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REPORT - Land Suitability Investigation to be provided to McWilliam's Wines

Prepared by

Thomas-M. Stein -

CROPSOL

Water & Environmental

October 2010

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Scope of study and report

This report was prepared as part of the Environmental Assessment for the proposed Winery Expansion of McWilliams Wines at Hanwood, NSW, by Thomas-M. Stein, a consultant with Cropsol Water & Environmental.

This report is part of a larger Development Application, and covers:

- (A) A summary water balance of the proposed vineyard areas.
- (B) An assessment of the potential groundwater and surface water impacts associated with the storage of water and wastes, and the use of the treated winery wastewater in the vineyard areas.
- (C) A statement of the suitability of soil structure to accommodate the application of treated wastewater.
- (D) Suggested guidelines for future monitoring regimes within the vineyard to collect soil, irrigation and wastewater data.

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1. Background and location

The proposed winery expansion will include a staged increase in winery crushing capacity from currently 34,000 tonnes per annum to ultimately 65,000 tonnes per annum over a period of approximate 15 years, with a staged increase of the bottling capacity over approximately 25 years. It is estimated that this increase in crushing and processing capacity will expand the wastewater generation from currently 44 ML, to ultimately 146 ML per annum. The construction of a proposed Wastewater Treatment Plant will produce treated wastewater which will be suitable to be incorporated in the overall irrigation water, and used to supplement irrigation requirements.

McWilliams Wines owns several irrigated vineyards in the closer vicinity and in pumping reach of the winery. Treated wastewater will be stored in lagoons, and then pumped through a closed pipe system to the vineyards, where it will be gradually incorporated into the overall irrigation water. The irrigation water is being applied through the existing drip irrigation system which provides full control of depth as well as spread of application. An overview of the location of the relevant vineyards is given in Figure 1.

The total vineyard size currently planted with grapes is approximately 442 hectare spread on three major blocks, with each block historically comprising of one or several farms with different farm numbers. However, all farms are managed conjointly as a single unit giving full control of depth and spread of irrigation and waste water applied.

Due to the winery production expansion, the building of the treatment plant and the demand for temporary water storage, about 2.3% reduction of the useable (cropped) area will occur over time, which however, can be considered to be minimal and insignificant due to the overall available field size and capacity. An overview of current as well as projected relevant field block and farm sizes is given in Table 1.

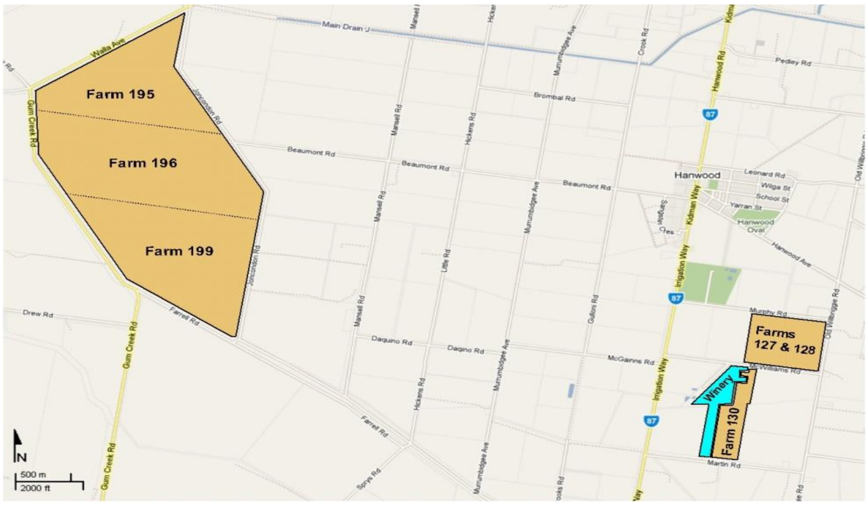

Figure 1:*Overview of farm locations of McWilliam's vineyards in Hanwood NSW.*

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Table 1: *Overview of current as well as projected relevant block and farm sizes of the McWilliam's vineyards in Hanwood.*

Block description	Farm No.	CURRENT planted area (ha)	PROJECTED planted area (ha)
Joncondon Road Block	195, 196 & 199	391.5	391.5
McWilliam Road Block	127 & 128	35.9	35.1
Winery Block	130-1 and 130-2	14.5	5.0
TOTAL		**441.9**	**431.6**

2. Report detail

2.1. (A) Summary water balance of proposed vineyard areas

2.1.1. Climate conditions

The projected areas lie within the Murrumbidgee Irrigation Area (MIA), approximately 6.5 kilometres South-East and 5.8 kilometres South of the town of Griffith in the Riverina, approximately 125 metres above sea level.

The climate of the area can be classified as semi-arid, with hot summers and extended periods above 35°C, peaking temperatures above 40°C, and winters with average minimum temperatures of approximately 3°C for July. Relevant climate data collected at the Hanwood CSIRO weather station span a period of 48 years, and show yearly rainfalls ranging between 144mm and 685 mm, with median average rainfall of 401 mm/year. The yearly potential evapotranspiration (ETo) ranges between 1,468mm and 2,225 mm, averaging 1,865 mm/year. The general yearly climatic water balance for the region can therefore be described as negative, where potential evapotranspiration far exceeds natural rainfall. Transferred onto the field level and non-ponding conditions, this means that under normal rain, vegetation, cropping conditions, and soils with good water holding capacity, water from natural rain events would rarely penetrate to lower soil profiles or contribute to the groundwater table but would be absorbed by the soil and evaporate from the surface or transpire through the plants.

2.1.2. Cropping and climate

Under current cropping conditions with winegrapes, actual crop water requirements (ETcrop) are based on potential evapotranspiration (ETo). These are adjusted to the cropping conditions by using specific crop coefficients (Kc) and other agronomic factors. Crop coefficients for the projected areas are based on NDVI values using remote sensing through satellite imaging. The values presented do not necessarily correspond with the "basal crop coefficient" commonly used in literature. The values that are presented here only show an indication of the current status of the crop. Rainfall and ETo distribution based on 48 years of records, ETcrop distribution extrapolated for grapes also for 48 years and based on measured crop coefficients (NDVI) from 2008 to 2010, as well as historic ETo values, provide a good summary of the specific hydrological conditions of the projected areas. Monthly estimates are shown in Figure 2.

The hydrological summary clearly indicates that based on long-term monthly averages, potential evapotranspiration always exceed long-term rainfall averages, and that actual vegetation and surface evapotranspiration may only be lower for a short winter period between May and July when the vines are dormant.

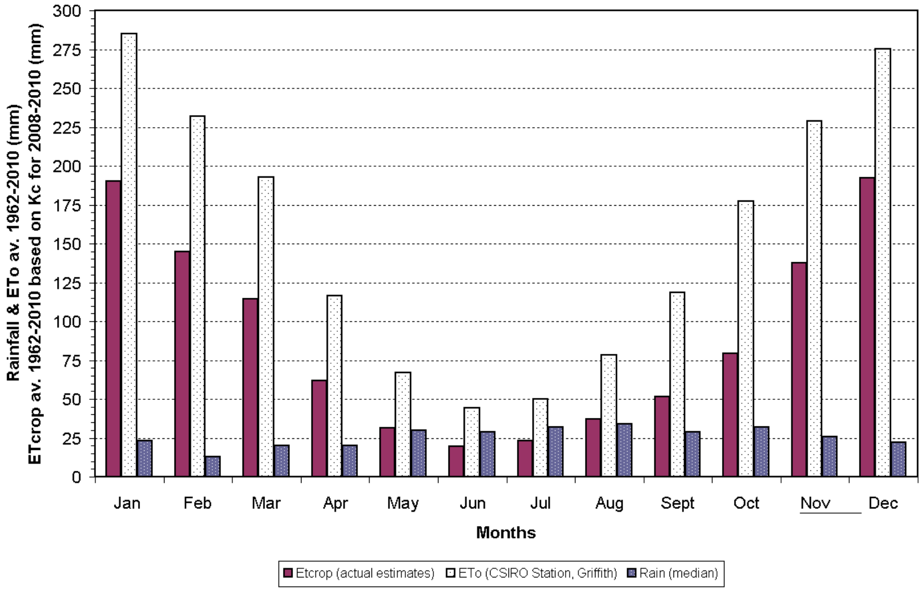

Figure 2: *Rainfall and ETo distribution based on 48 years of record and ETcrop distribution extrapolated for grapes for 48 years based on measured crop coefficients (NDVA) of 2008 til 2010. Station location: CSIRO Hanwood. (Data source: CSIRO Land and Water, Griffith 2010).*

2.1.3. Irrigation and climate

All the projected areas and farms are equipped with state-of-the-art drip irrigation and supply systems. Water is being delivered to the farm blocks through the Murrumbidgee Irrigation channels, and it is then stored temporarily in dams in order to provide more flexibility in time and length of water applications. These existing on-site irrigation water storages are located on two of the three major blocks, namely, the Joncondon Road Block with two dams supplying the Farms 199, 196 and 195, the McWilliam Road Block, with one dam supplying the Farms 127, 128, 130-1 and 130-2, and finally the Winery Block. An extension of the storage capacity is being planned for both locations.

The use of modern drip irrigation systems allows for controlled and variable application of irrigation and fertiliser, not only per farm or block, but also per sub-blocks and varieties, adjustable to specific crop requirements and soil condition. This does not only provide the means of effective water and fertiliser applications, but avoids water losses through uneven application, runoff or ponding, as water is only applied close to the vines on slightly raised beds with no runoff occurring.

All farms have been equipped with soil moisture monitoring probes, and these have been placed at strategic locations, allowing for moisture advances to be monitored and viewed throughout the soil profiles. Soil moisture monitoring is being conducted and evaluated on a regular basis throughout the cropping season. This allows for effective irrigation adjustments to take place depending on actual climate conditions and crop requirements. Over-irrigation and deep percolation also in respect to possible rainfall events are therefore being avoided.

Actual irrigation water applied is based on current crop water requirements using current climate conditions and adjustments for rainfall events. All applications are being recorded and soil moisture profiles monitored and adjusted if required. An example is given in Figure 3.

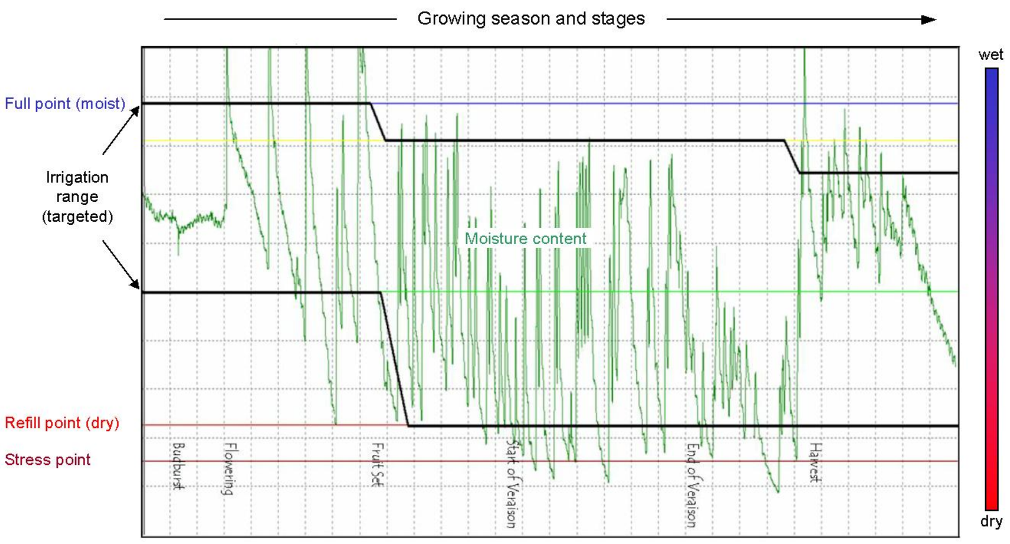

Figure 3: *Example of soil moisture monitoring and irrigation applications during the 2004/05 growing season for a "Ruby Cabernet" block on McWilliam's Farm 195.*

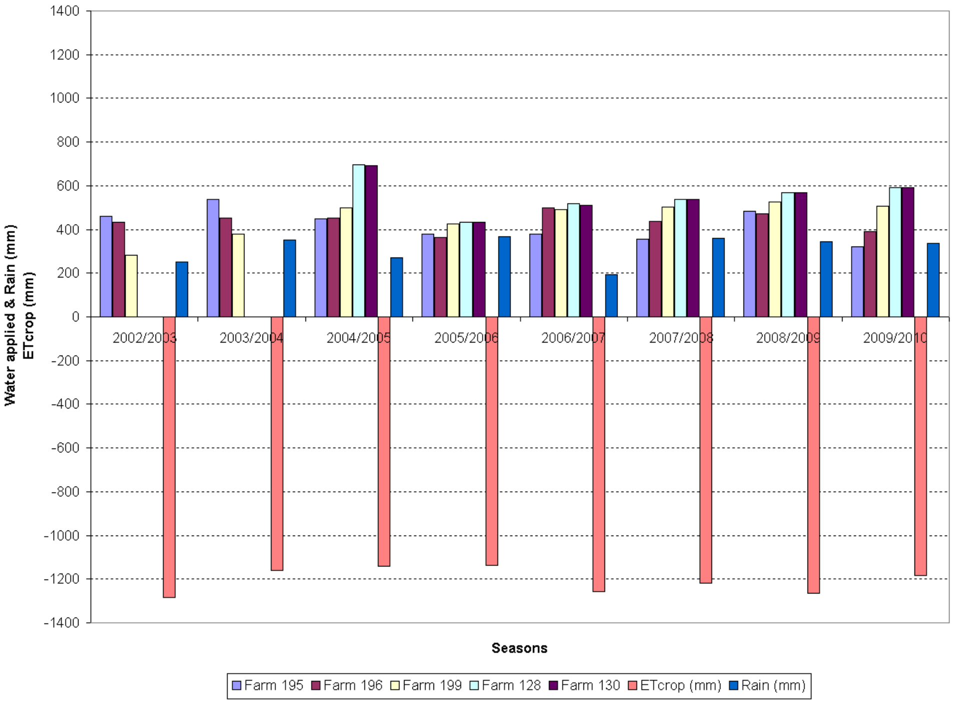

Figure 4: *Total water applied per farm as well as rainfall and computed water requirements for the growing seasons 2002/03 till 2009/10.*

All farms and blocks are being irrigated based on variety specific water requirements under given climate conditions. Average water applied per season is 430 mm, ranging from 320 mm to 700 mm per farm since the 2002/03 season. Best management practices are being applied, avoiding over irrigation and deep percolation while securing good and high quality production. A historic to current summary of total water applied to all the projected farm areas with an indication of actual rainfall and estimated crop water requirements is given in Figure 4.

In order to avoid water loss through deep percolation and creating unwanted groundwater table build ups, total water applied to the fields consisting of irrigation as well as rainfall should generally not exceed evapotranspiration losses through crop and surface areas. Soil moisture movement and profile monitoring, as well as water balance estimates, show that minimal if any water enters the groundwater for all the projected McWilliam's farm areas.

This is being backed by the observations that the existing tile drainage systems have run dry. This is particularly the case for the Farms 199, 196 and 195, which in the past were lying in the vicinity of rice farms with naturally high water tables. Since the reduction of the rice growing in that area water tables have been receded to a level below the drains so that drain flows could not be observed anymore.

Historic to current water balances for the projected McWilliam's areas indicate that total water applied generally does not exceed water used by the cropped area. A summary is given for the growing seasons 2002/03 till 2009/10 in Figure 5.

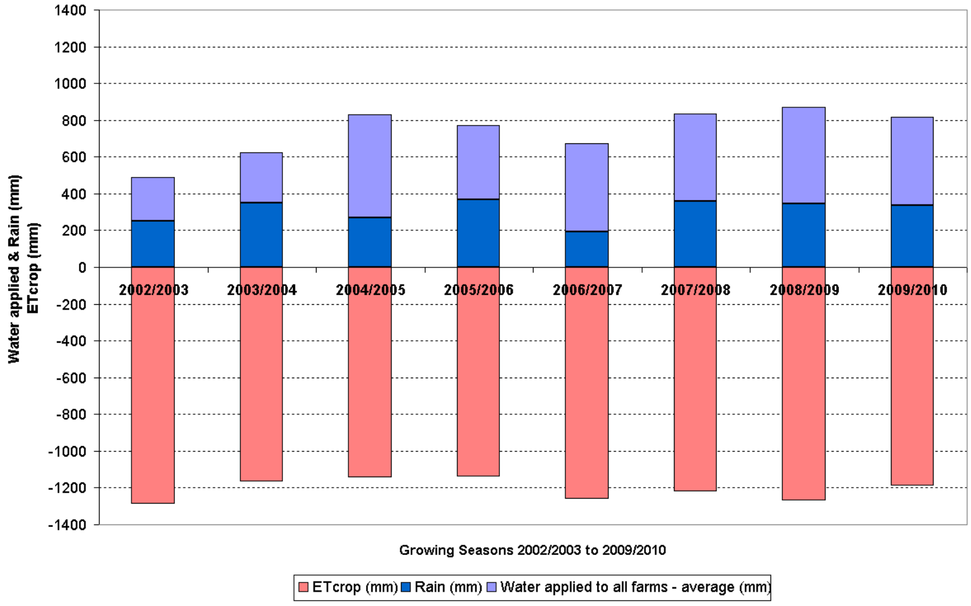

Figure 5: *Water balance of total water applied plus rain and computed water requirements for all farms for the growing seasons 2002/03 till 2009/10.*

2.2. (B) Assessment of the potential groundwater and surface water impacts associated with the storage of water and wastes, and the use of the treated winery wastewater in the vineyard areas.

2.2.1. Application of treated wastewater

2.2.1.1. Overview

The proposed winery expansion will include a staged increase in winery crushing capacity from currently 34,000 tonnes per annum to ultimately 65,000 tonnes per annum over a period of approximate 15 years, with a staged increase of the bottling capacity over approximate 25 years.

Based on historic performance and current growth figures, it is estimated that this increase in crushing and processing capacity will expand the wastewater generation from currently 44 ML to ultimately 146 ML per annum. A total of 146 ML is the designed wastewater output capacity. A construction of the proposed Wastewater Treatment Plant will produce treated wastewater, which will be suitable to be incorporated in the overall irrigation water and used to supplement overall irrigation requirements.

2.2.1.2. Yearly wastewater loads

The irrigation water and the incorporated treated wastewater would be applied through the existing drip irrigation system, which is already installed throughout the projected McWilliam's vineyards. The drip system provides the advantage of controlled irrigation with the option to direct any water and treated wastewater to any block of the vineyard depending on specific soil or crop requirement. With precision drip application, no ponding and surface runoff is occurring.

Treated wastewater will be temporarily stored in dams, and then pumped through a closed pipe system to the McWilliam's Wines owned vineyards (see Figure 1), where it will be gradually incorporated and blended into the overall irrigation water streams. The treated wastewater pipe and pumping system will provide the flexibility to direct the treated wastewater to all the vineyard blocks, namely the Joncondon Road Block, the McWilliam Road Block, and the Winery Block, providing even spread and hydraulic loading of the treated wastewater onto the entire vineyard areas.

The total planted vineyard area comprises 449.1 hectares. Due to establishment of the wastewater treatment plant and the storage lagoons, a slight reduction of planted vineyard size will reduce the final planted size to 431.6 hectares. Based on current wastewater loads of 44 ML, as well as projected final wastewater loads of 146 ML per annum, the total hydraulic loading through treated wastewater will currently be very low and only amount for 10 mm per annum, increasing over time to a total of only 33.8 mm per annum. This will initially amount to only 2.2% of the total water applied, peaking at 7.3% at projected full capacity.

The total expected hydraulic loading can therefore be considered to be very low, even at peak capacity. A summary is being provided in Table 2.

Table 2: *Summary of predicted hydraulic loadings of current and projected future volumes of treated wastewater applied to the entire vineyard area.*

	Total planted vineyard area	**Treated wastewater**	**Hydraulic loading Wastewater applied**		
			per cropped area	**per total water applied**	**Volume per area**
	(ha)	**(ML/a)**	**(mm/a)**	**(%)**	**(ML/ha/a)**
INITIAL	449.1	44	10.0	2.2	0.100
PROJECTED	*431.6*	*146*	*33.8*	*7.3*	*0.338*

In order to indicate the future hydraulic loading over time and consider the possible impact of the treated wastewater, historical rainfall data, irrigation water applied, and computed crop water requirement estimates were used. The application of treated wastewater has been incorporated as a steadily increasing volume and integral part of the future irrigation practice. These indicative results are shown in Figure 6 clearly showing the low impact the extra amount of treated wastewater load will have even when reaching peak capacity.

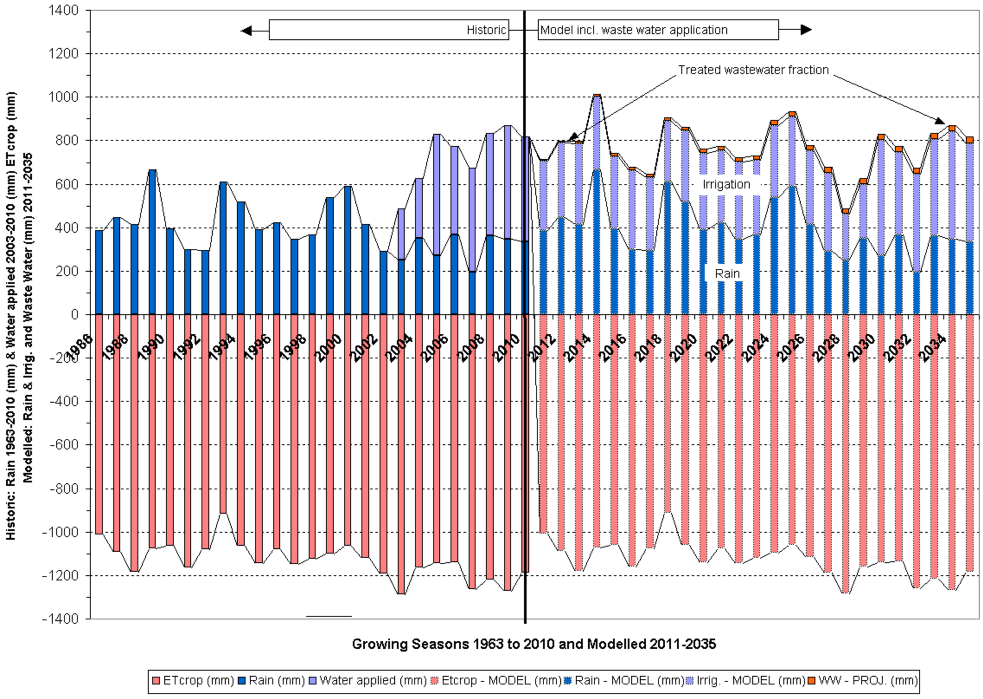

Figure 6: *Future hydraulic loading over time and possible impact of the treated wastewater as part of the predicted irrigation, based on historic data for rain, irrigation water applied and computed crop water requirement estimates. Initial wastewater load 2.2% and ultimate 7.3% of total water applied.*

2.2.1.3. Annual load distribution

Subject to the crushing and winery production processes, wastewater is being produced at different rates over the year. Peak wastewater outputs generally occur during the main vintage period between February and April, peaking in February and March, and reaching minimum outputs in the winter period of June. Currently, actual monthly wastewater outputs during vintage average at 8.5ML per month, with peaks just below 10ML per month between February and April. In the off-peak season, wastewater loads drop significantly ranging only between 1.8ML and 4.4ML per month.

As production-related variation in the monthly peak output may occur, a safety margin of 50% as been incorporated (modelled) into the monthly outputs, ensuring temporary storage and short-term application requirements are always met sufficiently. Total annual wastewater production will however not increase, and will remain at design capacity of ultimately 146 ML per annum. Based on current wastewater outputs, as well as the staged increase in winery crushing capacity over a period of approximate 15 years, and with a staged increase of the bottling capacity over 25 years, monthly wastewater outputs are expected to peak at 20ML, giving design values of a maximum 30ML for the month, with the highest expected output expected in February.

After the treatment process, wastewater will be incorporated into the irrigation dams and applied evenly over the projected area as part of the process of meeting crop water requirements. Based on the current area of 449 hectares, and ultimately the projected 442 hectares, peak design application depths per month would currently be 3.3 mm, and the 7 mm once full capacity has been reached. Both application depths would occur in the vintage period and include the safety margin of 50%.

The current as well as projected future monthly wastewater output distributions over a year are given as peak outputs, and shown in Figure 7.

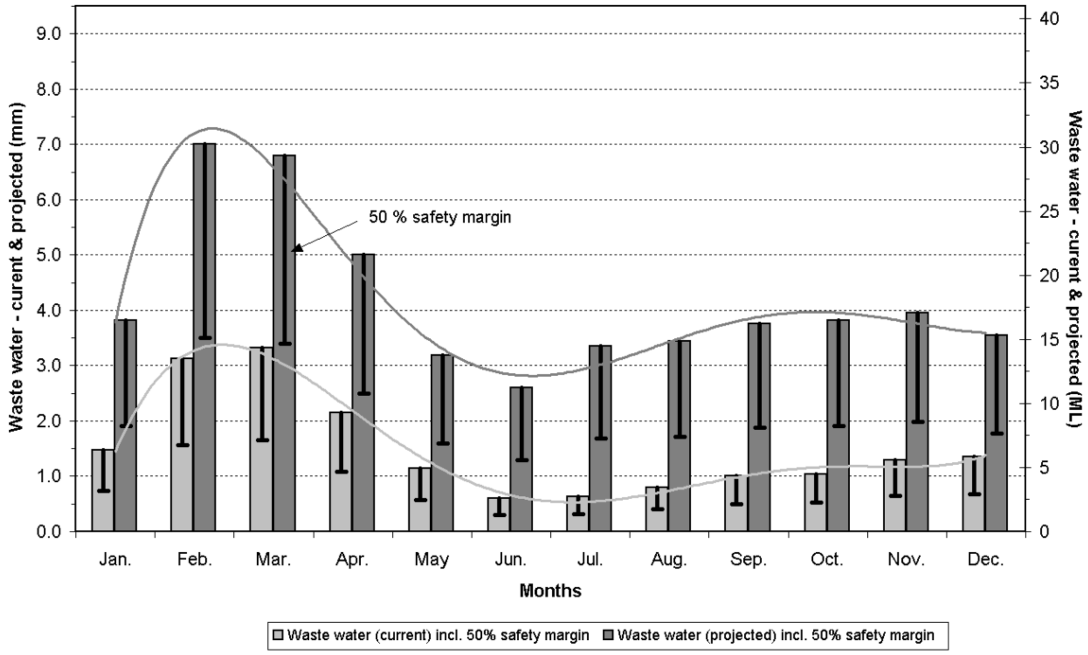

Figure 7: *Inital and projected future monthly wastewater output distributions over a year given as peak monthly output streams as well as peak monthly design streams latter including a safety margin of +50%. Monthly application depths are based on the current area of 449 ha and ultimately projected area of 442 ha.*

In order to establish a seasonal water balance over the timespan of a year, historic data for rain (48 years) and computed crop water requirement estimates were incorporated with the varying monthly wastewater loads, giving a clear indication of the water balance situation. Included are estimated monthly irrigation requirements, as well as an indication when surplus water loads from rain and wastewater could occur. The results are summarised in Figure 8.

Due to the general climatic conditions, under the current cropping regime even under a "no wastewater applied regime", a negative monthly water balance (irrigation demand) exists for nine out of twelve months. A positive climatic water balance (surplus water) may naturally occur predominantly during the winter period between May and July (see also Figure 2). Consequently some naturally induced drainage may be expected only through rain events during the winter period.

Monthly maximum projected wastewater loads follow the peak production processes during the vintage period between February and April, and then generally decrease from March onwards, reaching the minimum in June. Due to the generally negative potential water balance during the time from September to April, the monthly application of wastewater only amounts to 8.1 % of the crop water demand (including the 50% safety margin). No leaching will therefore occur from September to April.

During the critical months of May to August where some natural leaching and drainage may occur, the application of wastewater would need to be minimised based on actual soil moisture and precipitation data. Any surplus loads during that period would need to be temporarily stored to avoid any leaching and drainage into lower soil profiles or the groundwater. Maximum necessary storage capacity would need to accommodate wastewater loads produced from May to August. Under current conditions, the required wastewater storage buffering capacity would total 15ML, and would rise up to 55ML at projected full capacity. Both storage estimates include the 50% safety margin, and can be met by current and projected future storage dams. An overview detailing current and future storage capacities is given in Table 3.

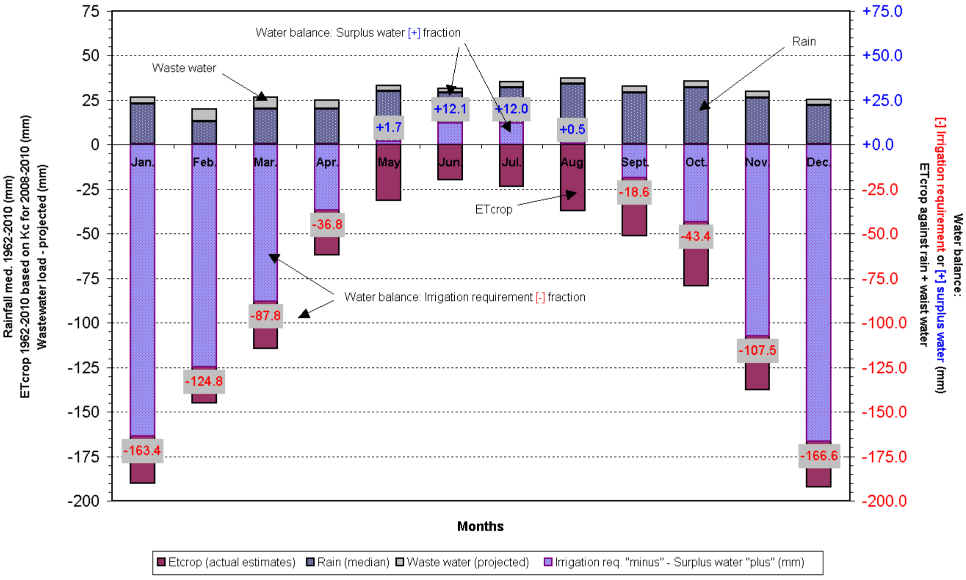

Figure 8: *Monthly water balance distribution over the time span of a year based on historic data for rain (48 years) plus estimates of varying maximum monthly wastewater loads against computed crop water requirement. With wastewater loads (+50& safety margin) included [-] indicating additional net irrigation requirements (example -87.8 mm) or [+] surplus water (example +12.1 and +12.0mm).*

2.2.2. Drainage

All projected farm areas have historically been levelled. With the move from flood to drip irrigation, most layout gradients remained, providing some means of surface water removal during and after extreme rain event.
For the projected farm areas, tile drainage systems had been installed in the past on the winery properties, with drainage spacings ranging from 40 metres to 50 meters. With improved irrigation practices of the areas, no drain flows from tile drainage systems have been recorded for the last eight years.

The current drainage system will keep being monitored in order to provide an effective intercept and additional safety mechanism for potential deep seepages that may occur. This will:
- Prevent deep seepage and the potentially contamination of ground water;
- Allow the handling and interception of excess water and contaminants washed in through major storm event or longer rain periods;
- Allow controlled leaching and disposal of excess nutrients and salts.

2.2.3. Groundwater

Approximately 20 observation bores had been sunk within the property boundary from 1954 till 1970. Based on local accounts, more than ten years ago water table depth had been higher. This was credited to the intensive rice production on some of the adjacent properties. With significant reduction of the rice production in that area as McWilliams Wines have planted wine grapes, and the improvements of irrigation management through the use of soil moisture probes, high water tables could not be observed anymore. This fact is also confirmed by the running dry of existing tile drain systems. With scheduled irrigations within a tile drained system, the proposed re-use is not expected to have any impact on the groundwater.

Groundwater observation wells (proposed 6 see Figure 9) will be established on strategic locations on all three block areas, and quality sampling and analysis will be conducted on a regular basis assuring continuous water level and quality monitoring and recording.

2.2.4 Water storage

Irrigation water storages, or holding dams connected to the Murrumbidgee Irrigation supply channel, have been established and additional dams are projected on two of the three blocks, mainly to buffer water delivery irrigation time requirements, and these dams will not be used to store any treated wastewater.

Storages relating to the proposed treated wastewater will be fully sealed and are located on Farm 199 and the Winery Block. They would form part of the wastewater treatment plant specifications, and details have been covered in auxiliary reports.

2.2.5 Surface water runoff

All projected farming areas are or will be irrigated through drip irrigation. Drip lines are located close to the vines which are grown on slightly raised beds. Water is being applied through point sources (drippers) at a rate lower than infiltration, and hence surface water ponding and possible runoff from irrigation normally doesn’t occur.

All projected farm areas lie in a topographically flat area, with natural elevation differences within the farm boundaries ranging only between 0.01% to 0.2 %. All areas have been levelled.

Some surface water accumulation and runoff may occur occasionally during heavy and extended rain events, predominantly in the areas between the rows, and not in the slightly elevated areas were the actual irrigation and waste water application would occur. Runoff from heavy and prolonged rain events will ultimately accumulate and move within the farm and field boundaries, and move towards the designed discharge points to the main open drain system. Through existing irrigation channel structures which are mostly located elevated on one side of the field, as well as the original flood irrigation concept of managing, retaining and directing the water on-farm, fields are still laid out with low retaining bunds allowing the discharge into the drainage system only to take place at specifically designed drainage discharge points. All discharge points are located at drainage collector channels. No wetland or natural streams are located in the direct vicinity of the projected farm areas, and no direct discharge into natural streams or wetlands can occur.

To avoid accidental discharge of runoff water into the drainage system, discharge outlets will be equipped with sluice gates, ensuring that potential runoff could be retained on-site and reused if required.

2.3. (C) Statement of the suitability of soil structure to accommodate the application of treated wastewater.

2.3.1. Soil surveys

An extensive soil survey was conducted with forty representative sampling points, and samples were collected from twenty-five centimetre and seventy-five centimetre depths. Soil chemical analyses were conducted by Sydney Environmental & Soil Laboratory Pty Ltd. Soil pit data is collected by Cropsol Soil & Irrigation Management is available for depths of up to 1.2 metres over the properties, as well as some soil survey data conducted by the CSIRO for the general Hanwood area. In addition to this information, bore logs of twenty observation bores located within the boundaries of the projected areas provided with general profile and soil type descriptions for depths of up to 10 meters and below.

2.3.2. Soil physical properties

The Winery Block has predominantly brown silty clays in the top layers, which change to silty loams to up to one meter in depth, and increasing fine sandy clay loams from 1.2 metres to 3 metres. Red brown sandy loams are found below approximately 3 metres, with coarse sands in layers below 4 metres.

In the McWilliam Road Block, predominantly brown silty clay loams in the top layers are found, changing from red-brown medium to light clays, to clay loams down to about one meter. Below one metre, fine sandy clay loams of light reddish brown textures dominate to about 3 metres in depth.

The large Joncondon Road Block has heavier red clay top soils to about 0.70 m depth in the northern section of the block, changing to dark brown medium clays towards the middle block, and dark brown clay loams in the southern part. The underlying layers to approximately 2.0 m are generally slightly lighter clays, with light grey colours in the northern section, red brown to light brown medium clays towards middle and southern sections. Especially in deeper layers below 3.5 metres, the content of fine sands increases.

In general, heavier soils, from silty clays to medium clays dominate the top soil profiles to a depth of approximately 1.5 metres throughout the proposed application areas. These soils can generally be described as having an adequate water holding capacity, of between 90-120 mm/m. They have a slow infiltration rates which prevents the rapid drainage of water and leaching of nutrients.

The predominant heavier soil textures provide a good basis for the application of treated wastewater. Not only do they provide sufficient water holding capacity to absorb the volumes applied, but also prevent the rapid drainage of water and nutrients into lower layers.

2.3.3. Soil chemical properties

A summary of all soil chemical results from 40 representative sampling points across all farms for the depths of 25 cm and 75 cm is given in Table 4, 5 and 6.

Organic carbon levels range between, 0.5 % to 1.1 % in the topsoils, and are naturally lower in the subsoil, ranging from 0.3 % to 0.5 %. They are considered low (see Table 4). Organic matter encourages soil microbial activities and increase CAC, as well as the water holding capacity and structural stability. Ideally values for organic carbon should be at least 1.2 % or higher, and are best around 1.6 to 1.8 % for good structural condition, high structural stability, pH buffering capacity to best accommodate wastewater loads. The application of mulch in the future will increase organic matter over the properties.

Generally salinity levels across all blocks can generally be described as low, ranging from 0.6dS/m to 2.1ds/m in the topsoils, with only slightly higher salinity levels in the subsoils, which range from 0.8dS/m to 2.1ds/m. These levels can be considered as good for grape growing lying in the optimal range for winegrapes. There are only two blocks on Farm 199 and 128 with spots of localised moderate salinity levels.

The average soil pH (H_2O) for the top soils across all blocks lies at 6.9, ranging from a minimum of 5.9 to a maximum of 8.7. The subsoils are generally more alkaline, with an average of 8.2, and values ranging from 7.3 to 9.2.

The levels of exchangeable cations for potassium range from 0.8 to 3.5 me/100g in the top soil, and 0.6 to 2.8 me/100g in the subsoil, and are therefore relatively high. The effective CEC (eCEC) levels lie predominantly in the ideal range. The levels for calcium are classified as high, and lie in the target range of 65 - 75 % of eCEC and are at acceptable levels. Levels of average exchangeable magnesium in the topsoils is considered to be high, with 9 me/100g it is lower than in the subsoils (13.2 me/100g), but varies significantly throughout the blocks ranging from approximately

5me/100g to 20 me/100g. The desirable proportion of CEC lies between 10% and 15%, with the soil averages of 34% for the topsoils and 28% for the subsoils being significant higher but not uncommon for heavy clay soils. The levels of exchangeable sodium, ranges from low (0.2 me/100g) to very high (4.1 me/100g). Excess sodium causes dispersion and destruction of soil structure, and will hinder infiltration. Acceptable sodium levels in soil would lie between 0.5 to 2.0% of the CEC.

Average phosphorus levels of 20mg/kg in the topsoil, and 6mg/kg in the subsoil, suggest medium to high availability (Colwell P) of P for the crop for the clay loams and heavier clays.

Table 4: *Summary of soil chemical analysis for salinity, pH and exchangeable cations from 40 representative sampling points at 25 and 75 cm depths covering all farm areas.*

Depth		**OC** #	**ECe**	**pH**	**Exchangeable Cations**								
				H_2O	**K**		**Ca**		**Mg**		**Na**		**Sum cat.**
		(%)	(ds/m)		(me/100g)	(%)*	(me/100g)	(%)*	(me/100g)	(%)*	(me/100g)	(%)*	(%)
25 cm	average	0.7	2.09	6.9	1.7	6.5	17.1	57.0	9.0	33.5	0.8	2.8	100
	min.	*0.5*	*0.60*	*5.9*	*0.8*	*2.0*	*7.1*	*42.5*	*5.2*	*14.8*	*0.2*	*0.9*	
	max.	*1.1*	*7.83*	*8.7*	*3.5*	*12.2*	*66.2*	*80.8*	*12.6*	*45.0*	*2.2*	*7.9*	
75 cm	average	0.4	2.13	8.2	1.4	3.2	36.8	64.8	13.2	28.4	1.5	3.4	100
	min.	*0.3*	*0.76*	*7.3*	*0.6*	*0.9*	*9.8*	*34.0*	*6.3*	*10.1*	*0.3*	*0.4*	
	max.	*0.5*	*3.96*	*9.2*	*2.8*	*8.7*	*74.8*	*88.4*	*19.2*	*50.9*	*4.1*	*10.7*	

Note: * Proportion of an effective CEC expressed as a percentage
\# Organic Carbon (%)

Nitrate levels range from low to adequate, and nitrate leaching is generally not to be expected.

Table 5: *Summary of soil chemical analysis for major anions from 40 representative sampling points at 25 and 75 cm depths covering all farm areas.*

Depth		**Major Anions**						
		PO_4 (Mehlich) (mg/kg)	**PO_4** (Colwell) (mg/kg)	**PBI (*)**	**NO_3** (mg/kg)	**NH_4** (mg/kg)	**N** (plant avail.) (mg/kg)	**SO_4** (mg/kg)
25 cm	average	18.4	20.3	74.5	15.0 #	2.7	9.0	126.3
	min.	*3.8*	*4.0*	*30.0*	*< 0.05*	*1.4*	*1.4*	*12.0*
	max.	*62.1*	*64.0*	*109.0*	*58.0 #*	*5.4*	*61.5*	*863.0*
75 cm	average	8.4	5.7	56.9	42.0 #	2.4	12.9	76.9
	min.	*3.9*	*2.0*	*20.0*	*< 0.05*	*1.4*	*1.4*	*6.5*
	max.	*22.7*	*18.0*	*117.0*	*138.0 #*	*4.3*	*141.5*	*270*

Note: (*) Phosphorus Buffering Index.
\# High nitrate levels relate to two particular areas only, see text for details.

The range of concentrations of micronutrients found in the McWilliam's vineyard soils generally correspond to other soils used for wine grape production. Generally micronutrients need to be monitored closely throughout the paddocks as pH and concentrations seem to vary widely.

Table 6: *Summary of soil chemical analysis for micronutrients from 40 representative sampling points at 25 and 75 cm depths covering all farm areas.*

Depth		**Micronutrients**				
		Fe (mg/kg)	**Mn** (mg/kg)	**Zn** (mg/kg)	**Cu** (mg/kg)	**B** (mg/kg)
25 cm	average	187	140	1.4	3.6	2.7
	min.	*76*	*64*	*< 0.64*	*1.8*	*1.0*
	max.	*420*	*249*	*3.4*	*8.2*	*22.0*
75 cm	average	76	178	0.8	2.0	3.1
	min.	*29*	*135*	*< 0.65*	*1.0*	*0.9*
	max.	*158*	*230*	*1.0*	*4.1*	*6.1*

2.3.4. Wastewater

The proposed wastewater will be treated to a level suitable to be incorporated into the overall irrigation stream, and applied to the projected irrigated vineyard area. A summary of the estimated water quality of the treated wastewater from the McWilliam's winery production is given in Table 7. Values are based on wastewater analysis conducted at the McWilliam's winery from 2006 to 2009, as well as estimates based on reference values commonly found for treated winery wastewater in the industry.

Table 7: *Estimated water quality of the treated wastewater in storage from the McWilliam's winery production and prediction of maximum loads at 44ML and 146ML wastewater applied per annum.*

Parameter		**Treated wastewater quality in storage**		**Maximum annual loading through applied wastewater**	
			Units	**INITIAL #** (mg/kg soil/a)	**PROJECTED ##** (mg/kg soil/a)
Acidity	(pH)	8.5			
Electrical Conductivity	(EC)	1600	(µS/cm)		
Total Dissolved Solids	(TDS)	976	(mg/l)	8.64	29.35
Chemical Oxygen Demand	(COD)	150	(mg/l)	1.33	4.51
Biochemical Oxygen Demand	(BOD)	10	(mg/l)	0.09	0.30
Suspended Solids		30	(mg/l)	0.27	0.90
Sodium	(Na)	133	(mg/l)	1.18	4.00
Calcium	(Ca)	22	(mg/l)	0.19	0.66
Magnesium	(Mg)	10	(mg/l)	0.09	0.30
Potassium	(K)	395	(mg/l)	3.50	11.88
Carbonate		<1	(mg/l)	0.01	0.03
Bicarbonate		315	(mg/l)	2.78	9.46
Sulphate		26	(mg/l)	0.23	0.78
Chloride		113	(mg/l)	1.00	3.40
Total Nitrogen		10.0	(mg/l)	0.09	0.30
Total Phosphorous		5.0	(mg/l)	0.04	0.15
Adj SAR		6.5			
SAR		5.9			

Note: # INITIAL: Based on a currently planted area of 442 ha and 44ML of treated wastewater applied per annum. Useable soil depth: 0.75 m.
PROJECTED: Based on a projected planted area of 432 ha and a maximum of 146ML of treated wastewater applied per annum. Useable soil depth: 0.75 m.

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The initial estimated water quality in Table 7 is that of the proposed treated wastewater in storage, and not of that actually proposed to be applied at the field level.

Treated wastewater will be incorporated into the overall irrigation water stream and the total amount of treated wastewater as a fraction of the total irrigation water applied per annum will only amount to a total of 2.2 %. At maximum capacity, this will increase to 7.3 % (see also Table 2). The wastewater will not only be diluted with very good quality irrigation water, but applications will be spread over time (see also Table 3 and Figure 8). Even during vintage times, when peak wastewater production loads occur (February to April), the total monthly wastewater fraction of the total monthly irrigation requirement to meet crop water demands will only be between 4.9 and 8.1 %. These values already include a 50 % safety margin.

Based on the concentration of mainly nitrogen, phosphorous, bio-oxygen demand (BOD), and the Total Dissolved Solids (TDS), an environmental classification of the strength of the treated wastewater in storage can be performed. The stored treated wastewater has low concentrations for total nitrogen and phosphorous, as well as low BOD values. Whilst the proposed soils where wastewater will be applied only have low salinity values, the higher values for TDS, an indication of combined concentration of salts, classify the wastewater to be of medium in respect to salt loads and can easily be monitored in the future.

The additional annual nutrient loads resulting from the wastewater applied can be considered as low to moderate. It is estimated that annual wastewater loadings the nutrients applied could predominantly, with the exception of sulphate, be offset by nutrient removed through the crops. At 'projected' full capacity, only nitrogen and phosphorus are likely to be removed by the crop and some accumulation may occur for potassium, calcium, magnesium and sulphate. A summary of the estimated soil nutrient balance for current and projected annual wastewater loadings is given in Table 8.

Table 8: *Estimated soil nutrient balance for current and projected annual wastewater loadings of 44ML and 146ML.*

Elements	Soil	INITIAL (#)				PROJECTED (##)			
		Loading		Balance		Loading		Balance	
	Property 0 - 0.75 m	Loading (#)	Increase per annum	Removal by crop (*)	Balance per annum	Loading (##)	Increase per annum	Removal by crop (*)	Balance per annum
	(mg/kg)	*(mg/kg soil/a)*	*(%)*	*(mg/kg soil/a)*	*(mg/kg soil/a)*	*(mg/kg soil/a)*	*(%)*	*(mg/kg soil/a)*	*(mg/kg soil/a)*
Potassium	607.8	3.50	0.58	4.13	-0.64	11.88	1.95	4.13	7.74
Calcium	5402.9	0.19	< 0.01	0.61	-0.42	0.66	0.01	0.61	0.05
Magnesium	1346.9	0.09	0.01	0.19	-0.10	0.30	0.02	0.19	0.11
Nitrogen	11.0	0.09	0.81	1.33	-1.24	0.30	2.74	1.33	-1.03
Phosphorus	13.0	0.04	0.34	0.35	-0.30	0.15	1.16	0.35	-0.20
Sulfate	101.6	0.23	0.23	0.15	0.08	0.78	0.77	0.15	0.64

Note: # "INITIAL" loading is based on 44ML of wastewater applied onto 442 ha; soil depth 0.75 m.
"PROJECTED" loading is based on 146ML of wastewater applied onto 432 ha; soil depth 0.75m.
* Removal of nutrients by crop is based on average yields of 15 t/ha (FW).

2.4. (D) Guidelines for future monitoring regimes within the vineyard to collect soil, irrigation and wastewater data.

In order to protect the environment and best manage the risk of using treated wastewater, a monitoring regime is recommended to be put in place which provides critical data and transparency into the effluent, nutrient, salt and water flows within the vineyard areas. The following areas need to be covered:

- In-storage wastewater quality monitoring
- Soil chemical and physical properties
- Soil profile water movement and content
- Climate data
- Drainage flows and drainage water quality
- Groundwater levels and water quality

Many of the sensors used to collect data on the above elements can be automatically connected onto the existing soil moisture monitoring system telemetry devices. This will provide instant access to crucial data and allows swift and informed decisions to take place in order to apply best management practices, as well as minimise risks of system errors to remain undetected over a longer period of time.

2.4.1. In-storage wastewater quality monitoring

The wastewater quality may naturally fluctuate due to the various stages of the winemaking process. In order to make informed decisions in regard to volumes, as well as timing of the application of treated wastewater onto the vineyard areas, wastewater quality will be need to be monitored frequently. Some wastewater quality buffering will naturally take place due to the larger storage volumes available. Sampling and analysis of the treated wastewater found in storage should be done weekly, and frequency could be increased during vintage. It should consist of parameters including acidity (pH), salinity (EC), COD. The main cations and anions, as well as the important micronutrients Fe, Mn, Zn, Cu and B could be monitored quarterly.

2.4.2. Soil chemical and physical properties

Soil characteristics of the vineyard soils are fairly well established. They have been monitored and documented since 2001. A well established grid of sampling points (40 used in 2010) is in use, covering most areas and individual blocks.

Initially, it is recommended that a soil chemical analysis should be carried out on an annual basis.

Soil physical conditions and soil structure are of significant importance, not only when it comes to plant growth, but also when the soil is being used to absorb and buffer treated wastewater and nutrient loads. Any soil physical changes also in respect to chemical interaction need to be considered in the future.

Changes to soil physical properties are more gradual and effects may be more long term, however, analysis should be checked every three years. If soil physical conditions remain stable, testing cycles could be eased extended.

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2.4.3. Soil profile water movement and content

The monitoring of the soil water movement throughout the profile is not only crucial for best agronomic practices, providing key indicators on optimal or critical soil moisture content for best production, but also indicates the direction and depth of flows and possible salt concentrations.

In respect to possible deep percolation and leaching into soil layers below the root zone, maintaining the existing soil moisture monitoring system will provide a clear indicator.

2.4.4. Climate data

Climate data is available from the relatively close-by meteorological station maintained by the CSIRO Land and Water in Hanwood. The data provided is generally suitable to be used as reference data and for long term planning.

2.4.5. Groundwater levels and water quality

No specific groundwater data could be obtained for the vineyard areas, but it has generally been accepted that water table depths are below three metres from the digging of soil sampling pits previously.

Minimum analysis should be conducted and it is recommended that a full analysis of the groundwater quality be conducted at the start of the project and repeated annually covering the parameters established in the treated wastewater (in-storage).

Groundwater observation wells should be placed near the main paths of groundwater entry and exits to the vineyards, as well as main treated wastewater storage areas. A more detailed description is given in Table 9 with suggested placements indicated in Figure 9.

Table 9: *Suggest number and locations of groundwater observation wells at McWilliam's vineyards.*

Block description	Farms		Suggested groundwater observation wells	
	No.	Size (#) (ha)	Number of Wells (#)	Description
Joncondon Road Block	195	101/101	2	Covering the northern and north-eastern perimeter of the block as well as the storage vicinity of the on-site irrigation water storage in the north-west western corner.
	199	141/141	2	Covering the central storage vicinity and the southern-side of the block.
McWilliam Road Block	(127)/128	36/35	1	Covers the north-eastern corner of the block.
Winery Block	130	15/5	1	Covers the southern side and the vicinity of the evaporation ponds and the existing and planned on-site wastewater storage facility.

Note: # INITITAL and PROJECTED planted vineyard areas.

Figure 9: *Suggested locations of groundwater observation wells on the McWilliam's farms 199, 196, 195, 128(/127) and 130.*

Reference/Source

Background data and information was provided by McWilliam's Wines Group, JJC Engineering Pty. Ltd. and Cropsol Consulting Services Pty. Ltd. Site visits were conducted.

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