Farm Environmental Management Plan

Report for Southdown Holdings Limited

Glen Eyrie Downs Station

August 2009

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1. Introduction

The Water Quality Study ('WQS') funded by Mackenzie Water Research Limited ('MWRL'), found that the additional irrigation proposed in the catchment could take place without significant adverse effects on the environment providing that nutrient reduction occurred on the farms.

The process that was advocated for ensuring this on-farm nutrient reduction was through Farm Environmental Management Planning. A clear process for building a Farm Environmental Management Plan (FEMP) was laid out in the WQS and has been followed here. An overview schematic of the process of building a FEMP is shown in Figure 1 below.

The responsibility of the implementation, monitoring and auditing of the plan lies with the farmer.

1.1 Purpose of a Farm Environmental Management Plan

This Farm Environmental Management Plan (FEMP) has been written to serve two purposes, to ensure the proposed farm system can meet the nutrient mitigation requirements set out by the Water Quality Study, and to identify and mitigate other farm specific environmental risks that arise from the inherent characteristics of the farm or from the proposed farm system and its management. These farm specific risks include uncontrolled discharges that are not identified in farm nutrient budget modelling but that may still have an environmental effect.

1.2 Why use a Farm Environmental Management Plan?

Farm management planning and the use of best management practices and mitigation methods are commonly used to reduce diffuse pollution from farms.

Diffuse pollution, as the name suggests, does not come from a single traceable source. In many cases the impacts are both temporally and spatially distanced from the source. This makes measurement from and traceability to an individual property difficult. For this reason, instead of measuring the losses, the emphasis is placed on the implementation of techniques that are known to reduce the contaminant.

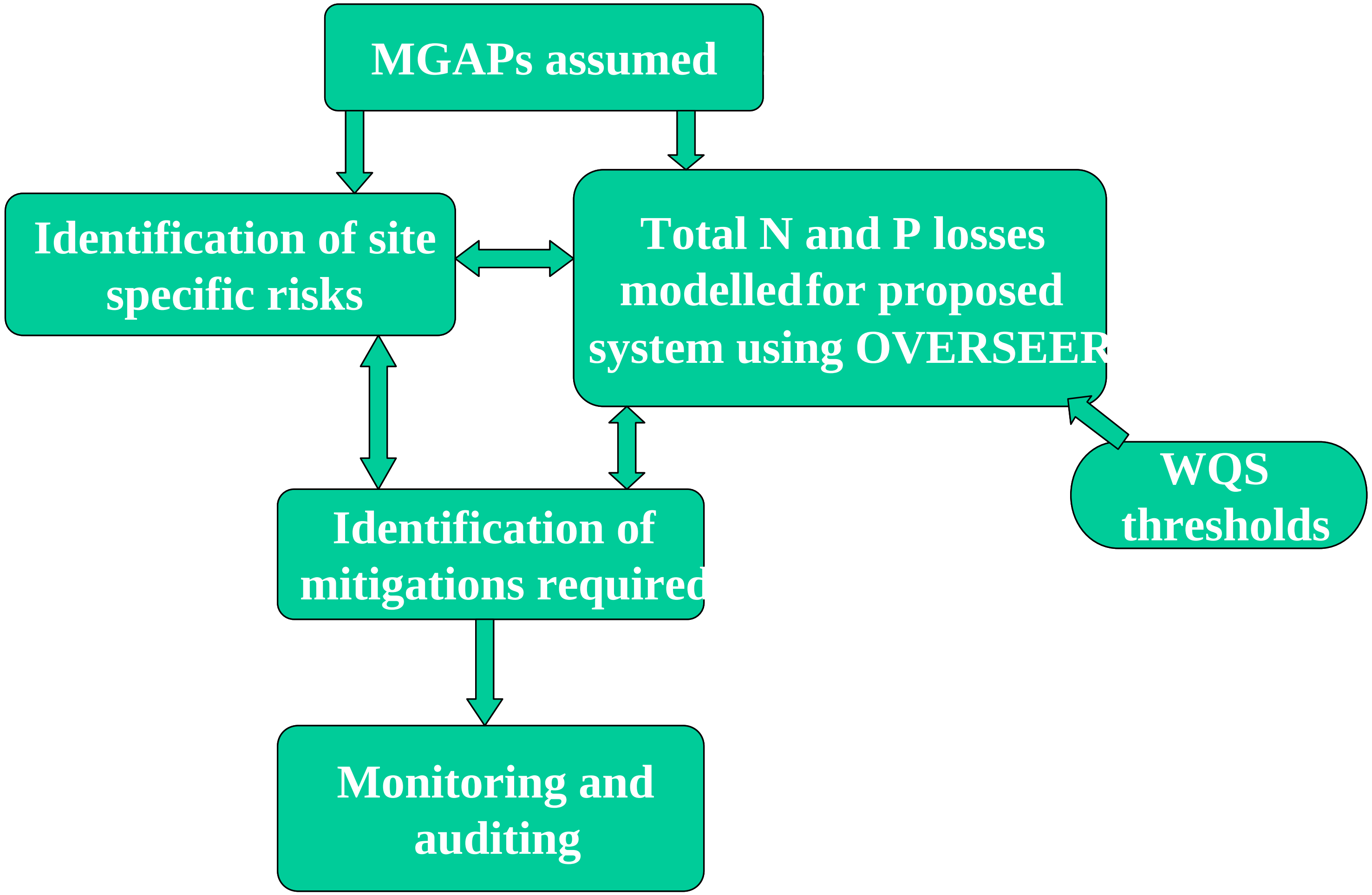
1.3 Scope of a Farm Environmental Management Plan

The development of a FEMP is divided into four sections:

- The first section describes Mandatory Good Agricultural Practices (MGAPs) that need to be implemented across the farm, and include the base assumptions of the OVERSEER model[1]. This helps to validate the use of the model on the property;
- The second section involves the construction of a representative farm model in OVERSEER and demonstrating the fulfilment of the nutrient mitigation required by the Water Quality Study; and
- The third section involves the identification and mitigation of site-specific environmental risks.
- The fourth section describes the proposed monitoring and auditing strategy.

[1] In the future, should an alternative model be used, the assumptions for that model would need to be specified in this good agricultural practice section.

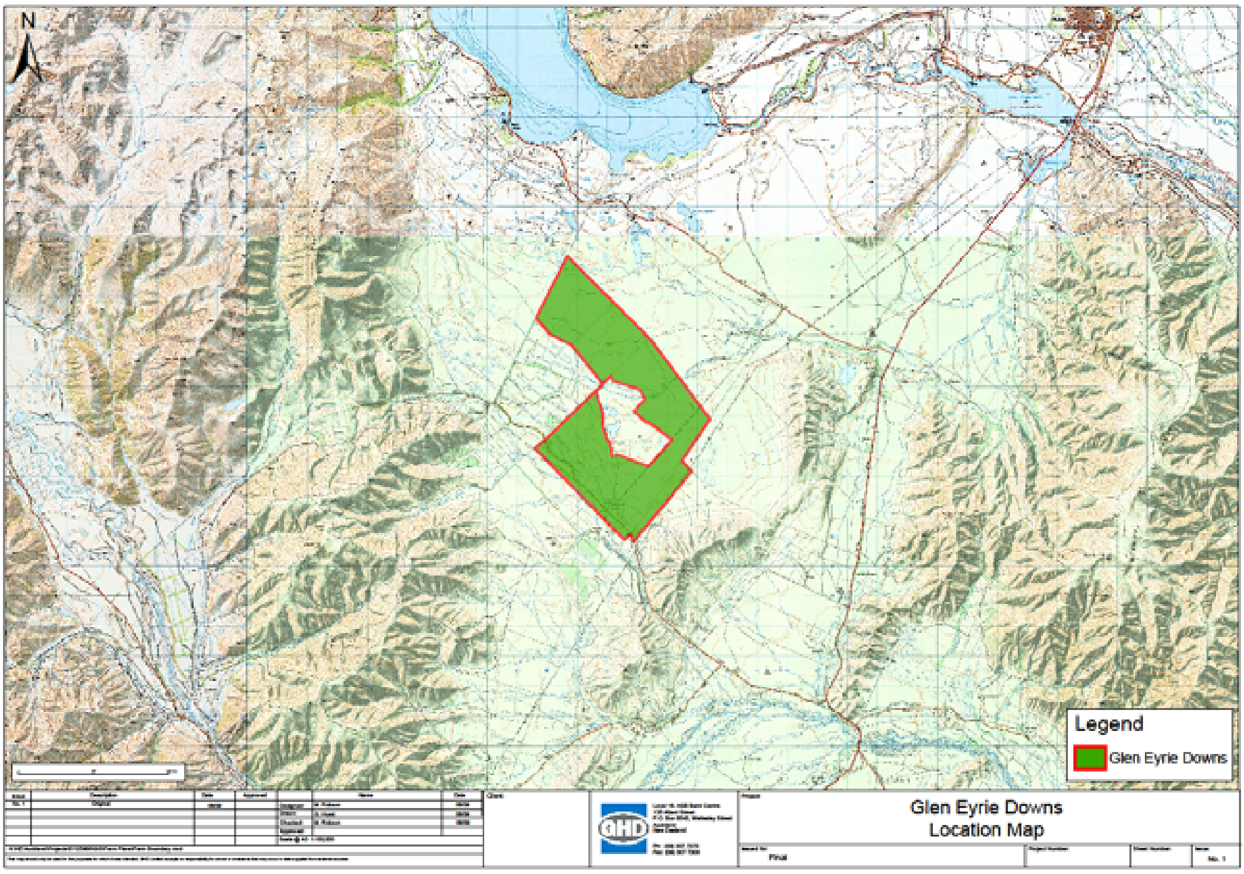
Figure 1 An overview schematic of the process of building a Farm Environmental Management Plan



2. Farm Description

Glen Eyrie Downs Station is located to the south of Lake Ohau approximately 15 km north of Omarama township (Figure 2). Glen Eyrie Downs Station is 2100 ha and is on flat and rolling country. This farm has undergone a dramatic transition over the past eighteen months. Previous to 2007 the farm was unstocked and was severely infested by wilding pine (Figure 3). They were progressively removed between September 2007 and February 2009 and burned. In 2008, the property was leased to Biodeisel NZ Ltd[2] for a minimum term of four years. There is a 4 year rotation of canola, spring barley, winter wheat and a ryegrass ley. Last season, approximately 700 ha were drilled with spring barley, 100 ha of canola, 200 ha of winter wheat and 300 ha of grass. The remainder of the property (approximately 700 ha) has been cleared and cultivated, but not planted. In general, the crops grew with little success, although there were some areas of fair and good growth. A report by Carey (2009) to investigate this poor growth indicated that increasing the soil pH, increasing the Olsen P and ensuring that sufficient nitrogen is supplied to the crop would remedy much of the poor performance.

Figure 2 Location map for Glen Eyrie Downs



[2] A subsidiary of Solid Energy.

Figure 3 Wilding pine infestation on Glen Eyrie Downs

2.1 Soils

The main soil series on Glen Eyrie is Ohau (> 80 %), although there are incursions of Fork and Cass/Cragieburn/Cox soils in the north of the property, Pukaki/ Holbrook soils in the east, Bendhu and Glen Eyrie soil in the south and Buscot/Sawdon/ Dobson soils running through the property along the course of the Wairepo Creek.

Soils of the Ohau series are well drained shallow to deep soils derived from loess or loess over till, and are characterised by well structured silt loam tops soils over well structured silt loam to stony fine sandy loam B horizon grading to stony fine sandy loam to loamy sand C horizon at 45-55 cm (Webb, 1992).

Two 100 m transects were sampled from 0-10 cm and below 10 cm. 10 cores were drilled at 10 m spacing along the transect and a representative bulked sample was taken. Figure 4 shows the location of the transect.

Figure 4 Location of soil transects on Glen Eyrie Downs

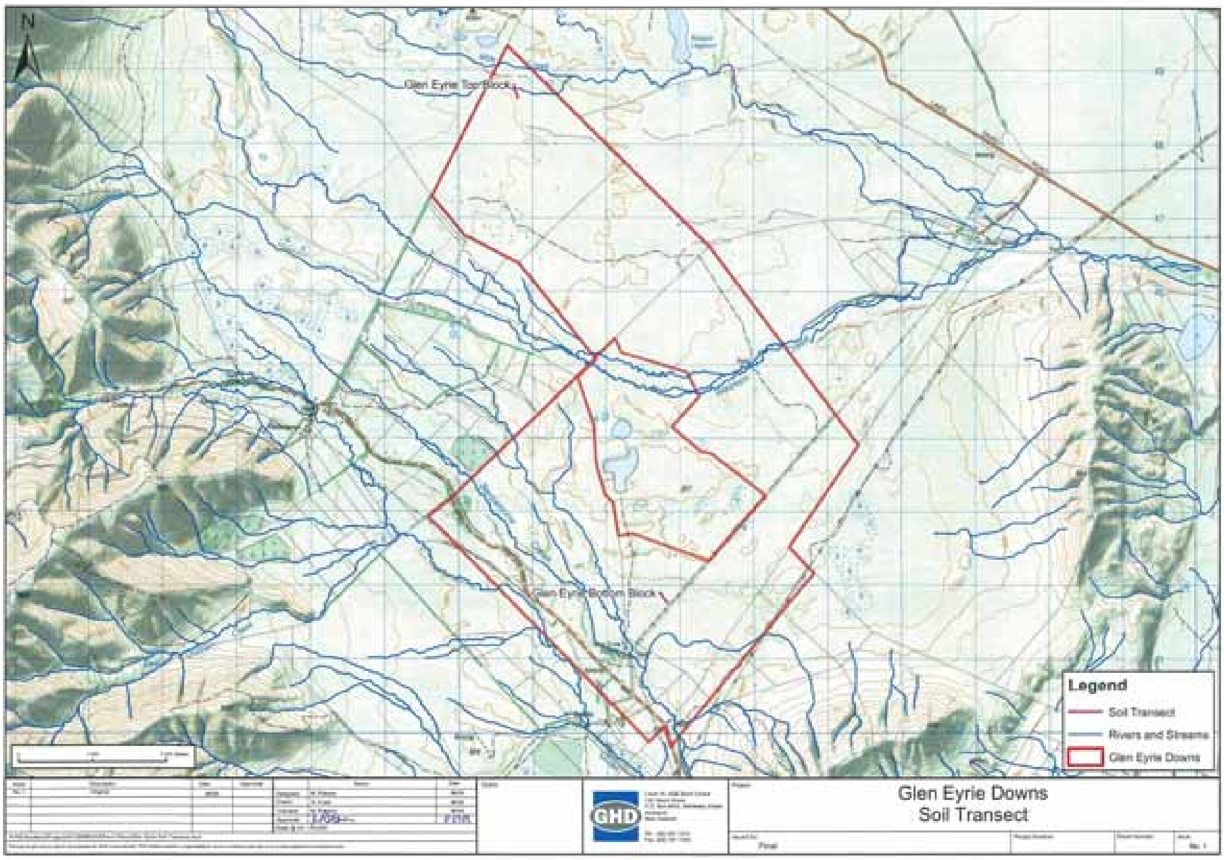


Figure 5 and 6 below show the range of depths to the C horizon in 10 m reaches along two 100 m transects. In each reach, the depth to the C horizon or to stones was ascertained by probing the soil 20-30 times. A minimum and maximum depth were recorded. During testing, there was repeated, although not ubiquitous, consolidation found in the top 10 cm. In soil pits dug on transect 1, the soils exhibited platy or massive structure in the top 20 cm, this is likely to have arisen from recent trafficking by machinery. In the deeper soils on transect 2, there was noticeable increase in density below approximately 40 cm.

In the top block, soils tested were more acidic (below 5.6) than the bottom block and were consequently tested for exchangeable-Al, these showed concentrations in the high toxicity range. Olsen P levels on both blocks are low to moderate and very low below 10 cm. Cation exchange capacity is moderate for both sites.

Figure 5 Soil depth to C horizon or stones over a 100 m transect on Glen Eyrie Downs Station (top block)

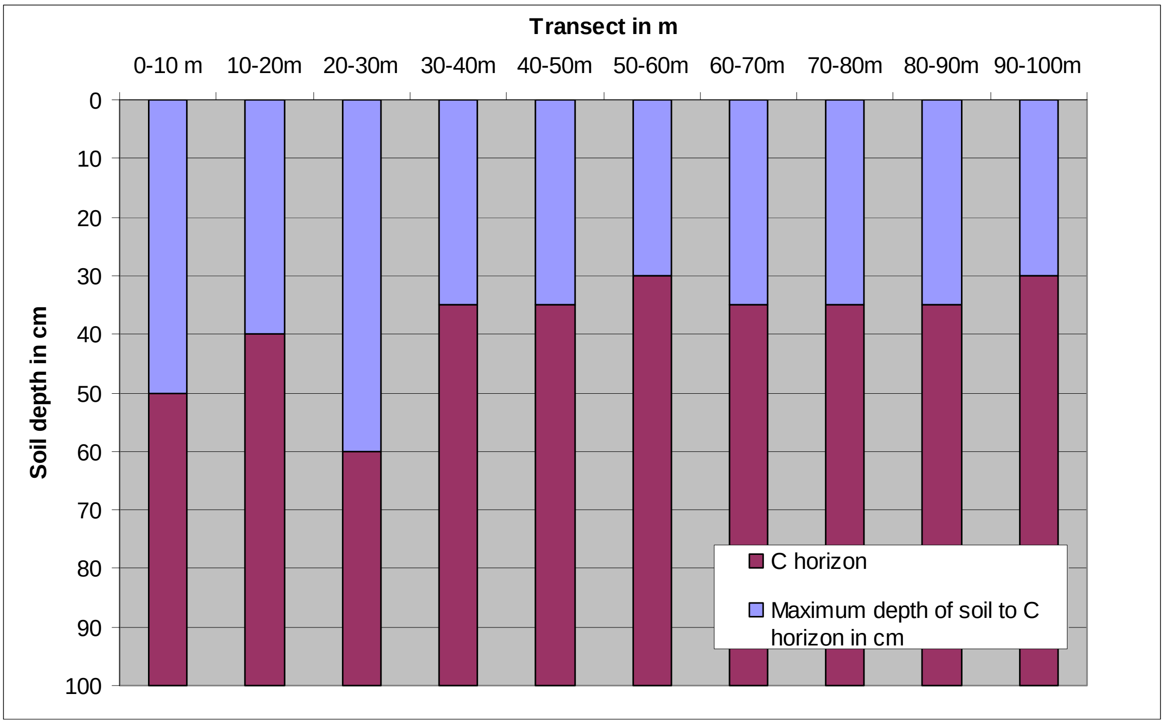
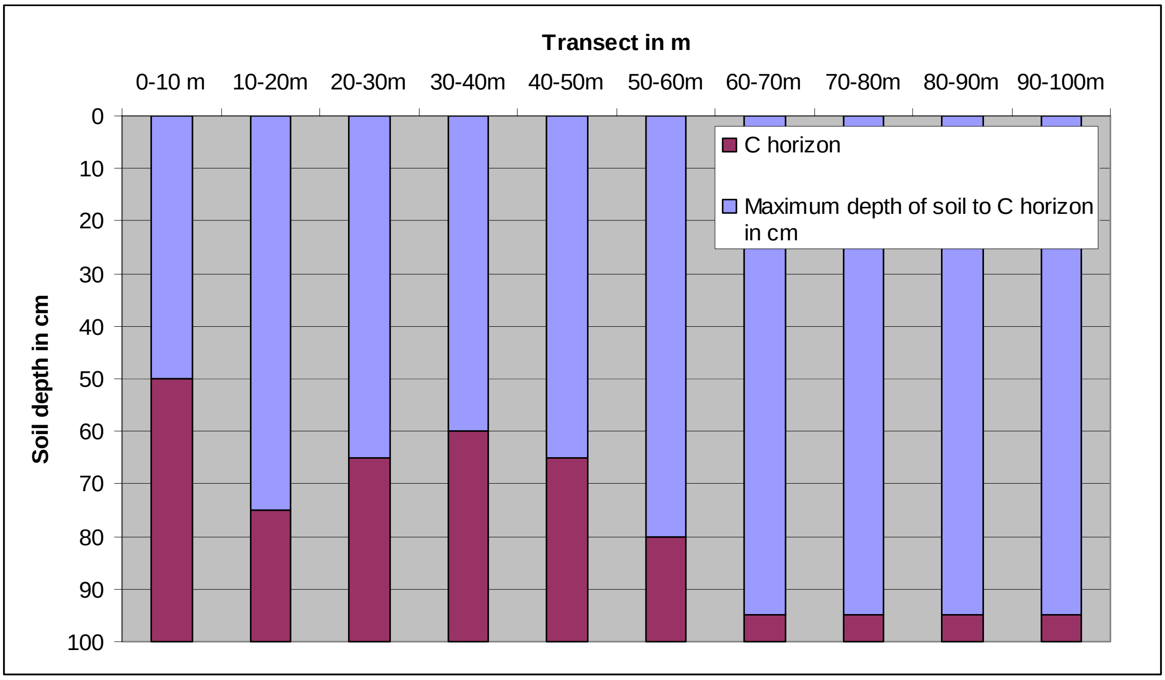


Figure 6 Soil depth to C horizon or stones over a 100 m transect on Glen Eyrie Downs Station (bottom block)



2.2 Climate

The climate in the Mackenzie Basin is characterized by dry summers and cold winters. Average annual rainfall on this station is 717 mm (GHD, 2009), and there is moderate variability in the monthly rainfall. Mean annual temperature is 10.3 degrees C, with a minimum winter temperature of < -2 degrees C (Snow and King, 2008).

2.3 Topography

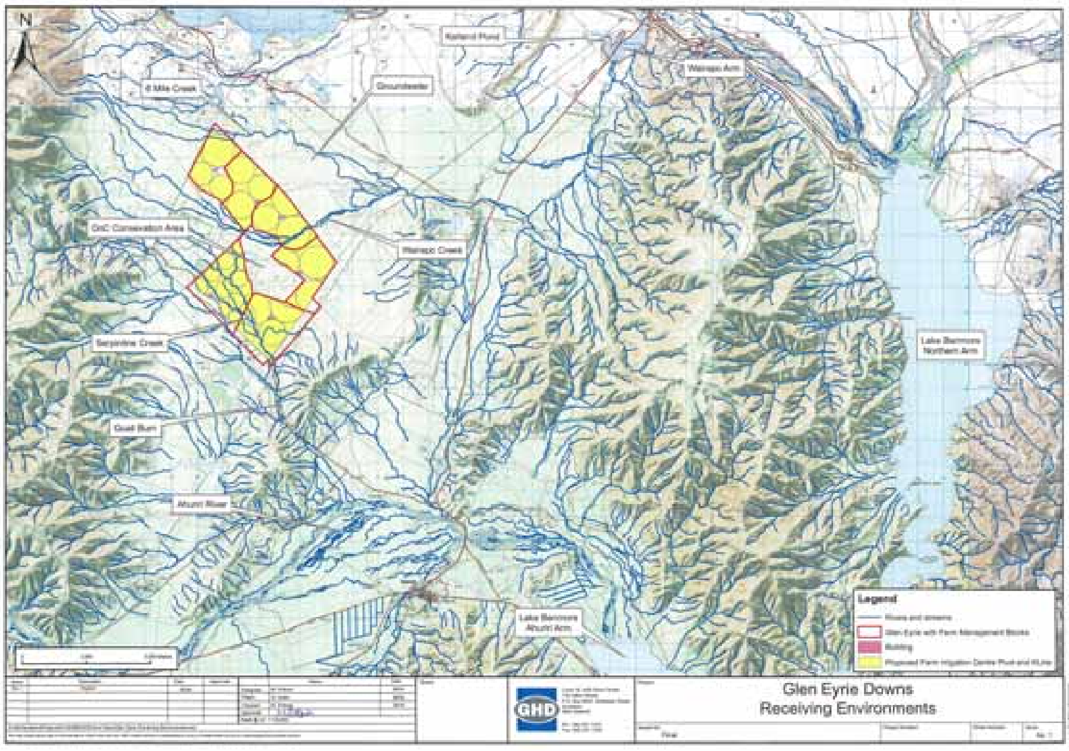
The slope of the land varies throughout the irrigated area; in general, however, the land gradient tends in a southeast direction. Across the property to the north of Serpentine Creek the land gradient ranges between approximately 0.009-0.012 m/m. South of Serpentine Creek, across the south-western corner of the property, the land slope is greatest reaching 0.04 m/m (Mitchell Partnerships, 2009a).

3. Environmental context

The environmental context of the farm is a reference both to local and wider receiving environments. Figure 7 shows the receiving environments of Glen Eyrie Downs.

The ecological impact of proposed practices on Glen Eyrie Downs, and the required mitigation for protection are discussed in full by Mitchell Partnerships (2009) and Ryder Consulting (2009) in their respective reports on ecology and aquatic ecology.

Figure 7 Map showing the receiving environments for Glen Eyrie Downs (available as an A3 in Appendix F)



3.1 Water Quality Study mitigation requirement

Glen Eyrie Downs Station, according to the WQS (GHD, 2009), lies in both the Wairepo Creek and the Quail Burn groundwater and surface water catchments (Appendix A). More detailed investigations have confirmed the direction of groundwater movement (Appendix B).

Table 1a and Table 1b show the calculated nutrient mitigation requirement of the receiving environments determined in the WQS and the resulting thresholds for N and P for Glen Eyrie Downs.

For this farm, the N mitigation requirements are the most stringent for groundwater and the P mitigations are most stringent for the Ahuriri Arm. These mitigation requirements cap Glen Eyrie's nutrient discharges at 38,139 kg N per annum and 1,621 kg P per annum.

3.2 Local receiving environments

The potential local receiving environments not captured in the WQS are the Serpentine Creek, Six Mile Creek and the QE II covenant on Ohau Downs and the DoC Kettleholes Reserve.

The direction of groundwater flow as predicted by the detailed groundwater modelling indicates that the groundwater is moving from west to east, however in the southern part of the property (below the DoC wetland) the flow turns to a southeasterly direction, following the general direction of the Serpentine Creek.

The Six Mile creek runs across the northern tip of the property. Historic modifications to the creek appear to have occurred within this section as the creek flows through a swampy area including several ponds, in an area of wilding pine (Ryder Consulting, 2009). The southern tributary of the creek is reported to only run after heavy and prolonged wet conditions (R Peacocke, *Pers Comm*. 2009). The Six Mile creek, once leaving the property enters the QE II covenant area on the neighbouring property, Ohau Downs Stations. The groundwater is also modelled to move in this direction.

The Serpentine Creek and a tributary of the Serpentine traverse the western and southern areas of the farm. The creek meanders through the lowest part of the valley and is associated with ephemeral wetlands along the stream course (Mitchell Partnership, 2009) as well as periodically waterlogged riparian margins. The Serpentine Creek discharges into the Quail Burn beyond the property boundary.

The DoC Kettleholes Reserve was established in 2004 when the tenure review process was completed and the area was recognised as a priority area of conservation (Mitchell Partnership, 2009). The modelled direction of the groundwater suggests that only the westernmost area of the property would impact on groundwater concentrations below the DoC reserve. The kettle holes are not thought to be groundwater fed, but as a result of impermeable or slowly permeable material capturing surface and shallow subsurface flow. The course of a tributary of the Wairepo Creek has been altered and now runs alongside an access track on Glen Eyrie Downs before entering the reserve.

Table 1a Water Quality Study mitigation requirements for Glen Eyrie Downs (GHD, 2009)

Farm	Surface water sub-catchment	Secondary surface water sub-catchment	Groundwater sub-catchment	Lake Sub-catchment	Proposed whole farm N loss from WQS	Proposed whole farm P loss/ha from WQS	Stream mitigation required for periphyton kg/ha irrigated land		Secondary stream mitigation required for periphyton kg/ha irrigated land		Stream mitigation required for ANZECC kg/ha irrigated land		Secondary stream mitigation required for ANZECC kg/ha irrigated land		Groundwater mitigation required kg/ha irrigated land		Lake mitigation required kg/ha irrigated land	
							N	P	N	P	N	P	N	P	N	P	N	P
GED	Quail Burn	Ahuriri	Quail Burn	Ahuriri Arm	72054	3792	-0.2	-0.5	1.1	-1.0	2.3	-0.5	0	0	0	0	-10.7	-1.1
GED	Wairepo	NA	Wairepo	Northern Arm/Ahuriri Arm	72054	3792	0	0	0	0	-1.9	-1	0	0	-16.4	-0.7	0	0

Table 1b Water Quality Study mitigation requirements for Glen Eyrie Downs continued

Stream mitigation required for periphyton kg/farm		Secondary stream mitigation required for periphyton kg/farm		Stream mitigation required for ANZECC kg/farm		Secondary stream mitigation required ANZECC kg/farm		GWR mitigation required kg/farm		Lake mitigation required kg/farm		Stream mitigation threshold for periphyton kg/year		Secondary stream mitigation threshold for periphyton kg/year		Stream mitigation threshold for ANZECC kg/year		Secondary stream mitigation threshold for ANZECC kg/year		Groundwater mitigation required threshold kg/year		Lake mitigation required threshold kg/year		Overall Farm thresholds for WQS mitigation kg/year	
N	P	N	P	N	P	N	P	N	P	N	P	N	P	N	P	N	P	N	P	N	P	N	P	N	P
-414	-1034	2275	-2068	4756	-1034	0	0	0	0	-22024	-2171	71640	2758	74329	1724	76810	2758	72054	3792	72054	3792	50030	1621	50030	1621
0	0	0	0	-3929	-2068	0	0	-33915	-1448	0	0	72054	3792	72054	3792	68125	1724	72054	3792	38139	2344	72054	3792	38139	1724

4. FEMP development

4.1 Stage 1 – Mandatory good agricultural practices

Table 2 below shows the mandatory good agricultural practices that will be adopted. These include the base assumptions of OVERSEER and therefore help validate the use of the model on the farm.

Table 2 Mandatory good agricultural practices

Mandatory good agricultural practices	What these practices mean on farm
Fertilisers applied according to code of practice for fertiliser use (NZFMRA, 2002).	The fertiliser users' code of practice aims to ensure that where fertilisers are used that they are used safely, responsibly and effectively and in a way that avoids, remedies or mitigates any adverse environmental effects. The code of practice includes guidance on fertiliser use, application, storage, transport, handling and disposal.
Use a fertiliser recommendation system and account for all sources of nutrients including applied effluents and soil reservoirs accounted for	Planning fertiliser applications to all crops, determining crop requirement and accounting for soil nutrients and organic nutrient supplies, all reduce the risks of applying excessive fertiliser above the crop requirement. This maximises the economic return from the use of fertilisers and reduces the risk of causing nutrient pollution of the environment Accounting for all sources of nutrients including imported sources and soil reservoirs is an important management measure in all farming systems and become especially important on farms where manure is produced and applied to the land. The re-application of organic manures to land is often thought of as a disposal of a waste product, and the available nutrients within the organic manures are not accounted for. The use of an integrated nutrient budgeting tool such as OVERSEER automatically accounts for nutrients supplied in organic manures.
Fertiliser application applied evenly	The even application of fertiliser is an assumption of the OVERSEER model as included in the fertiliser code of practice. Fertiliser spreaders should be tested and calibrated in-house at least annually and every 5 years by an independent auditor.
Irrigation and effluent applied evenly	The even application of water and or effluent is an assumption of the OVERSEER model. Irrigators should be tested and calibrated in-house at least annually and every 5 years by an independent auditor.
Crop, cultivation, nutrient inputs and yield records kept per farm management unit	Maintaining good crop input records is important for: ◗ The calculation of cumulative annual organic fertiliser applications and also their contribution to long term nutrient supply; ◗ The prediction of realistic crop yields that are used to determine crop requirements; ◗ Providing accurate inputs to the OVERSEER nutrient budgeting model that is being used here as a proxy for measuring diffuse nutrient losses.

Mandatory good agricultural practices	What these practices mean on farm
Good design of irrigation systems	Design will match soil properties and low application amounts on shallower soil to prevent summer drainage.
Robust irrigation scheduling	Good irrigation scheduling to prevent summer drainage.
Supplement and feeding out management	Proper storage of supplements and responsible methods of feeding out that do not result in accumulations of excreta on small proportions of the farm. Where large amounts of supplements are fed out, a feed pad should used.
Winter grazing management	Winter management of stock to prevent pugging and high densities of stock in one area for long times.

4.2 Stage 2 – OVERSEER and meeting WQS mitigation requirements

The WQS thresholds set for Glen Eyrie Downs, using the most stringent nutrient mitigation requirement, are 38,139 kg N per annum and 1,621 kg P per annum. Table 3 below shows the output from OVERSEER for the modelled proposed farming system at Glen Eyrie Downs. The results illustrate that the farm system mitigations proposed meet the N and P thresholds set out in the WQS. It should be noted that the modelling restrictions of OVERSEER are such that the greatest period of nil grazing possible is 6 months. On Glen Eyrie Downs, the proposed period of nil grazing is 8 months, extending the advantages for reductions in N and P losses by nil grazing beyond the modelled 6 months.

A list of OVERSEER model inputs and outputs are given in Appendices D and E.

Table 3 Total N and P losses modelled by OVERSEER for the proposed farming system on Glen Eyrie Downs and WQS thresholds

	OVERSEER modelling outputs kg/year	WQS threshold kg/year
Total N leaching/runoff	31,155[3]	38,139
Total P leaching/runoff	1,603	1,621

Using a highly developed setting, the modelled N losses increase to 58,054 kg N. As this setting allows for no immobilisation of N, and as a result the losses become highly sensitive to inputs. An increase in the length of time housed (from modelled) and a reduction in N fertiliser inputs is likely to deliver the required reduction. Modelling of the restricted system is understood to being updated for the December release of OVERSEER. To indicate sensitivity at using the is setting, just a reduction in the inorganic fertiliser N input from 130 kg N/ha to 103 kg N/ha delivered the required reduction in N losses (total farm N loss at 37,639 kg/year).

[3] Modelled at 400 kg MS/cow, the modelled outputs increase to 33,077 kg N and 1,605 kg P

4.3 Stage 3 – Identification and mitigation of site specific environmental risks

The Farm Environmental Risk Assessment (FERA) has been conducted on the proposed farming system (pre-mitigation), and has highlighted that there are potentially soil, effluent, stock, track, biodiversity and fertiliser environmental risks on the proposed farm and that there may be chemical risks as well. These risks are described below and are colour coded to indicate severity of risk or sensitivity of environment to risk, **high risk**, **medium risk** and **low risk**. All risks will need to be addressed in the Farm Environmental Management Plan (FEMP). The full FERA is attached as Appendix C.

4.3.1 Soil risks

The current soil risks identified are principally as a result of the land clearance resulting in disturbed and consolidated soils that, in some areas have been left bare over winter. These soils are at risk of erosion. In addition the soils have low pH which renders them susceptible to Al toxicity. The soil risks associated with the proposed farming system are; trafficking when wet, stock grazing over winter, and inversion tillage to establish pastures. The inherent soil risks associated with this farm is the presence of slaking or erobible soils.

4.3.2 Effluent risks

The effluent risks associated with the proposed farming system are, clean and dirty water are not separated on the yard, close to 200 kg N from organic manures will be applied, Silage liquor is not to be collected and spread to land and that direct discharges may occur from the silage pits.

4.3.3 Fertiliser risks

The fertiliser risks associated with the proposed farming system are that more than 50 kg fertiliser N is to be applied in a single application, and applications are not to be excluded in winter and autumn, Olsen P levels may exceed 30, fertiliser spreaders are not calibrated, and a suitable storage and filling area has not been identified.

4.3.4 Stock risks

The stock risks associated with the proposed farming system are that stock are not to be excluded from the watercourses, stock will spend some time grazing over winter, there are no provision for dealing with fallen stock, and there are no provisions for further reducing winter stock nutrient losses.

4.3.5 Water risks

The water risks associated with the proposed farming system are that stock are not to be excluded from the watercourses.

4.3.6 Runoff risks

The current runoff risks arise from running together of surface soils in exposed areas. When dry, these may form structurally massive caps that severely reduce infiltration and can lead to surface runoff. The inherent runoff risks associated with this farm are the presence of sloping fields in hydrologically connected areas, and the presence of a lot of water features on the farm. The existence of wetland and pond features indicates impermeable or slowly permeable areas. The runoff risks associated with the proposed farming system are the possibility of runoff from grazed areas reaching a watercourse, the grazing, albeit restricted, of stock over winter

4.3.7 Track risks

The current track risks arise from the presence of tracks in hydrologically connected areas, the tracks running through streams and the possibility of runoff from tracks reaching a watercourse. The track risks associated with the proposed farming system are that no devices for removing runoff from tracks before it reaches a watercourse have been identified and that no stock tracks, specifically maintained for stock have been planned.

4.3.8 Biodiversity risks

The pine infestation, its removal and the development of the land for cropping means that the vast majority of the property has very limited ecological value (Mitchell Partnerships, 2009). The beds and courses of some waterways have been modified by excavation, particularly in the upper reaches of the Wairepo Creek. Some undeveloped areas remain and the most valuable of these have been protected within the DoC reserve (Ryder Consulting, 2009). However, the Wairepo Creek margins provide a corridor of vegetation that contains natural elements and connects the Wairepo Kettleholes reserve with the grazed but uncultivated land on Ohau Downs. Any such stream channels and riparian vegetation in this heavily modified landscape can be considered to be of high ecological value and they preserve elements of indigenous species and processes that are now of limited distribution the Ecological District (Mitchell Partnerships, 2009). The Serpentine Creek, although modified is considered to have values to be protected under the partly operative Waitaki District Plan and the Serpentine Creek wetland area represents one of the few remaining riparian wetland in the this part of the Mackenzie Basin (Mitchell Partnerships, 2009).

The main biodiversity risk arises from the intensive grazing of stock on riparian margins and access of stock to the watercourse, and continued poor riparian habitat management.

4.3.9 Chemical risks

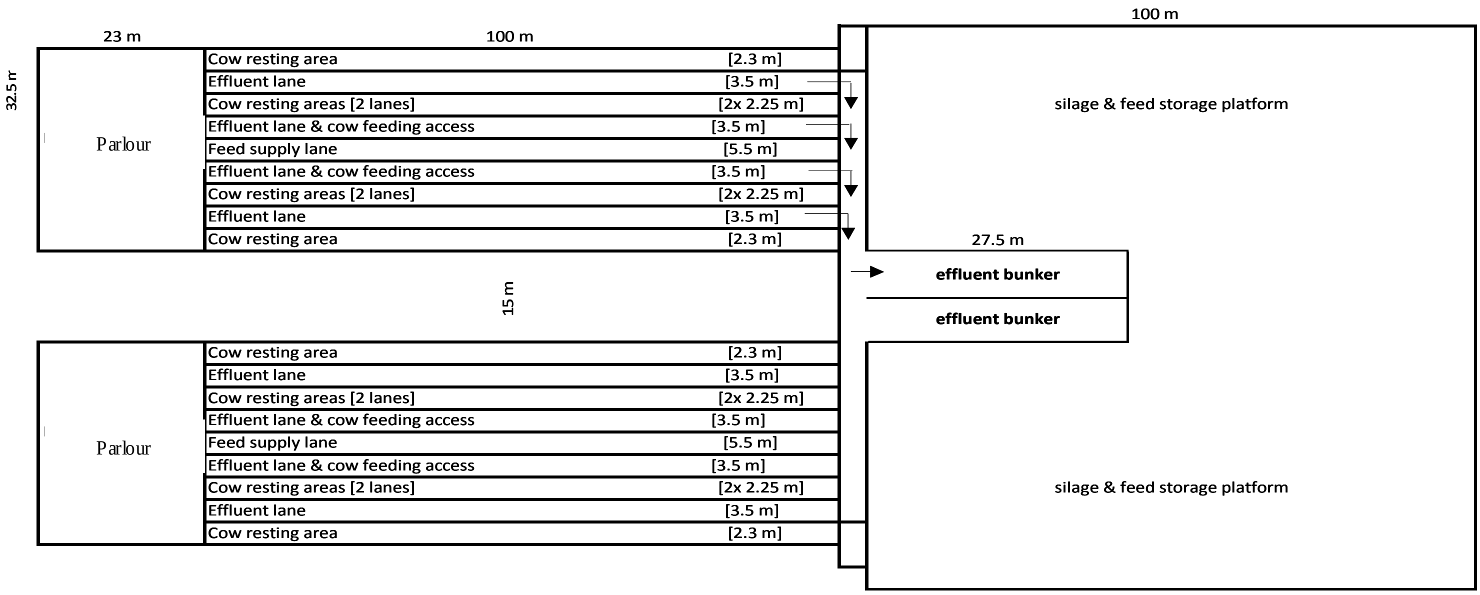
The chemical risks associated with the proposed farming system are that no provision for the safe storage, handling, using and disposing of chemicals has been made.

5. Proposed farm system with mitigations

The proposed farming system is an irrigated dairy farm with stock wintered on the farm using a cubicle stable system. The stock are planned to be housed full time for 8 months of the year and housed partially (12 hrs/day) for the remaining four months of the year. However, this system allows housing up to 365 days per year. The farm will primarily operate a cut and carry system to bring pasture to the herd in the barns. Pasture will be cut, conserved and fed to the herd throughout the year along with imported supplement (Englebrecht, 2009).

The layout of the cubicle stable is shown below in figure 8. The plan view shows the milking parlour on the left and the layout of the cubices in the centre interspersed with alternative effluent lanes and feeding lanes. Effluent is scraped along the effluent lanes and into the effluent bunker to be separated and then stored, also draining to the effluent bunker are the silage clamps, on the right. The whole unit is covered by a roof.

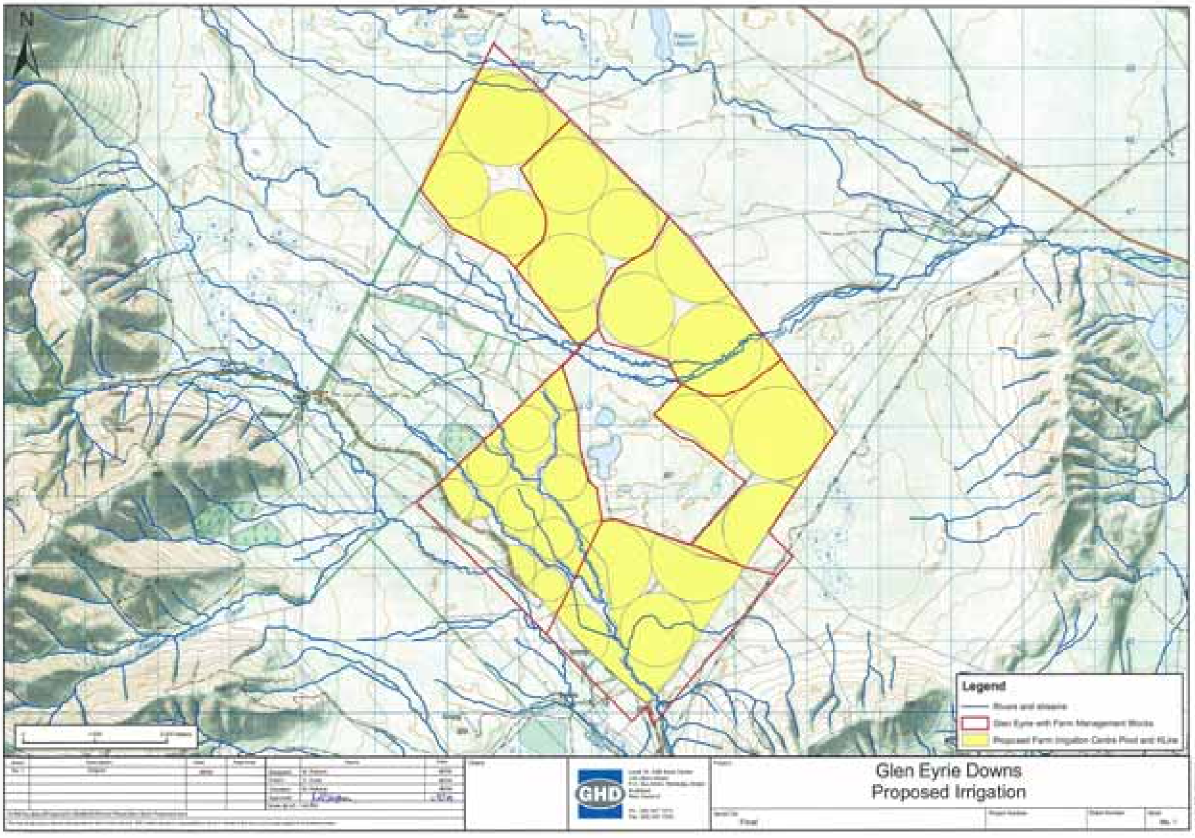
Figure 8 Proposed layout of the cubicle stables including silage clamp and effluent collection facility



5.1 Blocks

Six independent management units are proposed on the property (Figure 9), each comprising approximately 344 ha and carrying approximately 1167 milking cows.

Figure 9 Map showing proposed irrigation layout and farm management blocks on Glen Eyrie Downs (available as an A3 in Appendix F)



5.2 Soils

The FERA highlighted current soil issues from the clearance of groundcover and the areas of land that have been left bare, the consolidation of soil as a result of the land clearance, and soils with high exchangeable-Al concentrations that can affect plant growth. Potential soil issues arising from the vulnerable nature of the soils to erosion, the grazing of stock over winter and the possibility of trafficking soils when wet. The proposed mitigation measures are;

Irrigation and consequent full ground cover to protect the soil from erosion;

Increase pH to avoid Al toxicity problems;

The housing of stock over the winter period to remove potential for soil damage from grazing stock in adverse conditions; and,

No trafficking of soils when wet, and as this is not always possible, the annual monitoring and identification of soil compaction and documented remedial actions taken.

5.3 Stock

The dairy herds will consist of both Holstein and Holstein crosses, making in total a herd size of 7000 cows and at a stocking rate of 3.5 SU/ha. Young stock will be grazed off farm from weaning as will dry stock. Only milking cows will be present on the farm and milking cow numbers will be maintained throughout the year, (B. Englebrecht, *Pers Comm*, 2009).

The FERA highlighted potential stock issues arising from the non-exclusion of stock from watercourses, the non-control of dietary N and P, no provision for fallen stock and the partial grazing of stock over winter with no further provision for reducing these losses. The proposed mitigation measures are;

The exclusion of stock from watercourses by planting and fencing dual function riparian margins. The outermost area of the margin will be densely planted to aid attenuate flow and promote infiltration and sedimentation. The periodically waterlogged inner area of the margin will be protected and maintained in this waterlogged state to promote conditions favourable to denitrification. A minimum distance of 5 m from the outside bank of the watercourse has been agreed, although due to the meandering nature of the streams, the margins are usually greater than 5 m;

The closer management of the herd due to housing allows the feeding of animals according to their requirements (phase feeding);

All fallen stock will be collected; and,

The housing of stock over the winter period will mitigate winter stock nutrient losses.

5.4 Production

The irrigated area will be under ryegrass /white clover, fescues and chicory, however clover levels may be depressed by the even and substantial return of organic manures. Pasture production is expected to be approximately 13 t dry matter/ha on irrigated and fertilised land. An 85 % pasture utilisation rate has been assumed as the mechanical harvesting and feeding of silage in the cubicle stables will result in greater utilisation rates, and the lack of pasture damage from stock will enhance pasture production (Engelbrecht, 2009). Milk Solids production is expected to be approximately 350 kg MS/cow. The close management possible with housed herds will permit all year round calving and milking, taking advantage of the winter milk premium (Engelbrecht, 2009).

5.5 Manure, effluent and silage storage

5.5.1 Manure production

The stock are expected to be housed full time for 8 months and for 12 hours per day for 4 months. 7000 cows housed for this period will produce approximately 132000 m^3 of undiluted excreta stored in six individual facilities of 22,000 m^3. This includes some dilution from dairy washings[4], however, no yards drain to the collection area.

5.5.2 Manure handling

In the cubicle stables, alleys and other stocked areas will be regularly scraped down to deliver effluent to a sump at one end of the stables (Figure 8). From the sump, the effluent will be pumped to an effluent press and separated into liquid and solid fractions. Any leachate from around the effluent press area will drain into the liquid effluent collection system.

[4] Milking will either be done using a rotary bale or robotic milkers. Both will be undercover and with minimal water used in cleaning.

The FERA highlighted potential effluent issues arising from no clean and dirty water separation on the yards. The proposed management measure is:

<u>Clean</u> water will be separated in any uncovered yards and roof water either diverted and discharged to ground or collected and used.

5.5.3 Manure storage

There will be seven months storage, 22,000 m^3 in lined facilities for the liquid fraction. A freeboard of at least 750 mm will be maintained at all times. The solid fraction will have 12 months storage availability and it will be stored on covered concrete pads and will drain to the effluent storage facility.

5.5.4 Manure application

Effluent will be applied through the centre pivots and the solid fraction will be spread using a calibrated muck spreader or exported. Effluent will be injected to irrigation water prior to being irrigated. Effluent will be applied at the most appropriate times for crop uptake, during active pasture growth in the spring and summer. Effluent application depth will be determined by soil moisture deficit and a minimum of 5.9 mm of soil moisture deficit will be maintained.

No effluent will be applied within 20 m of the watercourse.

All applications will be recorded and accounted for when determining fertiliser requirements.

The FERA highlighted potential effluent issues arising from close to 200 kg /ha /year of organic N being applied. However, improved storage and prolonged housing may increase the effluent to be recycled to land. A total effluent loading rate of less than 200 kg/N/year permits this activity to maintain a consented activity status under ECan's dairy effluent rules. This threshold is in compliance with the consent for effluent application lodged for this property.

The proposed management measures are:

To test effluent nutrient concentrations during spreading season, and record cumulative applications;

If applications indicate that more than 200 kg N of organic manure will be added should all the remaining effluent and solid manure be applied, the solid fraction will be exported; and,

A farm map showing no spread areas should be clearly displayed in the farm office and if effluent is spread by tractor, these should be carried in tractor cabs.

5.5.5 Silage

The FERA highlighted potential effluent issues arising from silage liquor not being collected and spread to land and that direct discharges are made from the silage pits. The proposed management option is that silage is stored on a concrete pad and drains to the effluent collection facility (Figure 8). The silage liquor will be recycled to land along with effluent[5]. Due to the unknown nutrient concentrations in the liquor, the effluent will be regularly tested during spreading and cumulative applications recorded.

[5] The concrete will need to be an appropriate specification for containing silage as the liquor is highly corrosive.

5.6 Anticipated fertiliser use

Specific fertiliser recommendations will be produced on an annual basis using a recommended system. Plant nutrient supply will be estimated from both organic and inorganic fertilisers as well as N fixation using a nutrient budgeting system. The effluent and solid manure collected from the sheds will provide an important part of the nutrient requirement.

Nitrogen losses may occur during collection, storage and application and also when solid manure is applied, not all of the nutrients, especially the N will be immediately available. However these quantities would be sufficient to meet over half of the P and K requirements of a silage field with four cuts taken (MAFF, 2000).

Although a significant amount of N will be recycled, inorganic fertiliser will also be required. The P fertilisation strategy will be to build soil P concentrations to between 20 and 23 Olsen P, and to maintain them in this range. Full account will be taken of the organic fertiliser inputs of phosphorus through the use of a nutrient budget. The FERA highlighted potential fertiliser issues arising from more than 50 kg fertiliser N being applied in a single application, N applications occurring in autumn and winter, fertiliser spreaders not being calibrated and no suitable storage and filling area having been identified. The proposed mitigation measures are:

No N fertiliser to be applied in autumn and winter;

N fertiliser applications to be split to less than 50 kg N/ application;

Soil Olsen P levels to be maintained at or below 23;

Fertiliser spreaders to be on-farm calibrated annually and optimised;

Fertiliser will be stored in a covered area;

The identified fertiliser filling area will be at least 50 m from a watercourse of spring or bore and will have no drains that discharge to clean water or that can discharge straight to ground; and,

If liquid fertiliser used, fertiliser will be stored in a bunded tank and also protected from vehicle movements.

5.7 Chemical storage and management

The FERA highlighted that no chemical management strategy was in place. To satisfy the issues raised, the proposed management strategies are:

Where chemicals are used on farm, these will be stored in a secure shed. Containers and foil caps will be disposed of as hazardous waste, or triple rinsed and disposed of as non-hazardous;

The services of a professional crop adviser or other suitably qualified person will be used to advise on pesticide options, doses and tank mixes;

Sprayers will either be filled on a concrete yard draining to a sealed tank or a biobed or in the field. When filling, a portable bund will be placed beneath the induction hopper;

Back siphoning prevention measures will be used when filling sprayers, through the use of bowsers;

Tank washings will be resprayed to same fields ensuring no exceedance of dose;

Sprayer washdown area will drain to sealed tank or biobed and sprayers should be stored under cover; and,

'No spray' areas will be clearly marked on a map and displayed in the farm office and in the sprayer cabs. An emergency 'in case of a spillage' procedure should be clearly displayed in office, chemical store and sprayer filling area. A bucket of sand will be available in the sprayer filling area to be used on any spills.

5.8 Cultivations and trafficking

After initial cultivation for the establishment of permanent pasture, little cultivation is expected. Re-establishment of pastures is not expected to involve inversion tillage.

The FERA highlighted potential soil risks arising from trafficking soil when wet.

The proposed mitigation measure is:

Compaction caused by machinery movement will need to be identified on an annual basis between late autumn and mid spring, excluding times when land is frozen. Compaction is identified both through visual inspection (of the soil surface and plant stress indicators) and through testing for compaction using a soil penetrometer and digging verification pits. Identified compaction should be removed at the earliest opportunity with an appropriate technique for the depth of compaction.

5.9 Water and runoff

2,068 ha of the farm is planned to be irrigated at a rate of 600 mm/year, the proposed farm irrigation layout is shown in Figure 9. The source of the irrigation water is from Lake Ohau. In total, 26 centre pivots are proposed (16 full circle and 10 half circle). Final pivot design has avoided crossing watercourses as much as possible. In the one case where this is not possible, bridges will be constructed at wheel crossing points. Full details of the irrigation water take, transport and application can be found in the Aqualinc (2009) (3 August, 2009).

The FERA highlighted potential water and runoff risks arising from tracks running through streams and discharging runoff directly, pivot tracks going over watercourses, the possibility of runoff from grazed areas reaching a watercourse, stock access to watercourses and the grazing of stock over winter

The proposed mitigation measures are:

Riparian fencing will prevent stock encroachment of waterways;

Dual function riparian zones will be planted up as detailed in Section 5.3, to attenuate and remove nutrients entering the waterways.

Runoff from all tracks will be prevented from entering watercourse;

No effluent will be irrigated over watercourses and a 20 m layback will be observed; and

The restriction of stock access to waterways will require stock water facilities to be provided. However, due to the very restricted grazing system proposed, soils are not expected to be seriously damaged around troughs. Where damage does occur, this will be assessed during the annual soil compaction assessment, and remedial action taken if necessary.

5.10 Biodiversity

Mitigation measures to protect ecology are discussed in full in Ryder Consulting (2009) and Mitchell Partnerships (2009). In brief, riparian planting and fencing is proposed to prevent stock access, enhance remaining ecological value through planting and protection of indigenous species shade waterways, provide cover and habitat for fish and invertebrates and stabilise banks. Measures to protect avifauna include controlling pest species and predators.

Riparian fencing will prevent stock encroachment of waterways and dual function riparian zones will be planted up as detailed in Section 5.3.

6. Farm Environmental Management Plan for Glen Eyrie Downs

Table 4 below shows the all the mitigation and management tools that are proposed to be undertaken on Glen Eyrie Downs. Measures indicated as FEMP stage 1 are those identified as Mandatory Good Agricultural Practice, measures identified as FEMP stage 2 are those changes that have been modelled in OVERSEER to meet the WQS mitigation requirement, and those indicated as FEMP stage 3 are mitigation measures chosen to ameliorate site specific environmental risks on the farm and that are not modelled within OVERSEER. The table indicates in brief how the measures are to be monitored and audited, and a map showing the locations of the proposed mitigation measures is shown in Figure 10.

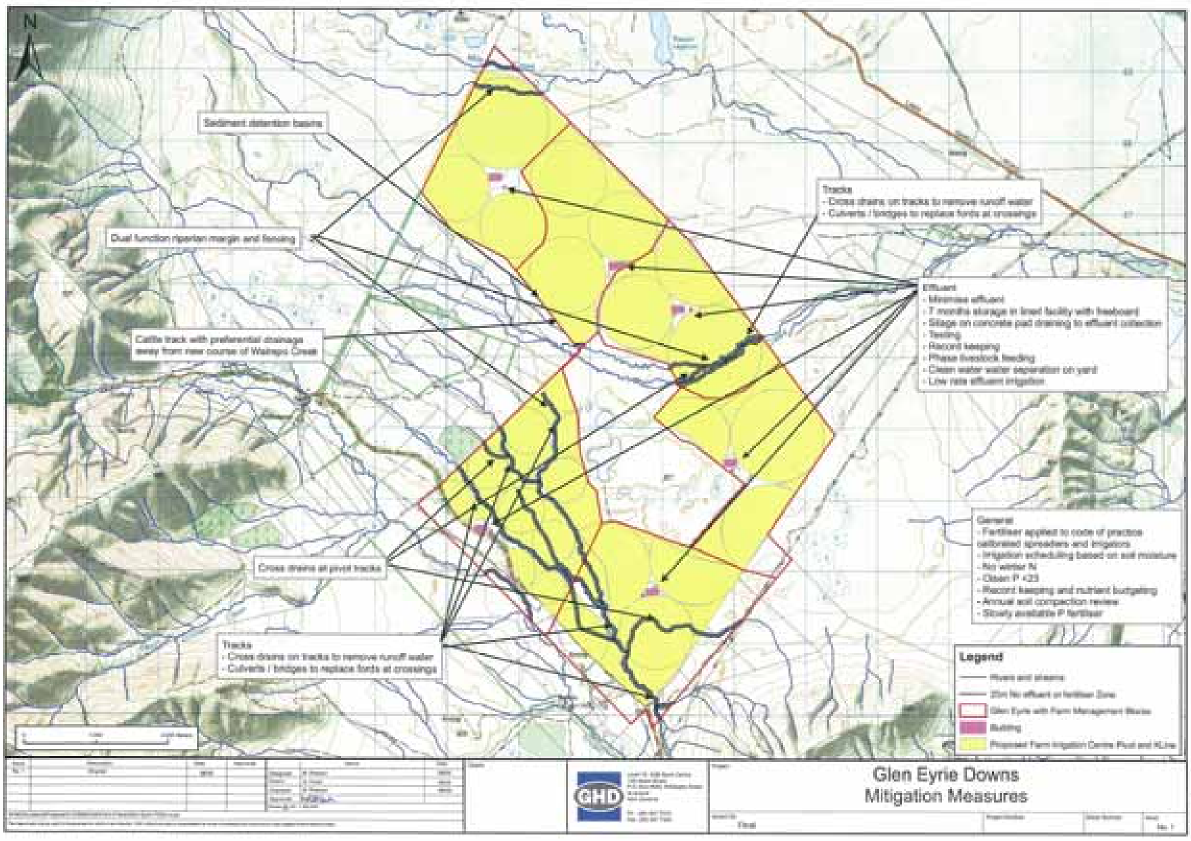
Table 4 Table of mitigation options, monitoring and auditing for Glen Eyrie Downs

FEMP stage	Measure	Monitoring	Auditing
1	Fertilisers applied according to code of practice for fertiliser use.		Self certification
1	Accounting for all sources of nutrients including applied effluents and soil reservoirs.	Soil and effluent testing and cumulative effluent inputs per management unit.	Reconciliation of fertiliser, effluent and soil records with nutrient budget for example blocks. Submission of examples soil and effluent tests.
1	Even fertiliser application.	Calibrate and optimise fertiliser spreaders annually and every 5 years by an external auditor.	Submission of testing and calibration.
1	Even irrigation and effluent application.	Calibrate and optimise irrigators annually in house and every 5 years by an external auditor.	Submission of testing and calibration.
1	Record crop, cultivation, nutrient inputs and yields per farm management unit.	Upkeep of records.	Submission of example block records.
1	Good design of irrigation systems.	Design of irrigation system by a certified professional.	Irrigation system audited by a certified auditor every 5 years.
1	Robust irrigation scheduling.	Calculation of annual % effective water use.	Submission of annual % effective water use.

FEMP stage	Measure	Monitoring	Auditing
1	Supplement and feeding out management.	Not applicable as stock are wintered indoors	
1	Winter grazing management.	Not applicable as stock are wintered indoors.	
2	Nil grazing for 8 months.	Field records showing when restricted grazing starts and ends.	Signed field records.
2	Restricted grazing for 4 months.	Field records showing when restricted grazing starts and ends.	Signed field records.
2	Minimisation of effluent produced through separating and discharging clean.		Annual auditing visit. Photographic evidence of extent of roofing, diversion on any open yards and robotic milkers.
2	Fencing stock out of waterways through riparian fencing and planting.	Surface water testing of race as it enters and exits the property.	Annual auditing visit to check integrity of fence.
2	Dual function riparian margins with a minimum width of 5 m from the outer bank of the stream.	Annual wet weather survey to assess whether there is runoff through margins.	Annual wet weather survey.
2	No winter application of fertiliser.	Field records.	Signed field records.
2	N fertiliser applications split to under 50 kg N/application.	Field records.	Signed field records.
2	Effective separation of liquid and solid fraction of effluents and part removal of solid fraction.	Effluent testing including dry matter and cumulative application records.	Submission of test results. Annual audit visit. Submission of proof of solid fraction export.
3	Effluent Storage.		Storage volume calculation and plans submitted. Annual audit visit.
3	Low rate irrigation of dilute effluent.	Irrigation scheduling and cumulative application records.	Submission of example irrigation schedules and cumulative application records.
3	Improved ground cover to protect from wind erosion.	Annual quadrat testing for % cover in all blocks and photographs.	Submission of testing results and photographs.

FEMP stage	Measure	Monitoring	Auditing
3	Identify and remove soil compaction and consolidation.	Annual soil compaction assessment.	Submission of assessment and remedials.
3	Phase feeding of livestock.	Feed ration monitoring	Submission of example of feed rations.
3	Clean water separated from roofs and any uncovered yards, collected and used or diverted discharged to ground.		Annual wet weather survey.
3	Silage stored on a concrete pad and draining to effluent collection facility.		Submission of silage clamp plans. Annual audit visit.
3	Silage liquor and effluent regularly tested for nutrient content in spreading season.	Implicit within mitigation – accounting for all nutrient sources	Implicit within mitigation – accounting for all nutrient sources
3	Olsen P of below 23 maintained.	Regular soil testing (every 3 years).	Submission of soil tests.
3	Fertiliser stored in covered area.		Photograph of storage area. Annual audit visit.
3	Identified fertiliser filling area will be at least 50 m from a waterway and will have no drains or direct discharges to ground.		Photograph of filling area, and map showing drains and watercourses. Annual audit visit.
3	If liquid fertiliser is used, fertiliser will be stored in a bunded tank.		Photograph of storage area. Annual audit visit.
3	Chemical storage and management.		Submission of proof of 'approved handler' status.
3	Prevention of runoff from tracks entering waterway through series of cross drains approaching the waterway.	Annual wet weather survey to assess whether there is runoff.	Photographic evidence of cross drains. Submission of wet weather survey results and remedials.

Figure 10 Annotated map with key mitigation options and locations on Glen Eyrie Downs (available as an A3 in Appendix F)



6.1 Monitoring and Auditing

Monitoring and auditing of the FEMP are as important as the plan itself.

Table 4 above shows the monitoring suggested for the mitigation and management options chosen for Glen Eyrie Downs. Table 5 below shows the frequency and parameters for the monitoring, and Figure 11 shows these monitoring points on a map of the property.

Additional monitoring will be carried out in conjunction with other farmers in the sub-catchments by the Mackenzie Irrigation Company, on the Wairepo Creek, the Quail Burn, the Ahuriri River, in the Ahuriri Arm and Northern Arm of Lake Benmore, and in the Wairepo Creek and Quail Burn groundwater sub-catchments.

Detailed groundwater modelling has been conducted for the farm and the modelled nitrate contribution from Glen Eyrie Downs to groundwater concentrations have been modelled for 5, 20 and 30 years. These outputs are shown in Appendix B. The maximum modelled contribution from Glen Eyrie Downs to groundwater nitrate concentrations after 5, 20 and 30 years, is 0.3, 0.25 and 0.25 mg/l nitrate-N respectively.

Table 5 Location, frequency and parameters for monitoring on Glen Eyrie Downs

		Location	Frequency	Measured parameters to include	Triggers	Contingency plan if triggers are exceeded
Soil	Soil nutrient testing	All blocks in rotation	1 in 3 years	Standard suite of soil nutrients, pH C, N and organic matter	Olsen P of 23	Reduce or stop addition of P fertiliser to area and monitor.
Soil	Soil compaction survey	All blocks	Annually	Surface and subsoil compaction	Compaction, surface capping	Remove compaction with appropriate tool.
Soil	Wet weather survey	All blocks	Annually	Runoff from tracks and centre pivot tracks and overland flow through riparian margins	Runoff occurring	Immediately review current runoff mitigation options for pivot tracks. Introduce further runoff removal infrastructure. Runoff through riparian margins should be attenuated through placement of temporary barriers or detention pits for larger volumes until source of runoff can be identified and addressed.
Effluent	Irrigated effluent nutrient testing	All blocks receiving effluent	Regularly throughout spreading season	Total N, nitrate, ammonia, dissolved reactive phosphorus, BOD	NA	
Effluent	Cumulative effluent application	All blocks receiving effluent	Record each time effluent is applied	Application depth	200 kg/ha effluent N including solid fraction	Store solid fraction until exportation can be arranged. Export enough of solid fraction to maintain application at less than 200 kg.
Water	Groundwater quality	On farm bore	2 x per year at mid depth of aquifer	Total Nitrogen, nitrate, ammonia, total Kjeldahl nitrogen, total phosphorus, dissolved reactive phosphorus.	> 2 mg/l nitrate-N from current modelled baseline conditions	If groundwater analysis indicates an excedence of 2 mg/l above current modelled baseline, the N application to land should be reduced or stock withheld for longer until a root cause analysis can be conducted.
Water	Surface water quality	Entry and exit of Wairepo Creek and Serpentine Creek and main tributary on property boundaries	Monthly for first couple of years to establish patterns	Total Nitrogen, nitrate, ammonia, total Kjeldahl nitrogen, total phosphorus, dissolved reactive phosphorus, suspended solids.	No significant decrease in water quality	If comparative surface water analysis indicates a decrease in surface water quality across the property, the degraded determinands should be identified, as these will indicate the likely cause of the contamination, while a full root cause analysis is undertaken. If the determinands suggest effluent, then effluent irrigation should cease on the implicated pivots. If the analyses indicate stock encroachment, the stock should be withheld from the connected paddocks.

		Location	Frequency	Measured parameters to include	Triggers	Contingency plan if triggers are exceeded
Water	Irrigation application		Annually in house and 1 in 5 years by an independent	Application uniformity	>80 %	Optimisation of the irrigator performance will be performed at the time of testing.
Fertiliser	Fertiliser application		Annually in house and 1 in 5 years by an independent	Application uniformity		Optimisation of the spreader performance will be performed at the time of testing.
Pasture	Ground cover	All blocks	2 x per year	% Ground cover	>80 %	Soil nutrient and compaction testing should be performed to identify possible causes.

Figure 11 Map showing location of monitoring points on Glen Eyrie Downs (available as an A3 in Appendix F)

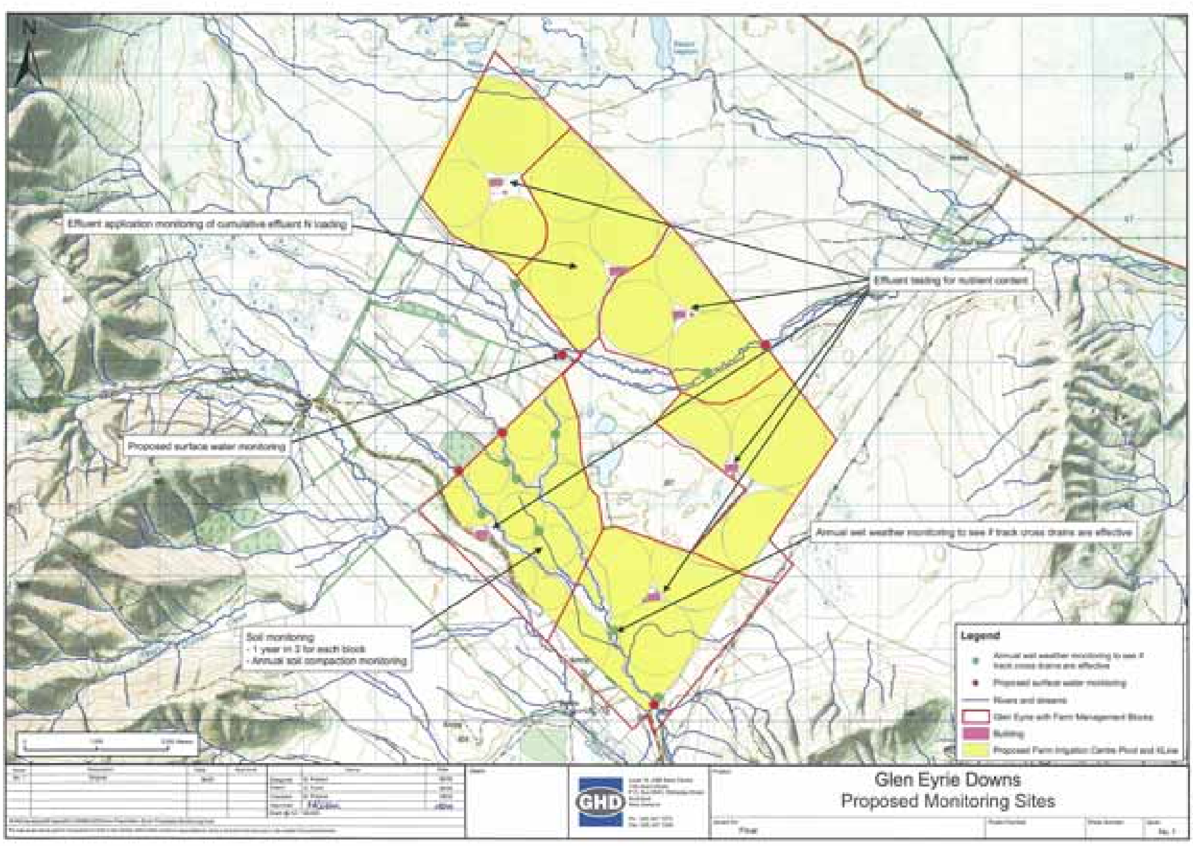
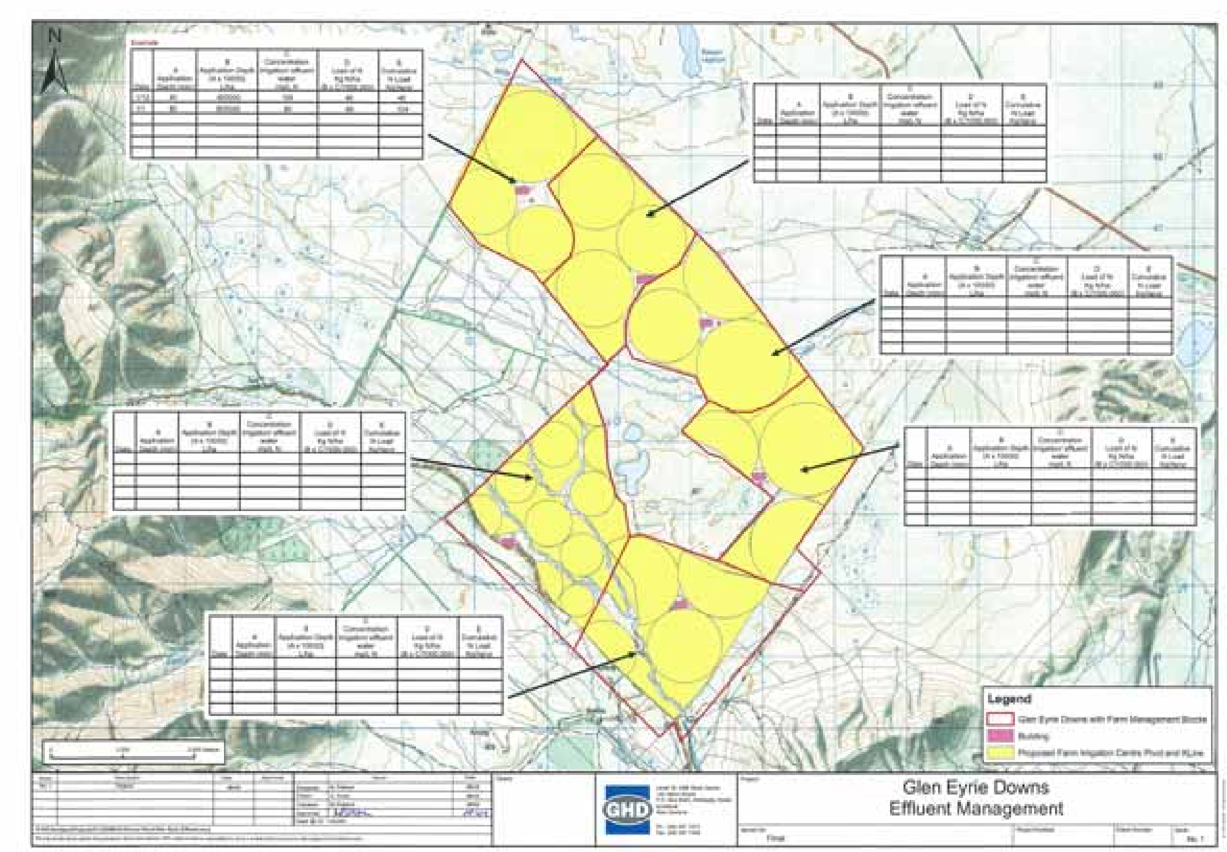


Figure 12 **Map showing block effluent applications and cumulative loading on Glen Eyrie Downs (available as an A3 in Appendix F)**



Where triggers are exceeded, the immediate contingency plans in Table 5 should be implemented while a 'root cause' analysis is carried out. Any further mitigation measures to be adopted as a result of monitoring should be added to Tables 5, 6 and 7.

1) Is the current mitigation option implemented correctly?

No – Implement and monitor

Yes – to 2)

2) Has anything changed in the farm system?

Yes – remodel and monitor

No – to 3)

3) Have there been abnormal conditions at the time of trigger breach?

Yes – continue monitoring to see if trigger breach continues

No – Seek advice of suitably qualified person to further investigate root cause and suggest appropriate further mitigation.

If emergency conditions occur that risk a pollution event, such as severe flooding event that puts the effluent storage system at risk or a catastrophic failure of the effluent system, seek immediate guidance from you regional council:

Environment Canterbury 0800 76 55 88

6.1.1 Auditing

The auditing process allows both the farm operator to illustrate, and other interested parties to have confidence that the management practices and mitigations planned for the farm are being implemented. In addition, the audit shows that there is a mechanism for the adaptive management of the property should the chosen mitigation or management not perform to expectations.

An annual audit is proposed, and requires both external and in-house input. The annual audit should be completed and submitted to Environment Canterbury by end of July each year.

Table 6 below shows the proposed contents of an annual audit report for Glen Eyrie Downs.

Table 6 Table showing proposed contents of an annual audit report for Glen Eyrie Downs

Audit measures	Action in the case of non-compliance
Additional auditing that must be done externally	
Check the clean and dirty water separation methods in and around the cubicle stables, parlour and yards, plus photographs	If any contamination of clean water is found all water should be directed to effluent store until problem is found and effective separation is verified
Check for evidence of direct discharges from the cubicle stables, parlour and yard area	Any direct discharge must be stopped immediately. Temporary barriers such as straw bales may be used to take up any discharges until permanent structures are in place
Riparian margins should be checked for signs of overland runoff through the margin.	Where there is evidence of runoff through the riparian margin, temporary barriers or detention pits should be dug (not in the riparian margin) to attenuate runoff while the source of the runoff is investigated and the integrity of the dense vegetation is inspected.
Check riparian planting and fencing is present where it should be and that it is intact, plus photographs	Any failure in the integrity of the fencing should be repaired immediately or a barrier placed around gap to prevent stock access until repair is made
Check the effluent press and liquid and solid fractions and also the destination of any liquid from the press area.	All liquid should drain into effluent storage. Any discharge must be stopped immediately. Temporary barriers such as straw bales may be used to take up any discharges until permanent structures are in place
Check the storage of liquid fraction for visible signs of discharge and maintenance of freeboard. When empty, the integrity of the lining should be checked and repairs made if necessary.	Any uncontrolled discharge of effluent must be stopped immediately. If a failure of the lining is suspected, the store must be pumped out and the lining inspected and repaired if necessary The freeboard should be maintained at all times.
Check the storage of solid fraction and destination of seepage if occurs	All liquid should drain into effluent storage. Any discharge must be stopped immediately. Temporary barriers such as straw bales may be used to take up any discharges until permanent structures are in place
Check the storage of silage for visible signs of discharge and destination of silage liquor	All liquid should drain into effluent storage. Any discharge must be stopped immediately. Temporary barriers such as straw bales may be used to take up any discharges until permanent structures are in place
Check fertiliser storage and filling area.	There should be no possibility of loss of fertiliser to drains or direct discharge to ground. Any drains should be covered, or the filling area moved to where no discharges will occur.
Annual audit of OVERSEER nutrient budget and report based on previous 3 years. Submission of compliance with thresholds	Should the OVERSEER report show losses exceeding the threshold, further mitigations should be adopted to effect a reduction in nutrient loss to below thresholds.

Audit measures	Action in the case of non-compliance
Fertiliser spreader and irrigation testing and calibration 1 in 5 years by independent auditor	Spreaders and irrigators not performing should be recalibrated
Additional auditing that can be done either externally or internally	
Reconciliation of fertiliser, effluent and soil records with nutrient budget and fertiliser recommendations	Where reconciliation is not possible and an over application has occurred, this should be rectified in the following year
Submission and brief interpretation of soil, effluent, water quality, supplement and machinery calibration tests	Where triggers have been exceeded, immediate contingency plans should have been effected and a root cause analysis conducted. The results of which should be presented here.
Submission of field records demonstrating fertiliser and effluent practice and nil and restricted grazing periods	Where field records show variation from proposed nil and restricted grazing, changes must be justified and the farm shown to remain within threshold limits, or the practice must revert to the proposed system
Submission of proof removal of solid manure fraction if required	If calculation indicate that a part of the solid fraction will have to be removed and no removal has occurred, spreading should cease and solids stored until a suitable recipient can be found.
Submission of silage clamp and effluent storage design plans	Once approved, the plans need only to be submitted once
Submission of example irrigation schedules and calculated water use efficiency	Where calculated water use efficiency is such that the trigger is exceeded, remedial action of how the system is to be optimised should be submitted, and followed up in the next audit
Annual quadrat testing for % ground cover, submission broad findings	Where poor groundcover is found and cause assessed, the remedials should be implemented and followed up in the next audit
Annual soil compaction survey, submission broad findings and remedials	Where poor soil structure is found and cause assessed, the remedials should be implemented and followed up in the next audit
Annual wet weather survey, submission broad findings and remedials	Where runoff is found and cause assessed, the remedials should be implemented and followed up in the next audit
Annual fertiliser spreader and irrigation testing and calibration	Spreaders and irrigators not performing should be recalibrated
Auditing that must be done internally	
Self certification for application of fertiliser according to code of practice	Any failures in observing the code of practice for applying fertiliser should be rectified and followed up in the next audit
Submission of proof of 'approved handler' status	Inappropriate handling of chemicals should cease until an approved handler is in place

7. Summary

This FEMP has been written to serve two purposes, to illustrate that the proposed farm system can meet the nutrient mitigation requirements set out by the Water Quality Study, and to identify and mitigate other farm specific environmental risks that arise from the inherent characteristics of the farm or from the proposed farm system and its management. These farm specific risks include uncontrolled discharges that are not identified in farm nutrient budget modelling but that may still have an environmental effect.

The mitigation and management measures detailed in Table 4 lay out the techniques that have been adopted to fulfil these two objectives. The WQS thresholds and modelling outputs from OVERSEER detailed in Table 3 illustrate that the proposed farming system meets the WQS thresholds and the risk assessment and mitigation measures proposed in Sections 4 and 5 illustrate how site specific environmental issues, including uncontrolled discharges, have been identified and are mitigated.

The monitoring and auditing of this plan, addressed in Sections 5 and 6 allow the performance of the measures chosen to be monitored and where they are performing sub-optimally, these can be addressed through the root cause analysis process.

8. References

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Appendix A

WQS ground and surface water sub-catchments for Glen Eyrie Downs

Appendix B

Detailed groundwater modelling for Glen Eyrie Downs

Appendix C

Farm Environmental Risk Assessment

Appendix D

OVERSEER Input Parameters

Appendix E

OVERSEER Output Data

Appendix F

A3 maps

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Document Status

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