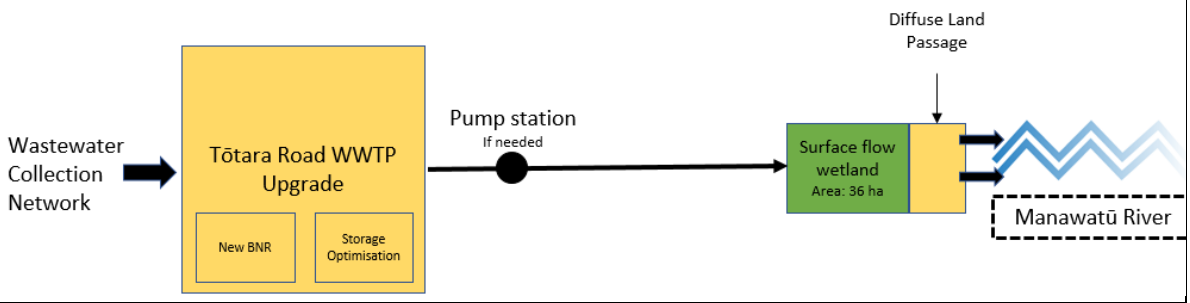
These options have been outlined here for information only. If either variant of option 1 is identified as the BPO then opportunities to achieve more complete mixing will be thoroughly investigated. Such investigation would need to consider all implications and values relevant to the discharge.

3.3 Glossary

A glossary of terms being used for the entire project is included in Appendix A.

4 Options Summaries

4.1 Option 1: R2(b) River Discharge with Enhanced Treatment

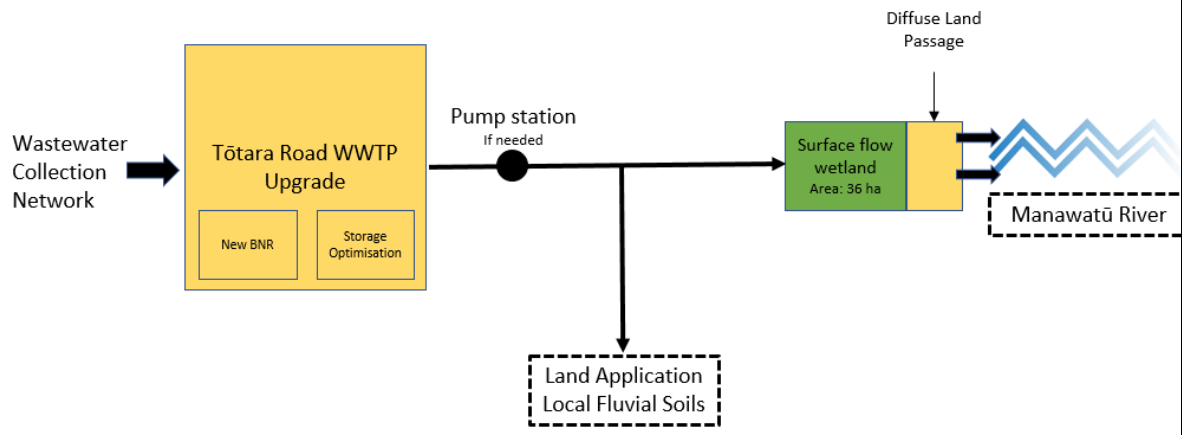
	
a. Flow triggers for treatment levels	100% of treated wastewater discharged to the Manawatū River at the Tōtara Road site. Additional Phosphorus (DRP) removal applied as River flow falls below 75 m^3/s (DRP = 0.2mg/L below median flow) with greater removal as River flow drops further below half median flow (DRP = 0.1mg/L below half median flow). Additional treatment will be required when river flows are low to meet SIN = 2mg/L for low flow.
b. Treatment upgrades	Treatment Level 4 High level of nitrogen and phosphorous removal, and includes membrane filtration. Membranes provide additional disinfection, treated wastewater has zero suspended solids and very low BOD content. The following new infrastructure is required: • New fine screens • New grit removal facilities (replacing existing) • Additional primary sedimentation tanks (for population growth) • New activated sludge bioreactors • New membrane bioreactors (MBRs) and associated equipment • New carbon dosing facilities • New waste activated sludge thickeners • Upgrade of the existing UV disinfection facility
c. Wetland / land passage	Surface flow wetland approximately 36Ha (Wetland 1) with diffuse land passage discharge to water (Land Passage 1).
d. Conveyance upgrades	Due to the size of the wetlands some additional conveyance costs for the wetland or land passage have been allowed for in the wetland indicative cost estimates.
e. Regional Scheme	Treatment would have to be upgraded to a higher level to mitigate effects of additional flow on the river, or would require discharge to land to be added to the scheme. WWTP upgrades would be required for additional flow.

<table>
<tr><th></th><th></th></tr>
<tr><td>f. Staging Possibilities</td><td>The activated sludge and membrane bioreactors can be easily staged, with 2-3 bioreactor trains and 3-4 MBR trains constructed initially and additional bioreactor and MBR trains deferred until required by population growth.</td></tr>
<tr><td>g. Comparative cost estimate</td><td>Comparative Cost Estimate in millions.

<table><tr><th>NPV</th><th>$337</th></tr><tr><td>Treatment</td><td>$183</td></tr><tr><td>Conveyance</td><td>$1</td></tr><tr><td>Wetlands & Land Passage</td><td>$45</td></tr><tr><td>Land Application Infrastructure</td><td>-</td></tr><tr><td>Land Application Land Purchase</td><td>-</td></tr><tr><td>Total Capex (P50 Contingency)</td><td>$241</td></tr><tr><td>Y1 O&M</td><td>$6</td></tr><tr><td>Net Income per annum</td><td>$0</td></tr></table></td></tr>
<tr><td>h. Key Matters</td><td>River discharge point likely to be within Palmerston North City boundary, depending on location of wetland and / or land passage
High level of treatment which increases as river flow falls
Treatment targeted at nutrient (nitrogen and phosphorous) removal
Potential for staging of treatment plant upgrades to match growth
Lowest NPV cost but high O&M cost
Will be expected to require wetland and land passage to be acceptable to iwi</td></tr>
</table>

4.2 Option 2: R2(b) River discharge with Enhanced treatment, 75% ADWF to Land at low River flow

Formerly a variation of Option 1.



a. Flow triggers for treatment levels	Majority of treated wastewater discharged to the Manawatū River at the Tōtara Road site, with 75% ADWF applied to land when River flow is less than half median (37.5m^3/s). Additional Phosphorus (DRP) removal applied as River flow falls below 75 m^3/s (DRP = 0.2mg/L below median flow) with greater removal as River flow drops further below half median flow (DRP = 0.1mg/L below half median flow). Additional treatment will be required when river flows are low to meet SIN = 2mg/L for low flow.
b. Treatment upgrades	Treatment Level 4 High level of nitrogen and phosphorous removal, and includes membrane filtration. Membranes provide additional disinfection, treated wastewater has zero suspended solids and very low BOD content. The following new infrastructure is required: • New fine screens • New grit removal facilities (replacing existing) • Additional primary sedimentation tanks (for population growth) • New activated sludge bioreactors • New membrane bioreactors (MBRs) and associated equipment • New carbon dosing facilities • New waste activated sludge thickeners • Upgrade of the existing UV disinfection facility
c. Wetland / land passage	Surface flow wetland approximately 36Ha (Wetland 1) with diffuse land passage discharge to water (Land Passage 1).
d. Land application location	Inland, fluvial soils
e. Land use alternatives	Potential sites are typically all High Productivity Soils. The recommended land use is Cut and Carry (Lucerne or Barley).

<table>
<tr><th></th><th colspan="2"></th></tr>
<tr><td rowspan="3">f. Land application area requirements[6]</td><td>Irrigation Area Required (ha)</td><td>585</td></tr>
<tr><td>Buffer Area Required (ha)</td><td>175</td></tr>
<tr><td>Total Area Required (ha)</td><td>760</td></tr>
<tr><td>g. Land application infrastructure</td><td colspan="2">• A significant proportion of the scheme is located in a flood area so the irrigation will all be via k-line irrigators (50%) and centre pivot (50%).
• 40,000 m^3 active volume onsite storage facility (lined), lagoon area 1 ha, 4m operational depth + 1m freeboard.</td></tr>
<tr><td>h. Conveyance upgrades</td><td colspan="2">Due to the size of the wetlands, some additional conveyance costs for the wetland or land passage have been allowed for in the indicative cost estimate for the wetlands.
Discharge of ADWF has been assumed to be as per Inland site 1.
630mm dia pipeline in the road reserve (11km long, depending on sites location)
Pump stations including power supply (1 No.)</td></tr>
<tr><td>i. Regional Scheme</td><td colspan="2">Treatment would have to be upgraded to a higher level to mitigate effects of additional flow on the river, or a greater percentage would need to be discharged on to land.
WWTP upgrades would be required for additional flow.
Additional land would need to be purchased to meet the requirement of 75% ADWF to land.</td></tr>
<tr><td>j. Staging Possibilities</td><td colspan="2">The activated sludge and membrane bioreactors can be easily staged, with 2-3 bioreactor trains and 3-4 MBR trains constructed initially and additional bioreactor and MBR trains deferred until required by population growth.
It may not be necessary to install all land application infrastructure initially, though the land would be expected to be secured for the future land areas required.</td></tr>
<tr><td>k. Comparative cost estimate</td><td colspan="2">Comparative Cost Estimate in millions.

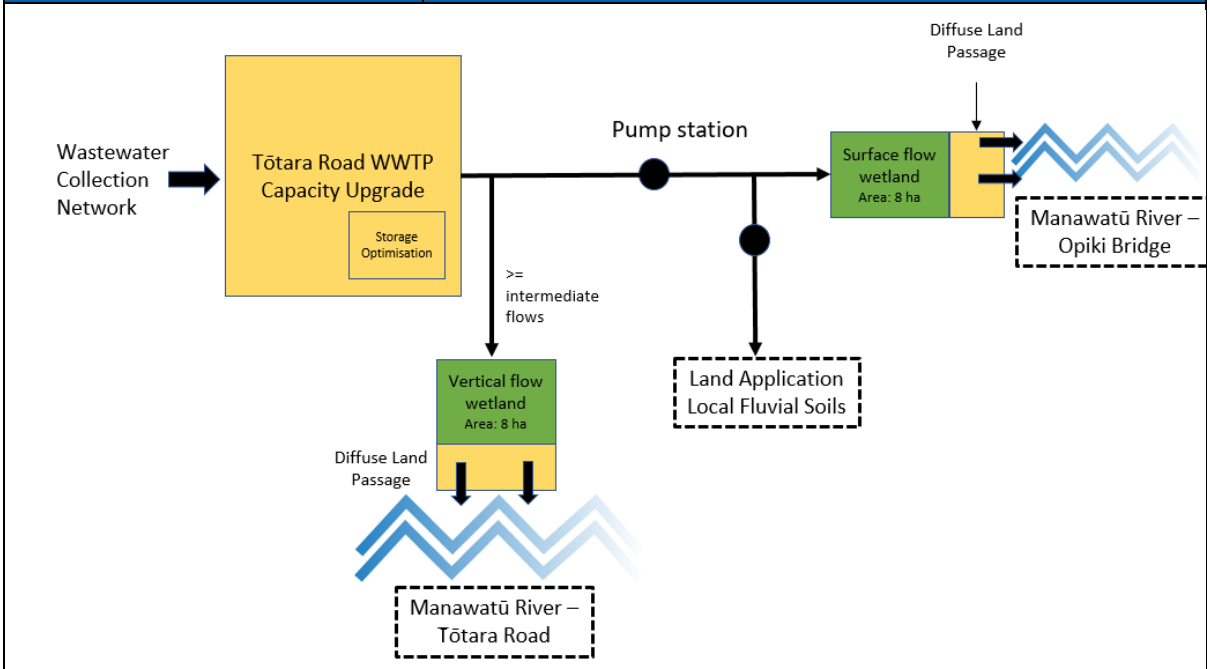
<table>
<tr><th>NPV</th><th>$496</th></tr>
<tr><td>Treatment</td><td>$183</td></tr>
<tr><td>Conveyance</td><td>$58</td></tr>
<tr><td>Wetlands & Land Passage</td><td>$44</td></tr>
<tr><td>Land Application Infrastructure</td><td>$36</td></tr>
<tr><td>Land Application Land Purchase</td><td>$52</td></tr>
<tr><td>Total Capex (P50 Contingency)</td><td>$387</td></tr>
<tr><td>Y1 O&M</td><td>$7</td></tr>
<tr><td>Net Income per annum</td><td>$0.3</td></tr>
</table>
</td></tr>
</table>

[6] These areas are based on the possible land application sites assessed in WP15.1.

I. Key Matters	• River discharge point likely to be within Palmerston North city boundary, depending on location of wetland and / or land passage • High level of treatment which increases as river flow drops • Treatment targeted at nutrient (nitrogen and phosphorous) removal • Potential for staging of treatment plant upgrades to match growth • Relatively small land area and number of land parcels affected • Will be expected to require wetland and land passage to be acceptable to iwi

4.3 Option 3: Dual R+L(b) Two River discharge points with 75% ADWF to Land at low River flow

Formerly Option 2



a. Flow triggers for different discharge elements*	When the River flow is greater than 62m^3/s the treated wastewater would be discharged, via wetland/land passage, to Manawatū River at or near Tōtara Rd. When the River flow is between 62m^3/s and 37.5m^3/s the treated wastewater would be discharged, via wetland/land passage, to Manawatū River below Opiki Bridge and Oroua confluence. When the River flow is less than half median flow (37.5m^3/s) 75% of ADWF would be discharged to land (condition to apply year-round), whilst still maintaining enough flow to keep the wetlands alive. This option has discharge to the River at all times when the River flow is above 37.5m^3/s (half median flow).
b. Treatment upgrades	Treatment Level 2 Provides a similar level of treatment to the existing WWTP with chemical phosphorous removal, at River flow less than median flow (75m^3/s). The following new infrastructure is required: • New grit removal facilities (replacing existing facilities) • Additional primary sedimentation tanks for growth • New aerators and baffles in the existing aerated lagoons • Additional chemical clarifier • Upgrade of the existing UV disinfection facility

c. Wetland / land passage	For the discharge at or near Tōtara Road, a vertical flow wetland (Wetland 2) with a diffuse land passage discharge (Land Passage 1) to the Manawatū River. For the discharge below Oroua, a surface flow wetland (Wetland 1) with a diffuse land passage discharge (Land Passage 1) to the Manawatū River. There will likely be a need to configure the flow arrangements to keep the wetlands alive during the time the treated wastewater is applied to land.	
d. Potential downstream discharge location(s)	Proposed Opiki discharge location is below Oroua confluence.	
e. Land application location	Inland, fluvial soils	
f. Land use alternatives	Potential sites are typically all High Productivity Soils. The recommended land use is Cut and Carry (Lucerne or Barley).	
a. Land application area requirements[7]	Irrigation Area Required (ha)	670
	Buffer Area Required (ha)	200
	Total Area Required (ha)	870
g. Land application infrastructure	• Centre pivot irrigators (80% of area) with solid set irrigators in between (20% of area). • 30,000 m^3 onsite storage facility (lined), lagoon area 1 ha. • Rapid infiltration with capacity of 5,000 m^3/day, typically used 1 day per year.	
h. Conveyance upgrades	Discharge to river below Opiki bridge: 1300mm dia pipeline in the road reserve (14km long to Opiki discharge point) Pump stations including power supply (1 No.) Discharge to land: 1300mm dia pipeline in the road reserve (7 km long, depending on site location) Pump stations including power supply (included in above)	
i. Regional Scheme	Treatment would have to be upgraded to a higher level (potentially BNR plant) to mitigate effects of additional flow on the river, or a greater percentage would need to be discharged on to land. WWTP upgrades would be required for additional flow. Additional land would need to be purchased to meet the requirement of 75% ADWF to land.	
j. Staging Possibilities	Based on projected flows, the additional chemical clarifier can be deferred until required by population growth. Land application infrastructure could be staged though the land may need to be secured early.	

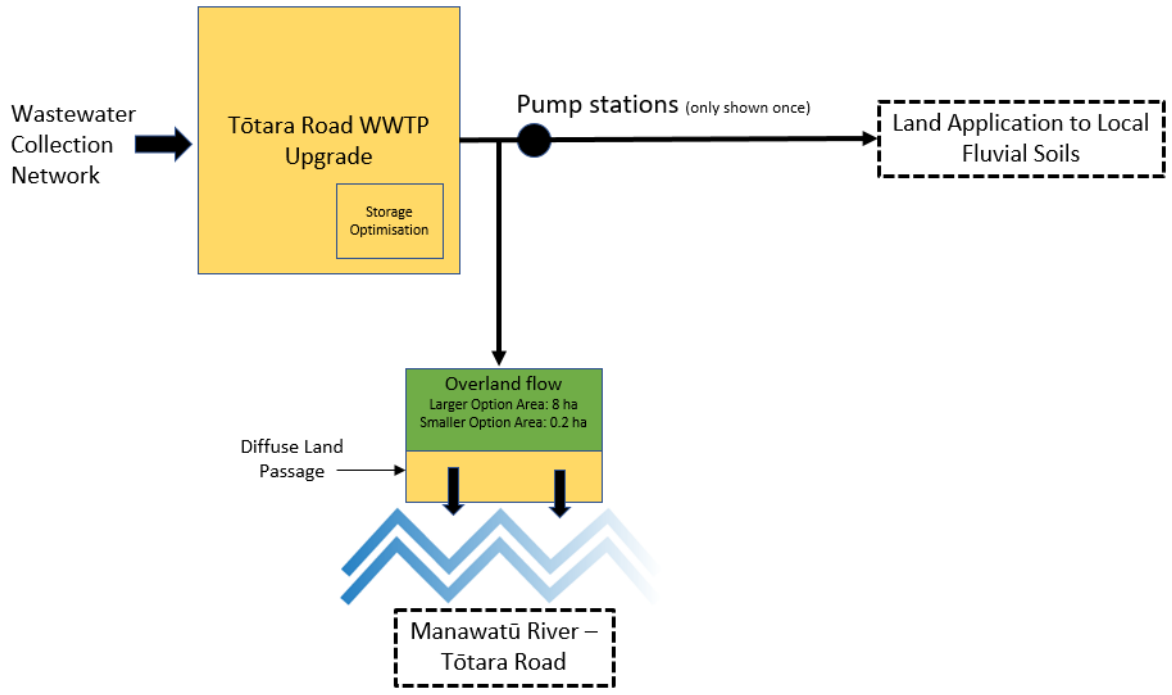
[7] These areas, are based on the possible land application sites assessed in WP15.1.

<table>
<tr><td></td><td>Conveyance pipework would have to be constructed for the future flows required, however pumps could be staged for growth.</td></tr>
<tr><td>k. Comparative cost estimate</td><td>Comparative Cost Estimate in millions.

<table><tr><th>NPV</th><th>$419</th></tr><tr><td>Treatment</td><td>$56</td></tr><tr><td>Conveyance</td><td>$117</td></tr><tr><td>Wetlands & Land Passage</td><td>$21</td></tr><tr><td>Land Application Infrastructure</td><td>$53</td></tr><tr><td>Land Application Land Purchase</td><td>$60</td></tr><tr><td>Total Capex (P50 Contingency)</td><td>$318</td></tr><tr><td>Y1 O&M</td><td>$6</td></tr><tr><td>Net Income per annum</td><td>$0.3</td></tr></table></td></tr>
<tr><td>l. Key matters</td><td>• Would remain largely a river discharge
• Opiki/Oroua confluence River discharge located outside of Palmerston North City boundary
• Land application would be in area of high value, productive soils
• Relatively small land area and number of land parcels affected
• Costs are associated with conveyance and land application rather than treatment
• The smaller application area is less impacted by the uncertainty around archaeological sites
• Dual discharge points take advantage of the variable assimilative capacity of the River in different locations</td></tr>
</table>

4.4 Option 4: L+R (a) / 97% of time to Land (Inland)

Formerly Option 3 (a)



a. Flow triggers for different discharge elements	Treated wastewater would be applied to land approximately 97% of the time. The remaining 3% of the time discharge is to the Manawatū River at Tōtara Rd which equates to approximately 11 days of highest discharge, and 954,000m^3 of volume. These days are expected to be when river flow is also high.
b. Treatment upgrades	Treatment Level One Provides a similar level of treatment to the existing WWTP without chemical phosphorous removal. Would require the following new infrastructure: • New grit removal facilities (replacing existing facilities) • Additional primary sedimentation tanks (for population growth) • New aerators and baffles in existing aerated lagoons • Upgrade of existing UV disinfection facility Alum dosing to remove phosphorus is not required. Existing clarifier will be used for continuous clarification.
c. Wetland / land passage	Overland flow (Land Passage Type 4) and diffuse land passage (Land Passage Type 1) discharge to water.
d. Land application location	Inland, fluvial soils.

<table>
<tr><td>e. Land Use Alternatives</td><td colspan="2">Inland sites typically dominated by High Productivity Soils, i.e. the fluvial/loam soils. The recommended land use is Cut and Carry (Lucerne of Barley).</td></tr>
<tr><td rowspan="3">f. Land application area requirements</td><td>Irrigation Area Required (ha)</td><td>2,890</td></tr>
<tr><td>Buffer Area Required (ha)</td><td>870</td></tr>
<tr><td>Total Area Required (ha)</td><td>3,760</td></tr>
<tr><td>g. Land application infrastructure[8]</td><td colspan="2">• Centre pivot irrigators (80% of area) with solid set irrigators in between (20% of area).
• 160,000 – 200,000 m^3 active volume onsite storage facility (lined), lagoon area 4 ha.
• Rapid Infiltration with a capacity of 60,000 m^3/day, typically used 10-20 days per year.</td></tr>
<tr><td>h. Conveyance upgrades</td><td colspan="2">1300mm dia pipeline in the road reserve (11km long, depending on sites location)
Pump stations including power supply (1 No.)</td></tr>
<tr><td>i. Regional Scheme</td><td colspan="2">Land application hydraulicly limited so would require additional land area which could be difficult for the size of the land areas identified in the inland fluvial sites. Likely treatment would have to be upgraded to a higher level (e.g. BNR plant with alum dosing for phospohorous) to allow greater discharge to the River.
WWTP upgrades would be required for additional flow.
If additional land was purchased for application conveyance system may need to be increased (additional or upsized pipelines).</td></tr>
<tr><td>j. Staging Possibilities</td><td colspan="2">There are limited options for staging of new infrastructure at the WWTP as this option maintains the existing process.
Land application infrastructure could be staged though the land may need to be secured early.
Conveyance pipework would have to be constructed for the future flows required, however pumps could be staged for growth.</td></tr>
<tr><td>k. Comparative cost estimate</td><td colspan="2">Comparative Cost Estimate in millions.

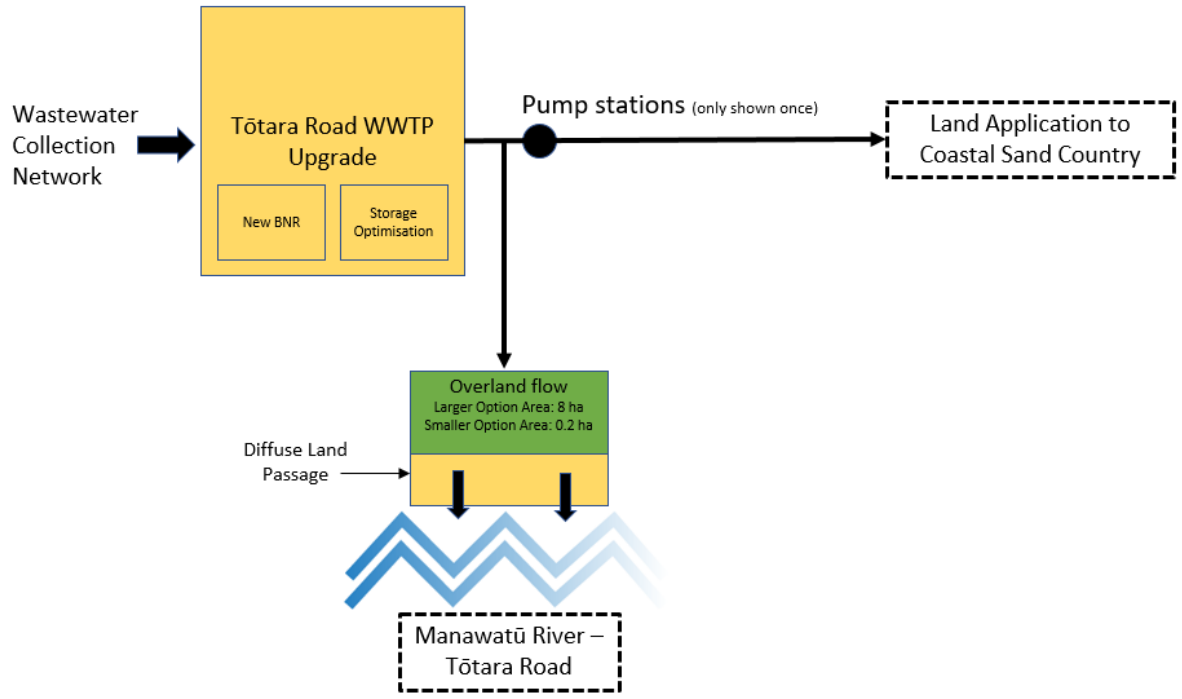
<table><tr><th>NPV</th><th>$604</th></tr><tr><td>Treatment</td><td>$50</td></tr><tr><td>Conveyance</td><td>$97</td></tr><tr><td>Overland Flow & Land Passage</td><td>$15</td></tr><tr><td>Land Application Infrastructure</td><td>$182</td></tr></table></td></tr>
</table>

[8] The areas and volume of storage and rapid infiltration basins are dependant on the site selected, and the balance between irrigation/storage/rapid infiltration is an estimate at this time.

	Land Application Land Purchase	$249
	Total Capex (P50 Contingency)	$605
	Y1 O&M	$4
	Net Income per annum	$5
l. Key matters	• Discharge likely to be outside of Palmerston North city boundaries • Still discharges to the River in exceptional flow conditions • Large land area required and would require security on on-going use of land • Includes supplementary storage facilities and rapid infiltration facilities • Large land area required, comprising large number of land parcels and neighbours • In area of High Value land, productive soils, but would manage to enhance crop production at dry weather times • High number of known and identified archaeological sites in areas under investigation • Key matter of groundwater protection of bore supplies in/adjacent to the area • Would be largest land application of municipal wastewater in NZ by far (5 to 6 times the next largest by area) • Minimised discharges to the River – expected to meet Horizons One Plan Policy 5-11, providing the 3% to the River can be accommodated. • Compatible with existing WWTP operation (without need for phosphorous removal clarifier)	

4.5 Option 5: L+R (b) / 97% of time to Land (Coastal)

Formerly Option 3 (b)



a. Flow triggers for different discharge elements	Treated wastewater would be applied to land approximately 97% of the time. The remaining 3% of the time discharge is to the Manawatū River at Tōtara Rd which equates to approximately 11 days of highest discharge, and 954,000m^3 of volume. These days are expected to be when river flow is also high.
b. Treatment upgrades	Treatment Level 3 Requires nitrogen removal which is not provided by the current treatment plant. Would require the following new infrastructure: • New grit removal facilities (replacing existing facilities) • Additional primary sedimentation tanks (for population growth) • New activated sludge bioreactors • 2 x additional secondary clarifiers and return activated sludge pumping • New waste activated sludge thickeners • Upgrade of the existing UV disinfection facility Additional treatment is required for the coastal sites, compared to the inland, fluvial sites, as there is less take up of nutrients by forestry on sand country, and leaching needs to be managed. Phosphorous removal would not be required when flow is being discharged to land, or with very high flows to the

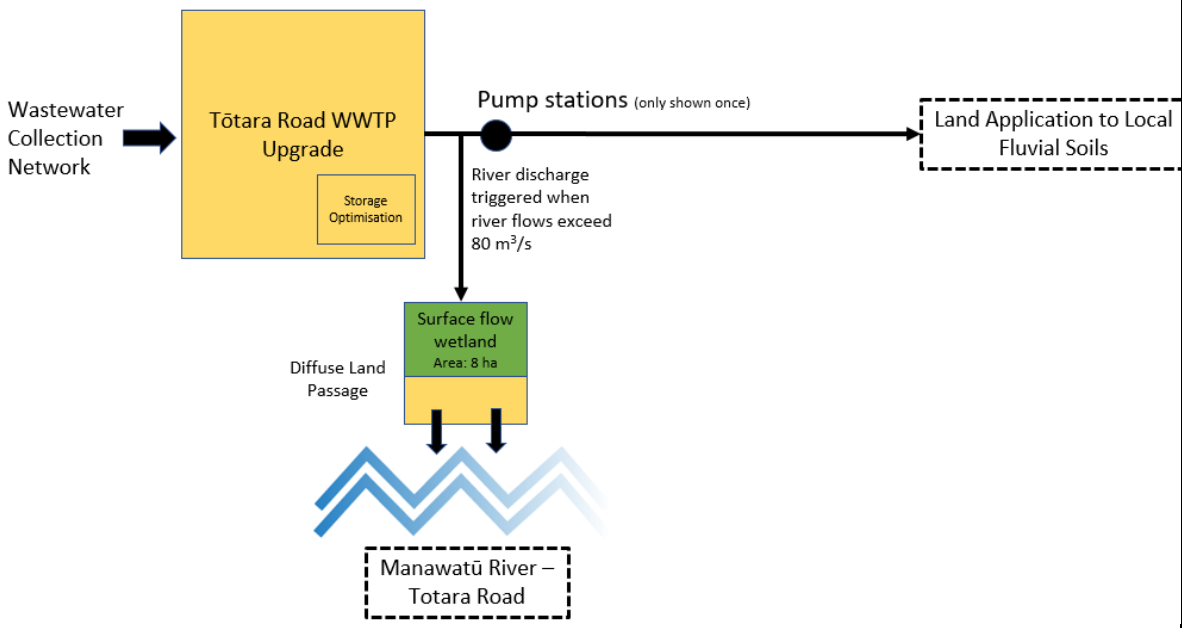
<table>
<tr><td></td><td colspan="2">River, so the existing alum dosing clarifier could be removed.</td></tr>
<tr><td>c. Wetland / land passage</td><td colspan="2">Overland flow (Land Passage Type 4) and diffuse land passage (Land Passage Type 1) discharge to water</td></tr>
<tr><td>d. Land application location</td><td colspan="2">Coastal sand country</td></tr>
<tr><td>e. Land use alternatives</td><td colspan="2">The coastal land application sites are typically dominated by sandy soils. Exotic Forestry is the recommended land use for these regions.</td></tr>
<tr><td rowspan="3">f. Land application area requirements</td><td>Irrigation Area Required (ha)</td><td>1,975</td></tr>
<tr><td>Buffer Area Required (ha)</td><td>595</td></tr>
<tr><td>Total Area Required (ha)</td><td>2,570</td></tr>
<tr><td>g. Land application infrastructure</td><td colspan="2">• Solid set irrigation.
• 160,000 m^3 onsite storage facility (lined), lagoon area 4 ha.
• Rapid Infiltration with a capacity of 50,000 m^3/day, typically used 10 days per year.</td></tr>
<tr><td>h. Conveyance upgrades</td><td colspan="2">1300mm dia pipeline in the road reserve (estimated 36km long, depending on sites location)
Pump stations including power supply (4 No.)</td></tr>
<tr><td>i. Regional Scheme</td><td colspan="2">Would require additional land area which could be difficult for the size of the land areas identified for this option, but possible in the coastal environment. Alternative is treatment upgraded to a higher level (e.g. BNR plant) to allow greater level of application on to existing land as not hydraulically limited.
WWTP upgrades would be required for additional flow.
If additional land was purchased for application conveyance system may need to be increased (additional or upsized pipelines).</td></tr>
<tr><td>j. Staging Possibilities</td><td colspan="2">The new activated sludge process can be staged, with two bioreactor trains and one clarifier constructed initially and a third bioreactor train and second clarifier deferred until required.
Land application infrastructure could be staged though the land may need to be secured early.
Conveyance pipework would have to be constructed for the future flows required, however pumps could be staged for growth.</td></tr>
<tr><td>k. Comparative cost estimate</td><td colspan="2">Comparative Cost Estimate in millions.

<table><tr><th>NPV</th><th>$836</th></tr><tr><td>Treatment</td><td>$157</td></tr><tr><td>Conveyance</td><td>$298</td></tr></table></td></tr>
</table>

	Overland Flow & Land Passage	$15
	Land Application Infrastructure	$170
	Land Application Land Purchase	$81
	Total Capex (P50 Contingency)	$733
	Y1 O&M	$7
	Net Income per annum in Y26-30 (tree harvest)	$13
l. Key matters	• Discharge outside of Palmerston North city boundaries • Large land area required and would require security on ongoing use of land • Uncertainty about archaeological risk in the coastal areas • High capital cost but income stream from forestry • Depending on location groundwater flows likely to be to ocean, so less potential than inland options for (any) contamination of bore water.	

4.6 Option 6: L+R (d-1) to Land <80m^3/s / 53% of the time to Land (inland)

Formerly Option 4 (d-1)



a. Flow triggers for different discharge elements	Treated wastewater would be applied to land when Manawatū River flow is less than 80m^3/s, removing flow from the River approximately 53% of the time. When the River flow is greater than 80m^3/s, and on the highest 3% of days by WWTP flow (exceptional flow conditions), the treated wastewater would be discharged to the Manawatū River near the Tōtara Rd outfall.	
b. Treatment upgrades	Treatment Level 2 Provides a similar level of treatment to the existing WWTP with chemical phosphorous removal. The following new infrastructure is required: • New grit removal facilities (replacing existing facilities) • Additional primary sedimentation tanks for growth • New aerators and baffles in the existing aerated lagoons • Additional chemical clarifier • Upgrade of the existing UV disinfection facility	
c. Wetland / land passage	Surface flow wetlands (Wetland 1) and Land Passage	
d. Land application location	Inland, fluvial soils.	
e. Land use alternatives	Inland land application sites typically dominated by High Productivity Soils, i.e. the fluvial/loam soils. The recommended land use is Cut and Carry (Lucerne of Barley).	
f. Land application area requirements	Irrigation Area Required (ha)	1,540
	Buffer Area Required (ha)	460

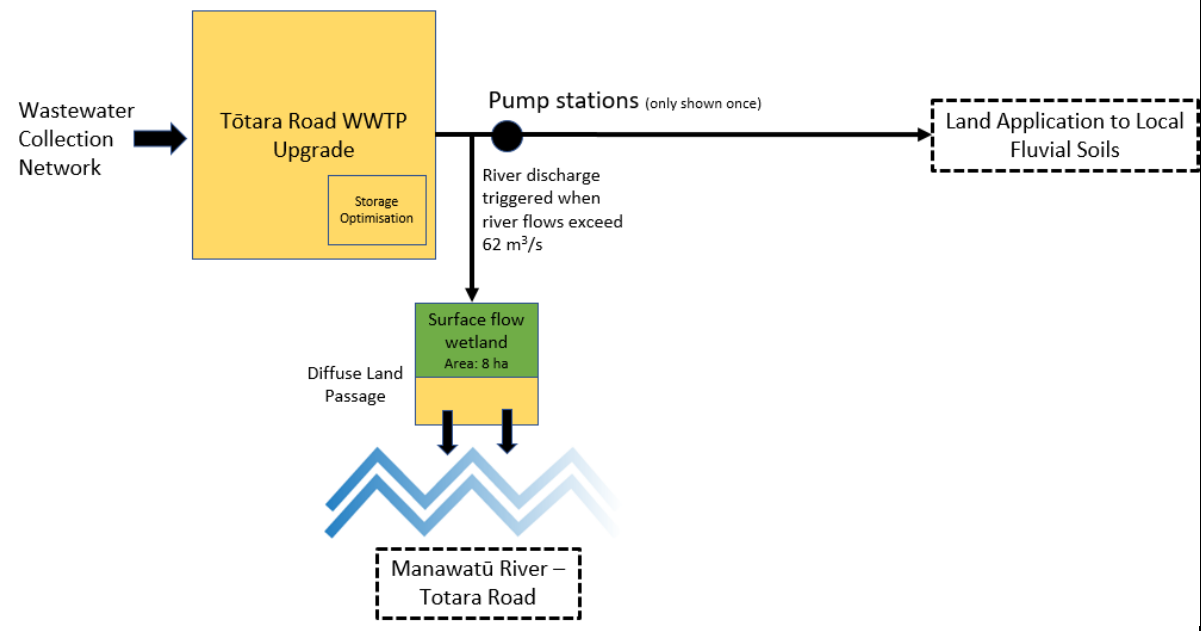
<table>
<tr><td></td><td>Total Area Required (ha)</td><td>2,000</td></tr>
<tr><td>g. Land application infrastructure</td><td colspan="2">• Centre pivot irrigators (60 - 80% of area) with solid set irrigators in between (20 - 40% of area).
• 80,000 – 90,000m^3 onsite storage facility (lined), lagoon area 2 – 2.25 ha.</td></tr>
<tr><td>h. Conveyance upgrades</td><td colspan="2">1300mm dia pipeline in the road reserve (approximately 11km long)
Pump stations including power supply (1 No.)</td></tr>
<tr><td>i. Regional Scheme</td><td colspan="2">Land application hydraulicly limited so would require additional land area. Alternative would be to have additional treatment upgrades to a higher level (i.e., BNR plant with alum dosing for phosphorous) to allow greater discharge to the River.
WWTP upgrades would be required for additional flow.
If additional land was purchased for application conveyance system may need to be increased (additional or upsized pipelines).</td></tr>
<tr><td>j. Staging Possibilities</td><td colspan="2">Based on projected flows, the additional chemical clarifier can be deferred until required by population growth.
Land application infrastructure could be staged though the land may need to be secured early.
Conveyance pipework would have to be constructed for the future flows required, however pumps could be staged for growth.</td></tr>
<tr><td>k. Comparative cost estimate</td><td colspan="2">Comparative Cost Estimate in millions.

<table><tr><th>NPV</th><th>$470</th></tr><tr><td>Treatment</td><td>$56</td></tr><tr><td>Conveyance</td><td>$97</td></tr><tr><td>Wetlands & Land Passage</td><td>$9</td></tr><tr><td>Land Application Infrastructure</td><td>$99</td></tr><tr><td>Land Application Land Purchase</td><td>$136</td></tr><tr><td>Total Capex (P50 Contingency)</td><td>$410</td></tr><tr><td>Y1 O&M</td><td>$5</td></tr><tr><td>Net Income per annum</td><td>$1</td></tr></table></td></tr>
<tr><td>l. Key matters</td><td colspan="2">• Discharge outside of Palmerston North city boundaries
• Wetlands would need to be kept alive when discharging to land
• Discharge to the River reduced to around 57% of the time</td></tr>
</table>

	• Significant land area required involving large number of parcels and landowners • Less cost than L+R (a) as there is reduced irrigation in wetter (winter) periods. • Large number of known and identified archaeological sites in areas under investigation • Critical requirement is protection of bore supplies in/adjacent to the area • Compatible with existing WWTP operation (without need for phosphorous removal clarifier)

4.7 Option 7: L+R (d-2) to Land <62m^3/s / 43% of the time to Land (inland)

Formerly Option 4 (d-2)



a. Flow triggers for different discharge elements	Treated wastewater would be applied to land when Manawatū River flow is less than 62m^3/s, removing flow from the River approximately 43% of the time. When the River flow is greater than 62m^3/s, and on the highest 3% of days by WWTP flow (exceptional flow conditions), the treated wastewater would be discharged to the Manawatū River near the Tōtara Rd outfall.	
b. Treatment upgrades	Treatment Level 2 Provides a similar level of treatment to the existing WWTP with chemical phosphorous removal. The following new infrastructure is required: • New grit removal facilities (replacing existing facilities) • Additional primary sedimentation tanks for growth • New aerators and baffles in the existing aerated lagoons • Additional chemical clarifier • Upgrade of the existing UV disinfection facility	
c. Wetland / land passage	Surface flow wetlands (Wetland 1) and land passage	
d. Land application location	Inland, fluvial soils	
e. Land use alternatives	Inland land application sites typically dominated by High Productivity Soils, i.e. the fluvial/loam soils. The recommended land use is Cut and Carry (Lucerne of Barley).	
	Irrigation Area Required (ha)	1,260

<table>
<tr><td rowspan="2">f. Land application area requirements</td><td>Buffer Area Required (ha)</td><td>380</td></tr>
<tr><td>Total Area Required (ha)</td><td>1,640</td></tr>
<tr><td>g. Land application infrastructure</td><td colspan="2">• Centre pivot irrigators (60 - 80% of area) with solid set irrigators in between (20 - 40% of area).
• 80,000 – 90,000m^3 onsite storage facility (lined), lagoon area 2 – 2.25 ha.</td></tr>
<tr><td>h. Conveyance upgrades</td><td colspan="2">1300mm dia pipeline in the road reserve (11km long)
Pump stations including power supply (1 No.)</td></tr>
<tr><td>i. Regional Scheme</td><td colspan="2">Land application hydraulicly limited so would require additional land area. Alternative would be to have additional treatment upgrades to a higher level (i.e., BNR plant with alum dosing for phosphorous) to allow greater discharge to the River.
WWTP upgrades would be required for additional flow.
If additional land was purchased for application conveyance system may need to be increased (additional or upsized pipelines).</td></tr>
<tr><td>j. Staging Possibilities</td><td colspan="2">Based on projected flows, the additional chemical clarifier can be deferred until required by population growth.
Land application infrastructure could be staged though the land may need to be secured early.
Conveyance pipework would have to be constructed for the future flows required, however pumps could be staged for growth.</td></tr>
<tr><td>k. Comparative cost estimate</td><td colspan="2">Comparative Cost Estimate in millions.

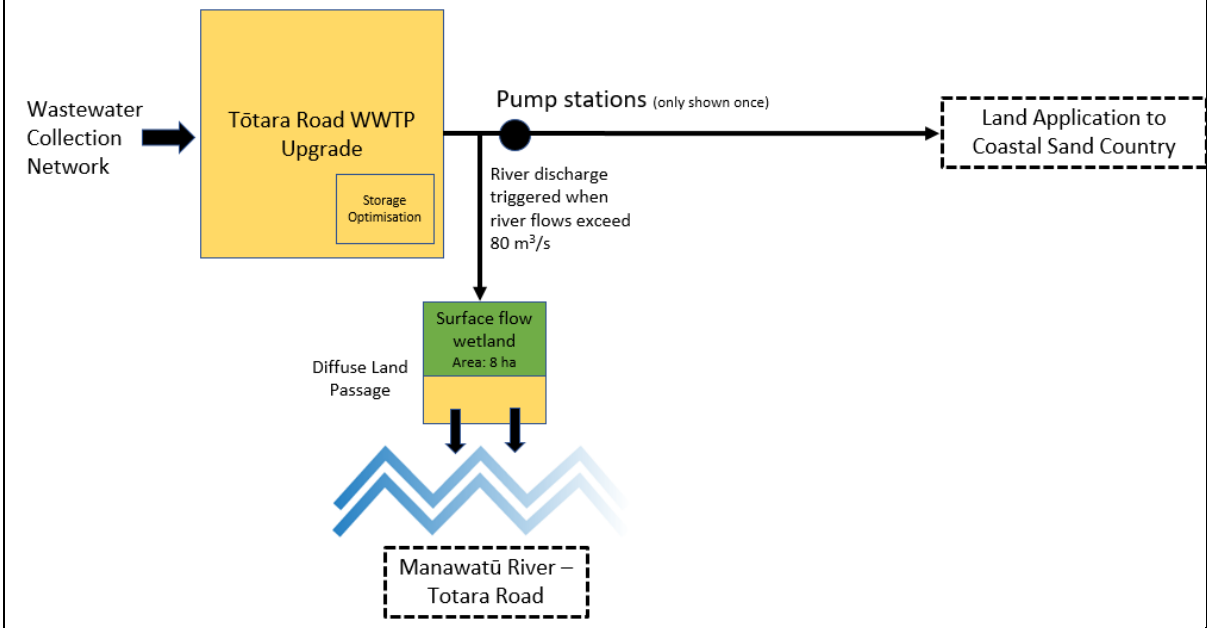
<table><tr><th>NPV</th><th>$433</th></tr><tr><td>Treatment</td><td>$56</td></tr><tr><td>Conveyance</td><td>$97</td></tr><tr><td>Wetlands & Land Passage</td><td>$9</td></tr><tr><td>Land Application Infrastructure</td><td>$83</td></tr><tr><td>Land Application Land Purchase</td><td>$111</td></tr><tr><td>Total Capex (P50 Contingency)</td><td>$369</td></tr><tr><td>Y1 O&M</td><td>$5</td></tr><tr><td>Net Income per annum</td><td>$1</td></tr></table></td></tr>
<tr><td>l. Key matters</td><td colspan="2">• Discharge outside of Palmerston North city boundaries
• Wetlands would need to be kept alive when discharging to land</td></tr>
</table>

	• Discharge to the River approximately 57% of the time • Significant land area required involving large number of parcels and landowners • Less cost than L+R (a) as there is reduced irrigation in wetter (winter) periods. • Large number of known and identified archaeological sites in areas under investigation • Critical requirement is protection of bore supplies in/adjacent to the area • Compatible with existing WWTP operation (without need for phosphorous removal clarifier)

4.8 Option 8: L+R (e-1) to Land <80m^3/s / 53% of the time to Land (coastal) TN = 35 mg/L

Formerly Option 4 (e-1)

Option 8 has an additional option which utilises a higher level of treatment, Treatment Level 3, and a reduced land area. This option was considered at this stage of the analysis due to the increased in the land costs. It has a NPV of $712M.



a. Flow triggers for different discharge elements	Treated wastewater would be applied to land when Manawatū River flow is less than 80m^3/s, removing flow from the River approximately 53% of the time. When the River flow is greater than 80m^3/s, and on the highest 3% of days by WWTP flow (exceptional flow conditions), the treated wastewater would be discharged to the Manawatū River near the Tōtara Rd outfall.
b. Treatment upgrades	Treatment Level 2 Provides a similar level of treatment to the existing WWTP with chemical phosphorous removal. The following new infrastructure is required: • New grit removal facilities (replacing existing facilities) • Additional primary sedimentation tanks for growth • New aerators and baffles in the existing aerated lagoons • Additional chemical clarifier • Upgrade of the existing UV disinfection facility
c. Wetland / land passage	Surface flow wetlands (Wetland 1).
d. Land application location	Coastal, sandy soils

<table>
<tr><td>e. Land use alternatives</td><td colspan="2">The coastal land application sites are typically dominated by sandy soils. Exotic Forestry is the recommended land use for these regions.</td></tr>
<tr><td rowspan="3">f. Land application area requirements</td><td>Irrigation Area Required (ha)</td><td>2,800</td></tr>
<tr><td>Buffer Area Required (ha)</td><td>840</td></tr>
<tr><td>Total Area Required (ha)</td><td>3,640</td></tr>
<tr><td>g. Land application infrastructure</td><td colspan="2">• Solid set irrigation.
• 60,000 m^3 onsite storage facility (lined), lagoon area 1.5 ha.
• Rapid Infiltration with capacity of 15,000 m^3/day, typically used 1 days per year.</td></tr>
<tr><td>h. Conveyance upgrades</td><td colspan="2">1300mm dia pipeline in the road reserve (36km km long)
Pump stations including power supply (4 No.)</td></tr>
<tr><td>i. Regional Scheme</td><td colspan="2">Would require additional land area which could be difficult for the size of the land areas identified for this option, but possible in the coastal environment. Alternative is treatment upgraded to a higher level (i.e., BNR plant) to allow greater level of application on to existing land as not hydraulically limited. WWTP upgrades would be required for additional flow. Conveyance system may need to be increased (additional or upsized pipelines) for the additional flow.</td></tr>
<tr><td>j. Staging Possibilities</td><td colspan="2">Based on projected flows, the additional chemical clarifier can be deferred until required by population growth.
Land application infrastructure could be staged though the land may need to be secured early.
Conveyance pipework would have to be constructed for the future flows required, however pumps could be staged for growth.</td></tr>
<tr><td>k. Comparative cost estimate</td><td colspan="2">Comparative Cost Estimate in millions.

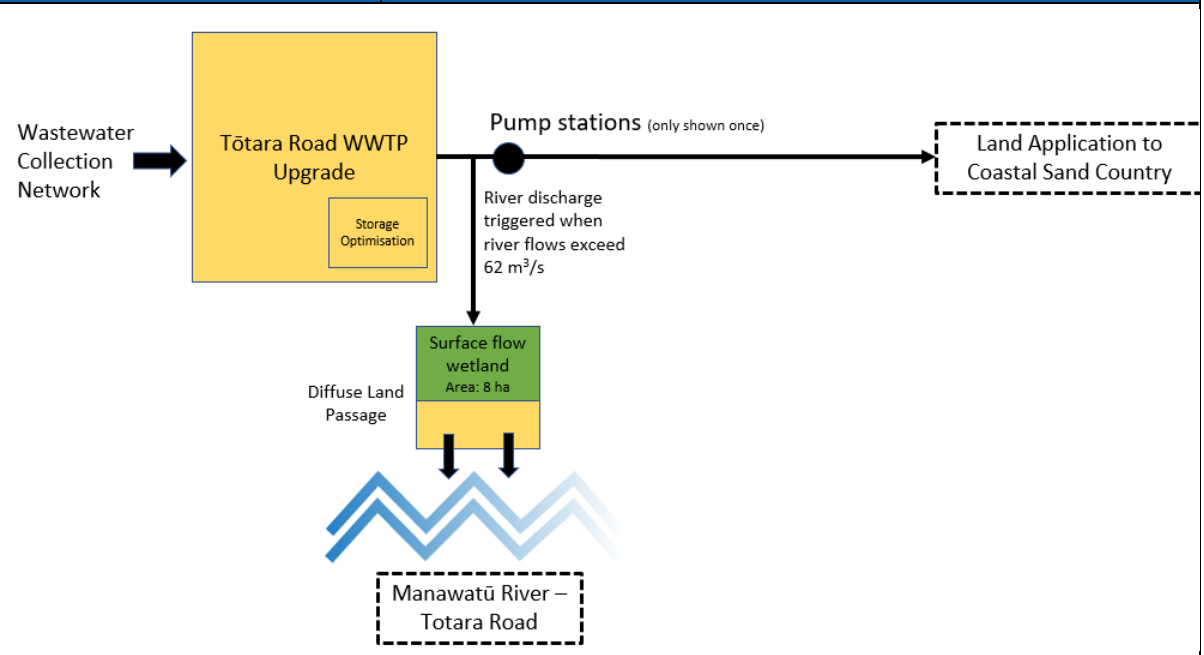
<table>
<tr><th>NPV</th><th>$786</th></tr>
<tr><td>Treatment</td><td>$56</td></tr>
<tr><td>Conveyance</td><td>$298</td></tr>
<tr><td>Wetlands & Land Passage</td><td>$9</td></tr>
<tr><td>Land Application Infrastructure</td><td>$218</td></tr>
<tr><td>Land Application Land Purchase</td><td>$114</td></tr>
<tr><td>Total Capex (P50 Contingency)</td><td>$708</td></tr>
<tr><td>Y1 O&M</td><td>$5</td></tr>
</table>
</td></tr>
</table>

	Net Income per annum in Y26-30 (tree harvest)	$18
l. Key matters	• Discharge outside of Palmerston North city boundaries • Wetlands would need to be kept alive when discharging to land • Discharge to the River reduced to approximately 47% of the time • TN = 35mg/L results in reasonably large land area required and would require security on ongoing use of land. Alternative would be higher level of treatment and smaller land area. • High capital cost but income stream from forestry • Less cost than L+R (b) as less irrigation in wetter (winter) periods. • Depending on location groundwater flows likely to be to ocean, so less potential than inland options for (any) contamination of bore water	

4.9 Option 9: L+R (e-2) to Land <62m^3/s / 43% of the time to Land (coastal) TN = 35 mg/L

Formerly Option 4 (e-2)

Option 9 has an additional option which utilises a higher level of treatment, Treatment Level 3, and a reduced land area. This option was considered at this stage of the analysis due to the increased in the large costs and it has a NPV of $697M.



a. Flow triggers for different discharge elements	Treated wastewater would be applied to land when Manawatū River flow is less than 62m^3/s, removing flow from the River approximately 43% of the time. When the River flow is greater than 62m^3/s, and on the highest 3% of days by WWTP flow (exceptional flow conditions), the treated wastewater would be discharged to the Manawatū River near the Tōtara Rd outfall.
b. Treatment upgrades	Treatment Level 2 Provides a similar level of treatment to the existing WWTP with chemical phosphorous removal. The following new infrastructure is required: • New grit removal facilities (replacing existing facilities) • Additional primary sedimentation tanks for growth • New aerators and baffles in the existing aerated lagoons • Additional chemical clarifier • Upgrade of the existing UV disinfection facility
c. Wetland / land passage	Surface flow wetlands (Wetland 1).
d. Land application location	Coastal, sand dune location

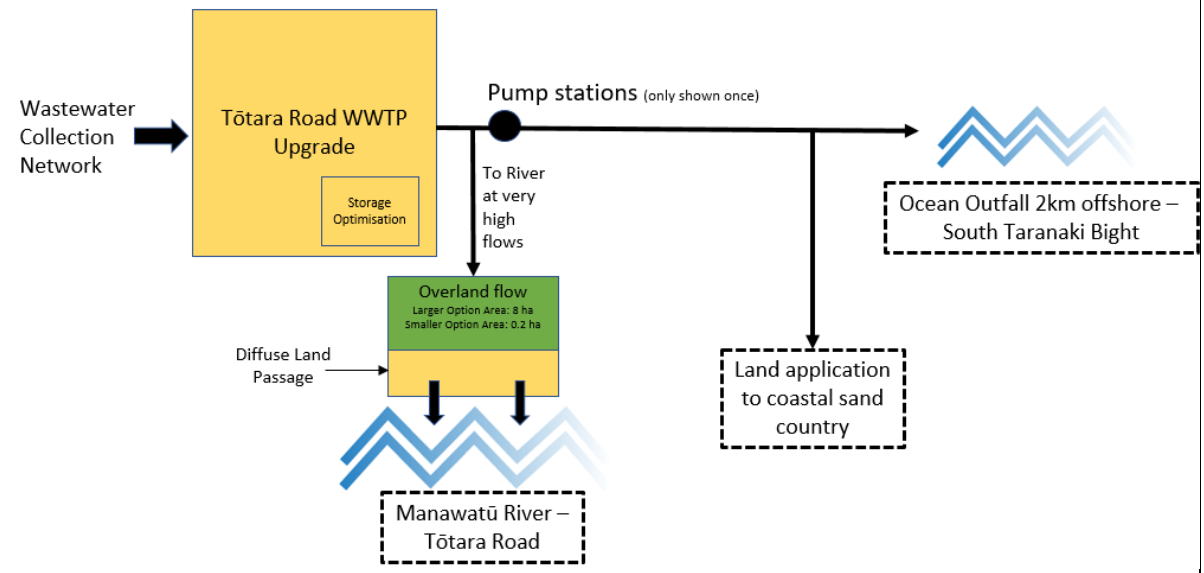
<table>
<tr><td>e. Land use alternatives</td><td colspan="2">The coastal land application sites are typically dominated by sandy soils. Exotic Forestry is the recommended land use for these regions.</td></tr>
<tr><td rowspan="3">f. Land application area requirements</td><td>Irrigation Area Required (ha)</td><td>2,315</td></tr>
<tr><td>Buffer Area Required (ha)</td><td>695</td></tr>
<tr><td>Total Area Required (ha)</td><td>3,010</td></tr>
<tr><td>g. Land application infrastructure</td><td colspan="2">• Solid set irrigation.
• 50,000 m^3 onsite storage facility (lined), lagoon area 1.5 ha.
• Rapid Infiltration with capacity of 15,000 m^3/day, typically used 1 days per year.</td></tr>
<tr><td>h. Conveyance upgrades</td><td colspan="2">1300mm dia pipeline in the road reserve (36km long)
Pump stations including power supply (4 No.)</td></tr>
<tr><td>i. Regional Scheme</td><td colspan="2">Would require additional land area which could be difficult for the size of the land areas identified for this option, but possible in the coastal environment. Alternative is treatment upgraded to a higher level (i.e., BNR plant) to allow greater level of application on to existing land as not hydraulically limited but nitrogen (leaching) limited.
WWTP upgrades would be required for additional flow.
Conveyance system may need to be increased (additional or upsized pipelines) for the additional flow.</td></tr>
<tr><td>j. Staging Possibilities</td><td colspan="2">Based on projected flows, the additional chemical clarifier can be deferred until required by population growth.
Land application infrastructure could be staged though the land may need to be secured early.
Conveyance pipework would have to be constructed for the future flows required, however pumps could be staged for growth.</td></tr>
<tr><td>k. Comparative cost estimate</td><td colspan="2">Comparative Cost Estimate in millions.

<table>
<tr><th>NPV</th><th>$730</th></tr>
<tr><td>Treatment</td><td>$56</td></tr>
<tr><td>Conveyance</td><td>$298</td></tr>
<tr><td>Wetlands & Land Passage</td><td>$9</td></tr>
<tr><td>Land Application Infrastructure</td><td>$182</td></tr>
<tr><td>Land Application Land Purchase</td><td>$94</td></tr>
<tr><td>Total Capex (P50 Contingency)</td><td>$652</td></tr>
<tr><td>Y1 O&M</td><td>$5</td></tr>
<tr><td>Net Income per annum in Y26-30 (tree harvest)</td><td>$15</td></tr>
</table>
</td></tr>
</table>

l. Key matters	• Discharge outside of Palmerston North city boundaries • Wetlands would need to be kept alive when discharging to land • Discharge to the River approximately 57% of the time • TN = 35mg/L results in reasonably large land area required and would require security on ongoing use of land. Alternative would be higher level of treatment and smaller land area. • High capital cost but income stream from forestry • Less cost than L+R (b) as less irrigation in wetter (winter) periods. • Depending on location groundwater flows likely to be to ocean, so less potential than inland options for (any) contamination of bore water

4.10 Option 10: O+L / Ocean with Land (coastal)

Formerly Option 6.



a. Flow triggers for different discharge elements	Treated wastewater (50% of ADWF) applied to land for an average of 6 months per year (nominally Nov – April inclusive). All other flows the treated wastewater would be discharged via the Ocean outfall, except on the highest 3% of days by WWTP flow (exceptional flow conditions), when the treated wastewater would be discharged to the Manawatū River near the Tōtara Rd outfall.	
b. Treatment upgrades	Treatment Level 1 Similar level of treatment to the existing WWTP without chemical phosphorous removal. Would require the following new infrastructure: • New grit removal facilities (replacing existing facilities) • Additional primary sedimentation tanks (for population growth) • New aerators and baffles in existing aerated lagoons • Upgrade of existing UV disinfection facility	
c. Wetland/land passage	Overland flow (Land Passage Type 4) and diffuse land passage (Land Passage Type 1) discharge to water.	
d. Land application location	Coastal, sand dune location	
e. Land use alternatives	The coastal land application sites are typically dominated by sandy soils. Exotic Forestry is the recommended land use for these regions.	
f. Land application area requirements	Irrigation Area Required (ha)	1,130
	Buffer Area Required (ha)	340

<table>
<tr><td></td><td>Total Area Required (ha)</td><td>1,470</td></tr>
<tr><td>g. Land application infrastructure</td><td colspan="2">• Solid set irrigation.
• 10,000 m^3 onsite storage facility (lined), lagoon area 0.5 ha.</td></tr>
<tr><td>h. Conveyance upgrades[9]</td><td colspan="2">1300mm dia pipeline in the road reserve (38km km long)
Pump stations including power supply to pump stations (4 No.)
1300mm dia outfall, 2km long. Buried a land end, sitting on sea bed, with diffuser arrangement at the end.</td></tr>
<tr><td>i. Offshore ocean outfall</td><td colspan="2">Ocean outfall 2km offshore with diffuser, approximate 20m depth at discharge.</td></tr>
<tr><td>j. Regional Scheme</td><td colspan="2">Would require additional land area. Alternative is treatment upgraded to a higher level (i.e., BNR plant) to allow greater level of application on to existing land as not hydraulically limited but nitrogen (leaching) limited.
WWTP upgrades would be required for additional flow.
Conveyance system may need to be increased (additional or upsized pipelines), including the ocean outfall scheme for the increased flow.</td></tr>
<tr><td>k. Staging Possibilities</td><td colspan="2">Based on projected flows, the additional chemical clarifier can be deferred until required by population growth.
Land application infrastructure could be staged though the land may need to be secured early.
Conveyance pipework would have to be constructed for the future flows required, however pumps could be staged for growth.</td></tr>
<tr><td>l. Comparative cost estimate</td><td colspan="2">Comparative Cost Estimate in millions.

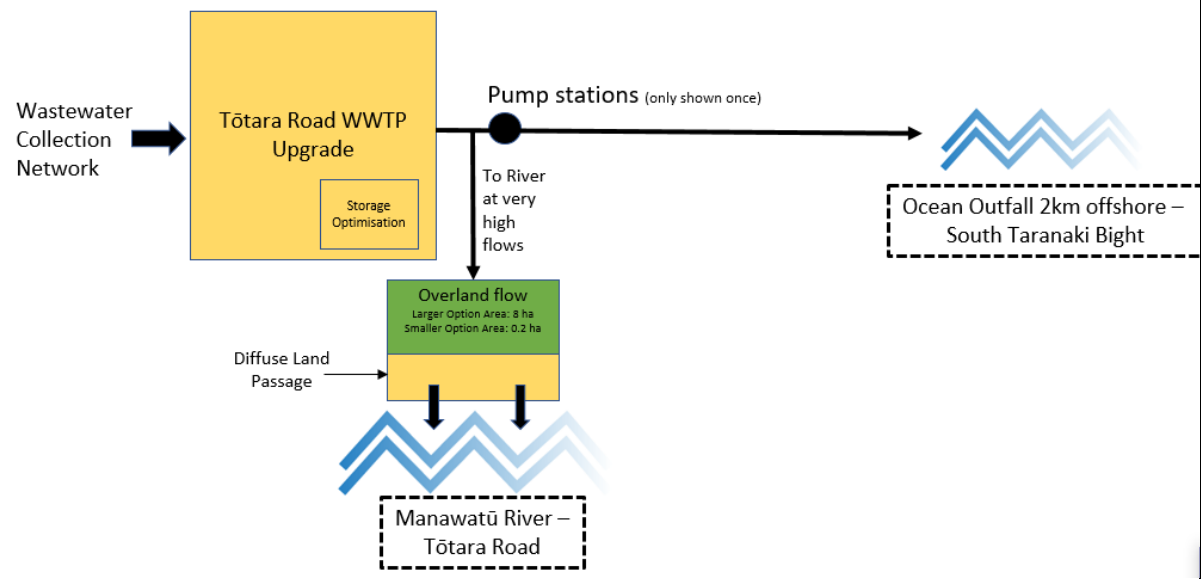
<table><tr><th>NPV</th><th>$621</th></tr><tr><td>Treatment</td><td>$50</td></tr><tr><td>Conveyance (including outfall & diffuser)</td><td>$328</td></tr><tr><td>Overland Flow & Land Passage</td><td>$15</td></tr><tr><td>Land Application Infrastructure</td><td>$93</td></tr><tr><td>Land Application Land Purchase</td><td>$48</td></tr></table></td></tr>
</table>

[9] It has been assumed that the land application sites are in near proximity to the ocean outfall starting point in the conveyance estimations.

	Total Capex (P50 Contingency)	$547
	Y1 O&M	$5
	Net Income per annum in Y26-30 (tree harvest)	$7
m. Key matters	• Discharge outside of Palmerston North city boundaries • Still discharges to the River in exceptional flow conditions • TN = 35mg/L results in larger land area required and would require security on ongoing use of land. Alternative would be higher level of treatment and smaller land area. • Small land area required and would require security on ongoing use of land • Large land parcels in this area so fewer affected parties • High capital cost but income stream from forestry • Less cost than L+R (b) 97% of the time to land (coastal) as less, or no, irrigation in wetter (winter) periods. • Depending on location groundwater flows likely to be to ocean, so less potential than inland options for (any) contamination of bore water • Compatible with existing WWTP operation (without need for phosphorous removal clarifier)	

4.11 Option 11: Ocean Discharge Only

Formerly a variation of Option 6



a. Flow triggers for different discharge elements	All treated wastewater would be discharged via the Ocean outfall, except on the highest 3% of days by WWTP flow, when the treated wastewater would be discharged to the Manawatū River near the Tōtara Rd outfall.
b. Treatment upgrades	Treatment Level 1 Similar level of treatment to the existing WWTP without chemical phosphorous removal. Would require the following new infrastructure: • New grit removal facilities (replacing existing facilities) • Additional primary sedimentation tanks (for population growth) • New aerators and baffles in existing aerated lagoons • Upgrade of existing UV disinfection facility
c. Wetland/land passage	Overland flow grass (Land Passage 4) and diffuse land passage (Land Passage 1) discharge to water.
d. Conveyance upgrades[10]	1300mm dia pipeline in the road reserve (approx. 38km long) Pump stations including power supply to pump stations (approx. 4 No.) 1300mm dia outfall, 2km long. Buried at land end, sitting on sea bed, with diffuser arrangement at the end.

[10] For the indicative comparative cost estimate calculation it has been assumed that the land application sites are in near proximity to the ocean outfall location in the conveyance estimations.

<table>
<tr><td>e. Offshore ocean outfall</td><td>Ocean outfall 2km offshore plus diffuser, approximate 20m depth at discharge.</td></tr>
<tr><td>f. Regional Scheme</td><td>WWTP upgrades would be required for additional flow.
Conveyance system may need to be increased (additional or upsized pipelines), including the ocean outfall scheme, for the increased flow.</td></tr>
<tr><td>g. Staging Possibilities</td><td>Limited opportunities for staging new infrastructure at the WWTP or conveyance system. Some pump costs could be deferred.</td></tr>
<tr><td>h. Comparative cost estimate</td><td>Comparative Cost Estimate in millions.

<table>
<tr><th>NPV</th><th>$480</th></tr>
<tr><td>Treatment</td><td>$50</td></tr>
<tr><td>Conveyance including outfall & diffuser</td><td>$328</td></tr>
<tr><td>Overland Flow & Land Passage</td><td>$15</td></tr>
<tr><td>Land Application Infrastructure</td><td>-</td></tr>
<tr><td>Land Application Land Purchase</td><td>-</td></tr>
<tr><td>Total Capex (P50 Contingency)</td><td>$406</td></tr>
<tr><td>Y1 O&M</td><td>$5</td></tr>
<tr><td>Net Income per annum in Y26-30 (tree harvest)</td><td>$0</td></tr>
</table>
</td></tr>
<tr><td>i. Key matters</td><td>• Discharge outside of Palmerston North city boundaries
• Still discharges to the River in high flow conditions
• High capital cost, no income stream
• Compatible with existing WWTP operation (without need for phosphorous removal clarifier)</td></tr>
</table>

Appendix 1: Glossary of Terms

Technical Glossary of Terms and Abbreviations
(Scientific and Resource Management)

Prepared as part of WP2

Term	Abbreviation	Meaning
Accrual Period		The period of relatively stable river flow conditions between one high flow event and the next, during which **periphyton biomass** can increase
Acute Toxicity		
alum		Aluminium sulphate
Average Daily Flow	ADF	Average Daily Flow
Average Dry Weather Flow	ADWF	Average Dry Weather Flow
Assessment of Effects on the Environment		This document is required under the Resource Management Act to support new resource consent applications.
Ash-Free Dry Weight	AFDW	Ash Free Dry Weight can be used as a measure for algae biomass
Algae		Simple chlorophyll-bearing cells. Most are aquatic and unicellular. Some may link to form colonies or filaments and become macroscopic. They are an evolutionary early form of plants.
Alkalinity		The chemical content of water/wastewater in terms of the carbonates, biocarbonates and hydroxides containing elements of calcium magnesium, sodium, potassium and ammonia.
Ammonia	NH^3	Measured as total ammonia NH_4 or as Ammonia N
Ammoniacal - nitrogen	NH^4 - N	
Australian and New Zealand Guidelines for Fresh and Marine Water Quality	ANZECC	
Benthic-Macroinvertebrates		Bottom-dwelling animals without backbones in streams (e.g. snails, works, caddisflies, mayflies, etc.)

Term	Abbreviation	Meaning
Best Practicable Option	BPO	As interpreted in the RMA, best practicable option in relation to a discharge of a contaminant or an emission of noise, means the best method for preventing or minimising the adverse effects on the environment having regard, among other things, to— (a) the nature of the discharge or emission and the sensitivity of the receiving environment to adverse effects; and (b) the financial implications, and the effects on the environment, of that option when compared with other options; and (c) the current state of technical knowledge and the likelihood that the option can be successfully applied
Biomass		The weight of living matter of an algae, plant or animal. For stream periphyton, this weight is usually expressed in terms of Ash-Free Dry Weight of chlorophyll *a* on an aerial basis
Biosolid		
Biota		Any assemblage of living organisms in a specific area
Biological Nutrient Removal (BNR)	BNR	This refers to the biological nitrogen and phosphorus removal process
Carbonaceous Biochemical Oxygen Demand ($cBOD_5$)		This is a measure of the organic strength or load of wastewater (measured as a five-day standard test)
cfu/100mL		A measure of colony forming units of micro-organisms per 100mL of liquid sample
Chemical Clarifier		A quiescent (settling) tank in which fine solids, usually measured as suspended solids are removed, aided by the addition of chemicals. In Council's phosphorus removal clarifier the chemical is alum (aluminium sulphate)
Chlorophyll *a*	Chl *a*	Chlorophyll is a pigment in algae and plants responsible for capturing energy from light to drive metabolic processes and the synthesis of organic matter from inorganic substances. Chlorophyll *a* can be used as a measure of algae biomass (the *a* stands for algae)
Chlorination		The disinfection of wastewater using chlorine chemicals
Chronic Toxicity		

Term	Abbreviation	Meaning
Coagulation		Coagulation (also known as flocculation) is a treatment process to precipitate phosphorous and flocculate the solids usually undertaken in a chemical clarifier.
Contaminant		As defined in the RMA, contaminant includes any substance (including gases, odorous compounds, liquids, solids, and micro-organisms) or energy (excluding noise) or heat, that either by itself or in combination with the same, similar, or other substances, energy, or heat— (a) when discharged into water, changes or is likely to change the physical, chemical, or biological condition of water; or (b) when discharged onto or into land or into air, changes or is likely to change the physical, chemical, or biological condition of the land or air onto or into which it is discharged
Chemical Oxygen Demand (COD)	CO	Chemical Oxygen Demand is a measure of the organic strength of the waste when measured chemically
Cumecs		Cubic metres per second (m^3/sec) – a flow rate for river and / or wastewater flow
Cumulative Effects		Those effects arising over time, and those effects that arise in combination with other effects. Any one incremental change may be insignificant in itself, but at some point in time or space, the accumulation of insignificant effects becomes significant
Cyanobacteria		Filiamentous bacteria containing chlorophyll and capable of full autotrophy (that is, capable of making nutrient from inorganic materials). Previously grouped with the algae, cyanobacteria are now recognised as a distinct group of organisms more closely related to bacteria. They are one of the most primitive groups of organisms
Dissolved Air Floatation	DAF	xxxxx
Diatoms		A large sub-group of algae containing a specific set of pigments and an internal shell
Decholorination		A chemical or physical process in which residual chlorine is partially or completely reduced.
Denitrification		A biological process in which nitrates are reduced to nitrogen gas

Term	Abbreviation	Meaning
Dissolved Inorganic Nitrogen	DIN	This is a combination of ammonia nitrogen + nitrate nitrogen
Disk Filter		A filtration system with rotating disks covered with cloth or other type of membrane to filter fine solids from the wastewater
Discharge Permit		A discharge permit refers to a consent to do something that would otherwise contravene section 15 of the RMA. In other words, a discharge permit is a consent to discharge contaminants into the environment.
Dissolved Oxygen	DO	
Dissolved Reactive Phosphorus	DRP	Dissolved Reactive Phosphorus (typically about 80% to 90% of Total Phosphorus (TP) in domestic wastewater) DRP = SRP (Soluble Reactive Phosphorus)
Dry Weather Flow	DWF	Average daily flow during a period without rain
Effect		As defined in the RMA, unless the context otherwise requires, the term effect includes— (a) any positive or adverse effect; and (b) any temporary or permanent effect; and (c) any past, present, or future effect; and (d) any cumulative effect which arises over time or in combination with other effects— regardless of the scale, intensity, duration, or frequency of the effect, and also includes— (a) any potential effect of high probability; and (b) any potential effect of low probability which has a high potential impact.
Enterococci		The presence of enterococci bacteria is used as an “indicator micro-organism” for pathogenic micro-organism, and is measure as a number of n/100mL of water or wastewater sample.
Environment		As defined in the RMA, environment includes— (a) ecosystems and their constituent parts, including people and communities; and (b) all natural and physical resources; and (c) amenity values; and

Term	Abbreviation	Meaning
		(d) the social, economic, aesthetic, and cultural conditions which affect the matters stated in paragraphs (a) to (c) or which are affected by those matters
Escherichia Coli	E.coli	This is a species of bacterium normally present in the intestinal tract of humans and other animals. The presence of E.coli means is used as an indicator of faecal contamination, and as a "micro-organism indicator" for pathogenic micro-organisms.
Ethanol		A chemical carbon source used as supplementary carbon for denitrification in the biological treatment process
Faecal Coliform	FC	The presence of faecal coliform bacteria is used as an "indicator micro-organism" for pathogenic micro-organisms measured as number of n/100mL of water or wastewater sample.
Flocculation		Flocculation (also known as coagulation) is a treatment process to precipitate phosphorous and flocculate the solids usually undertaken in a chemical clarifier.
g/m^3 = mg/L		Grams per cubic metre being a concentration measure of a contaminant in liquid, g/m^3 is the same as mg/L and is in effect the same as parts per million (ppm)
Hectare	ha	Land area unit equating to 10,000m^2
Importance Level 3	IL3	Importance Level 3 – Structures that may contain crowds, have contents of high value to the community or pose a risk to large numbers of people in close proximity, such as conference centres, stadiums and airport terminals.
Indicator micro-organisms		There are a number of these identified above – expand definition
Litres per second	L/s	A measure of flow rate
Managed Aquifer Recharge	MAR	
Marcophytes		Larger, multi-celled aquatic plants (e.g. > 100cm) with differentiation of tissue to form distinct stems and leaves / pinnules. They include mosses, liverworts and true vascular aquatic plants such as oxygen weed and *Typha*
Moving Bed Bioreactor	MBBR	A Moving Bed Bioreactor is a compact integrated fixed film activated sludge system that contains thousands of polyethylene biofilm carriers which are mixed in an aerated tank

Term	Abbreviation	Meaning
Macroinvertebrate Community Index	MCI	This is used as an indicator of organic pollution
Mana Whenua		means customary authority exercised by an iwi or hapu in an identified area
Median Flow		The middle value of all river flows over a yearly period
Modified Ludzack-Ettinger	MLE	Modified Ludzack-Ettinger refers to a wastewater treatment process configuration which incorporates an anoxic-aerobic activated sludge process for biological nitrogen removal.
Most Probable Number	MPN	Statistical method of counting bacterial colonies.
Multi-Criteria Assessment (MCA)	MCA	
Net Present Value	NPV	
Nitrate (NO^3) and Nitrite (NO^2)		Nitrate and nitrite are oxidation states of nitrogen.
Nitrogen		
Nitrification		A biological process in which ammonia is converted first to nitrite and then to nitrate
Nitrifying Trickling Filter	NTF	Nitrifying Trickling Filter is an aerobic treatment process in which partially treated wastewater flows across a bed of highly permeable media to nitrify the wastewater, that is to convert the ammonia to nitrates
Nephelometric Turbidity Unit	NTU	Used for measuring turbidity
Nutrients		Organic or inorganic chemicals needed by organisms for growth and reproduction. In this, and as with most projects, the principle nutrients are the various forms of nitrogen and phosphorous.
O & M		Operation and Maintenance
One Plan		The Consolidated Regional Policy Statement, Regional Plan and Regional Coastal Plan for the Manawatu-Wanganui Region
Palmerston North City Council	PNCC	

Term	Abbreviation	Meaning
Pathogens		Disease causing microorganisms
Peak Dry Weather Flow	PDWF	Peak Dry Weather Flow for wastewater is the flows in litres per second, or cubic metres per second (cumecs)
Periphyton		A group of organisms in aquatic environment specialised to live on and exploit much larger (usually inert) surfaces. Groups of organism include fungi, bacteria, protozoa and algae. The most conspicuous group is the algae and this group is usually the focus of most studies of periphyton.
Phosphorous	P	
Peak Flow	PF	On an hourly basis (m^3/h
Population Equivalent	PE	
Potential of Hydrogen	pH	Measure of acid or base nature of liquid
Photosynthesis		The process which starches and sugars are produces within plan (or plant-like) cells using carbon dioxide, inorganic nutrients and sunlight. Sunlight is captured with the chlorophyll molecules.
Peak Wet Weather Flow	PWWF	
Quantitative Macroinvertebrate Community Index	QMCI	Quantitative Macroinvertebrate Community Index is used as an indicator of organic pollution based on full counts on individual invertebrates
Receiving Environment		The environment into which a contaminant discharge is made.
Reduced Level	RL	Reduced Level is the height above a sea level datum point
Soluble Inorganic Nitrogen	SIN	Soluble Inorganic Nitrogen is Ammonia + Nitrate + Nitrite
Soluble Reactive Phosphorous	SRP	Soluble Reactive Phosphorous is Dissolved Reactive Phosphorus = SRP = DRP
Stigeclonium sp		A genus of filamentous green algae
Suspended Solids	SS	Suspended Solids equals Total Suspended Solids
Total Suspended Solids	TSS	

Term	Abbreviation	Meaning
Taxa		Groups to which organisms are assigned according to the principles of taxonomy including species, genus, family, etc.
Total Dissolved Phosphorous	TDP	
Total Phosphorous	TP	
Trickling Filter		An aerobic, fixed-film treatment process in which wastewater flows across a bed of highly permeable media
Ultra Violet	UV	Ultra violet light irradiation used as a wastewater disinfection technique
Wastewater		The mix of domestic sewage, trade waste (industrial wastewater) and occasional rainwater and ground water during rainfall and/or high water table periods
Water Quality		The chemical and physical attributes of water such as turbidity, phosphorous concentrations, temperature and major ion concentrations
Water Quality Target		As defined by the One Plan, “Water Quality Target” means an objective or result for water quality towards which efforts are directed. The word “target” in the One Plan does not have the same meaning ascribed to it by the National Policy Statement for Freshwater Management 2011

Appendix 2: Cost Estimate Summaries

Appendix 2	
Project Name	PNCC WW BPO Technical Advisor
Project Number	310003011
Title	Short List Options Comparative Costs
Date	Aug-21
Notes	All costs exclude GST

Option Number	Option Code and Title	Treatment Level	Capital Costs ($M)							Y1 Operating and Maintenance (no income) $M	Net Income pa (Land Application) Y26-30 pa for Coastal Land $M	Net Present Value (NPV) $M
			Treatment Including P&G, Design and Contingency $M	**Conveyance** Including P&G, Design and Contingency $M	**Wetlands & Land Passage** Including Land Purchase, P&G, Design and Contingency $M	**Land Application Infrastructure** Including P&G, Design and Contingency $M	**Land Application Land Purchase (Land Application)** Including P&G, Design and Contingency $M	**Planned Works** Including P&G, Design and Contingency $M	**Total** Including P&G, Design and Market Contingency $M			
1	R2 (b) River Discharge with Enhanced Treatment	4	$183	$1	$45	$0	$0	$12	$241	$6	$0.0	$337
2	R2(b) River discharge with Enhanced treatment, 75% ADWF to Land at low River flow	4	$183	$58	$44	$36	$52	$12	$387	$7	-$0.3	$496
3	Dual R+L(b) Two River discharge points with 75% ADWF to Land at low River flow	2	$56	$117	$21	$53	$60	$12	$318	$6	-$0.3	$419
4	L+R (a) 97% of time to Land (inland)	1	$50	$97	$15	$182	$249	$12	$605	$4	-$4.5	$604
5	L+R (b) 97% of time to Land (Coastal)	3	$157	$298	$15	$170	$81	$12	$733	$7	-$13.0	$836
6	L+R (d-1) to land <80m^3/s / 53% of the time to land (inland)	2	$56	$97	$9	$99	$136	$12	$410	$5	-$1.4	$470
7	L+R (d-2) to land <62m^3/s / 43% of the time to land (inland)	2	$56	$97	$9	$83	$111	$12	$369	$5	-$0.9	$433
8	L+R (e-1) to land <80m^3/s / 53% of the time to land (coastal) TN = 35 mg/L	2	$56	$298	$9	$218	$114	$12	$708	$5	-$18.0	$786
9	L+R (e-2) to land <62m^3/s / 43% of the time to land (coastal) TN = 35 mg/L	2	$56	$298	$9	$182	$94	$12	$652	$5	-$15.0	$730
10	O+L / ocean with land (coastal)	1	$50	$328	$15	$93	$48	$12	$547	$5	-$7.0	$621
11	Ocean discharge	1	$50	$328	$15	$0	$0	$12	$406	$5	$0.0	$480

Notes
1. Average annual operating and maintenance cost is the average over 35 years
2. Operating and maintenance costs are from "Shortlist Options O&M Estimate 20210624"
3. Capex costs are from "PNCC WW Capital Cost Estimates for Review June 2021"
4. NPV discount rate 6%