Irrigation Management of Treated Water; MOD 16.

Executive Summary

In an email dated 26 July 2018 the EPA have requested further information regarding the capacity of Irrigation Areas to accommodate/dispose of the proposed extra volume of waste water associated with the MOD 16 proposal. Such an assessment of the irrigation areas within the Shoalhaven Starches Environmental Farm (The Farm) as requested by the EPA is required to include but not be limited to hydraulic, nutrient and salt balances. The EPA requires that the assessment follows the framework provided for by the *EPA's environmental guidelines- Use of Effluent by irrigation Management (Dec 2003)*.

The Farm has seen significant change since 2010 with the introduction of the Water Recovery Plant (WRP). Irrigation volumes have reduced significantly with the recycling of RO treated water back to the factory. Up to 75% water reuse efficiency has been achieved.

Soil EC (Electrical Conductivity) and ESP (Exchangeable Sodium Percentage) have also improved significantly in this time due to the WRP.

Nutrient levels are stable and slowing decreasing and more than adequate for agricultural production.

The Farm has seen a significant improvement in its condition since the commissioning of the WRP in 2010. This is demonstrated in both the technical data and also by the fact that it has been able to support new agricultural enterprises (cropping) that were previously not possible.

The increases in irrigation proposed in Mod 16 are incremental. The irrigation areas have sufficient capacity to accommodate this incremental increase irrigation volume in terms of Hydraulic capacity, Salt loading and nutrient balance.

Introduction

The Manildra Group has a 960-hectare property (The Farm) situated on the Shoalhaven Flood Plain. It is underlain by Holocene Acid Sulphate Soils (ASS) and dissected by Shoalhaven City Council's (SCC) drainage network. The Farm is an accumulation of land purchases since the 1980's.

The effective irrigation area is 520 hectares serviced by spray irrigation. Waterways have 40 metre buffer/exclusion zones adjacent to irrigation activities. There are 7 centre pivots and 183 hydrants for connecting travelling irrigators when scheduled. The Farm supports cattle production and produces forage and silage for sale and its own use.

Photo 1 Freshly cut mixed pasture, ryegrass and kikuyu, to be sold to local dairy.

Landform/Flood Potential/Surface Water

The Farm is geographically the lowest point in the landscape.

Run-off is not the major issue, but Run-On is; receiving floodwaters from neighbouring areas by drains &/or by tidal overtopping. Regional floods inundate the entire Farm delaying any irrigation activities. Most drains are bounded by SCC past spoil thus creating unintended bunded paddocks.

The Farm has 925 ML of pond storage capacity not including the 90 ML anaerobic and 110 ML aerobic ponds which are part of the Manildra Water Recovery Plant (WRP). Total on farm storage is 1125 ML.

Soil Limitations

Below is the Farm's soil limitations rated against the EPA/DEC irrigation guidelines

ESP (0-40cm)	Nil or Slight
ESP (40-100)	Moderate
ECe dS/m (0-70cm)	Severe (due to tidal influence)
ECe dS/m (70-100cm)	Severe (due to tidal influence)
Depth to seasonal watertable	Moderate
Depth to bedrock	Nil
Sat Hydraulic Conductivity	Nil or slight
Available water capacity	Nil or Slight
Soil pH	Nil or Slight
ECEC	Nil or Slight
Emerson Aggregate test	Nil or Slight
Phos P sorption	Moderate

EPA/DEC Guidelines re Table 2.2

Effluent Quality

The Irrigation water quality since the commissioning of the Water Recovery Plant is a mixture of treated waters from the WRP. The average EC is 3.5 dS/m, pH of 8.0 and TSS mg/l is negligible due to the RO process. The following table show summaries the improvement in Irrigation water quality since the implementation of the WRP.

EPA/DEC Guidelines re Table 3.1	**Before WRP**	**After WRP (2010)**
Total Nitrogen mg/l	High	Medium
Total Phosphorus mg/l	High	Low
BOD5 mg/l	High	Low
TDS mg/l	High	High

Irrigation and Rainfall

Figure 1 is a summary of the past 15 calendar years of rainfall and irrigation applied depth (mm).

Climatic cycles in drought from 2003 to 2006 show the irrigation opportunity was available due to low soil moisture storage.

A flood cycle started in 2013 where the soil moisture had increased. This was due to flooding and run-on raising regional water tables. Once lowered then scheduled irrigation activities resumed.

Figure 1

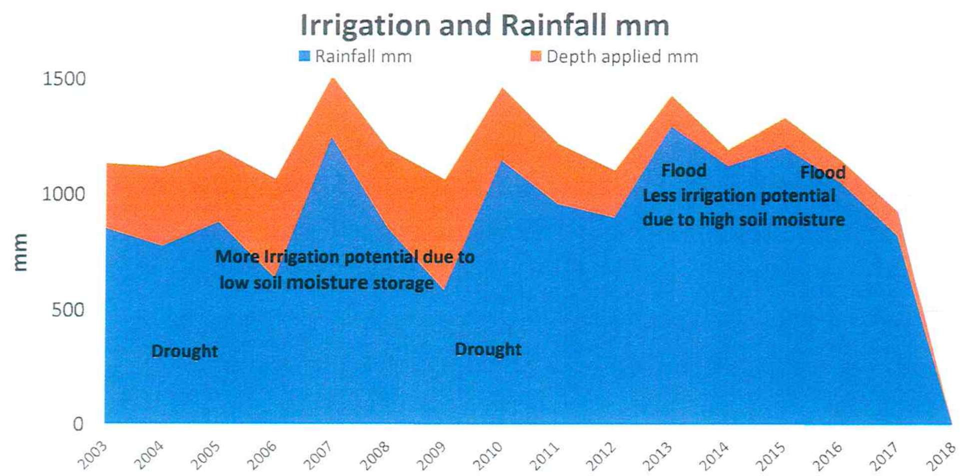
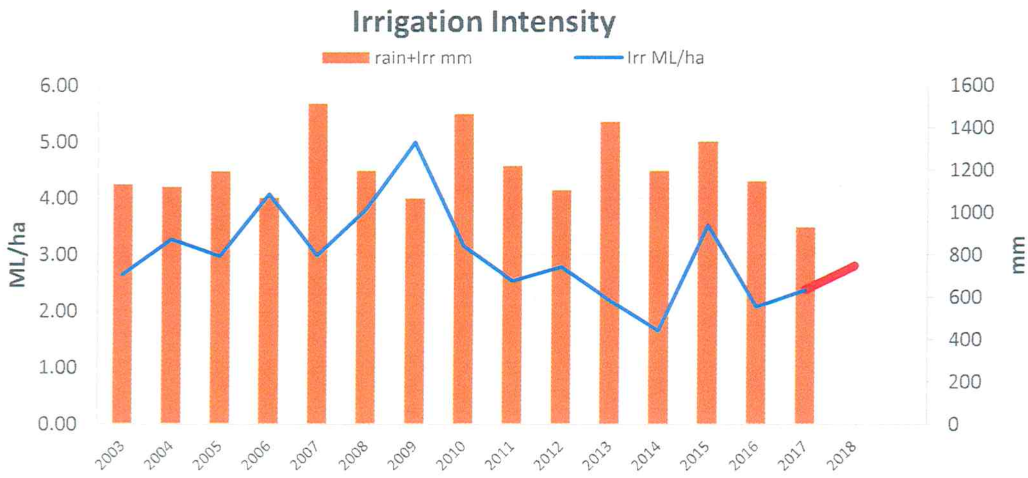


Figure 2, below, depicts the total depth of water (rainfall + irrigation) applied to the 520 ha of effective irrigation area. The irrigation intensity is the average volume applied per year to the irrigation area. Prior to the WRP the irrigation intensity ranged from 3 to 5 ML/ha. The WRP was commissioned in 2010 and provided the Company with a non-weather dependent option for water reuse. The RO potable permeate was returned the factory reducing the hydraulic loading on the irrigation area.

Since then irrigation volume has reduced except after the regional flooding where WRP wastewater was stored in the wet weather ponds. Irrigation increased in 2015, to reduce the volume stored in the ponds.

The Farm has already demonstrated its ability to be productive under high and low irrigation intensities. The projected Irrigation Intensity following MOD16 will be 2.8 ML/irrigated ha/year and is depicted in RED Figure 2 and is well within the previously demonstrated irrigation capacity.

Figure 2



Agricultural Production

Before the WRP the Farm produced forage grasses either for grazing or silage. Essentially this cut and remove practice was an export of nutrients off the property. It also extended the viability of additional irrigation.

Pastures were either winter active perennial ryegrass usually under pivots and the summer active naturalized kikuyu across the rest of the farm, either irrigated or dryland. Grazing was excluded on the pivots.

The WRP decreased the water available for irrigation. With almost half the irrigation volume, there was the opportunity to grow maize for silage which had only been attempted once in the early 1990's. Maize requires water for vegetative production but needs a senescence period for the grain to develop and dry. Previously that critical drying period could never be guaranteed.

Cropping also is an important activity for nutrient removal from the soil. Another opportunity was to sod-sow many of the traditional kikuyu pastures with Italian ryegrass. This provides feed all year either as grazed or cut as chop for dairy customers.

This shift in agriculture has been enabled by the reduction in irrigation volumes. Further changes are being implemented and trialed for the lower elevation areas of the Farm

Photo 2, 3 and 4 Maize harvesting for silage. Certificate awarded to Manildra Group Farm as State winners for the NSW Silage Quality.

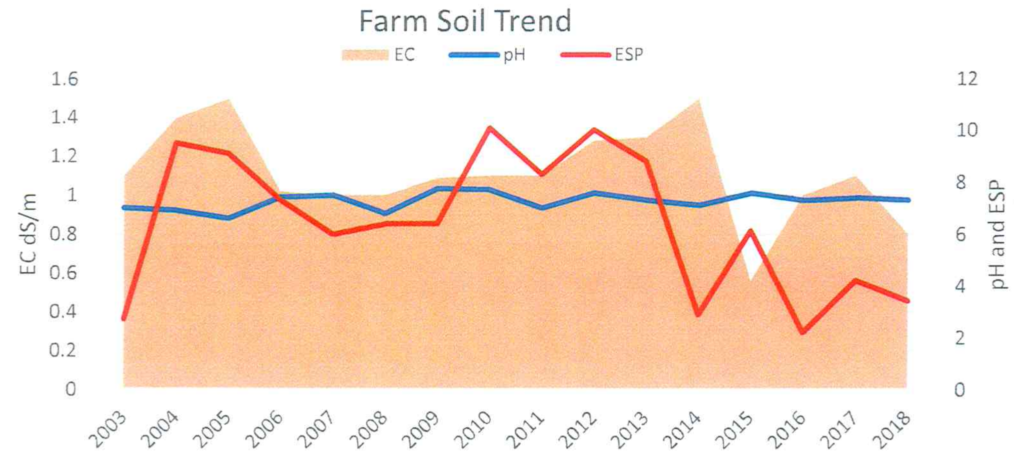
Soil Salinity and Sodicity

The data in Figure 3, has been summarized using the current EPA Annual License Return format.

Historical soil data from 2003 to 2017 from previous Environmental Farm Reports was retrieved to suit the current EPA requirement.

Every year one third of the Farms irrigation soils are sampled, including 2 long term soil profile sites plus 10 long-term surface soil transects. The data presented is the average of 24 values for each parameter for the vadose zone (0-60 cm). This also aligns with the rootzone in our agricultural system.

Figure 3



Past root zone salinities were higher than the Farms current levels ranging from 1.5 to 1.0 dS/m $EC_{1:5}$. Historically the climatic cycles are variable. The soil salinity has decreased since the commissioning of the WRP.

The Exchangeable Sodium Percentage (ESP) historically fluctuates between Sodic (6-15%) and Non-Sodic (<6%) levels due to climatic and inundating estuarine flood conditions. Irrigation quality prior to the

WRP was relatively uniform and post WRP we are seeing the same fluctuations but on a smaller scale. The Farm soils have decreased from Sodic levels to Non-Sodic since 2014.

These results are very encouraging. It is noted that the ESP and EC are very dependent on climatic cycles and the time lag from the commissioning of the WRP is to be expected.

Soil pH fluctuates between neutral and slightly alkaline. A change in fertilizer type and WRP processes are being evaluated for future rises in soil pH.

Soil Organic Carbon and Nutrients

Figure 4 summarises the Soil nutrient status for the past 15 years.

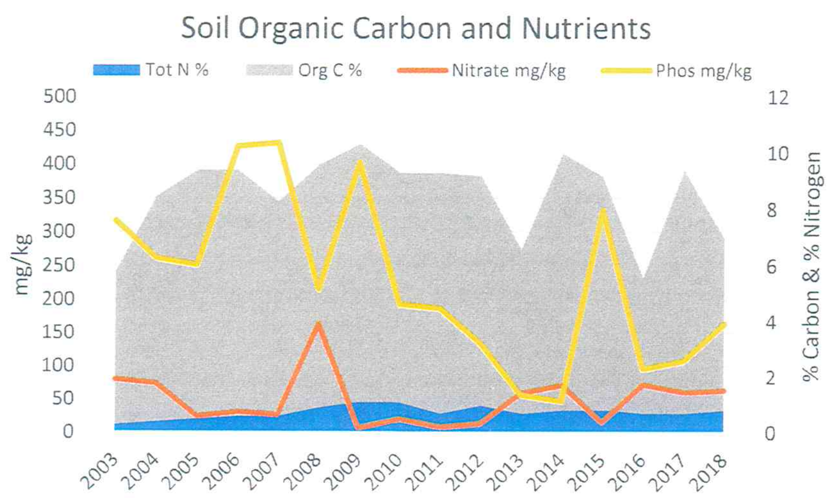
Soil Organic Carbon (OC%) levels for broadacre farming require 1-2%. Desirable OC% levels for pastures are 2-5% whilst the Manildra Farm has up to 10 OC%. Corn silage and permanent pastures with sod sowing/minimum tillage techniques will be continued.

Total Nitrogen (N%) levels are historically high as to be expected for a Holocene swamp. N% peaked in 2009 prior to the WRP commissioning. Levels are decreasing due to the anaerobic digestor converting wastewater nutrients to industrial biogas for energy production back to the Manildra Boiler house.

The desired range for cropping nitrate is 10-50 mg/kg. N% stored in soil is mineralized by cropping becoming partially plant available but tillage also reduces the infiltration rate by interrupting continuous pores. To reduce that, a rotation between fertilizer application and ploughing has been adopted maintaining water infiltration with the right amount of nitrate required for plant use.

This will take years to reduce in this controlled manner; alternatively, "crashing" nitrate levels will be more hazardous in the long term. The data is showing more than adequate levels of nitrate available for agricultural use. The potential for nutrient escape is low due to little slope, buffer zones and pivot/paddock design.

Figure 4



Historically phosphorus has been very high but the Phosphorus Buffering Index (BPI) indicates the soils ability to bind up phosphorus and be unavailable for plant uptake. The Farm's soil still has this ability. Phosphorus is tied up by low pH, Calcium, Organic Carbon and Iron.

In the sub-soil, iron is very high, ex Holocene estuarine pyritic swamp, with a matching low pH so phosphorus would be immobilized at depth. In the top-soil, high OC% and past hydrated lime (calcium) applications reduce phosphorus mobility.

Phosphorus just like nitrogen, will be managed by minimum tillage cropping.

All forms of Nitrogen and Phosphorus have decreased demonstrating the soils ability to store and utilize the nutrients by agricultural production.

Conclusion

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12/10/15

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Reference

DEC NSW (2003) Use of Effluent by Irrigation; Environmental Guidelines.