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Report

Duvauchelle Wastewater Irrigation Option Concept Report

Prepared for Christchurch City Council

Prepared by Beca Ltd

8 March 2019

Revision History

Revision Nº	Prepared By	Description	Date
A	**Amber Murphy**	Draft for Client Review	30/05/2018
B	**Amber Murphy**	Update for SoW106 scope	08/03/2019

Document Acceptance

Action	Name	Signed	Date
Prepared by	**Amber Murphy**		08/03/2019
Reviewed by	**Greg Offer**		08/03/2019
Approved by	**Greg Offer**		08/03/2019
on behalf of	Beca Limited		

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1 Background

This project involves preparing a concept design and cost estimate for beneficial use of treated wastewater from the Duvauchelle Wastewater Plant to irrigate the golf course in Duvauchelle as the preferred alternative to the current discharge of treated wastewater into Akaroa Harbour.

Phase 1 of the project was summarised in the CH2M Beca report *Duvauchelle Wastewater Irrigation Feasibility Assessment, Rev B, November 2017* which included concept design options and cost estimates. This report is intended to summarise Beca's findings from further investigations and completes the current scope of HDM Statement of Work 106.

2 Information Received

Following the November 2017 initial feasibility study, the following information was received from Council:

- Discharge flow from the Duvauchelle Wastewater Treatment Plant (01 December 2017 – 31 March 2018)
- Updated discharge flow from the Duvauchelle Wastewater Treatment Plant (01 April 2018 – 31 August 2018)
- Rainfall data from the Akaroa EWS station for the same periods
- Akaroa Golf Club fairways map
- Akaroa Golf Course drone and LiDAR survey data (mesh, point cloud, contour plan, aerial photo mosaic, and flyover video)

A site visit was undertaken with the Akaroa Golf Club 04 December 2017 to review the site condition and discuss design options. A second site visit was undertaken 05 September 2018 to review overland flow paths on site.

3 Review of Wastewater Flow Data

The concept option designs described in this report were completed based on the 01 December 2017 – 31 March 2018 discharge flow and rainfall datasets. Review of the wastewater flow data identified the following key summary figures:

- Average daily discharge: 125 m^3/day
- Maximum discharge 328 m^3/day (during 181.8 mm total rainfall storm event)

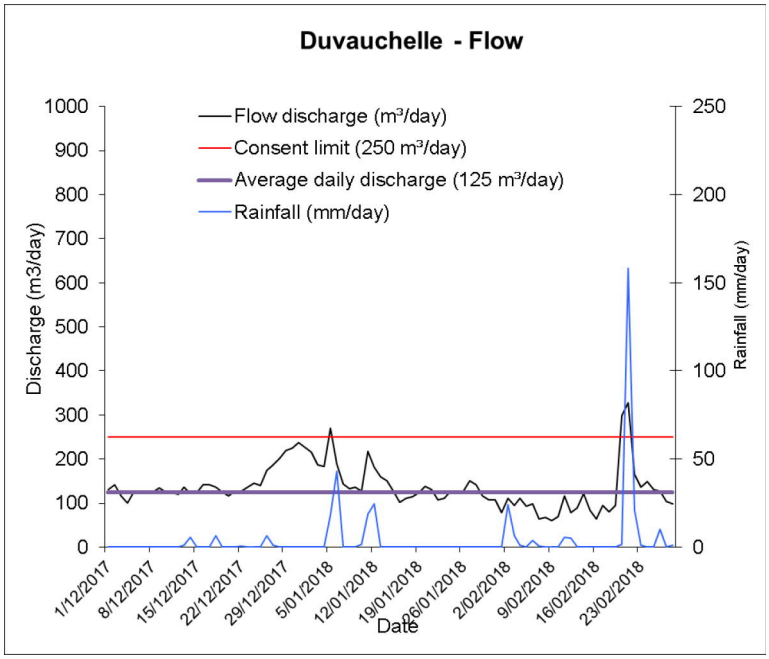

Figure 1 - Flow data 01/12/2017 - 31/03/2018

A synthetic long term discharge record from 1972 to 2018 was developed based on the data. Dry weather and wet weather discharge was separated out from the measured data.

- Average Dry Weather Flow (ADWF) (summer): 110 m³/day
- Average Dry Weather Flow (ADWF) (Christmas period): 196 m³/day

Event totals for rainfall and discharge during the storm events were calculated. The corresponding average dry weather flow was subtracted from the wet weather flows to estimate Inflow and Infiltration (I&I). A linear relationship between event rainfall versus I&I was derived. This relationship was used to model inflow and infiltration based on rainfall (this is approximate, if the scheme is to be developed further, additional rigor will be needed in assessment and modelling of flows).

Long term rainfall and potential evapotranspiration data was obtained from NIWA's Virtual Climate Network Station (VCNS 20116) for the period 1972 - 2018. The virtual station is located approximately 3.5 km north of the proposed land disposal area. The developed average dry weather flows were applied to the long term record. No increase in future dry weather flows was assumed, it was assumed any increase from development or growth are minimal and are countered in I&I reductions through renewals over the scheme life.

The rainfall versus I&I flow relationship was applied to the VCNS series to estimate wet weather discharge for the period 1972 - 2018.

The catchment is small, with a relatively new pipe network. Council has indicated that infiltration would be most likely from a few point sources, which could be identified in future council investigations and repaired. Distributed temperature sensing may be a useful tool for identifying I&I issues; this has been used successfully in Akaroa.

No increase in I&I during winter was assumed (the available flow record is during a summer period); winter I&I can increase due to higher ground water conditions. At present the risk of higher winter I&I is unquantified and needs to be managed as the project progresses. Flow monitoring during winter will assist with understanding this.

3.1 Updated April – August 2018 flow data review

Following the development of the concept options, addition flow and rainfall data for the period 01 April 2018 – 31 August 2018 was received. A high level comparison review to the existing dataset was undertaken of this data.

Dry weather flow

- The normal discharge over the May to mid-July period appears to be marginally higher than the normal discharge over Summer/Autumn months.
- In discussing with PDP, they advised base flow changes in the new data would probably not result in a large difference to the irrigation/storage modelling.
- With this additional flow data, we have a reasonable understanding of the baseflow: being 110–125 m^3/day).

Wet weather flow

- In the existing data, a 158.4 mm rainfall event on 21/02/2018 (one day rainfall, total event 181.8 mm) resulted in 328 m^3 of discharge flow
- In the updated dataset 43.4 mm of rainfall on 16/07/2018 resulted in 682 m^3 of discharge. A second event of 35.4 mm on 13/06/2018 resulted in 498 m^3 of discharge flow.
- These differences (“spikes”) in rainfall discharge relationship would change the modelled linear relationship between an event rainfall versus I&I. Indicatively, the single 16/07/2018 rainfall event could cause 700 m^3 of inflow to the modelled storage requirements, with the existing event rainfall versus I&I relationship it would have been approximately 200 m^3. This change has the potential to impact the overall storage requirements of the concept options, and therefore storage pond requirements.

This discharge flow response in the updated dataset may be indicative of I&I behaviour; it is a similar pattern to that experienced in Akaroa however not as substantial. We understand that Council are in the process of installing additional flow meters on the pump stations, which will provide additional valuable data to improve the accuracy of the flow analysis and design work. Council also have the option in the future of undertaking DTS to identify any point source I&I issues in Duvauchelle, and undertake targeted works to reduce I&I. The wastewater network in Duvauchelle consists of plastic pipes, and compared to the Akaroa system is relatively newer, and expected to be in better condition.

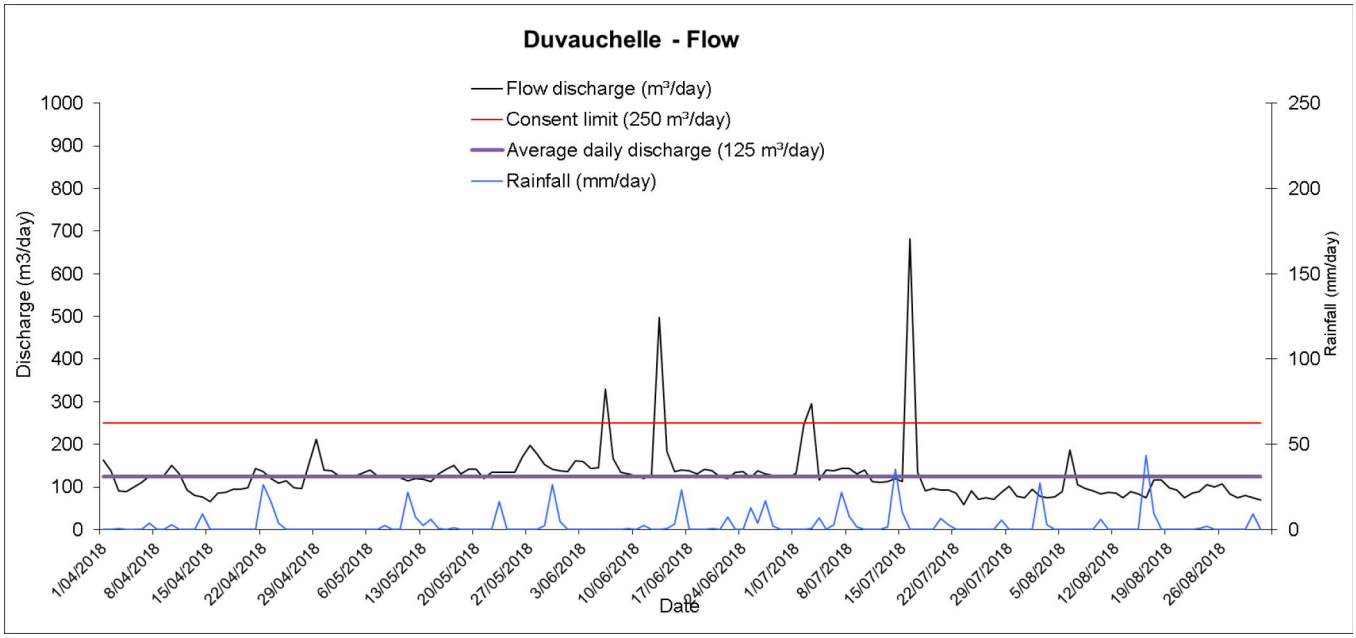

Figure 2 - Flow data 01/04/2018 - 31/08/2018

3.2 Data Confidence

The accuracy of the synthetic flow record depends entirely on the accuracy of the measured discharge data provided for the period 1/12/2017 to 31/03/2018. It is assumed that the average dry weather flow from the limited measured period is representative of the whole year, and that year a representative year. The model calculates I&I based on the relationship of rainfall vs. flow for the measured period. Due to the limited number of data points this relationship should only be considered as approximate.

We recommend that flow and rainfall records and continued to be recorded, and used to re-run the synthetic flow model. Due to the current flow record available, we recommend this analysis is updated at each project stage as it may have a significant effect on required irrigation area and storage volume. We understand council are in the process of installing flow meters on each of the two pump stations, which will provide additional valuable data to improve the accuracy of the design work. We also recommend Council undertake a calibration check on the treatment plant flow meter now that is has been installed for 9 months.

3.3 Golf Course Annual Irrigation Volume

The volume of water irrigated by Akaroa Golf Club to the fairways and greens during the 2017/2018 summer irrigation period has been estimated as 13,650 m³.

Based on an irrigation period of 100 days, and an irrigation area of 2 ha (slightly larger area than only the greens and tees) this is equivalent to the assumed recommended maximum irrigation rate of 7 mm/day.

The irrigation volume calculation is based on:

- Pump: Starline Model 65x40-250 with a 275 mm impeller and a 22kW motor pumping at 10 L/s
  - based on data recorded on site by Andrew Brough (PDP) and his personal communications with staff at 43South who are the current suppliers of this pump.
  - Confirmation of the actual pump model, impeller size, and flow rate have not been confirmed by the Golf Club.
- Power Usage: Annual power used for irrigation of 8340 kWh.

  - based on the power information supplied by Akaroa Golf Club for the meter at the Greenkeepers Shed. Over winter when no irrigation took place there was still some power used which is attributed to lighting etc. within the shed. This winter power use was averaged to represent the power used within the shed (lighting etc.) when irrigation was occurring. The actual usage for the winter months along with calculated average usage for irrigation months was removed from the total power used to obtain the estimate of the power used by the irrigation pumps.
- Estimated Irrigation Volume = power used / pump motor power * pump flow per hour
  = 8340 / 22 * (10L/s*3600s=36 m³/hr)
  = 13,647 m³

This is an estimate based on the 2017/2018 irrigation period. The actual irrigation water used by the Golf Club will have varied between years depending on environmental conditions.

4 Soil Moisture Balance Model

The synthetic record from 1972 - 2018 was run through a soil moisture balance model to estimate storage requirements under a range of irrigation areas. The model assumes full pasture, drip irrigated to soil moisture balance (i.e. no irrigation if PAW of 48 mm is exceeded) and a maximum application rate of 7 mm/day. The assumption is that the irrigation will be hydraulically limited. We have not looked at nitrogen loadings at this initial stage although this was considered in the ecoEng report (2013). Figure 3 shows the storage required under a range of irrigation areas.

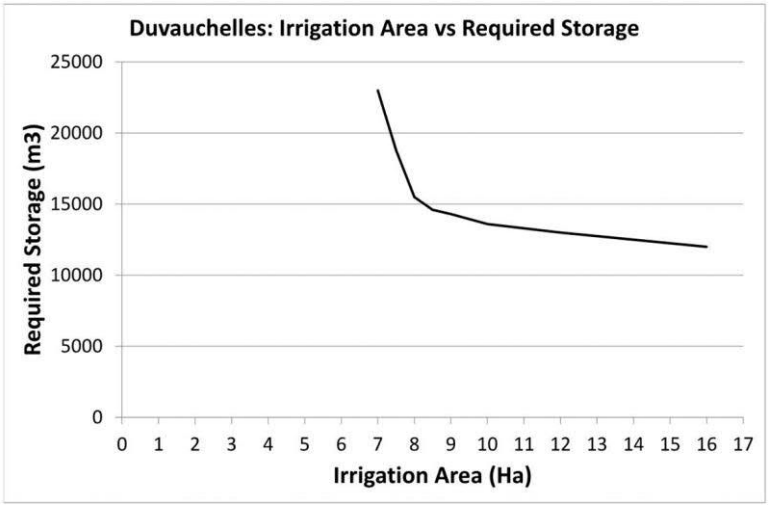

Figure 3 - Duvauchelle Irrigation area versus storage required (assuming land 100% good drainage properties)

5 Irrigable Areas and Required Storage

5.1 Irrigable Area Criteria

Criteria were used to define feasible irrigable land areas in Duvauchelle, the complete analysis was described in *Duvauchelle Wastewater Irrigation Feasibility Assessment, Rev B, November 2017*. Due to the limitations around using spray irrigation on a public facility, and near boundaries it has been assumed for this phase of the work that all irrigation would be via the buried dripper approach. Since the initial analysis, the irrigable land feasible for dripper irrigation has been recalculated to:

- Exclude any land with a slope greater than 15° (land from15-19° could be irrigated by dripper (not spray) if forested, land greater than 19° is not suitable for irrigation)

- Include land within 5-25m of a residential boundary
- It is also assumed that only land within the Golf Course and A&P showgrounds is to be irrigated

It may be possible to spray irrigate some parts of the golf course, this will not affect the irrigation area required nor the storage provision. Additional criteria described below excluded land assessed as being too close to waterways, coastal environments, or boundaries.

Table 1- Assessment Criteria for Land Suitable for Dripper Irrigation

Selection Criteria	Dripper irrigation option	Basis for Criteria Selection
Land Stability	- Include land that is less than 15 degrees slope and downslope to coastline same grade or less - Include land that has no identified instability within or downhill of area - Exclude land that, if it became unstable, could pose risk to downslope residences and infrastructure	- To minimise risk of land instability resulting from irrigation
Stream setback	25m to centreline of continuous flowing streams (note that there is the opportunity to reduce this 10m depending on their on-site classification)	To minimise the potential for nutrients in irrigated wastewater to migrate through shallow groundwater into surface water courses.
Coastline setback	25m	To minimise the potential for nutrients in irrigated wastewater to migrate through shallow groundwater into coastal waters.

5.2 Land Drainage Class

Test pits were excavated across the Duvauchelle Golf Course on 5th and 6th October 2017 to identify soil types and confirm the presence of any low permeability layers or frangipans. This identified three areas based on the soil profiles present:

- Good drainage: Good drainage, ~8ha: irrigation could be achieved all year around apart from instances during winter where the soil becomes saturated. The favourable conditions arise from the appearance of relatively good draining soils, a flat topography and/or on-site experience.
- Moderate drainage ~4ha: irrigation could be achieved however it would be limited to the three months during summer, potentially extending another 3 months or so in instances where the weather has been favourable. These areas mostly had a drainage limiting layer (mostly at approximately 0.7 m below ground, however even above that the soil was often tight) or the topography was relatively steep which may mean the water simply runs off and pools on the lower ground.
- Poor drainage ~10ha deficit: Irrigation only would be appropriate during dry summer months when ground conditions are favourable. This area that has very limited drainage, the conclusion of which was reached by the tight, wet, clay bound material, which was backed up by the grounds keepers comments that suggested those areas were always wet.

5.3 Irrigable Area and Required Storage

The identified irrigable land (section 5.1) was overlain over the drainage classes (section 5.2). The GIS analysis of this identified a total of 10.9 ha of irrigable land, shown in the map in Appendix A.

However only 5.0 ha of the irrigable land is classed as “good” drainage and thus able to be irrigated all year. A specific irrigation regime identified in Table 2 was run through the soil moisture balance model to estimate storage requirements. Storage is required to contain peak flows that cannot be applied through irrigation when the flow exceeds the daily maximum amount of water that can be applied to the available land.

Approximately 18,500 m³ of storage is required for 10.9 ha of irrigable land.

Table 2 - Duvauchelle Irrigation Operating Regime

Drainage Class	Irrigation Operating Regime	Area (ha)
Good	All year	5.0
Moderate	Summer + shoulder only (Oct – Apr)	2.5
Poor	Summer only (Dec – Feb)	3.4
Total assumed irrigable area		10.9

Note that the provision of a storage pond of this scale (refer section 6) may result in up to a 1 ha reduction of the area of feasible irrigable land. In addition the model does not include an allowance for rainfall on to the surface of any pond; a buffer would need to be provided for this in detailed design. Sensitivity modelling has shown that the removal of 1 ha of "good" drainage land results in an increase to the storage requirement to 20,500 m³. Although the impact is more significant where the storage pond is located on "good" drainage land, "moderate" and "poor" drainage land has a significant contribution to reducing the overall storage requirement. The 2.5 ha of "moderate" land is reasonably important as it helps to empty out the storage in the shoulder months in preparation for the critical winter months. If this land was removed from the irrigable land regime, this would result in an increase to the storage requirement to 33,000 m³.

6 Wastewater Irrigation Options

Possible irrigation and storage locations within the Golf Course site were reviewed. Key criteria included:

- The location of golf course fairways and other infrastructure
- Site grade, contours, and topography
- buffers around waterways, residential properties and coastal zones.

Four options have been developed for utilising the treated wastewater from Duvauchelle treatment plant. Options are described below and sketches are provided in Appendix B. Artists impressions are provided in Appendix C.

The following infrastructure requirements have been included in all concept options:

- Pump station located at Duvauchelle WWTP for pumping treated wastewater from treatment plant to irrigation area, sized to take peak flows
- Wastewater rising main sized to take peak flows
- Storage pond built as cut to fill using local materials
- Pump station for pumping from the storage pond to the irrigation area(s)
- Buried drip irrigation to 11 ha of pasture at the golf course

The assumption has been made that the storage will be constructed as a single, covered, earth bunded pond with a plastic liner. This is because this offers the most economical means for constructing large volumes of storage and has a moderate visual impact on the landscape. A pond cover provides added protection against any potential nuisance issues and wave run up concerns, however has a visual and cost impact. The requirements for a cover should be discussed further.

The pond volumes are based off the supplied survey data, and calculated 0.5m contours. The volumes are approximate and expected accuracy is +/- 2000m³. Cut and fill calculations for the purpose are approximate and based off the assumption of a single pond. The depth to rock at each site is unknown. If shallow rock is found this will increase costs.

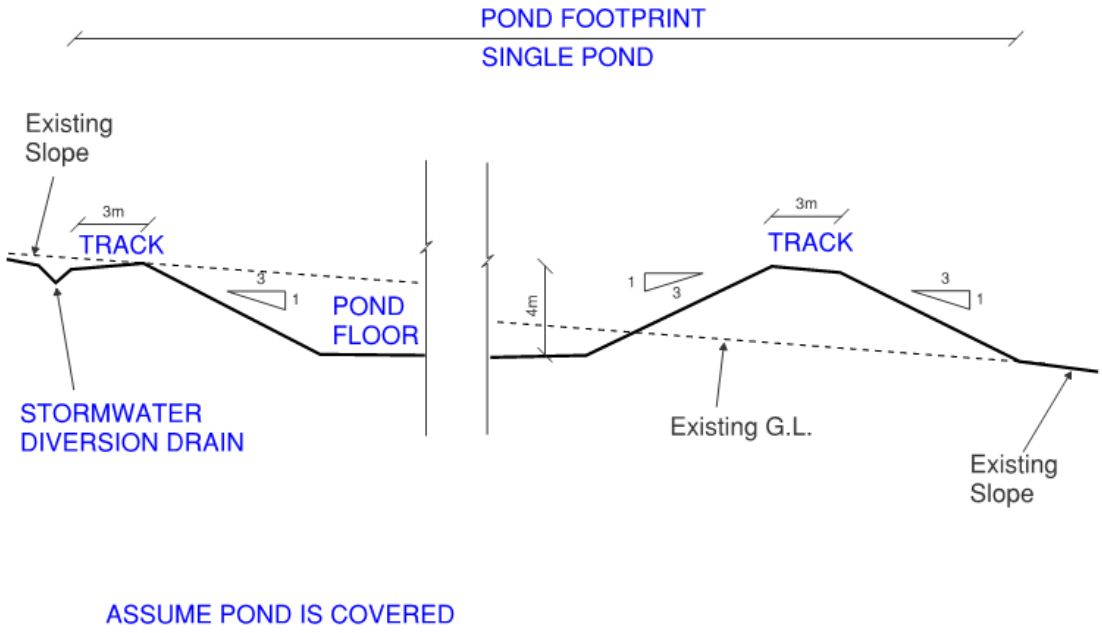

Figure 4 - Typical Storage Pond Cross-Section

6.1 Option 1 – 100% Irrigation, Storage on Golf Course

This option accommodates the maximum feasible irrigation to land within the golf course site. The required storage (19,000 m³) is provided within "moderate" drainage land on the golf course. The storage pond covers the 11th green and small portion of its fairway, and covers a large portion of the fairway on the 12th hole.

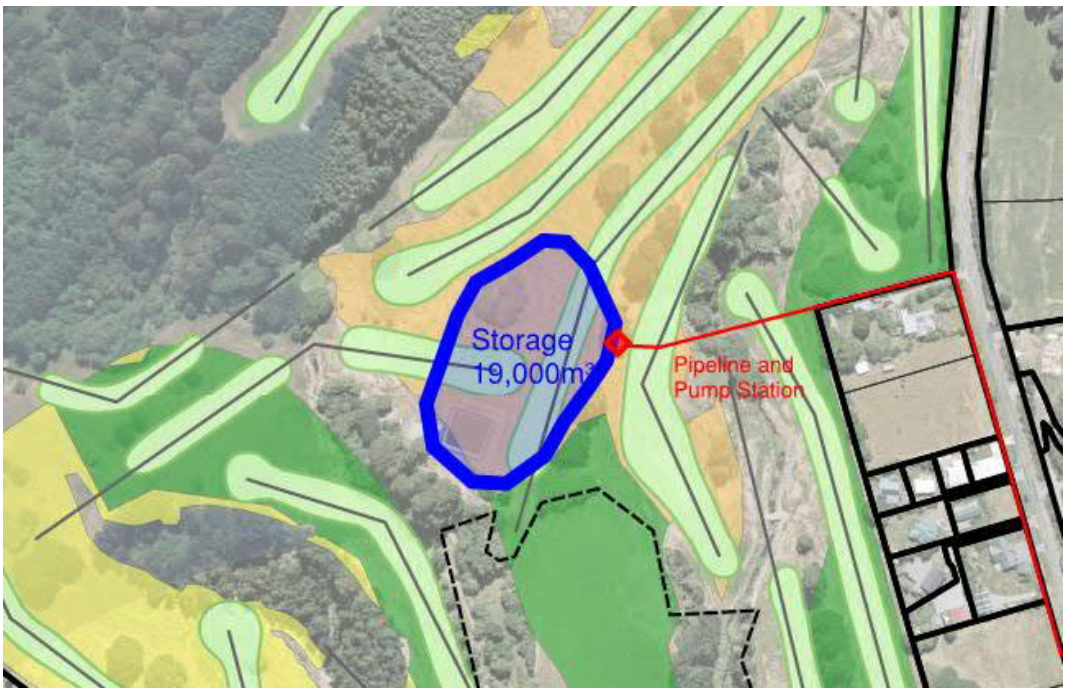

Figure 5 - Option 1

6.2 Option 2 – 100% Irrigation, Storage on Golf Course and partly on A&P Showgrounds

This option accommodates the maximum feasible irrigation to land within the golf course site. The required storage (19,000 m³) is provided within “moderate” and “good” drainage land on the golf course and the A&P showgrounds. The storage pond covers the 11th green, and covers the 12th tee and part of the fairway, and also covers part of the showgrounds. A potential option for fairway redevelopment without loss of overall length is shown.

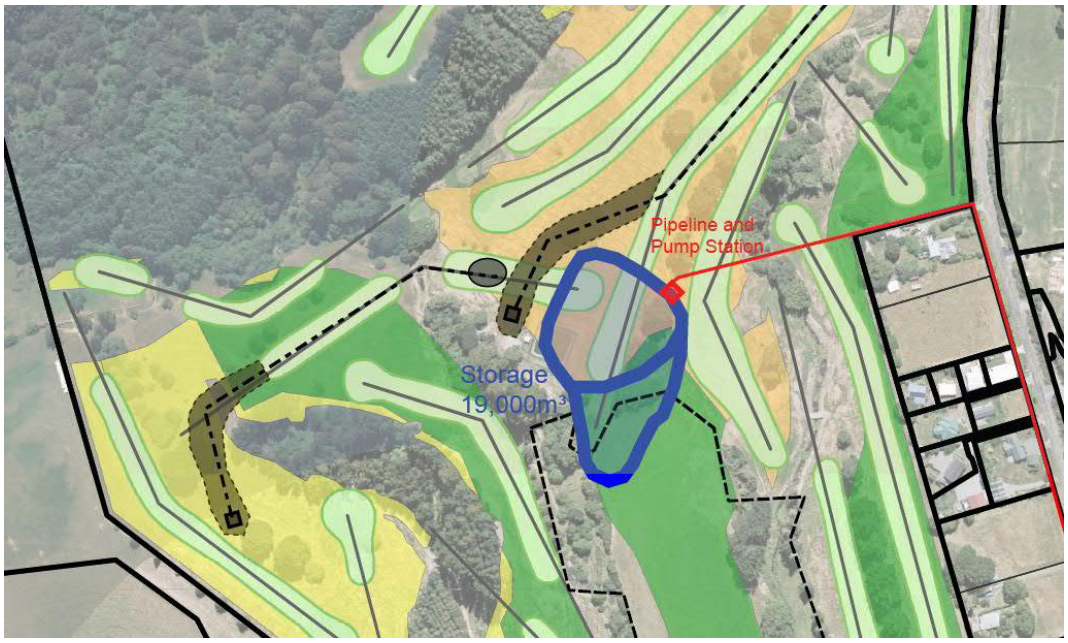

Figure 6 - Option 2

6.3 Option 3 – 100% Irrigation, Storage on A&P Showgrounds

This option accommodates the maximum feasible irrigation to land within the golf course site. The required storage (20,000 m³) is provided within “good” drainage land on the A&P showgrounds. The storage pond covers almost half of the showgrounds. Despite the pond taking up land with good drainage that could otherwise be irrigated the impact on storage volume is minor because winter irrigation onto any land is a small amount only and the pond size is dependent on inflow rather than outflow.

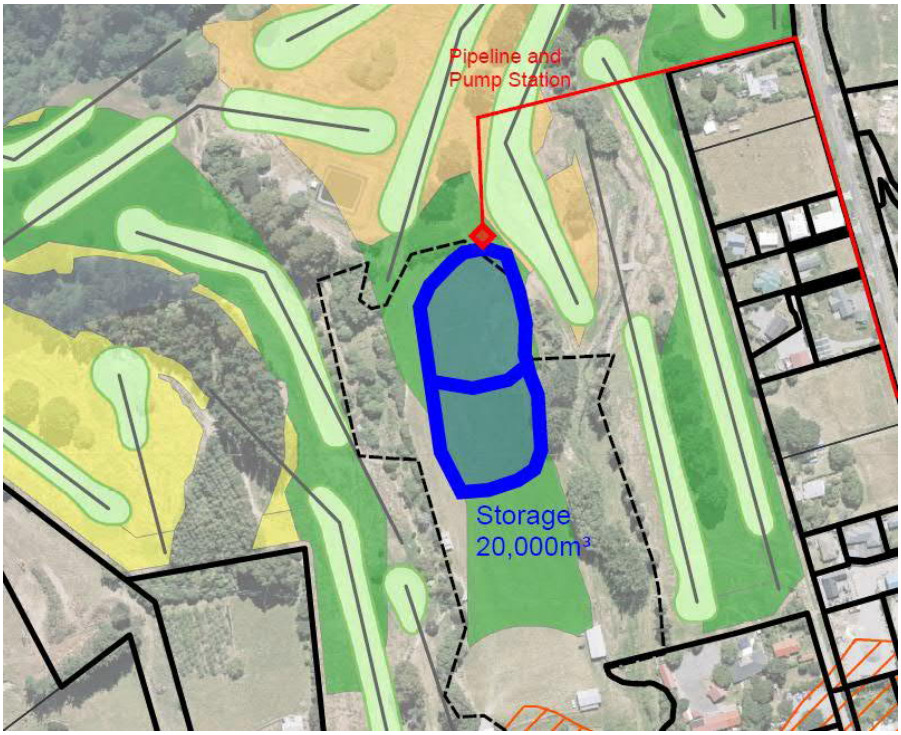

Figure 7 - Option 3

6.4 Option 4 - Combined Irrigation + Bore Injection

Maximum practical storage is provided within the golf course without any adjustment to golf course layout. The pond fits in between the existing fairways/greens but provides limited storage (3,000 m³). The restricted storage requires a combined irrigation option and deep well injection to ground.

For the purposes of option comparison, it has been assumed that only the “good” drainage land will be irrigated. In the poorest irrigation years, regardless of irrigation area, no irrigation can occur for around three months (May, June, July) due to wet weather conditions. To keep the maximum storage under 3000 m³ during this three month period, the maximum irrigation flow would need to be restricted to 33 m³/day, the remaining would have to be injected into deep bores. During summer months, it is likely all flow can be irrigated on the 5.0 ha of “good” land. The combined irrigation and injection analysis is complex, and would need modelling in future stages of the project. The question of how extensively the gold course would be irrigated also needs to be resolved.

Additional treatment of the wastewater would be required prior to well injection to reduce suspended solids content, as solids can clog the bores. This could be in the form of a new disc filter at the wastewater treatment plant. Further to this, periodic dosing of the boreholes with chlorine may be required to clear any build-up of biofilm.

For option assessment, it has been assumed two bores, and two disc filters are required.

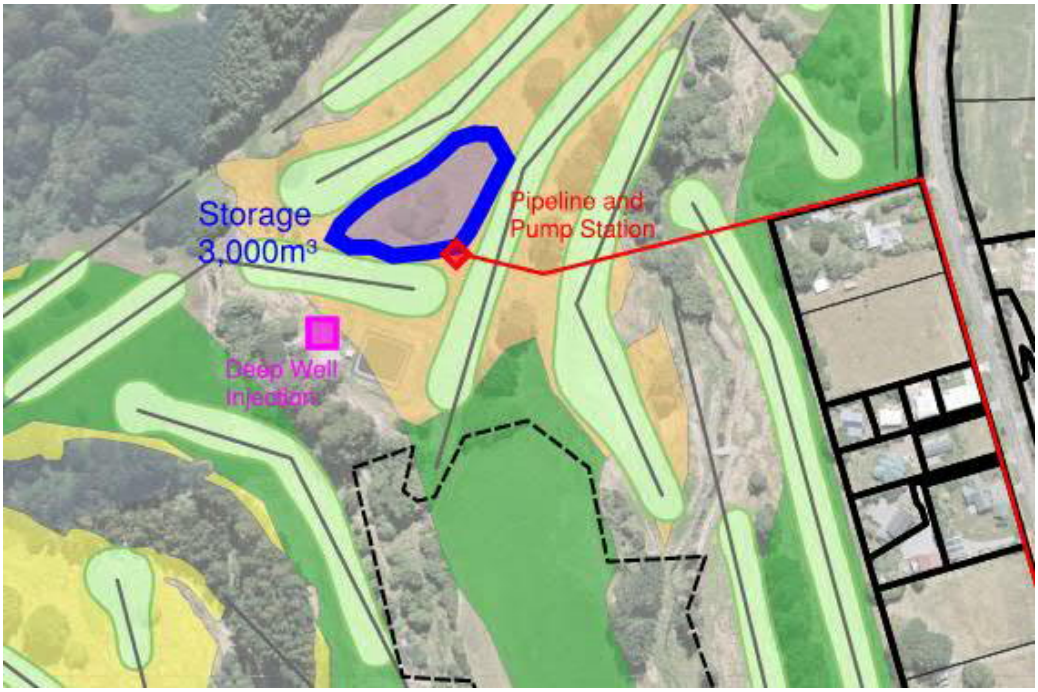

Figure 8 - Option 4

6.5 Capital Cost Estimates

A breakdown of the cost estimates for the options considered are provided in Appendix D and are summarised for the four options below:

Table 3 - Capital Cost Estimate

Option	Rough Order Capital Cost
Options 1 - 3	$4.0M - $5.0M
Option 4	$3.3 - $4.2M

6.6 Safety in Design

Safety in Design is a key consideration in the development of a wastewater irrigation design. An initial Safety in Design assessment was completed by the project team for all identified options and is attached in Appendix G. It is recommended Safety in Design principles be reviewed at different phases of design as the scope of the project is further defined. Some Safety in Design issues highlighted in this study are noted below.

Key Design Actions:

- Archaeological assessment
- Consenting and statutory approvals
- Refinement of storage pond design (pond location, balance/ratio of area to depth, incorporation of golf course design and operational consideration, consideration of overland flow paths)
- Odour/mosquito/bird attraction risks to be evaluated
- Detailed Design to consider debris screens in pond, landscaping of pond embankments, and pump station operational features
- If well injection included in the preferred option, review if any tangible risks to groundwater exist

- Review overall wastewater system with respect to how a bypass / emergency discharge would operate, consider if existing outfall could be retained.

Key Construction / Operational Risks:

- The creation of a large pond within a public utilised site introduces a hazard
- Construction timing important (with respect to wet weather, golf course operations, and the A&P Show)
- Wet weather introduces hazards during construction
- Presence of existing service/utilities
- The construction site will be within public domain / an active golf course: Management of access, communications, and traffic will be important.

7 Consenting / Planning Assessment

A consentability / authorisations review for each option has been undertaken, refer to Appendix E for the full assessment.

7.1 District Plan

The zoning of site area is Open Space Community Parks (OPC). Part of the site is located within the Coastal Environment Overlay and the Coastal Environment "Other Area of Natural Character in Coastal Environment" (NCCE 1.0) Overlay. The site is located within Silent File Area 10a. There are two "Environmental Asset Waterways" (streams) on the site.

The proposed activities associated with wastewater disposal are considered to be a "utility" under the Christchurch District Plan. Construction or operation of structures for the conveyance, treatment, storage or retention/detention of water, wastewater and stormwater by the Council or a network utility operator are permitted activities provided the activity complies with the Built Form Standards for the OCP.

In respect of the Built Form Standards for the OCP Zone, standard for site coverage or the building footprint of the storage pond is unlikely to be met. In addition, the internal boundary setbacks will be infringed for Options 2 and 3 if the golf course and showgrounds sites are regarded as separate sites.

The use of the land for irrigation of wastewater to pasture is not considered to be permitted in terms of Rule 11.8.1 P2 as the rule refers to structures only. The use of land for the irrigation of wastewater is defined as a utility and requires resource consent as a discretionary activity in terms of Rule 11.4.3.

Based on current options none of the overlays/notations trigger specific resource consents other than those identified above.

7.2 Regional Plan

In terms of the relevant Environment Canterbury planning documents the following is of relevance to the proposed options:

- The use of land for a community wastewater treatment system and discharge of treated sewage effluent from a community wastewater treatment system is a discretionary activity under Rule 5.84 of the LWRP, which includes the irrigation of wastewater to land.
- The western part of the site is identified as "High Soil Erosion Risk" in the LWRP. Earthworks associated with any development may require resource consent as a restricted discretionary activity under Rule 5.171. However it is noted that Rule 5.170 does not apply to works for which a building consent from

Christchurch City Council has been obtained so any earthworks associated with a building are exempt from this rule.

- The southern part of the site is identified as overlying an unconfined or semi-confined aquifer. Rule 5.75 of the LWRP requires any excavation to maintain 1 m between any excavation and the aquifer and 50m separation from a waterbody. Earthworks in this area therefore may require resource consent under Rule 5.76 as a restricted discretionary activity.
- The discharge of treated wastewater into deep injection bores into groundwater is a discretionary activity under General Rule 5.6 of the LWRP.
- It is assumed that the storage ponds will have an impermeable liner and accordingly the discharge of treated effluent through the base of the storage ponds will not occur. If there is a discharge, resource consent as a discretionary activity under Rule 5.84 of the LWRP is required.
- The discharge of contaminants to air from the disposal of human sewage effluent including the storage pond/irrigated areas is a discretionary activity under Rule 7.63 of the CARP given that Rules 7.50-7.52 cannot be complied with.

7.3 Planning Summary

A preliminary assessment of effects on the environment of land based disposal and bore injection has identified potential adverse effects that will be required to be addressed include visual impacts, odour, and effects on surface water and groundwater.

The site is located in proximity to some sensitive uses including residences, Duvauchelle School and Akaroa Harbour and waterways so appropriate design will be required. The site also is located in a Silent File area so consultation with Ngai Tahu will be also required. Potentially, earthworks associated with the storage ponds within the site could result in a requirement to apply for an Archaeological Authority, particularly as the site is identified as being in a Silent File Area.

A number of resource consents for the proposal will be required from both Christchurch City Council and Environment Canterbury including use of the site for wastewater disposal, setbacks for buildings, the discharge of wastewater to land and to the deep injection bores, potential earthworks and discharge to air.

8 Overland Flow Assessment

A high level flood path assessment has been carried out to determine whether downgradient properties would be at risk of a sudden release of water from any of the four proposed pond options, the intent to determine whether more refined dam break modelling or pond redesign is required. A detailed description of the analysis is included in Appendix F.

Each pond option has been modelled separately. The assessment replicates a release of the water in the pond as a result of a 5m wide breach (Option 4) or 10m (Options 1-3) in the pond bund. The breach takes ten minutes to develop. The resulting hydrograph has been developed using HEC-HMS software, and applied to a 2D ground surface in HEC-RAS.

The pond breach hydrographs have been applied generally at the lowest current ground levels underlying the pond bunds. The DEM ground surface was represented using Councils' 2008 LiDAR, which was used in preference to more recent point cloud data that included trees, building, other full/partial obstructions that would incorrectly divert or impede modelled flows. The downstream boundary of the model is Akaroa Harbour.

Figures 9 and 10 shows the maximum flood extents from each model run.

The results for Options 1, 2 and 4 show water leaving the channel of Pawson Stream adjacent to the upper end of the show grounds. This is a flatter part of the golf course, before the stream becomes more confined as is flows towards the school. However, all the flow that has left the stream returns to the channel about 100 m upstream of the school.

Option 3 discharges water to Pawsons Stream further downstream than the other options, and has the biggest flow (being the biggest pond system). As such, the extent of flooding in the stream is greater than the other options, with indications that shallow flood water could encroach upon the school site. The school site is lower than the showground on the right bank of Pawsons Stream, and so more susceptible to flooding.

Downstream of the school, the flood modelling indicates that water will spill out of the main channel on both sides of Pawsons Stream, with the majority of flow crossing (and ponding on) the camp ground between the show grounds and the highway. The Plunkett Room is in the southeast corner of this plot, but on slightly raised ground, which appears to protect it from flooding.

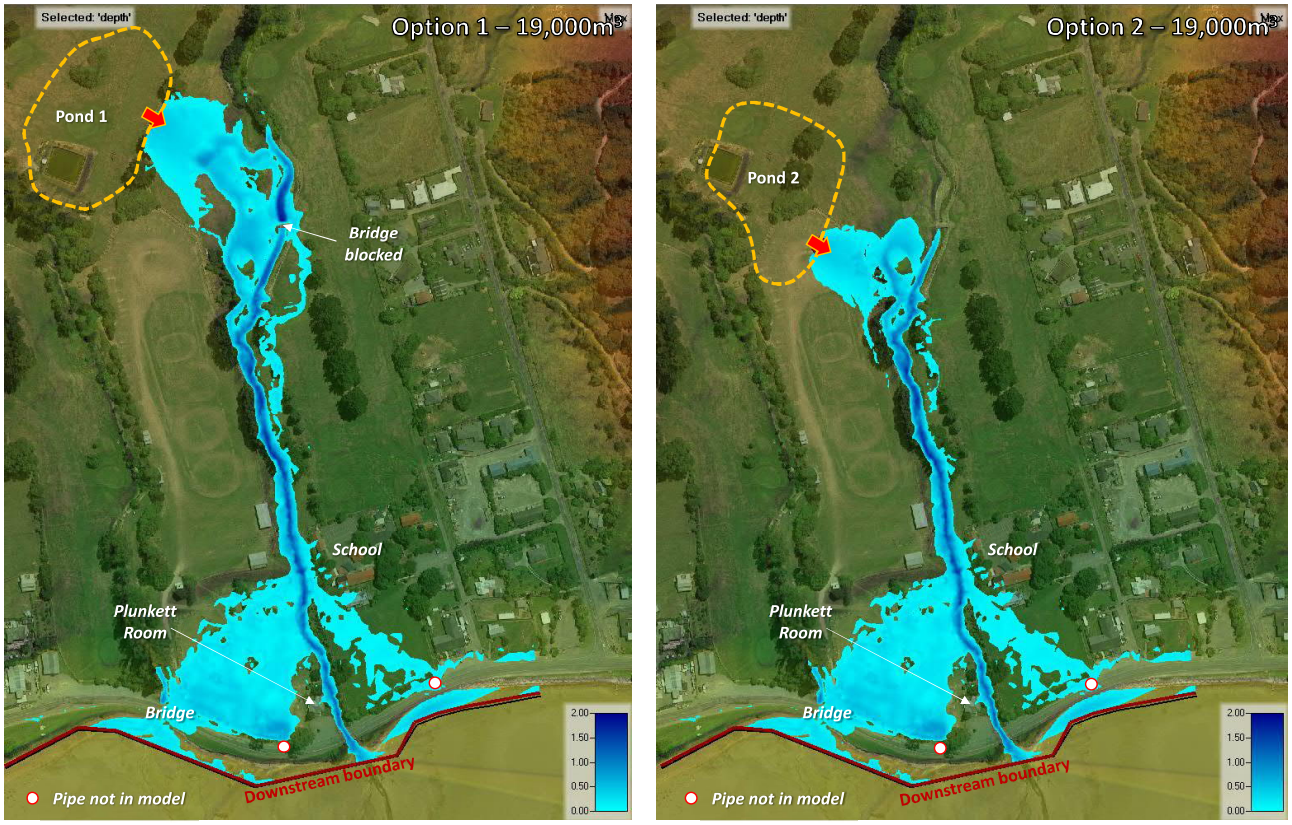

Figure 9 - Modelled Flood Extents (Pond Options 1 and 2)

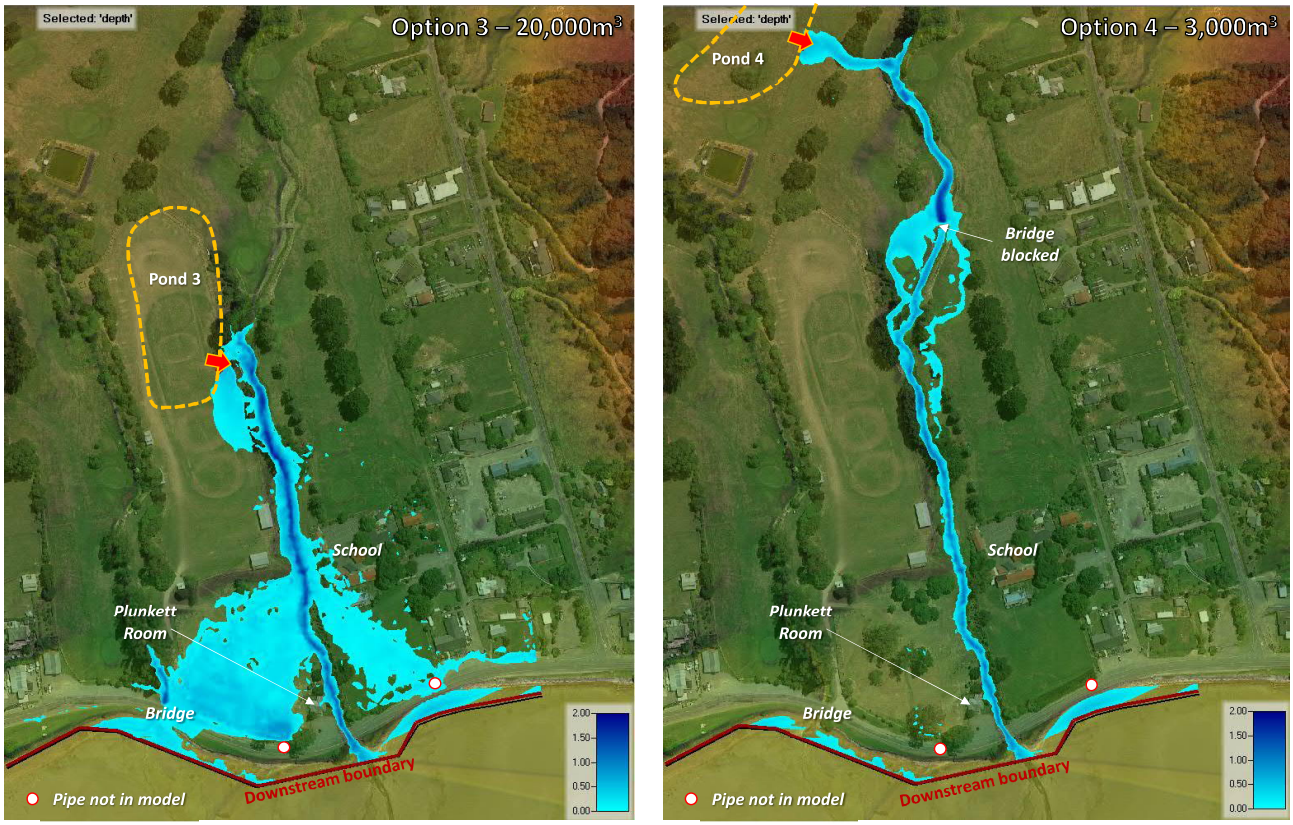

Figure 10 – Modelled Flood Extents (Pond Options 3 and 4)

The conclusion of the high level flood modelling of failure of the storage pond options is that the majority of flow will be retained in the Pawsons Stream channel as is passes behind the Duvauchelle School site. However, the flood extents indicate that floodwaters are close to (or just) entering the school site, and so the school is potentially at risk of flooding from a breach in the proposed ponds, with pond Options 1, 2, and 3 representing the greatest risk. However, the high level assessment described here may over-estimate the risk of flooding; largely due to simplified representation of the pond breach, limited refinement of the ground model, and not including some stormwater pipes and infrastructure in the model.

Therefore, it is recommended that the flood modelling of the ponds is refined once a preferred option has been identified and during detailed design of the pond.

9 Summary and Recommendations

9.1 Summary

The key findings are:

- There is suitable land on the Duvauchelle Golf Course for irrigation of wastewater to land
- A large amount of storage is required to contain peak wet weather flows if 100% of wastewater is to be irrigated
- There is limited suitable land for the volume of storage required for a pasture irrigation scenario
- If storage is provided on the golf course, this is likely to impact on the golf course configuration with the layout of at least one fairway being affected
- Storage will always be required but can be reduced through either:

  - Irrigation to trees (rather than pasture) through purchase of land outside of the gold course and establishment of new plantations.
  - Borehole injection of treated wastewater
- Cost estimates indicate that the four options are relatively comparable, with all between $3.3million and $5.0million.

The preferred option for long term reuse or disposal of treated wastewater from the Duvauchelle Wastewater Treatment Plant is irrigation to land at the council owned land at the Akaroa Golf Course / A&P Showgrounds.

9.2 Risk and Recommendations

The top identified risks at this project stage are described below. Suggestions for future analysis and actions are recommended.

1. Flow uncertainty: recommend council continue to collect flow metering records, and complete flow measurement calibration and validation of the plant discharge flow data
2. Consultation and communications: ongoing updates and sharing of knowledge and learning from Akaroa project and Duvauchelle project stakeholders suggested
3. Deep well injection technical feasibility (due to geomorphology and other variables): further studies and investigation would be required
4. Storage pond risks from geotechnical stability / overtopping / dam collapse. Consideration and refinement of modelling once a preferred option is selected and during detailed design is recommended
5. Modelling assumptions: Review and refine soil moisture water balance assumption as improved data comes to hand.

This work is intended as a feasibility and cost assessment only and the following further work is recommended, depending on which options are progressed further:

- Stakeholder discussions and consultation
- Review implications of Akaroa bore injection work for Duvauchelle scheme
- Confirmation of preferred option(s) through evaluation based on technical feasibility, stakeholder views, risk (including consentability and technical) and cost
- Further develop preferred option(s) and costs
- Downstream activities; review programme, Council LTP process and subsequent activities.

Refer to *Duvauchelle Wastewater Irrigation Feasibility Assessment, Rev B, November 2017* for wider project recommendations.

Appendix A

Duvauchelle Irrigable Areas Map

GIS@beca.com

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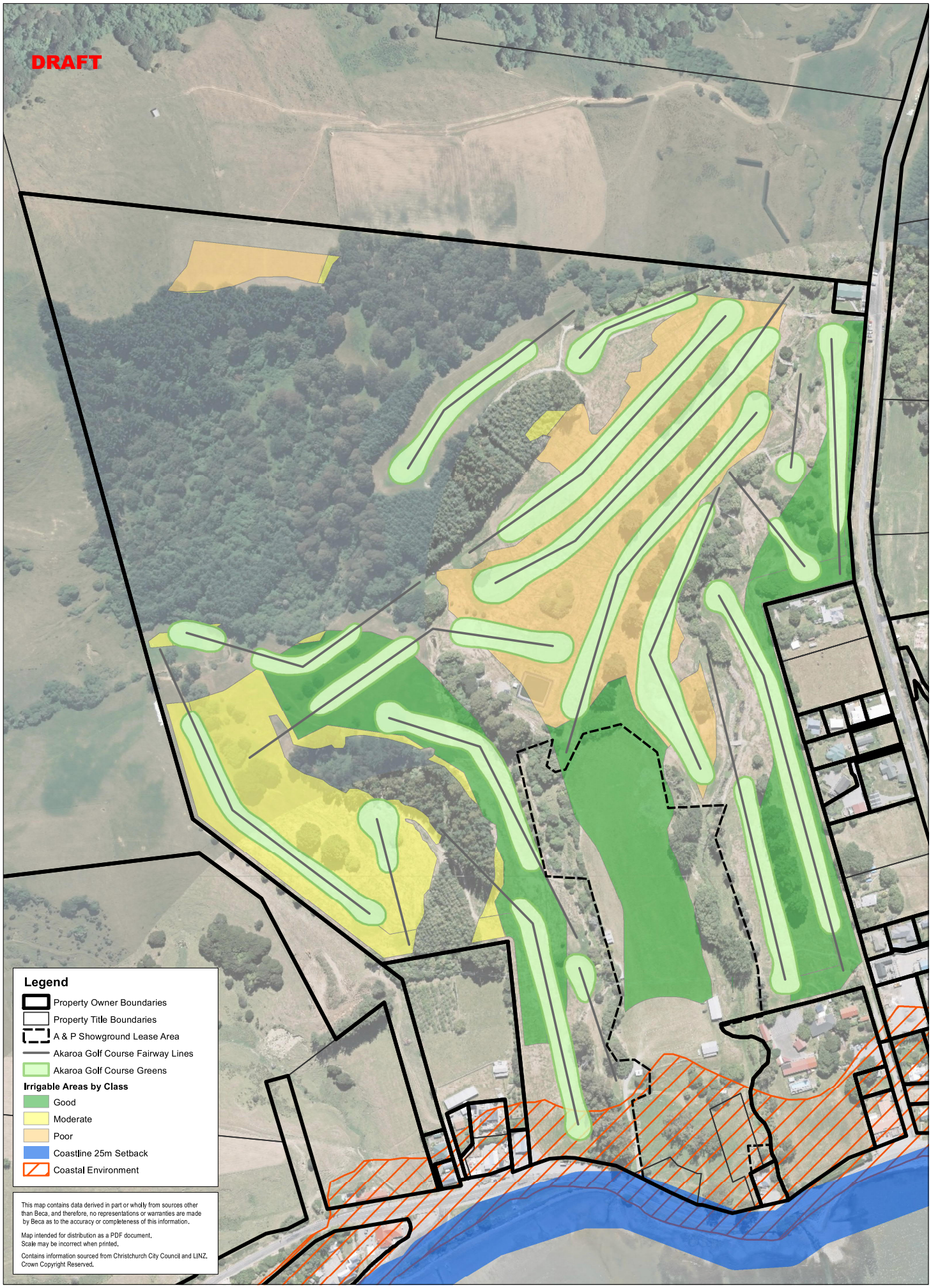

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Metres

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2	BDJ	DRAFT	DRAFT	02/05/2018
1	BDJ	DRAFT	DRAFT	30/04/2018

Title:

Duvauchelle Study Area

Dripper and K-Line Irrigation

Client: Christchurch City Council

Project: Akaroa Wastewater Upgrade

N

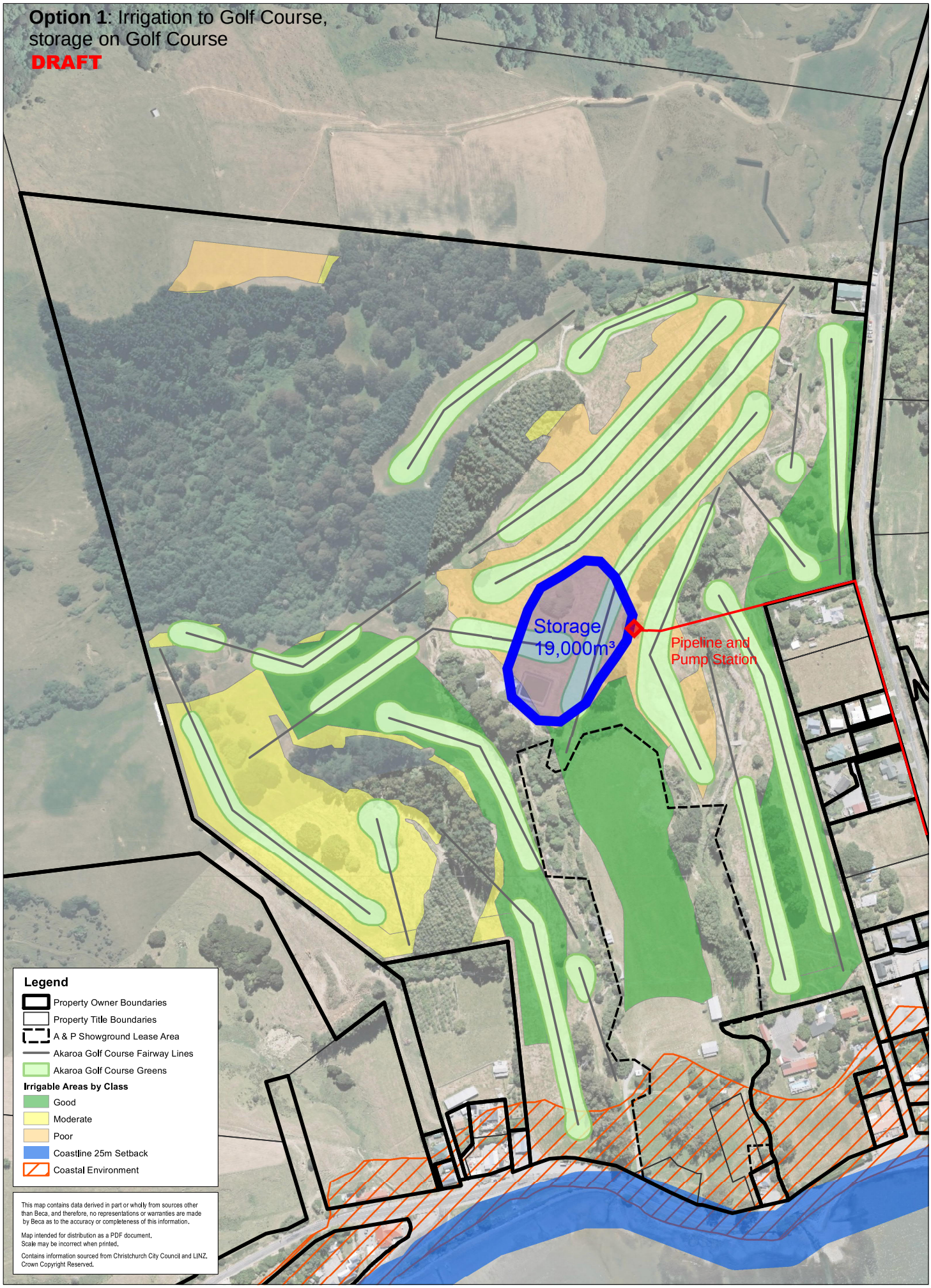
CH2M BECA

Discipline: GIS

Drawing No: GIS-6517986-20-43f

Appendix B

Option Sketches



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Title:

Duvauchelle Study Area

Dripper and K-Line Irrigation

Client: Christchurch City Council

Project: Akaroa Wastewater Upgrade

N

CH2M BECA

Discipline: GIS

Drawing No: GIS-6517986-20-43f

GIS@beca.com

Option 2: Irrigation to golf course, storage on Golf Course and partly on A&P Showgrounds

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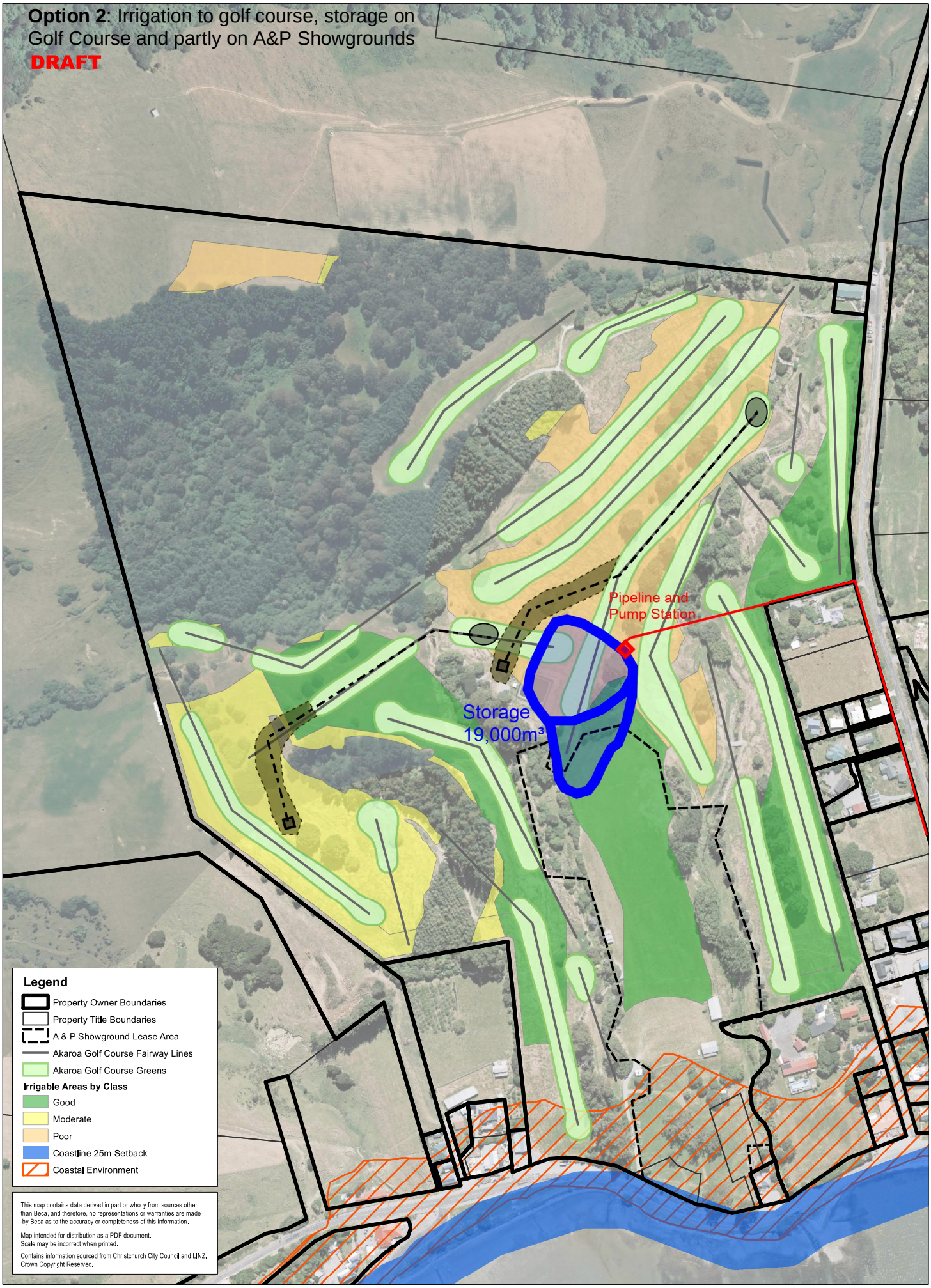

Legend

- Property Owner Boundaries
- Property Title Boundaries
- A & P Showground Lease Area
- Akaroa Golf Course Fairway Lines
- Akaroa Golf Course Greens

Irrigable Areas by Class

- Good
- Moderate
- Poor
- Coastline 25m Setback
- Coastal Environment

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2	BDJ	DRAFT	DRAFT	02/05/2018
1	BDJ	DRAFT	DRAFT	30/04/2018

Title:

Duvauchelle Study Area

Dripper and K-Line Irrigation

Client: Christchurch City Council

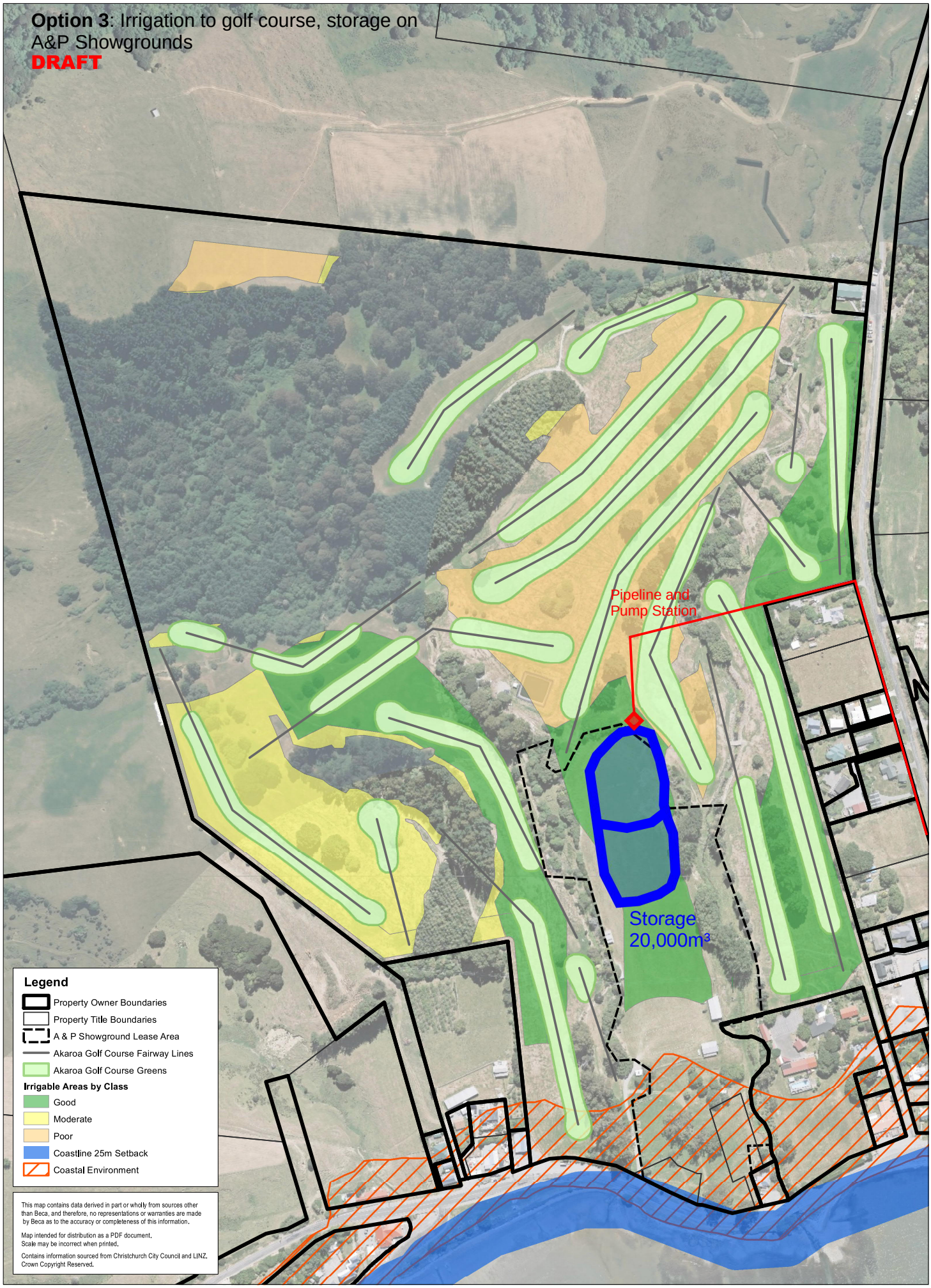
Project: Akaroa Wastewater Upgrade

N

CH2M BECA

Discipline: GIS

Drawing No: GIS-6517986-20-43f



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2	BDJ	DRAFT	DRAFT	02/05/2018
1	BDJ	DRAFT	DRAFT	30/04/2018

Title:
Duvauchelle Study Area
Dripper and K-Line Irrigation

Client: Christchurch City Council

Project: Akaroa Wastewater Upgrade

N

CH2M BECA

Discipline: GIS

Drawing No: GIS-6517986-20-43f

GIS@beca.com

Option 4: Combined irrigation (Golf Course "good" drainage only) and Deep Bore Well Injection, storage on Golf Course (avoid any fairway impact)

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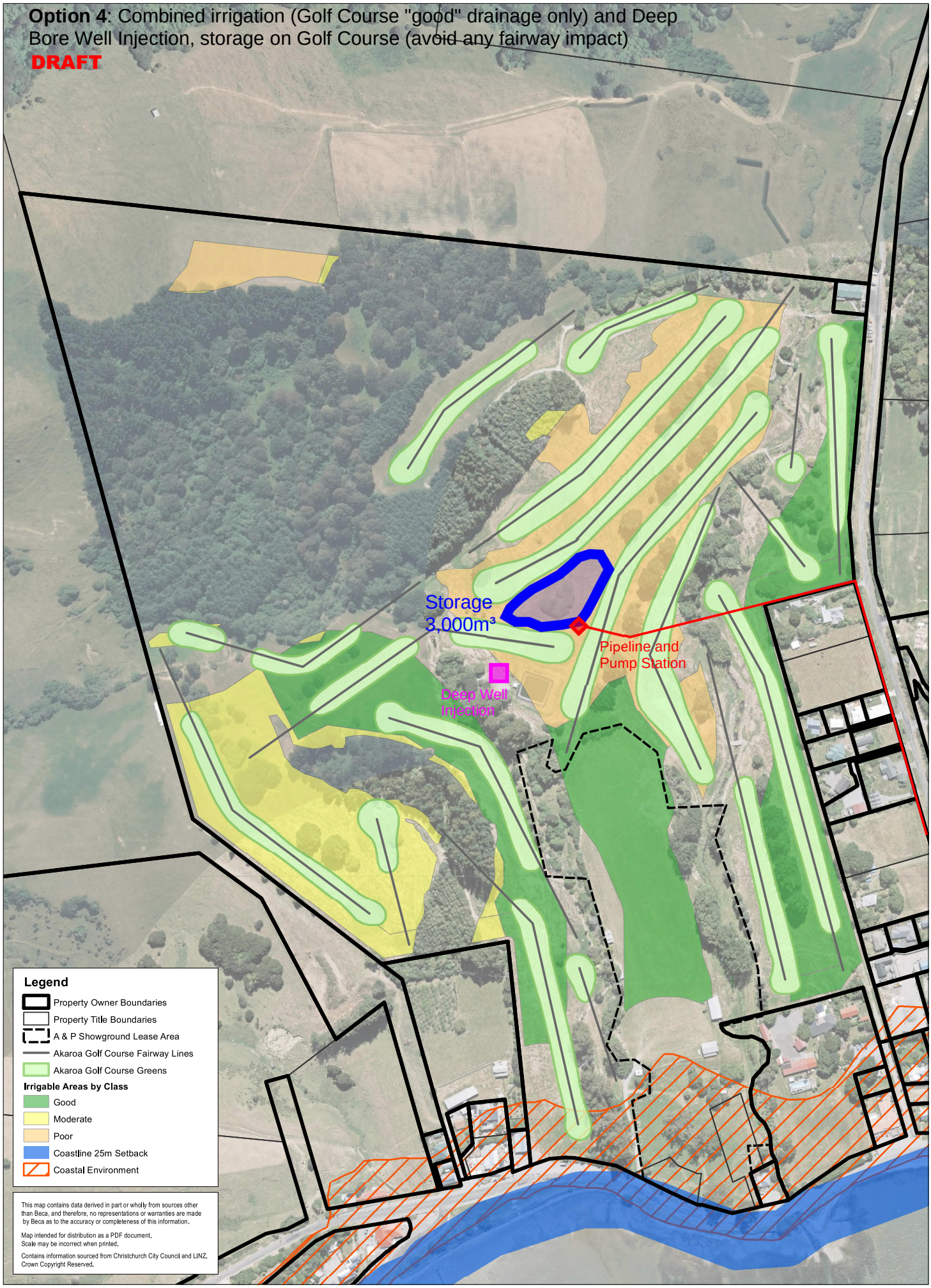

Legend

- Property Owner Boundaries
- Property Title Boundaries
- A & P Showground Lease Area
- Akaroa Golf Course Fairway Lines
- Akaroa Golf Course Greens

Irrigable Areas by Class

- Good
- Moderate
- Poor
- Coastline 25m Setback
- Coastal Environment

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Revision	Author	Verified	Approved	Date
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1	BDJ	DRAFT	DRAFT	30/04/2018

Title:

Duvauchelle Study Area

Dripper and K-Line Irrigation

Client: Christchurch City Council

Project: Akaroa Wastewater Upgrade

N

CH2M BECA

Discipline: GIS

Drawing No: GIS-6517986-20-43f

Appendix C

Artists Impressions of Options

DRAFT
STORAGE POND LOCATION

100% Irrigation, Storage on Golf Course and partly on A&P Showground

Option 2

Before - How it looks now, view from hole 2

After - Artist impression of two ponds close to eachother, view from hole 2

DRAFT
STORAGE POND LOCATION

100% Irrigation, Storage on Golf Course and partly on A&P Showground - Pond half full
Option 2

Before - How it looks now, view from hole 2

After - Artist impression of two ponds close to eachother, view from hole 2

DRAFT
STORAGE POND LOCATION

100% Irrigation, Storage on Golf Course and partly on A&P Showground - Pond empty

Option 2

Before - How it looks now, view from hole 2

After - Artist impression of two ponds close to eachother, view from hole 2

DRAFT

Option 3 - 100% Irrigation, Storage on A&P Showground: Storage pond location - Artist impression for information only

DRAFT

Option 4 - Combined Irrigation + Bore Injection: Storage pond location - Artist impression for information only

DRAFT

Option 4 - Combined Irrigation + Bore Injection: Storage pond location with membrane cover - Artist impression for information only

Appendix D

Option Cost Estimates

Duvauchelle Wastewater Alternative Disposal Options

Concept Stage Cost Estimates

Option	Description	Area (ha)	Pond (m3)	Construction Estimate	Expected Range
Option 1:	Subsurface Irrigation to Golf Course	10.9	19,000	$4,720,000	$4M to $5M
Option 4:	Subsurface Irrigation to Golf Course and Deep Well Injection	4.1	3,000	$3,910,000	$3.3M to $4.2M

General Estimate Exclusions

Goods and Services Tax (GST).
Construction escalation beyond date of estimate.
Foreign Exchange costs.
Staged or phased handover or commissioning.
Council reserves and Development Contributions.
Legal / accounting fees.

Project Specific Exclusions

Christchurch City Council direct costs (project staffing etc).
Golf Course owner project-related costs.
Compensation for loss of income for Golf Course and clubs.
Geotechnical investigations.
Geotechnical ground improvement / treatment.
Incurred costs to date.
Fast track or accelerated programme.
Work outside normal working hours.
Treating & handling contaminated soil and materials.
No allowance for relocating existing services.
Transformer and power supply upgrades.
Cartage of excavation spoil - assumed disposed of on site.
Contractor temporary accommodation costs (P&G).
Landscaping around pond.
Archaeological finds, project archaeologist.
Land access costs.
Allowance for Land Purchase - assumed not required.

Assumptions

All quantities and dimensions are approximate - subject to design development.
Measurements based on GIS and Googlemaps.
Allowance for Professional Fees for design and management is based upon single design from preliminary design through to completion - excludes concept design stage costs.
Allowances included for P&G (12%), Contingency (30%), Professional Fees (13%).
The estimates assumes continuity of work and unobstructed access to site.
Estimate assumes project will be procured as a traditional, competitive tender with at least 3 tenderers.

Risks

Design development; design scope and basis (flow rates).
Subsurface drip irrigation system supply and installation costs - subject to design.
Drilling of boreholes - subject to design and investigation.
Effect upon golf course and reinstatement.
Sizing and design of pump stations.
Transformer/power supply upgrades.
Land costs/easements and access.
Archaeological finds.

Limitation

The estimates above should be considered as high-level comparative estimates intended for feasibility appraisal.
Further design, investigation and cost estimation will be required prior to financial commitments are made.

Duvauchelle Wastewater Alternative Disposal Options

Concept Stage Cost Estimate **Option 1: Subsurface Irrigation to Golf Course**

Description of works:

Pump station and 1.2km PE wastewater conveyance pipe from WWTP to Golf Course
Storage ponds - 1No x 19,000m3 at Duvauchelle (golf course)
Sub-surface drip irrigation to 10.9Ha pasture at Duvauchelle (golf course)

Total Estimate **$4,720,000**
Expected Range **$4M to $5M**

REF	DESCRIPTION	UNIT	QUANTITY	RATE	SUBTOTAL	TOTAL	COMMENT
1.0	**PUMP STATION**					**$150,000**	
1.01	Construct pump station near WWTP including small 20m2 blockwork building, duty/standby pumps, mechanical, electrical, controls and civil site works	LS	1	$150,000		$150,000	5kW pumps
2.0	**WASTEWATER SUPPLY PIPE**					**$285,600**	
	Pipeline from WWTP to Pond						
2.01	Allowance for pipeline from WWTP to Storage Pond - allow 1200m x DN140 PN12 PE100 pipe, trenched in road berm, including all valves, fittings, thrust restraint, pressure/air valve arrangements, road crossings and traffic management	m	1,200	$238		$285,600	200m of length lies in the golf course, one stream crossing
3.0	**STORAGE POND - 19,000m3**					**$1,640,325**	
3.01	Construct 1No x 19,000m3 pond, including earth embankments from stabilised locally won materials, complete with HDPE liner to pond base and sides, HDPE cover, leak detection and under drainage system, access road to top of pond embankment	m3	19,000	$80		$1,520,000	Refer to comments on storage info
3.02	Cut-off drain on uphill side of pond; assume shallow open drain discharging to local stream	m	155	$15		$2,325	
3.03	Construct access road to pond; allow 200m long x 3m wide from Pawsons Valley Rd; assume 300 thick AP65 on geotextile	m2	600	$30		$18,000	allow to excavate and dispose spoil on site, supply and place AP65 on geotextile; no allowance for bridge over stream - assume use existing
3.04	Stock fencing to both sides of road - 7 wire post & batten type	m	400	$45		excluded	assume not required to maintain golf course open areas
4.03	Provisional allowance for landscaping to realign fairway and green layout affected by Pond location	PS	1	$100,000		$100,000	
4.0	**TREATMENT - SUBSURFACE DRIP IRRIGATION TO PASTURE**					**$675,800**	6 ha
4.01	Construct subsurface drip (SSD) irrigation system to service 6ha of golf course turf surface, including site clearance, booster pump station, power supply to site, all valving, submain and laterals, dripper irrigation tape/pipe	ha	10.9	$50,000		$545,000	assumed dripper tape/pipe is installed via mole plough or similar; minor allowance for power cable to site - assume power supply with sufficient capacity is nearby
4.02	Provisional allowance to restore golf course turf surface	ha	10.9	$12,000		$130,800	Allow 6ha x $12,000/ha
	NET CONSTRUCTION ESTIMATE					**$2,751,725**	
	Preliminaries & General and Margin - 12%	LS	1			$330,000	
	GROSS CONSTRUCTION ESTIMATE					**$3,081,725**	
	Contingency - 30%	LS	1			$920,000	
	TOTAL CONSTRUCTION BUDGET					**$4,001,725**	
	Allowance for Professional Fees - 13%	LS	1			$520,000	
	Allowance for Resource Consents	LS	1			$200,000	
	Allowance for Land Purchase	LS	1			excluded	assume none required
	Rounding	LS	1			-$1,725	
	TOTAL ESTIMATE					**$4,720,000**	rounded

Duvauchelle Wastewater Alternative Disposal Options

Concept Stage Cost Estimate **Option 4: Subsurface Irrigation to Golf Course and Deep Well Injection**

Description of works:

Pump station and 1.2km PE wastewater conveyance pipe from WWTP to Golf Course
Storage ponds - 1No x 3,000m3 at Duvauchelle (golf course)
Sub-surface drip irrigation to 4.1ha pasture at Duvauchelle (golf course)
2No x injection bores 130m deep located on golf course

Total Estimate **$3,910,000**
Expected Range **$3.3M to $4.2M**

REF	DESCRIPTION	UNIT	QUANTITY	RATE	SUBTOTAL	TOTAL	COMMENT
1.0	**PUMP STATION**					**$350,000**	
1.01	Construct pump station near WWTP including small 20m2 blockwork building, duty/standby pumps, mechanical, electrical, controls and civil site works	LS	1	$150,000		$150,000	5kW pumps
1.02	Allowance for disc filter at WWTP	Prov Sum	1	$200,000		$200,000	
2.0	**WASTEWATER SUPPLY PIPE**					**$285,600**	
	Pipeline from WWTP to Pond						
2.01	Allowance for pipeline from WWTP to Storage Pond - allow 1200m x DN140 PN12 PE100 pipe, trenched in road berm, including all valves, fittings, thrust restraint, pressure/air valve arrangements, road crossings and traffic management	m	1,200	$238		$285,600	200m of length in golf course
3.0	**STORAGE POND - 3,000m3**					**$413,100**	
3.01	Construct 1No x 3,000m3 pond, including earth embankments from stabilised locally won materials, complete with HDPE liner to pond base and sides, HDPE cover, leak detection and under drainage system, access road to top of pond embankment	m3	3,000	$130		$390,000	Refer to comments on storage info; assumes soil on site is suiteable for use in bund construction
3.02	Cut-off drain on uphill side of pond; assume shallow open drain discharging to local stream	m	40	$15		$600	
3.02	Construct access road to pond; allow 250m long x 3m wide from Pawsons Valley Rd; assume 300 thick AP65 on geotextile	m2	750	$30		$22,500	allow to excavate and dispose spoil on site, supply and place AP65 on geotextile; no allowance for bridge over stream - assume use existing
3.03	Stock fencing to both sides of road - 7 wire post & batten type	m	500	$45		excluded	assume not required to maintain golf course open areas
4.03	Provisional allowance for landscaping to realign fairway and green layout affected by Pond location	PS	1	$0		excluded	assumed not required
4.0	**TREATMENT - SUBSURFACE DRIP IRRIGATION TO PASTURE**					**$254,200**	6ha
4.01	Construct subsurface drip (SSD) irrigation system to service 4.1ha of golf course turf surface, including site clearance, booster pump station, power supply to site, all valving, submain and laterals, dripper irrigation tape/pipe	ha	4.1	$50,000		$205,000	assumed dripper tape/pipe is installed via mole plough or similar; minor allowance for power cable to site - assume power supply with sufficient capacity is nearby
4.02	Provisional allowance to restore golf course turf surface	ha	4.1	$12,000		$49,200	Allow 4.6ha x $12,000/ha
5.0	**Injection Bores**					**$951,000**	
	Target depth below sea level	m	100				
	Starting site elevation (m above sea level)	m	30				
	Depth of drilling	m	130				
5.01	Construct injection boreholes - drill and install casing and screen to 100m deep below sea level, testing	No	2	$169,000		$338,000	total for reinjection bores $1680/m
5.02	Construct reinjection bore headworks	No	2	$50,000		$100,000	
5.03	Drill 8No x 160m deep monitoring bores	No	2	$169,000		$338,000	
5.04	Construct headworks to reinjection bores	No	2	$25,000		$50,000	
5.05	Allow for instrumentation to monitoring bores	No	2	$10,000		$20,000	
5.06	Allow for Telemetry and RTU for monitoring bores	LS	1	$20,000		$20,000	
5.07	Allow for civil works - access road, gate and fencing to perimeter of site	LS	1	$10,000		$10,000	
5.08	Allow to bring power supply to bore site	LS	1	$25,000		$25,000	
5.03	Allowance for mechanical and pipework between irrigation pumpstation and bores	LS	1	$50,000		$50,000	
	NET CONSTRUCTION ESTIMATE					**$2,253,900**	
	Preliminaries & General and Margin - 12%	LS	1			$270,000	
	GROSS CONSTRUCTION ESTIMATE					**$2,523,900**	
	Contingency - 30%	LS	1			$760,000	
	TOTAL CONSTRUCTION BUDGET					**$3,283,900**	
	Allowance for Professional Fees - 13%	LS	1			$430,000	
	Allowance for Resource Consents	LS	1			$200,000	
	Allowance for Land Purchase	LS	1			excluded	assume none required
	Rounding	LS	1			-$3,900	
	TOTAL ESTIMATE					**$3,910,000**	rounded

Appendix E

Consenting Review

Duvauchelle Wastewater Irrigation Resource Consents/Authorisations

1.1 Overview

This section considers the following matters in relation to wastewater disposal at the Duvauchelle site:

- Resource consents that may be required from the Christchurch City Council in respect of the operative Christchurch District Plan (CDP) and from Environment Canterbury in respect of the various regional plans.
- Other consents/authorisations that may be required.

It is noted that there are 4 options for disposal as follows:

- Option 1 -100% Irrigation, Storage on Golf course
- Option 2 -100% Irrigation, Storage on A and P Showgrounds and Golf course
- Option 3 -100% Irrigation, Storage on A and P Showgrounds
- Option 4 -Combined Irrigation and Bore Injection

Components of the options include:

- wastewater rising main
- storage pond
- pump station for pumping from the storage pond to the irrigation areas
- buried drip irrigation to 11ha of pasture at the golf course
- injection bore(s)

1.2 CDP Requirements

1.2.1 Zoning and Overlays

In terms of the CDP the following identifies the zoning, overlays and other notations that apply to the site:

- The zoning of site area is Open Space Community Parks (OCP) as shown on Figure 1. The adjoining zonings include the Residential Banks Peninsula Zone (RBP) which applies to residences along Pawsons Valley Road and State Highway 73; the Special Purpose Zone (School) (SPS) which applies to Duvauchelle Primary School, and Rural Banks Peninsula (RuBP).
- The site is crossed by a demarcated 33kv Electricity Distribution Line .
- The site located in a Liquefaction Management Area overlay (LMA).
- The site has a ‘Remainder of Port Hills and Banks Peninsula Instability Management Area’ Overlay.

- Part of the site is located within the Coastal Environment Overlay and the Coastal Environment “Other Area of Natural Character in Coastal Environment” (NCCE 1.0) Overlay.
- The site is located within Silent File Area 10a (as notated Planning Map 70C) which is identified in Appendix 9.5.6.2 Schedule Mahaanui Iwi Management Plan Silent Files and Kaitōrete Spit.
- There are two “Environmental Asset Waterways” (streams) on the site generally flowing north to south towards Akaroa Harbour.

Figure 1: Site shown on Planning Map 70 of CDP

1.2.2 CDP Provisions

The proposed activities associated with wastewater disposal are considered to be a “utility” under the CDP. Rule 11.3a of Chapter 11 Utilities and Energy states that the rules that apply to utilities are set out in Rules 11.4-11.8.

Utilities Rule 11.8.1 P2 states that the “Construction or operation of structures for the conveyance, treatment, storage or retention/detention of water, wastewater and stormwater by the Council or a network utility operator” are permitted activities provided the activity complies with the Built Form Standards for the Open Space Community Parks (OCP). It is considered that the irrigation pipes and drippers, pump station building, storage pond and deep injection bores are permitted by the

above rule given that the structures are used for the conveyance, treatment and storage of wastewater

In terms of the Built Form Standards for the OCP Zone referred to in Rule 11.8.1P2 for utilities, the standards in large part refer to bulk and location of buildings. This by definition includes the storage pond and as such the standards will be applicable to the storage pond and pump station building. This is discussed briefly below.

- A minimum set back of 7.5 m from roads and 20m from State Highways (Built Form Standard 18.4.2.1)
- Setbacks of 3 m from internal boundaries (Built Form Standard 18.4.4.2);
- Site coverage of buildings or the footprint shall not be greater than 10% of the site area or 250 m^2 whichever is the lesser (Built Form Standard 18.4.2.6);

If development of the site in terms of the siting of the storage pond or pump station building results in a breach of these Built Form Standards resource consent as a restricted discretionary activity under Rule 18.4.1.3 would be required. The Council's discretion is limited to the Built Form Standards that are not met. In respect of these standards site coverage or the building footprint of the storage pond is unlikely to be met. In addition the internal boundary setbacks will be infringed for Options 2 and 3 if the golf course and showgrounds sites are regarded as separate sites (given the storage pond for these options straddles the boundary between these two sites).

However, the use of the land for irrigation of wastewater to pasture is not considered to be permitted in terms of Rule 11.8.1 P2 as the rule refers to structures only. The use of land for the irrigation of wastewater is defined as a utility and requires resource consent as a discretionary activity in terms of Rule 11.4.3.

Based on current options none of the overlays/notations (i.e. 33kv Electricity Distribution Line, Liquefaction Management Area overlay, 'Remainder of Port Hills and Banks Peninsula Instability Management Area' Overlay, Coastal Environment Overlay and the Coastal Environment "Other Area of Natural Character in Coastal Environment" (NCCE 1.0) Overlay and Silent File Area 10a) trigger specific resource consents other than those identified above.

1.4 Regional Plan Provisions

In terms of the relevant Environment Canterbury planning documents the following is of relevance to the proposed options:

- The use of land for a community wastewater treatment system and discharge of treated sewage effluent from a community wastewater treatment system is a discretionary activity under Rule 5.84 of the LWRP, which includes the irrigation of wastewater to land.
- The western part of the site is identified as "High Soil Erosion Risk" in the LWRP (See figure 2). Earthworks associated with any development may require resource consent as a restricted discretionary activity under Rule 5.171 if the earthworks exceed the specified limits (more than 10 m^3 and cut and fill is greater than .5 m) in Rule 5.170 (k) of the LWRP. It is noted that Rule 5.170 does not apply to works for which a building consent from Christchurch City Council has been obtained so any earthworks associated with a building are exempt from this rule.
- The southern part of the site is identified as overlying an unconfined or semi-confined aquifer. Rule 5.75 of the LWRP requires any excavation to maintain 1 m between any excavation and the aquifer and 50m separation from a waterbody (see Figure 2).

Earthworks in this area therefore may require resource consent under Rule 5.76 as a restricted discretionary activity.

- The discharge of treated wastewater into deep injection bores into groundwater is a discretionary activity under General Rule 5.6 of the LWRP.
- It is assumed that the storage ponds will have an impermeable liner and accordingly the discharge of treated effluent through the base of the storage ponds will not occur. If there is a discharge, resource consent as a discretionary activity under Rule 5.84 of the LWRP is required.
- The discharge of contaminants to air from the disposal of human sewage effluent including the storage pond/irrigated areas is a discretionary activity under Rule 7.63 of the CARP given that Rules 7.50-7.52 cannot be complied with.

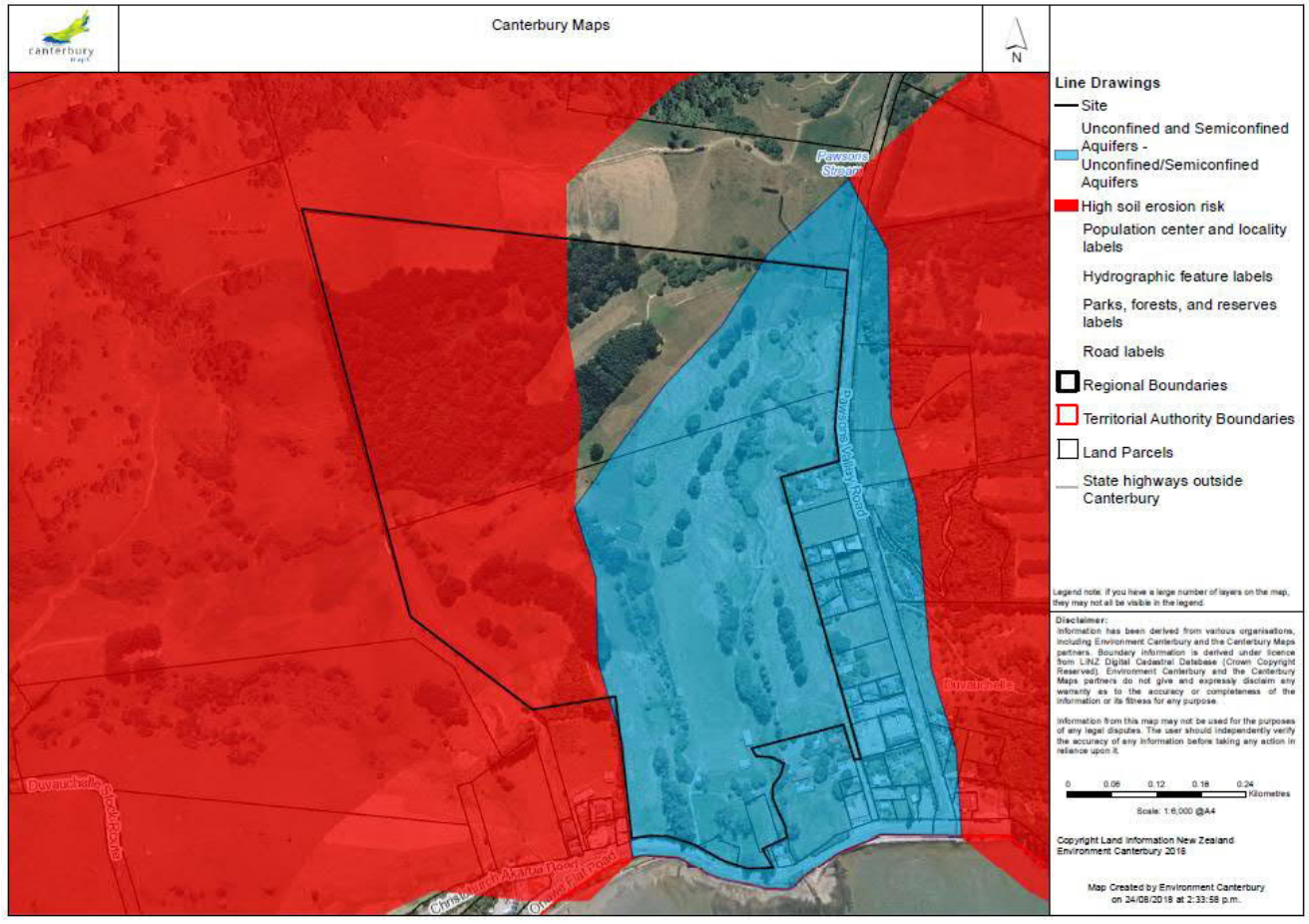

Figure 2: Site with LWRP Notations

1.5 Preliminary Assessment of Effects

This section provides a preliminary assessment of the likely effects on the environment of land-based disposal and bore injection at the site. The assessment is only preliminary at this is stage because no detailed baseline studies or investigations (other than geotechnical) have occurred.

Landscape/Visual Effects

In terms of the "buildings" as it relates to the storage pond, provided the pond is integrated with existing contours and is naturalised by planting then potential adverse effects can be reduced to acceptable levels. The pumping station building is anticipated to be of a relatively small scale and therefore will not result in significant adverse effects. The irrigation of the site will also result in some "greening of the landscape" but any potential adverse effects are reduced by the existing patchwork of different land uses in the area including the golf course itself. It appears that irrigating the golf course with water is a permitted activity in terms of the Open Spaces Community Parks and as such a permitted baseline can be established.

Geotechnical risks

No geotechnical risks have been identified given that all land with a slope of more than 15 degrees and areas of identified instability have been excluded from irrigation, and only those parts of the site with suitable drainage characteristics will be utilised for irrigation.

Effects on Soils, Groundwater and Surface water

In respect of these matters the following is of relevance:

- The treated wastewater quality from the normal operation of the treatment plant will be suitable for land application and none of the individual contaminants are likely to affect soil structure.
- Treated wastewater would be applied to land at rates that meet the assimilative capacity of site vegetation and soils.
- There is one identified water take that is in use within 2 km of the site and an assessment should be taken to ascertain any adverse effects on the water supply.
- The condition of existing waterways at the sites has not been assessed and any discharge into streams that then enter coastal areas would require assessment of the potential to cause adverse effects. However the possible locations for storage ponds and irrigation areas have been determined using setback distances that have been selected to minimise the risk of discharge into the streams on site (and ultimately Akaroa Harbour).

Pond/Irrigation Odours

There is a risk of odour being an issue particularly given the proximity of sensitive uses including Duvauchelle Primary School and the residences in Pawsons Valley Road. The effects can be mitigated by the quality of the wastewater, buffer distances to sensitive uses, the use of sub surface irrigation and possible use of a storage pond cover.

Heritage and cultural effects

The site is located in a Silent File Area and accordingly Ngai Tahu should be consulted on the proposal to identify any concerns they may have.

Public Health

Potential adverse effects on public health can be mitigated by the quality of the wastewater, buffer distances to sensitive uses, the use of sub surface irrigation (no spray irrigation is proposed) and use of a storage pond cover, which may be utilised.

Noise Effects

Noise effects from sources such as irrigation equipment and pump stations is anticipated to be minor and can be mitigated by measures such as insulation and maintenance of separation distances from sensitive uses.

Deep Bore Effects

If deep bore injection is feasible on the site key matters to consider will be the quality of the wastewater to be discharged into the bores, effects on nearby drinking water bores, the dilution available in the ground and effects on the Akaroa Harbour.

1.6 Archaeological Sites

Section 42 of the Heritage New Zealand Pouhere Taonga Act (2014) states that unless an Archaeological Authority is granted from Heritage New Zealand, no person may modify or destroy an archaeological site.

An “archaeological site” is defined as “a place that was associated with human activity that occurred before 1900”. Potentially, earthworks associated with the storage ponds within the site could result in a requirement to apply for an Archaeological Authority, particularly as the site is identified as being in a Silent File Area.

1.7 Summary

A number of resource consents for the proposal will be required from both CCC and ECan including use of the site for wastewater disposal, setbacks for buildings, the discharge of wastewater to land and to the deep injection bores, potential earthworks and discharge to air.

Potential adverse effects that will be required to be addressed include visual impacts, odour, and effects on surface water and groundwater. The site is located in proximity to some sensitive uses including residences, Duvauchelle School and Akaroa Harbour and waterways so appropriate design will be required. The site also is located in a Silent File area so consultation with Ngai Tahu will be also required.

Appendix F

Pond Flow Path Analysis

File Note

By:	Michael Law	**Date:**	19 October 2018
Subject:	**Duvauchelle golf course ponds - dam break analysis**	**Our Ref:**	3363074

1 Background and Approach

Options are being considered for the storage of treated wastewater in ponds on Duvauchelle Golf Course and Show Grounds. Four pond options are being considered; ranging in size from 3,000 m^3 to 20,000 m^3, and sited at four different locations. The golf course is drained by Pawsons Stream, which flows along the east side of the show grounds before discharging under the highway to Akaroa Harbour. A smaller stream drains the western side of the gold course and showgrounds.

A primary school backs onto Pawsons Stream downstream of the golf course and the Plunkett Room are located next to the stream immediately upstream of the bridge under the highway.

A high level flood path assessment has been carried out to determine whether the school, Plunkett Rooms, or other properties would be at risk of a sudden release of water from any of the four proposed pond options. The assessment will determine whether more refined dam break modelling or pond redesign is required. Each pond option has been modelled separately; assuming the sizes shown in Table 1-1. The assessment replicates a release of the water in the pond as a result of a 5m (Option 4) or 10m (Options 1-3) wide breach in the pond bund. The breach takes ten minutes to develop. The resulting hydrograph has been developed using HEC-HMS software, and applied to a 2D ground surface in HEC-RAS.

Table 1-1 Pond options and dam parameters

Pond	Volume (m3)	Bund height (m)	Breach parameters	
1	19,000	2.0	Time to develop	10 minutes
2	19,000	2.0	Width	5 metres
3	20,000	2.0	Side slope	2H:1V
4	3,000	1.5		

Figure 1-1shows the modelled extent and the location of where the pond breach hydrographs have been applied, which are generally the lowest current ground levels underlying the pond bunds. The right-hand image shows the DEM ground surface CCC's 2008 LiDAR, which was used in preference to more recent point cloud data that included trees, building, other full/partial obstructions that would incorrectly divert or impede modelled flows. The downstream boundary of the model is Akaroa Harbour. The location of Duvauchelle School and the Plunkett Rooms are indicated.

The modelled duration for each pond was one hour, as this was long enough for water to drain away from the pond locations. The models were run using a sub-one second computation interval, and results reported at one minute intervals.

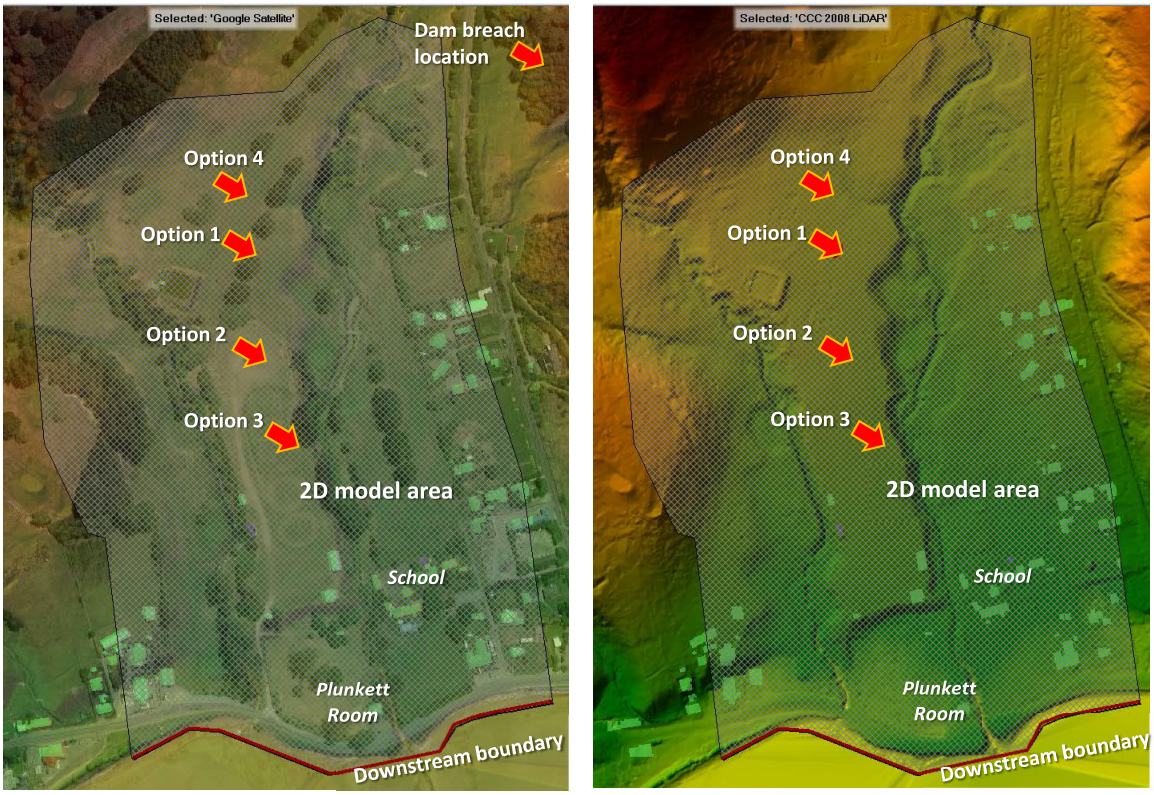

Figure 1-1 Model extents and pond breach locations

2 Model results

Figure 2-1 (options 1 and 2) and Figure 2-2 (options 3 and 4) shows the maximum flood extents from each model run.

The results for Options 1, 2 and 4 show water leaving the channel of Pawson Stream adjacent to the upper end of the show grounds. This is a flatter part of the golf course, before the stream becomes more confined as is flows towards the school. A bridge on the golf course has not been modelled, so as to replicate blockage of the structure. However, all the flow that has left the stream returns to the channel about 100 m upstream of the school.

Figure 2-3 shows the Pawsons Stream channel looking downstream, with the school building visible on the left. The school site is lower than the showground on the right bank, and so more susceptible to flooding.

Option 3 discharges water to Pawsons Stream further downstream than the other options, and has the biggest flow (being the biggest pond system). As such, the extent of flooding in the stream is greater than the other options, with indications that shallow flood water could encroach upon the school site.

Downstream of the school, the flood modelling indicates that water will spill out of the main channel on both sides of Pawsons Stream, with the majority of flow crossing (and ponding on) the camp ground (Figure 2-4) between the show grounds and the highway. The Plunkett Room is in the southeast corner of this plot, but on slightly raised ground, which appears to protect it from flooding.

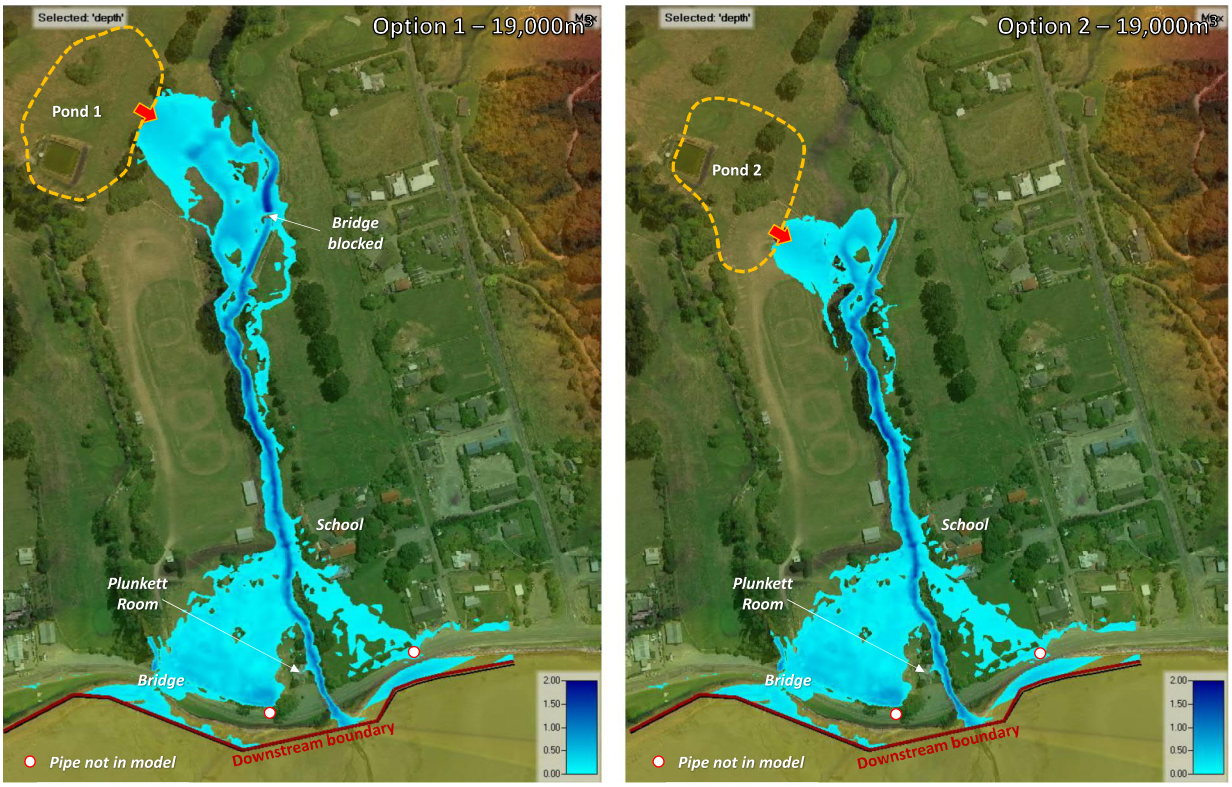

Figure 2-1 Flood extents - Options 1 and 2

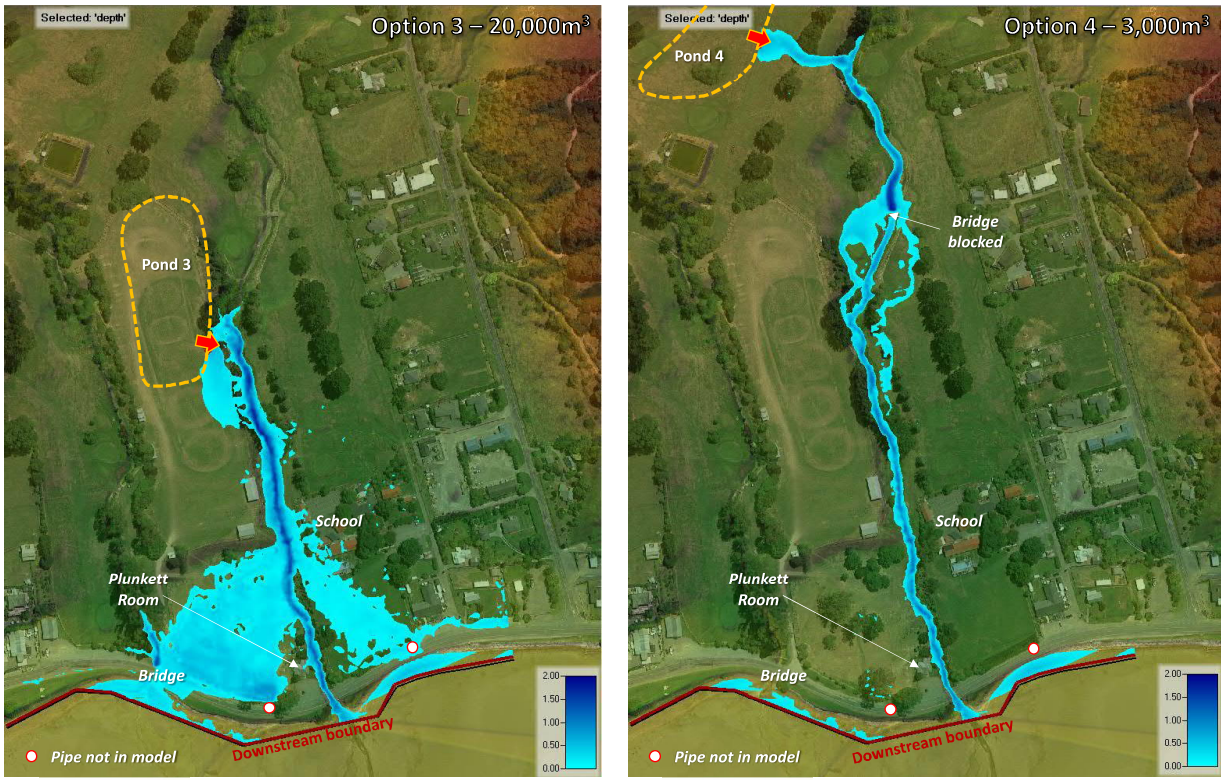

Figure 2-2 Flood extents - Options 3 and 4

Figure 2-3 Pawson Stream at Duvauchelle School

Figure 2-4 Camp ground (vehicle parked in Plunket Room car park)

3 Conclusion

The conclusion of the high level flood modelling of failure of the treated wastewater pond options is that the majority of flow will be retained in the Pawsons Stream channel as is passes behind the Duvauchelle School site. However, the flood extents indicate that floodwaters are close to (or just) entering the school site, and so the school is potentially at risk of flooding from a breach in the proposed ponds, with pond options 1, 2, and 3 representing the greatest risk. However, the high level assessment described here may over-estimate the risk of flooding; largely due to simplified representation of the pond breach, limited refinement of the ground model, and not including some stormwater pipes in the model.

Therefore, it is recommended that the flood modelling of the ponds is refined once a preferred option has been identified. This will include:

- Refinement of the DEM to improve definition of the stream channel. This will be done in conjunction with better definition of land use and ground roughness; in the current modelling, a uniform Manning's roughness of 0.06 was used except for buildings where a value of 1.0 was used.
- Include stormwater pipes under the highway. Currently, the Pawsons Stream Bridge is included, as is a rough representation of the bridge for the smaller stream draining the west side of the golf course and show grounds.
- 'Burning' the proposed ponds into the DEM, which will allow the dam break hydrograph to be generated with HEC-RAS rather than importing it from HEC-HMS
- Consideration of what would happen were a breach to occur concurrently with a severe storm event in the catchment. The modelling undertaken to date is for a 'sunny day' scenario, where the pond breach occurs when the pond is full but stream flows are normal.

Michael Law

Appendix G

Safety in Design Comments

Safety in Design
Small Job Design Risk Assessment Form

Job Name / No: **Duvauchelle WW** Date **7/11/2018**

Scope Options assessment of wastewater irrigation to land at Duvauchelle

Does the project have any hazards / risks* associated with design elements ?
(check against the following Hazard Guide Words List)

It is intended that this form will provide evidence of a Design Risk Assessment for small and simple projects where no hazards / risks* are anticipated. For larger, or any small projects where hazards / risks* are identified, the risks and assessment should be recorded on the F27/02 Design Risk Assessment Register

Hazard Guide Words	Prompts	Y / N	Comments
Confined Spaces	Access, Egress, Ventilation, Rescue	Y	Assumption is that drainage changes will be open channel / subsoil drain - not confined spaces. The Pump Station will be a submersible pump in a wet well (non accessible, remove pump for O&M remotely).
Construction	Mobile plant, Lifting, Exertion, Sequence, Timing, Complex design	Y	Lot of earthworks, site is in public domain, managing access will be important consideration. Other users include Pony Club and A&P Show Ground. Public access, fencing of site, Traffic management Important for construction. Contractor communications (letter drops etc) will be important part of managing public H&S risks during construction Injection well: drilling the bore has hazards including discharge of drilling fluids and test water, source of test water. Pipe laying (typical) Discovery of archaeological site of landfills a risk, will need archaeological assessment prior to works.
Demolition	Ease, Issues, Documentation, Asbestos	Y	Based on early PDP Geotechnical Investigations, likely excavation will not impact volcanic rock: BUT may impact river boulders which would entail rock breaking - contractor to be made aware on conditions and risks.
Documentation / Other	QA, Testing	Y	Consents and statuary approvals required. Contract to ensure contractor complies. Vegetation and tree removal likely to be required - use of appropriate contractor advised.
Egress / Access	No. of entry/egress points, Caught, Trapped, Emergency egress, Obstructions, Lighting, External Impacts, People and Equipment, Frequency of movements, Drowning	Y	Pond at time both empty and full, change in water levels would be slow. Pond embankments at 1V:3H - walkable. Pump Station assumed not accessible, see 'Confined Space'
Electrical	Underground, overhead, heating, proximity, spacings, clearances, isolation for maintenance access, HV, cable locations	N	Nothing of note. Minimal power required for pump station. May be possible to use solar for Well heads.
Eliminate / Combine	Movements, Mobile plant, Lifting, Exertion, Sequence, Timing, Simplify	N	None identified
Ergonomics	Posture, Manual Handling, RSI, Discomfort, Fatigue, Stress, Effect on PPE, Visibility, Slips, Trips	Y	Mowing of golf course required, design to facilitate safe access. Including on pond embankment. Pond embankment may need landscaping and O&M planning.
Fire / Explosion / Heat	Prevention/Detection, Suppression/Protection, Emergency Procedures, Sparks/Earthing	N	None identified

General Planning	Surrounding environment, Site clearance, Access (within and to site), Layout	Y	Golf balls may end up in pond and public may attempt to retrieve (safety risk? Treated WW? Drowning?) - need assessment with council. Embankment landscape design may assist. Debris will fall on pond - may require a grated outlet for irrigation water source - need to consider O&M/access of that outlet. Attraction of birds on pond - Avian flu risk etc + and contamination from bird faeces. Over irrigation of golf course a concern (leaching, and 'puggy' soil) - will need operation plan and monitoring. Grass growth will increase with irrigation, requiring additional mowing and other golf course maintenance activities.
Heights / Depths	Working at heights/depth, Falls, striking by falling objects, Scaffolding (space to fit)	N	Pressure main trenching up road to pond/station. Trenching will be relatively shallow.
Interfaces External to the Project	Public safety, Traffic, Adjacent Property, Power/Services, External fire, Day/Night/Weekend, Emergency Services, Noise, Dust/Pollution/Vibration	Y	Injection has a perceived risk to groundwater: investigation in to the tangible risks to groundwater users to be completed and minimisation of any risks undertaken.
Load / Force / Energy	High, Excess, Low, Insufficient, Additional Loads, Dynamics, Temporary Weakness, Tension, Compression, PE, KE, Inertia, Movement, Fluid Flows	Y	Storage pond 'dam break' risk: initial flow path assessment completed of full pond discharge over 10min - in this case water is retained in existing gullies. Further review of path at Highway recommended. Embankment design to mitigate risk required. Communication with stakeholders recommended.
Movement Direction	Stability, Compression, Physical Damage, Vibration, Friction, Slip, Rotation, Up, Downwards, Reverse, Expansion, Tension, Rollover	N	None identified
Moving Plant & Machinery	Internal, External, Above, Below	Y	Additional mowing vehicles required for irrigated grass, more ongoing moving plant activities.
Natural Sources Impacting the Works	Extreme Weather, Lightning, Dust, Temperature, Ground, Water, Snow, Ice, H2S, Noise, Earthquake, Floods, High Wind	Y	Wet conditions during construction at risk to public safety, construction vehicles, and working site conditions.
Position / Location	Too high, too low, too far, Misaligned, Wrong Position	Y	A flow meter may be required at Treatment Plant - need to check appropriateness of location and access. Monitoring bore and injection bores - need to assess best location with minimisation of impacts on golf course activities. Review any impacts of flood paths/overland from land above the Pond/Pump Station, and any diversion. Vehicles driving into the pond a risk at up gradient end of storage pond (no embankment) - to consider in design, a barrier / separation / landscaping required?
Site Caused Environment	Asbestos, Vapour/Dust, Effluent/Waste, Noise, Flooding, Heat/Cold	Y	Weather. Stormwater flows during wet weather at hazard, sediment control important, risk of collapse of any excavation so need appropriate control and management. Public objections, vandilisation and protest a risk - engagement with community and Runanga important. Midges/Mosquitos - risk of introduction of breeding ground. Odour? NB proximity to housing in wind direction (NE) Check wet weather flows bypasses at WWTP? to confirm operation of WWTP and adjust design/operation accordingly. Investigation retention of outfall for emergency events discharge.
Size / shape	Too big/small/heavy/light, unexpected shape	Y	Review location of storage pond with respect to golf club and A&P and Pony Club movements. Review balance of depth and area.

Timing	Too late, early, short, long, Sequence, Extended delays	Y	Shut down of golf course difficult. Management of construction timing important. A&P show in January.
Toxicity / Safety	PPE, Chemicals, Safety Showers, Eye Wash, Barriers/Guards, Lead/Asbestos, PCB's, Oil, SF6, Handling, Ventilation, Gases, Pressure Venting, overflows (provision)	Y	Stabilisation of pond embankment may be required (handling of hazardous materials a hazard), cost of importing fill materials high, and we will have material to dispose of from cut on site.
Utilities/Services	Lighting, Air/Water, Fuel/Electricity, Oxygen, Water, Gas	Y	Service strike risk: Before-U-dig and services potholing in design and construction required.

Summary:

Key Design Actions:

- Archaeological assessment
- Consenting and statuary approvals
- Refinement of storage pond design (location, area-depth balance, golf course design and operations, overland flow paths)
- Odour/Mosquito/Bird Attraction risks to be evaluated
- Detailed design to consider debris screens, landscaping of embankments, Pump Station operations
- If well injection included, review if any tangible risks to groundwater exist
- Review system bypass / emergency discharge (outfall to be retained?)

Key Construction / Operational Risks:

- The creation of a large pond within a public utilised site introduces a hazard
- Timing important (wet weather, golf course operations, A&P Show)
- Wet weather poses risks during construction
- Services during construction
- Construction site within public domain / active golf course: Management of access, communications, and traffic important

Review completed by following (minimum should be JM & JD):

Name	Role
Ellen Conley	Attendee
Amber Murphy	Job Manager
Greg Offer	Job Director
Rae Stewart	Attendee

* Hazards / risks considered are those that are project / site specific, non-standard / bespoke designs, special processes, high hazard risks (e.g. non 'business as usual' hazards) that have been identified at the time of the review(s).