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3 June 2015

Attention: Grant Pedersen

RE: Addendum 3
Mangawhai Wastewater Disposal Options Study – Golf Course MEDLI Modelling and Wetland Disposal

Performance modelling has been undertaken for effluent management at Mangawhai golf course. Effluent in excess of golf course irrigation requirements will be sent to a constructed wetland. *Model for Effluent Disposal using Land Irrigation* (MEDLI) has been used to simulate the performance and impacts of a subsurface drip irrigation scheme across the designated golf course areas. Modelling was also used to examine the resulting increase in groundwater levels and leached pollutant loads.

1.1 Daily Effluent Irrigation System Modelling

Water, nutrient and salt modelling was undertaken using *Model for Effluent Disposal using Land Irrigation* (MEDLI). MEDLI is a water and nutrient mass balance model developed by the Queensland Department of Natural Resources and Mines (now DERM) and the CRC for Waste Management and Pollution Control (Gardner and Davis, 1998). It is capable of simulating storage pond dynamics, irrigation scheduling, plant growth, transpiration and nutrient uptake, soil water and nutrient dynamics and salinity on a daily time step over long periods (up to 100 years).

Desktop and field data were collated and used to build MEDLI models for the potential effluent irrigation scenarios. Input parameters and model construction is detailed in the following sub-sections.

1.1.1 Modelling Objectives

The effluent irrigation area should not cause permanent or sustained degradation of land with respect to;

- waterlogging and extensive periods of soil saturation;
- creation of conditions that are toxic to plant / biological activity;
- sodicity and soil structural decline;
- erosion;
- soil salinisation; and
- the long term accumulation and contamination of land with pollutants (nutrients, metals).

Sodicity, structural decline, erosion, salinisation and pollutant accumulation are all highly unlikely under the scenarios in this sandy environment. MEDLI modelling has been used to evaluate waterlogging (which is also highly unlikely) and plant growth and health.

The following soil water performance objectives were applied to the irrigation scenarios to ensure waterlogging was not an issue. On this site, waterlogging would be driven by elevated groundwater levels in lower lying areas of the course.

Table 1 Performance Objectives for Waterlogging and Soil Water Conditions

Parameter	Average Annual Target	Frequency / Duration Target
Saturated soil for >24 hours	≤1 day/year (0.3%)	≤50% years with a Max. 10% days/year
Soil water at or near field capacity at end of daily timestep	≥275 days/year (75%)	Min. 183 (50%) days/year for ≥90% years.
MEDLI Growth Stress Index	No months >0.1 (minor)	

1.1.2 Modelling Scenarios

Irrigation of Mangawhai Golf Course was assumed to be closely linked to plant water requirements in order to control potential for winter groundwater mounding. Irrigation would occur where a soil water deficit is present within the soil profile. Model input parameters are provided in Appendix A.

Daily effluent flow data provided by the client was analysed and scaled based on average and 90th percentile flows to create a timeseries for the ultimate design flow in 2044 as defined in Harrison Grierson (2014). Modelling is based on this ultimate design flow series and can be seen in Figure 1. Design effluent concentrations for both the winter and summer periods were also provided by the client.

The deficit irrigation scenario was tested using an irrigation schedule which involved a maximum application rate of 5 mm/d and irrigation trigger at 2 mm soil water deficit. Results of this analysis are presented in Section 1.1.4.

It was indicated that treated effluent storage at the WWTP would be increased to around 1-2 ML, and therefore this was modelled within MEDLI using a storage size of ~1.5ML. This would provide ~2 days storage at ultimate design flows. A 30 ha irrigation area was adopted based on approximate areas identified across the golf course by the client.

A summary of modelling scenarios is provided below.

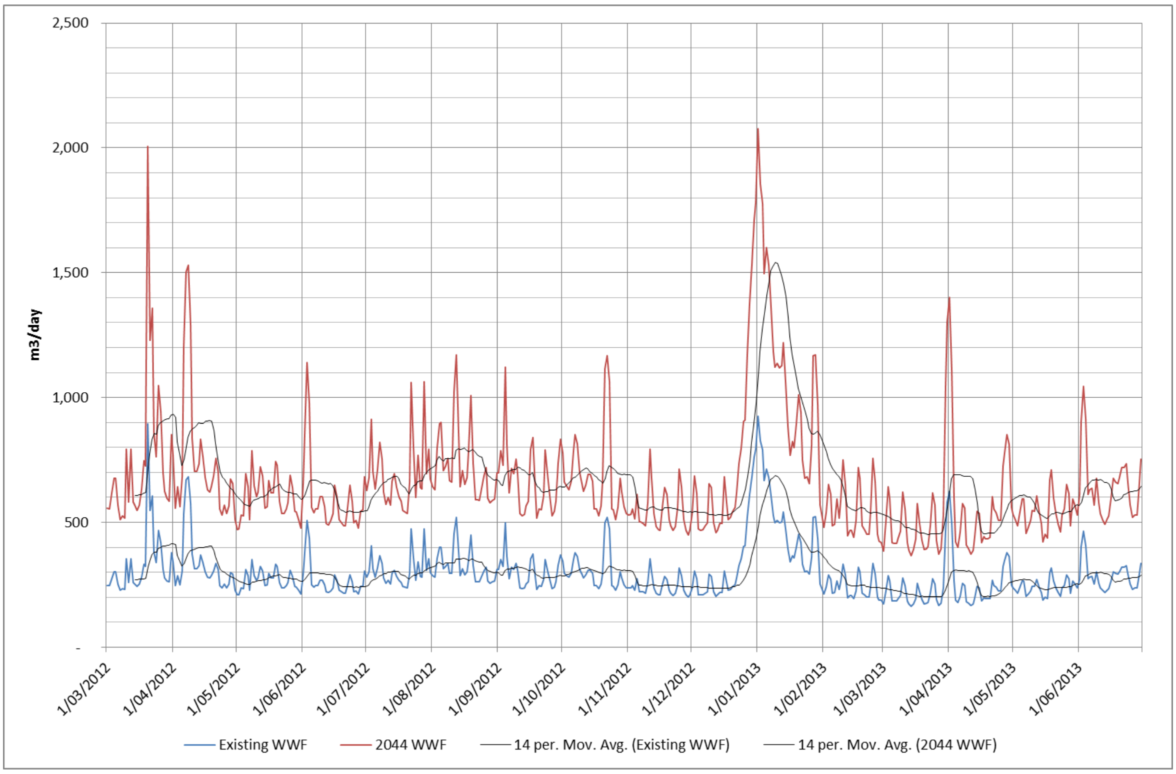

Figure 1 Modelling Daily Effluent Flow Timeseries

Table 2 MEDLI Modelling Scenario Summary

Scenario	Effluent Quality TN/TP (mg/L)	Effluent Storage	Irrigation Schedule	Irrigation Rate (Ave. / Max)	Irrigation Area (ha)
Deficit Irrigation – Ultimate Design Flows	15 / 10 (summer) 7 / 3 (winter)	2 days (1-2 ML)	Irrigation triggered at 2mm soil water deficit 0mm beyond drained upper limit	0.89 / 5 mm/day	30

1.1.3 Bio-Physical Input Data

MEDLI requires bio-physical input data in order to provide a representative water and nutrient mass balance for the irrigation site. The required bio-physical data include the following:

- Climate data;
- Soil and landscape data; and
- Vegetation data.

These bio-physical data requirements are described in detail below.

1.1.3.1 Climate

MEDLI requires daily rainfall, evaporation, solar radiation, and maximum and minimum temperature for the irrigation site. For this study interpolated data from SILO (DataDrill) were obtained in MEDLI format from Queensland DERM for the nearest available location (Leigh - 36.27 deg. S, 174.80 deg. E). The MEDLI modelling period was set at 28 years (1971 – 1998). A summary of monthly climate statistics is provided in Figure 2.

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CLIMATE INFORMATION
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Enterprise site: Leigh                          -36.3 deg S  174.8 deg E
Weather station: LeighNZ_36.273S_174.796E

  ANNUAL TOTALS    10 Percentile  50 percentile  90 Percentile
Rainfall mm/year         963.        1095.         1557.
Pan Evap mm/year        1223.        1309.         1406.

      MONTHLY        Jan  Feb  Mar  Apr  May  Jun  Jul  Aug  Sep  Oct  Nov  Dec  Year
Rainfall      (mm)    75   61  108   97   89  138  129  124  109   90   71   68  1157
Pan Evap      (mm)   182  155  137   97   70   48   50   63   86  117  142  169  1315
Ave Max Temp DegC     23   23   22   20   18   16   15   15   16   17   19   21    18
Ave Min Temp DegC     16   17   16   14   12   11   10   10   10   12   13   15    12
Rad   (MJ/m2/day)     24   22   17   12    9    7    8   10   14   18   22   25    15
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Figure 2 Summary Statistics for SILO MEDLI Climate Data

1.1.3.2 Soil and Vegetation Characteristics

MEDLI soil parameters were developed based on the assumed sandy soil profile across the golf course. MEDLI soil parameters for the site used in modelling are detailed in Appendix A. Some parameters were inferred based on soil texture, structure, colour and depth using published data on Australian soils (Gardner and Davis 1998, Hazelton and Murphy 2007, AS/NZS1547:2012). In addition, calculations were undertaken to determine a limiting horizontal hydraulic conductivity for the sandy soil present based on the high groundwater that exists across the site.

The plant species assumed for the irrigation area was very well maintained Kikuyu and therefore Ryegrass default parameters were adopted. MEDLI vegetation parameters for the irrigation sites used in modelling are detailed in Appendix A.

1.1.4 Modelling Results

Figure 3 and 4 present monthly total irrigation demands (mm and ML) for the Mangawhai Golf Course subsurface drip irrigation system.

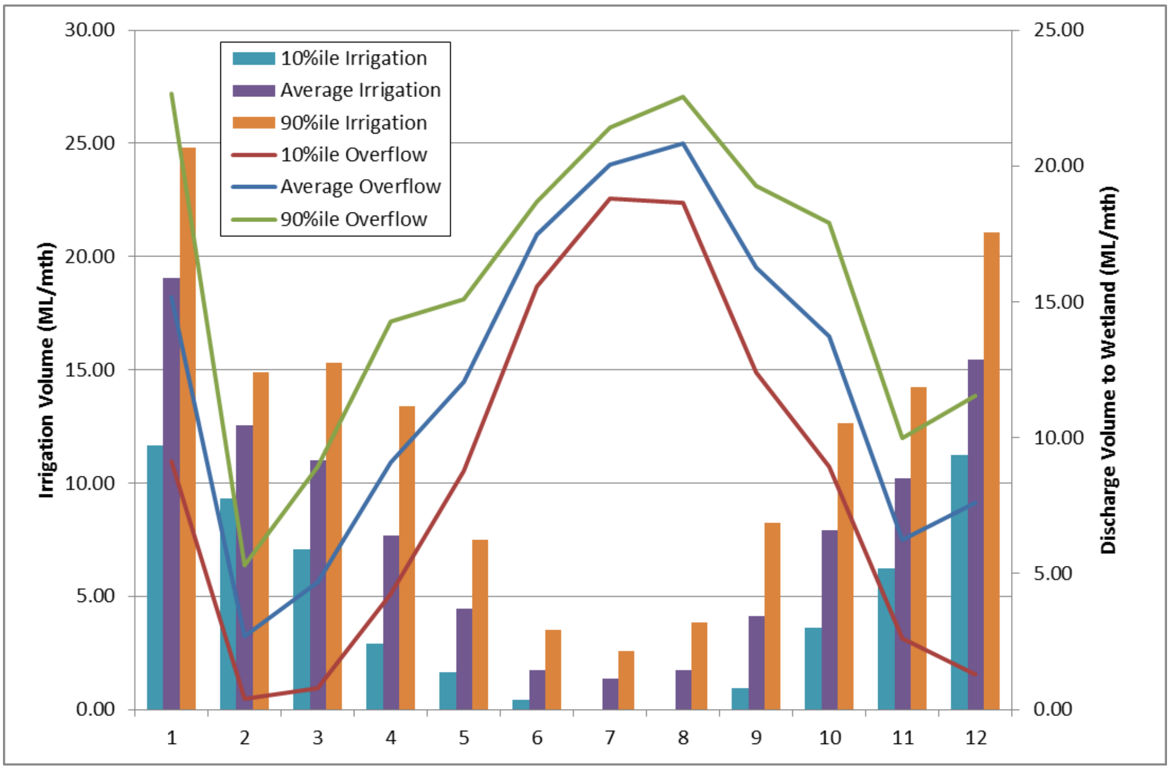

Figure 3 Irrigation and Wetland Discharge Modelling Analysis

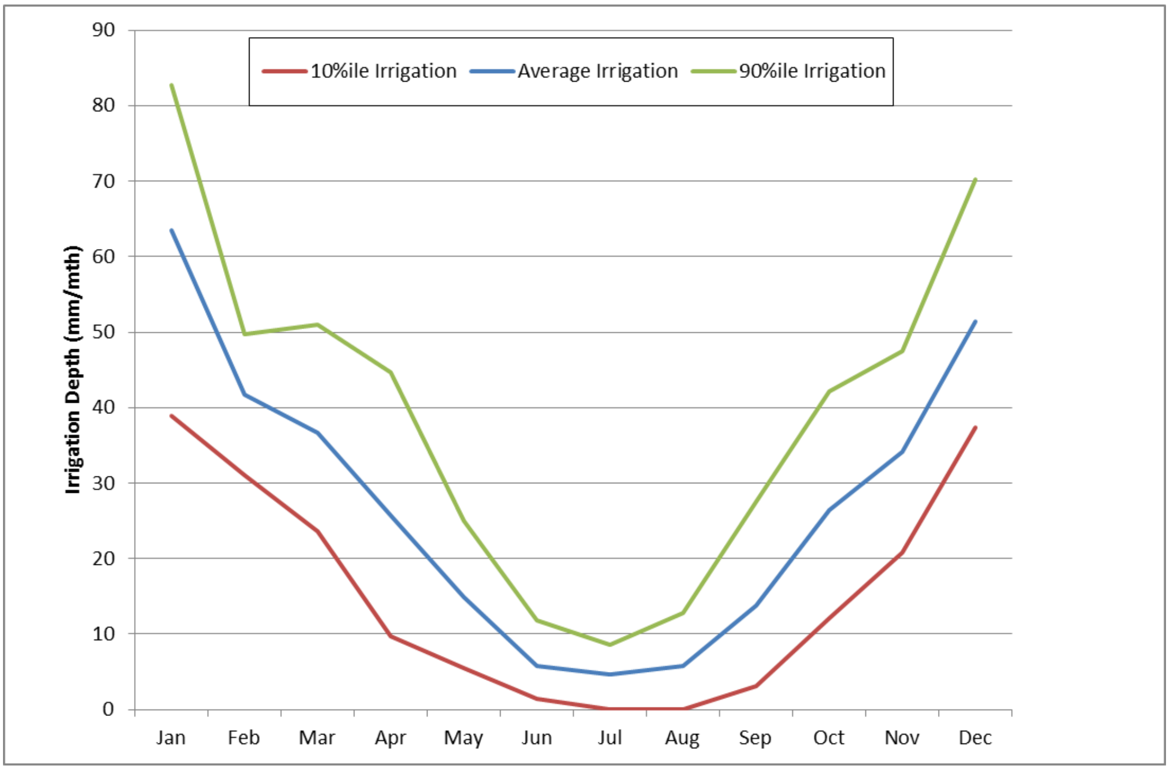

Figure 4 Irrigation Demand Modelling Results

As can be seen irrigation to the golf course fairways and grass areas needs to be reduced during the winter to ensure the site is not over irrigated and the golf course surface is suitable for use. Plant water demand over the 30 ha irrigation area simply does not have the capacity to irrigate all of the design flow even during summer (mainly due to the peak holiday loading) and therefore not in winter under ultimate flow conditions. It can be seen that there are approximately 5 months per year where current design flows cannot be managed by irrigation.

Nutrient modelling results are presented in the table below. They represent average annual concentrations discharging to groundwater via deep drainage. Further attenuation of nutrient loads would be expected in groundwater flow as it moved towards the estuary.

Table 3 Key Modelling Results Summary

Nutrient Loading Rate (TN/TP)	Storage Overflow	Nutrient Loads in Deep Drainage			
		Nitrate		Phosphate	
kg/ha/year	ML/yr (%)	Average (kg/year)	Average (mg/L)	Average (kg/year)	Average (mg/L)
22 / 10 (winter concentrations)	145 (60%)	78	0.4	3	0.01

1.2 Hydraulic Constraints

MEDLI irrigation modelling parameters were developed to simulate likely winter drainage constraints posed by elevated groundwater levels. Specifically, drainage of the soil profile was limited to the estimated groundwater flow rate below the golf course. Modelling outcomes indicated the proposed irrigation schedule did not exceed drainage capacity (based on the targets presented in Table 1).

Additional checks were completed to evaluate the potential for seasonal changes to watertables as a result of the irrigation schedule. This was completed using a steady state model (Hantush) published by Poeter *et* al, 2005). Results are preliminary due to the range of assumptions that need to be made regarding hydrogeology and topography.

The model assumes a steady state recharge of groundwater from an effluent management system that for this project has been taken as the net change in deep drainage as a result of irrigation in winter. Typical aquifer hydraulic conductivities (8 – 20 m/day) and depths (10 – 30 metres to aquifer base) were tested.

Steady state groundwater levels are predicted to increase by 0.4 – 0.8m during winter **as a result of golf course irrigation**. It will be important to ensure potential impacts on local groundwater hydrology are confirmed. This should include the potential impact of wetland discharge of excess effluent to the estuary.

1.3 Wetland Performance

Preliminary modelling of a free surface wetland was undertaken based on Reed *et al* (1995) using both standard published rate constants and calibrated rate constants from West Byron STP in northern NSW.

The latter were used as they represent constants calibrated against receipt of advanced secondary to tertiary effluent for polishing purposes. Outcomes are presented in the following tables.

Table 1 Reed *et al* (2005) Wetland Performance Modelling (Standard Rate Constants)

BMT WBM Pty Ltd: REED VOLUMETRIC FREE WATER SURFACE WETLAND PROCESS DESIGN MODEL										
Source: Reed, Crites and Middlebrooks (1995) *Natural Systems for Waste Management and Treatment*										
INPUTS										
Wetland Area		15	m^3/day					**Effluent Quality Target Approach** (leave blank if not relevant)		
		C$_i$	C$_*$	**Wetland Dimensions (performance assessment approach)**						C$_e$
BOD$_5$	mg/L	10	2	Length	m	180		BOD$_5$	mg/L	
TSS		8	2	Width		60		TSS		
NH$_4$		1	0.02	Depth		0.5		NH$_4$		
NO$_3$		6	1	Porosity	decimal	0.65		NO$_3$		
TN		7	1					TN		
TP		2	1	No. Cells in Series		1		TP		
Faecal C.	cfu/100ml	14	0	Min. Water Temp	deg C	8		Faecal C	cfu/100ml	
C$_i$ = influent concentration				Rate Constants And Temp Coefficients						
C$_*$ = background concentration				Reed et al (1995)						
Adopted temperature coefficients and reference temperature rate constants (only complete for site specific values)										
Parameter				**BOD$_5$**	**NH$_4$**	**NO$_3$**	**Pathogen**			
Rate Constant at reference temp.			K_R, d^{-1}	0.03	0.8	4	27			
Temp. coefficient for rate constant			θ_R	1.06	1.048	1.15	1.19			
RESULTS										
Predicted Effluent Quality										
BOD$_5$	mg/L	2	Based on a wetland area of …		10800	m^2				
TSS		2.00		**Other Data**						
NH$_4$		0.02		Hydraulic Loading Rate	0.14	cm/day				
NO$_3$		1.000		HRT	234.00	days				
TP		1.000		Carbon:Nitrate	536	:1				
Faecal C.	cfu/100ml	0								

Table 2 Reed *et al* (2005) Wetland Performance Modelling (West Byron STP Constants)

BMT WBM Pty Ltd: REED VOLUMETRIC FREE WATER SURFACE WETLAND PROCESS DESIGN MODEL										
Source: Reed, Crites and Middlebrooks (1995) *Natural Systems for Waste Management and Treatment*										
INPUTS										
Wetland Area		15	m^3/day					**Effluent Quality Target Approach** (leave blank if not relevant)		
		C$_i$	C$_*$	**Wetland Dimensions (performance assessment approach)**						C$_e$
BOD$_5$	mg/L	10	2	Length	m	180		BOD$_5$	mg/L	
TSS		8	2	Width		60		TSS		
NH$_4$		1	0.02	Depth		0.5		NH$_4$		
NO$_3$		6	1	Porosity	decimal	0.65		NO$_3$		
TN		7	1					TN		
TP		2	1	No. Cells in Series		1		TP		
Faecal C.	cfu/100ml	14	0	Min. Water Temp	deg C	8		Faecal C	cfu/100ml	
C$_i$ = influent concentration				Rate Constants And Temp Coefficients						
C$_*$ = background concentration				User Defined						
Adopted temperature coefficients and reference temperature rate constants (only complete for site specific values)										
Parameter				**BOD$_5$**	**NH$_4$**	**NO$_3$**	**Pathogen**			
Rate Constant at reference temp.			K_R, d^{-1}	0.03	0.8	4	27			
Temp. coefficient for rate constant			θ_R	1.06	1.048	1.15	1.19			
RESULTS										
Predicted Effluent Quality										
BOD$_5$	mg/L	2	Based on a wetland area of …		10800	m^2				
TSS		2.00		**Other Data**						
NH$_4$		0.02		Hydraulic Loading Rate	0.14	cm/day				
NO$_3$		1.000		HRT	234.00	days				
TP		1.000		Carbon:Nitrate	536	:1				
Faecal C.	cfu/100ml	0								

Regardless of rate constants, minimum background concentrations (represented by C* concentrations) would be absolute minimum performance expectations. However, we note site specific calibration of these first order decay equations is recommended in order to obtain more refined performance predictions. It should be noted that published data on the performance of wetland systems in polishing highly treated effluent is limited and variable with respect to percentage reductions. As discussed, a more refined wetland design model can be developed through collection of site specific / local data.

Of greater importance to effective performance will be management of potential groundwater mounding impacts associated with wetland discharge, particularly during winter months. It will be essential to consider these impacts as part of subsequent design stages.

1.4 Outcomes

Deficit irrigation of golf course fairways, general grass areas and selected bushed areas was taken forward, in addition to excess effluent discharge to a constructed wetland.

A key constraint for the proposed irrigation scheme is the mounding of groundwater beneath the irrigation area, wetland discharge point and raising of the high groundwater across the site. The potential impacts have been tested at a screening level using a steady state groundwater model developed by Bob Seigrist from the Colorado School of Mines (keynote from SWWS 2012). The irrigation rates are predicted to increase the winter watertable by 0.4-0.8 m. More information on hydrogeology, surface topography and drainage will be required to confirm if this is a constraint. It is important to note the need for more refined understanding of groundwater dynamics and quality across the site given the implications for the irrigation scheme.

Assumed summer and winter effluent nutrient concentrations are well within plant nutrient demands. As a result crop uptake may not be optimised. Importantly, the greenkeepers would be looking to apply fertiliser to the site beyond these effluent nutrient loads to maintain health grass cover. Whilst summer nutrient concentrations could be lifted, there will be a limit based on potential for nutrient leaching whilst looking to maximise irrigation depths.

A free surface wetland (as proposed in Appendix 9 of Harrison Grierson (2014)) is expected to provide some additional polishing of treated effluent. However, performance expectations for such configurations (highly treated influent) vary on a site specific basis.

Yours Faithfully
BMT WBM

Ben Asquith

2 Reference

Gardner, T. and Davis, R. (eds.) (1998) MEDLI Version 1.2 Technical Manual. Queensland Department of Natural Resources and Mines: Primary Industries and the CRC for Waste Management and Pollution Control.

Harrison Grierson (2014) Mangawhai Wastewater Scheme – Potential Effluent Disposal Options.

Hazelton, P. and Murphy, B. (2007) Interpreting Soil Test Results: What do all the numbers mean? CSIRO Publishing

Reed, S.C., Crites, R.W. and Middlebrooks, E.J. (1995) *Natural Systems for Waste Management and Treatment*. McGraw Hill, New York.

Standards Australia (2012) AS/NZS1547:2012 On-site domestic wastewater management. Standards Australia.

Poeter, E.J. McCray, J. Thyne, G. and Siegrist. R. (2005) *Guidance for Evaluation of Potential Groundwater Mounding Associated with Cluster and High Density Wastewater Soil Absorption Systems*. National Decentralised Water Resources Capacity Development Project, Washington University, St Louis, MO.

Reed, S.C., Crites, R.W. and Middlebrooks, E.J. (1995) Natural Systems for Waste Management and Treatment. McGraw Hill, New York.

Appendix A MEDLI Input Parameters

Parameter	Unit	Modelled Value Winter Irrigation	Source
Enterprise - Effluent Characteristics			
Type		Other	Enables daily time series and modern sewers
EC	ds/m	1	Not critical given soil type.
TDS	mg/L	640	As above
Average Effluent Volume	ML/day	0.68	Provided by client: scaled for ultimate design flow
Total Nitrogen	mg/L	7	Provided by client
Total Phosphorous	mg/L	3	Provided by client
Enterprise - Irrigation			
Area		30	Provided by client based on available areas.
Method		Subsurface	Assume laterals of subsurface irrigation dripline
Minimum		0 ML/ha/day	Key outcome from MEDLI modelling. Application based on available soil water capacity and nutrient leaching.
Maximum		At Full Scheduled Application Rate	
Trigger		2mm SWD	
Application		0mm beyond DUL	
Enterprise - Pond			
Volume at Outlet	ML	Daily flow	
Technical - Pond			
Hydraulic Retention Time	days	2	Operational storage to enable modelling
Max Length of Wetted Surface	m	20	Modelled as a closed (tank) storage to enable MEDLI to function.
Max Width of Wetted Surface	m	18.8	
Max Water Depth	m	4	
Freeboard	m	0.3	
Drawdown	m	4	
Technical - Soil Water			
No. of Layers		4	
Curve No.		82	Calibrated based on long-term runoff coefficient (surface runoff to rainfall ratio)
Soil Layer Thickness (Layer 1,2,3,4)	mm	200, 300, 200, 200	Indicative soil profile developed based on assumed sandy soil profile across the irrigation areas (depths to be finalised)
Lower Strorage Limit (Layer 1,2,3,4)	%v/v	11, 6, 9, 9	MEDLI Manual (based on texture/structure)
Upper Storage Limit (Layer 1,2,3,4)	%v/v	17, 14, 16, 16	MEDLI Manual (based on texture/structure)
Saturated Water Content (Layer 1,2,3,4)	%v/v	37.2, 29.8, 32.6, 32.6	MEDLI Manual (based on texture/structure)
Saturated Hydraulic Conductivity (Layer 1,2,3)	mm/hr	104, 125, 121	MEDLI Manual (based on texture/structure)
Saturated Hydraulic Conductivity (Layer 4) - Limiting Layer	mm/hr	0.83 (MEDLI Input) / 0.42 (Actual)	From Ksat Flow Calcs; limited by aquifer hydraulics based on high groundwater across the site
Technical - Plant			
Option		Continuous Pasture	MEDLI Defaults
Species		Kikuyu	Modelled using Ryegrass MEDLI parameters
Max Crop Coefficient		0.8	
Max Root Depth	mm	600	

Harvest Trigger Yield	kg/ha	4000	
Technical - Irrigation			
Nitrate N	%	35	MEDLI default parameters for subsurface irrigation method
Ammonium N	%	22	
Organic N	%	43	
Ammonium Loss During Irrigation Application	%	5	
Technical - Soil Phosphorous			
Initial Soil Solution P (Layer 1,2,3,4)	mg/L	0.01 (All)	MEDLI Defaults (sand); site specific data is not currently available. This is a low number and is considered appropriately conservative.
Adsorption Coefficient (Layer 1,2,3,4)		75 (All)	
Adsorption Exponent (Layer 1,2,3,4)		0.33 (All)	
Desorption Exponent (Layer 1,2,3,4)		0.15 (All)	
Techncial - Soil Nitrogen			
Nitrate N	mg/kg	7	Based on parameters for similar sites
Organic N	mg/kg	1	
Ammonification of Soil Organic N		0.00035	MEDLI Defaults
Denitrification		0.1	MEDLI Defaults

Parameter	Unit	Modelled Value	Source
		Summer Irrigation	
Enterprise - Effluent Characteristics			
Type		Other	Enables daily time series and modern sewers
EC	ds/m	1	Not critical given soil type.
TDS	mg/L	640	As above
Average Effluent Volume	ML/day	0.68	Provided by client: scaled for ultimate design flow
Total Nitrogen	mg/L	15	Provided by client
Total Phosphorous	mg/L	10	Provided by client
Enterprise - Irrigation			
Area		30	Provided by client based on available areas.
Method		Subsurface	Assume laterals of subsurface irrigation dripline
Minimum		0 ML/ha/day	Key outcome from MEDLI modelling. Application based on available soil water capacity and nutrient leaching.
Maximum		At Full Scheduled Application Rate	
Trigger		2mm SWD	
Application		0mm beyond DUL	
Enterprise - Pond			
Volume at Outlet	ML	Daily flow	
Technical - Pond			
Hydraulic Retention Time	days	2	Operational storage to enable modelling
Max Length of Wetted Surface	m	20	Modelled as a closed (tank) storage to enable MEDLI to function.
Max Width of Wetted Surface	m	18.8	
Max Water Depth	m	4	
Freeboard	m	0.3	
Drawdown	m	4	
Technical - Soil Water			
No. of Layers		4	
Curve No.		82	Calibrated based on long-term runoff coefficient (surface runoff to rainfall ratio)
Soil Layer Thickness (Layer 1,2,3,4)	mm	200, 300, 200, 200	Indicative soil profile developed based on assumed sandy soil profile across the irrigation areas (depths to be finalised)
Lower Strorage Limit (Layer 1,2,3,4)	%v/v	11, 6, 9, 9	MEDLI Manual (based on texture/structure)
Upper Storage Limit (Layer 1,2,3,4)	%v/v	17, 14, 16, 16	MEDLI Manual (based on texture/structure)
Saturated Water Content (Layer 1,2,3,4)	%v/v	37.2, 29.8, 32.6, 32.6	MEDLI Manual (based on texture/structure)
Saturated Hydraulic Conductivity (Layer 1,2,3)	mm/hr	104, 125, 121	MEDLI Manual (based on texture/structure)
Saturated Hydraulic Conductivity (Layer 4) - Limiting Layer	mm/hr	0.83 (MEDLI Input) / 0.42 (Actual)	From Ksat Flow Calcs; limited by aquifer hydraulics based on high groundwater across the site
Technical - Plant			
Option		Continuous Pasture	MEDLI Defaults
Species		Kikuyu	Modelled using Ryegrass MEDLI parameters
Max Crop Coefficient		0.8	
Max Root Depth	mm	600	

Harvest Trigger Yield	kg/ha	4000	
Technical - Irrigation			
Nitrate N	%	35	MEDLI default parameters for subsurface irrigation method
Ammonium N	%	22	
Organic N	%	43	
Ammonium Loss During Irrigation Application	%	5	
Technical - Soil Phosphorous			
Initial Soil Solution P (Layer 1,2,3,4)	mg/L	0.01 (All)	MEDLI Defaults (sand); site specific data is not currently available. This is a low number and is considered appropriately conservative.
Adsorption Coefficient (Layer 1,2,3,4)		75 (All)	
Adsorption Exponent (Layer 1,2,3,4)		0.33 (All)	
Desorption Exponent (Layer 1,2,3,4)		0.15 (All)	
Techncial - Soil Nitrogen			
Nitrate N	mg/kg	7	Based on parameters for similar sites
Organic N	mg/kg	1	
Ammonification of Soil Organic N		0.00035	MEDLI Defaults
Denitrification		0.1	MEDLI Defaults

Appendix B MEDLI Outputs Summary

Parameter	Unit	MEDLI Modelling Results Summary	
		No Irrigation Scenario	Irrigation Scenario (Winter)
Storage Water Balance			
INPUTS			
Average effluent inflow	ML/yr	242.9	242.9
Rain	ML/yr	0	0
OUTPUTS			
Evaporation loss	ML/yr	0	0
Seepage loss	ML/yr	0	0
Irrigation	ML/yr	0	97.8
Overflow	ML/yr	242.9	145.2
Irrigation Area - Water Balance	ha	30	30
INPUTS			
Irrigation	mm	0	326
OUTPUTS			
Soil Evaporation	mm	605	57
Transpiration	mm	8	660
Runoff	mm	49	21
Deep Drainage	mm	496	746
Irrigation Area - Nutrient Balance			
NITROGEN INPUTS			
Total N added in irrigation	kg/ha/yr	0	22.4
Total N added in seed		0.1	0.1
NITROGEN OUTPUTS			
TN Crop Uptake	kg/ha/yr	0.9	23
Denitrification		0.5	0.5
Leached NO3-N	kg/ha/yr	2.8	2.6
	kg/yr	84	78
	mg/L	0.60	0.40
PHOSPHORUS INPUTS			
Total P added in irrigation	kg/ha/yr	0	9.8
Total P added in seed		0	0
PHOSPHORUS OUTPUTS			
Change in adsorbed PO4-P	kg/ha/yr	0.5	0.1
TP Crop Uptake		0.1	7.4
Leached PO4-4	kg/ha/yr	0.500	0.100
	kg/yr	15	3
	mg/L	0.10	0.01
Pasture			
Dry Matter Yield	kg/ha/yr	52	3907
Net TN Removal		1	23
Net TP Removal		0	7