AGL Tiedman Irrigation Trial Fundamental Design Problems

This is not a Trial but an Area to dispose of Produced Water

Trial Objectives

There is not one report by Fodder King or AGL that clearly sets out the purpose and design of this 'Trial'. It is necessary to review documents from 2011 to 2013 to understand what is currently happening on the site and then the current situation is different from the trial design that was approved by DRE.

The report by Fodder King to AGL (October 2012) says in section 2.1

"The Stage 1A area is the trial irrigation area that is the major focus of the Soil Quality Monitoring and Management Program. This area will have intensive monitoring of soil, water and crops, and application, after blending, of most of the produced water for irrigation.

"The Stage 1A area is about 22ha in total of which 12-15 ha is planned to be irrigated using a linear move irrigator. Crop types are expected to be lucerne, forage sorghum, oats and selected pasture types."

"The Stage 2 area is approximately 15ha. These areas are unlikely to be irrigated during the early stages of the irrigation activities and will only be used if irrigation application rates on the Stage 1A and Stage 1B areas are less than anticipated."

So this project by Fodder King on behalf of ALG is about getting rid of Produced Water not experimenting with or trialling different water rates or salinities and the impact of these rates on the soil or environment. Stages 1B and 2 will only be irrigated if there is too much water for Stage 1A.

Section 3.2 says *"the objectives of the Stage 1A Irrigation Trial are to:*

> *a) Derive information on the performance of using blended water and improved soils to maximise the beneficial use of produced water. This trial will provide support data for the preparation of the Gloucester Project Extracted Water Management Plan;*
>
> *b) Provide information to optimise the design of a water treatment and storage system to match the beneficial re-use system; and*
>
> *c) In order to minimise the overall 'footprint' of the project on the surrounding landscape the trial is aiming to achieve blended water application rates in the range of 3-5 megalitres/hectare/year."*

Objective (a) is about "maximising" the use of produced water but it will not provide data on this because there is only one rate of blended water application across all treatments and only at one salinity level for any irrigation event. Because there are no variables in quality or quantity of water application there can be no analysis to maximise beneficial use.

Objective (a) says that data will support the preparation of the Extracted Water Management Plan but that Plan will be developed in early 2014 which is well before the trial is completed 2015 and even before any realistic data can be collected.

Objective (b) is about "optimising" design of treatment and storage but this is not a variable in the trial so there will be no data for such optimisation to be considered.

Objective (c) is about minimising the "footprint" so it is about getting the Produced Water on the smallest area without really exploring options. For example, there is no variation of the water quality or quantity applied to the various crops or soil treatments so the concept of minimisation is not logical.

Objective (c) is to "achieve blended rates" of 3-5 ML/Ha/yr of blended water containing 2000mg of salt per litre, that is applying 6-10 tonnes of salt per hectare per year. However, there is no variation of applied salinity rates across treatments so there can be no interpretation of treatment effects on water demand.

These Objectives are further confused by Section 3.3 that says *"the objectives of the Stage 1B and Stage 2 areas are to:*

> *a) Allow for the irrigation of the lowest salinity irrigation water stored in the holding dams to provide improved pasture for stock grazing across the property (which is the traditional land use);*
>
> *b) Provide additional irrigated land area (to the intensive Stage 1A area) in the early stages of irrigation so that "air space" can be provided in the holding dams for the blending of the more brackish produced water that is in storage."*
>
> *"The remainder of this Soil Quality Monitoring and Management Program focuses on the Stage 1A irrigation trial area where between 50 and 60 ML of produced water is expected to be irrigated."*

In this section (3.3) Objective (a) appears to irrigate with undiluted water and not blended water.

In this section Objective (b) is about getting produced water out of the storage dam onto the soil to enable clean water from the river to be added for dilution of the salt in the produced water.

The last sentence in this section says that 50-60 ML of produced water is to be applied to the 12 ha of irrigated land in Stage 1A. Unfortunately the report does not indicate the salinity of this water or the period over which it will be applied. However, other information in the report suggests that the period is 2 years and the salinity of produced water is up to 8000mg/L. This would mean that up to 480 tonnes of salt will be applied to 12 ha or 40T/ha over the 2 years. Section 3.2 of the report says "*blended water application rates in the range of 3-5 megalitres/hectare/year."* That is up to 5ML/ha/yr of water with 2tonnes/Ml of salt which means up to 10 tonnes of salt per hectare per year. The numbers in the various reports are not consistent.

By contrast the Water Management Plan (AGL 2012) states in section 4 that "*for this irrigation proposal, maximum irrigation rates are likely to be 4-6 ML/ha and the irrigation water quality will not exceed 3000 µS/cm, and for the main trial area the target is to use a blended water mix with a salinity between 1500 and 2000 µS/cm.*" In this case up to 6ML/ha at 3T/ML is an application of 18 T/ha of salt.

FK Report 2 (August 2013) has different figures for irrigation of Stage 1A as extracted below.

> between 100 and 180 megalitres (ML) of blended water will be irrigated across this area during the trial period.

This means 100ML to 180ML over 12 hectares in 2 years which is 4.25 to 7 ML/ha and up to 14T/ha of salt; different to the previous report.

There is a serious lack of consistency in the information presented by AGL and its advisors in reports to Government. It is no wonder that the public is confused and concerned; and this is only for salt so a similar problem exists for all the heavy metals and other pollutants.

Soil Characteristics

The Fodder King Report 2012 (FK 2012) states in Section 4.2 that the soil of the area is a Brown Sodosol as shown below.

> ***4.2 Baseline Data***
>
> Previous investigations by Fodder King (FK) (2011) have characterised the soils within the Stage 1A irrigation area. Existing soils within the Stage 1A irrigation area are described as clay loam and classified as Brown Sodosols. The soil samples were analysed for a standard chemical suite

Brown Sodosols are so named because they are saline at depth. Victoria Resources Online describes such soils as follows: "the surface is a shallow sandy loam or sandy clay loam, poorly structured, slight to moderately alkaline, low salinity and non-sodic; the subsoil is a deep poorly structured (sodic) medium to heavy clay, strongly alkaline and increasing salinity with depth". "Salt content is usually low to moderate in surface soils and high (greater than 1.0 dS/m) in subsoils. If these soils frequently become waterlogged, salinity levels may increase at shallow depths. The subsoil salinity is likely to restrict growth of salt sensitive species (legumes) from 50 cm below the soil surface."
(http://vro.dpi.vic.gov.au/dpi/vro/wimregn.nsf/pages/natres_soil_balrootan_undulated_sodosol)

These soil characteristics and problems for the site are confirmed by the "average" data presented in Appendix 1 of FK 2012 and some extracts are copied below. The trial site soil is certainly saline at depth so the concept of adding more salt in blended irrigation water is not logical. Unlike a typical Sodosal, the soil at the Tiedman site is very acidic and no explanation is given for this in any of the reports.

Extract from FK 2012 Appendix 1

Average n = 16

Depth	ECe	EC (1:5)	pH	NO2	NO3	Org-C	K	Ca	Mg	Na	Al	ECEC
cm	dS/m	dS/m	CaCl2	mg/kg	mg/kg	%	meq/ 100g	meq/ 100g	meq/ 100g	Meq /100g	meq/ 100g	meq/100g
0 - 10	0.50	0.06	4.65	<0.1	4.1	3.15	0.43	3.32	3.82	0.39	0.16	8.1
10 - 20	0.58	0.07	4.46	<0.1	2.2	1.27	0.32	2.54	6.66	0.78	0.26	10.6
20 - 30	0.64	0.08	4.35	<0.1	2.6	0.62	0.39	2.07	10.73	1.49	0.50	15.2
30 - 40	0.77	0.10	4.40	<0.1	2.1	0.51	0.42	1.54	11.91	1.82	0.46	16.2
40 - 60	1.29	0.14	4.62	<0.1	2.9	0.38	0.37	1.29	12.50	2.29	0.47	16.9
60 - 80	2.47	0.19	4.81	<0.1	2.1	0.27	0.37	1.46	11.92	2.64	0.41	16.8
80 - 100	2.89	0.16	4.90	<0.1	2.4	0.25	0.34	0.82	11.69	2.80	0.39	16.0
100 - 120	3.73	0.17	5.09	<0.1	2.0	0.26	0.29	0.73	11.19	2.71	4.54	19.5

The Appendix also contains the minimum and maximum values for the soil properties and this indicates a range of about three fold for each tested characteristic. This is a very large variation across the site that is not accounted for in the trial design. There has been no attempt to apply the various amelioration rates to the variation in soil properties across the experimental area. All plots receive the same chemical treatment; it is only the depth of slotting that varies but again this is not based on any inherent soil test results.

Maximum

Depth	ECe	EC (1:5)	pH	NO2	NO3	Org-C	K	Ca	Mg	Na	Al	ECEC
cm	dS/m	dS/m	CaCl2	mg/kg	mg/kg	%	meq/ 100g	meq/ 100g	meq/ 100g	Meq /100g	meq/ 100g	meq/100g
0 - 10	0.80	0.08	4.95	<0.1	6.8	6.34	0.76	6.00	5.17	0.87	0.65	10.9
10 - 20	1.70	0.22	4.72	<0.1	3.7	4.55	0.71	4.62	11.20	1.53	0.57	17.3
20 - 30	1.10	0.15	4.73	<0.1	3.9	0.92	0.65	3.57	16.50	2.98	1.57	22.2

Minimum

Depth	ECe	EC (1:5)	pH	NO2	NO3	Org-C	K	Ca	Mg	Na	Al	ECEC
cm	dS/m	dS/m	CaCl2	mg/kg	mg/kg	%	meq/ 100g	meq/ 100g	meq/ 100g	Meq /100g	meq/ 100g	meq/100g
0 - 10	0.3	0.04	4.18	0.1	1.2	1.77	0.26	2.13	2.43	0.08	0.03	5.4
10 - 20	0.2	0.03	4.2	0	1.1	0.52	0.16	0.94	2.98	0.28	0.01	5.5
20 - 30	0.3	0.04	4.02	0	1.6	0.33	0.23	0.63	6.04	0.63	0.07	9.4

Soil Amelioration

The soil at the site is not suitable for irrigation with saline water and Fodder King has advised AGL to ameliorate the soil as indicated below (FK 2012). The trail contains the following soil treatment at four depths of placement within slots dug into the soil:

5.1 Stage 1A Trial Irrigation area

The Stage 1A trial area will entail deep amelioration of soils over four treatment depths. The composition of the ameliorant to be incorporated into the irrigation area is shown in Table 2.

Table 2: Composition of ameliorant and loading rates

Material	Required application rate (Tonnes/ha)
Gypsum	4
Lime	8
Composted Feedlot Manure	50
Zeolite	5

The ameliorant has been designed to improve the water holding capacity, infiltration rate, nutrient retention and organic matter content of existing site soils. Required application rates to create a productive soil were based on recommendations in FK (2011) – the Baseline 1 study. The ameliorants will act to increase soil pH (currently acidic), increase Cation Exchange Capacity (CEC – currently low), decrease soil Exchangeable Sodium Percentage (ESP – currently high) and increase organic matter (currently low), all of which were noted as limiting factors to irrigation of crops. The ameliorants are expected to alter existing soils in such a way as to buffer the deleterious impacts on soil structure and soil quality in view of estimated irrigation loads and water quality.

The slots in the soil for the amelioration treatments are not adequately described in the Report Section 4.3 (FK 2012) because the depth of the four treatments is not defined. FK 2013 states that the slot depths are 0, 600, 950 and 1200mm.

4.3 Soil Amelioration

Deep slotting was designed for the specific purpose of improving acid-sodic soils down to depths of as much as 1.3 metres. The preliminary soil testing for Tiedmans indicated that they are acidic as well as being sodic, and therefore candidates for this type of treatment.

Deep slotting enables the thorough physical mixing of soil ameliorants such as organic matter, lime and/or gypsum into sodic soils at depths greater than 300 mm, which makes it a suitable match with deep rooted crops. A typical deep slotting example is provided in Figure 2 and is based on the average soil profile derived from the core sampling done within the trial plot area.

Figure 2 from FK 2012 is copied below and indicates that the slots are 200mm wide and spaced at 1000mm intervals across the surface but FK 2013 says the slots are 1500mm apart. Therefore, 12% of the soil is dug up and the ameliorant mixture is buried. This would not result in a "thorough mixing of soil ameliorants' as stated in the paragraph copied above. There will however be subsoil brought to the surface and this is not a good practice on Brown Sodosol soils.

The treatment or composition of the two top layers (135mm and 100mm) in Figure 2 cannot be understood due to lack of information. Section 8 of FK 2012 (reproduced below) provides some more information on this and suggests that the soil removed from the slots and the top 235mm are mixed with the ameliorants; then some of this mixture is put back into the slots and the remainder is spread across the surface at depths varied according to the depth of slots. The soil profile that results from this amount of physical and chemical change will be very complex in both the vertical and horizontal direction. This means that representative sampling will be complicated and require a large number of replications to avoid the bias of the slots.

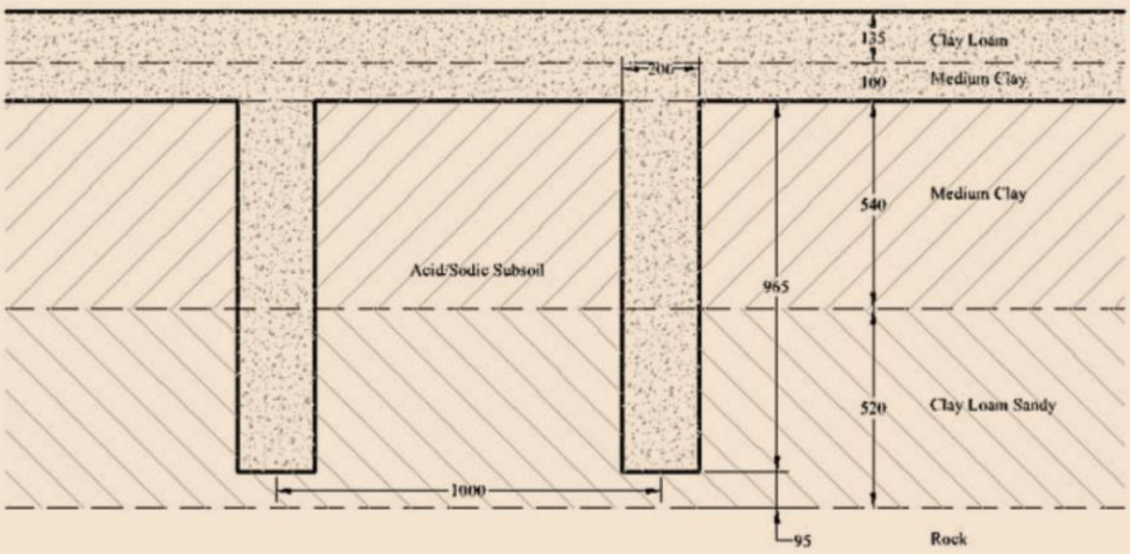


Figure 2: Sample Deep Slotting Cross Section based on Stage 1A Profile Logs

8 Soil Amelioration and Rehabilitation Plans

The existing soil in the Stage 1A area is a clay loam classified as a Brown Sodosol (FK, 2011) which will be ameliorated toward a Brown Dermosol (CSIRO Australian Soil Classification) prior to any irrigation activity. Each of the slotted profiles will have the ameliorated soil inserted and will also be incorporated across the top 24 cm of the entire area. Figure 8 and Figure 9 show

To suggest that the applied treatment process will ameliorate an existing Brown Sodosol toward a Brown Dermosol prior to any irrigation activity is a nonsense idea.

- Firstly, only about 12% of the soil volume is treated so most of the soil profile has not been altered;
- Secondly, the ameliorates will not significantly change the soil properties in the (maximum) period of 6 months between their incorporation into the soil and the first irrigation; and
- Thirdly, the CSIRO soil classification terminology and practice is not designed for such artificial situations.

The amelioration treatments will have very different affects across each of the plots in both time and space due to the ;

- incorporation process and its inherent variability,
- small amount of soil actually 'treated', vertical change will be a lot quicker than any horizontal change,
- variability in the original soil properties, and the
- time taken for the complex chemical and physical processes to operate at varying moisture contents introduced by the various slot depths and the subsequent irrigations with water and consequential introduction of other chemicals.

All of the variability factors discussed above mean that the measurement of change in a 2 year trial will be problematic and sampling would need to be far more comprehensive than is occurring in this 'trail'.

These factors are further complicated by the fact that extra amounts of lime (1.75 to 3.5 t/ha) were added to various plots prior to irrigation based on an inadequate set of Baseline 2 soil acidity results (FK 2013 section 4.5). The samples were taken to 100mm depth and there is no explanation for this depth despite incorporation of ameliorants to 235mm. There is no discussion as to why the plots varied or why the various amounts of lime were added. This is inadequate reporting.

Soil Sampling

The following diagram (Fig 4) is from FK 2012 and shows the location and number of sampling sites.

These sites in Figure 4 were selected in order to:

- enable comparisons with the baseline soil sampling locations (CS1 – CS16);
- cover the general contour (differences in elevation) and expected drainage within the irrigation area;
- maintain the high sampling density of 1 sample/0.77 hectares; and
- have one sample point in each trial plot.

The first dot point is not a reasonable assumption because the variability across the site is so large (FK Annex 1 copied above). A statistical comparison is not possible with such a small sample size.

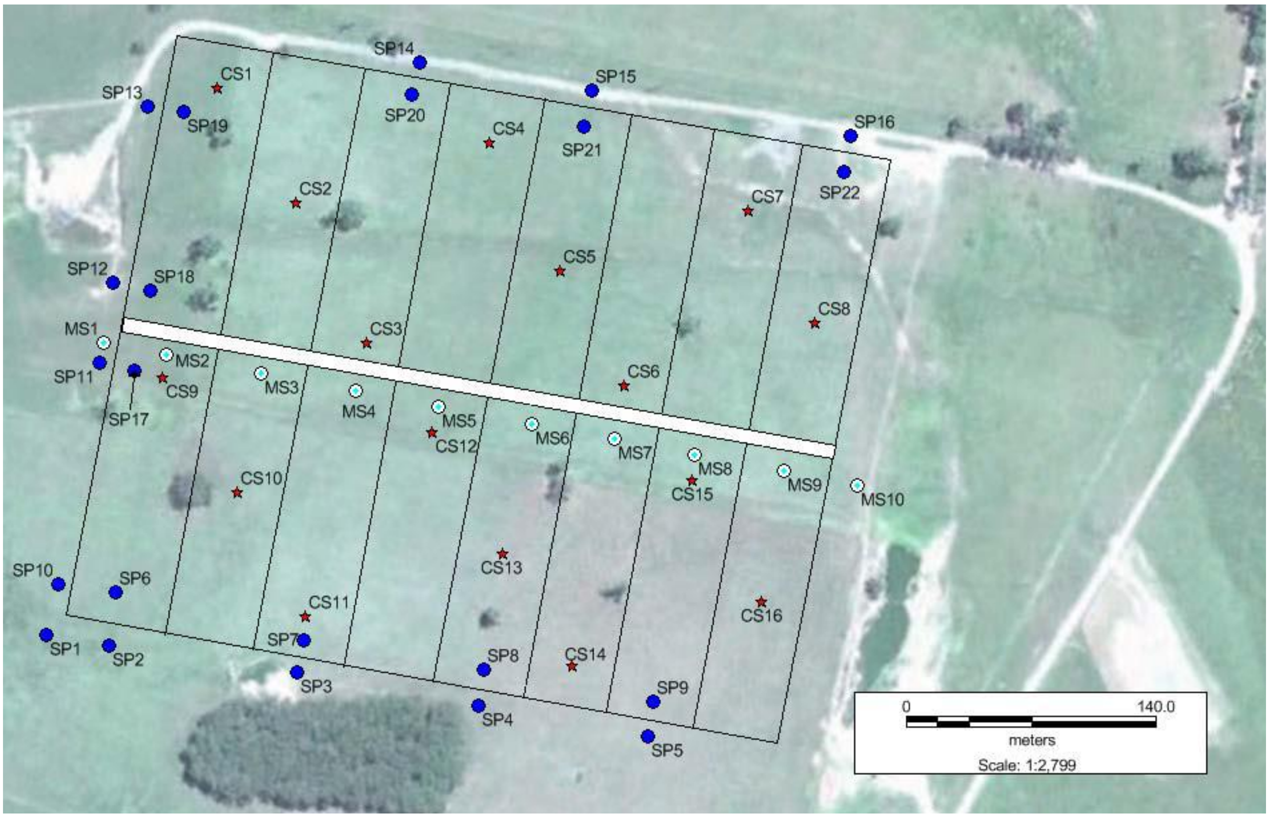
The second point is not acceptable because the soil surface has been substantially changed due to the trenching process and incorporation of large amounts of 'ameliorants'. FK2013 Appendix 1 (reproduce here on the next page) indicates that there is a height difference of >10m across the site and can vary by 3-5m in any plot with different slope gradients within various plots.

The third point is incorrect because 1 sample per 0.77ha is not a high density of sampling for such analysis due to the very variable nature of the soil and its characteristics. This variability is demonstrated by the data presented (pages 3 - 4 above) from Annex 1 of FK 2012 that shows the minimum to maximum variations are three fold for many characteristics. There should be at least 7 and preferably 9 sample sites for each plot in order to adequately account for within treatment variation. The location of sample points in relation to the amelioration slots is critical to data interpretation but this is not discussed in FK 2012.

Point four is not true. There is not a sample point for soil moisture or groundwater in each plot. Given the large surface gradient differences, and therefore runoff differences within the plots, there should be at least 7 and preferably 9 sample sites for each plot. The moisture difference at various horizontal distances from the slots will be very large and there will also be interactions between depth of slots and distance.

As presented in Figure 4, the soil sampling sites (CS) are somewhat on the contour lines (mapped in Sheet 01A of Annex 1 FK 2013) but this means they bear no relationship to the soil moisture sampling points (MS) and therefore no possible cause and effect relationships can be analysed between soil moisture and any other soil property. Similarly, there is no analysis possible of any relationship between soil moisture (MS) and groundwater (SP) because of the large spatial differences between sampling sites.

In summary, the soil sampling regime is entirely unacceptable for this type of trial due to the very large inherent soil variability and the non-uniformity of amelioration changes over time and space.

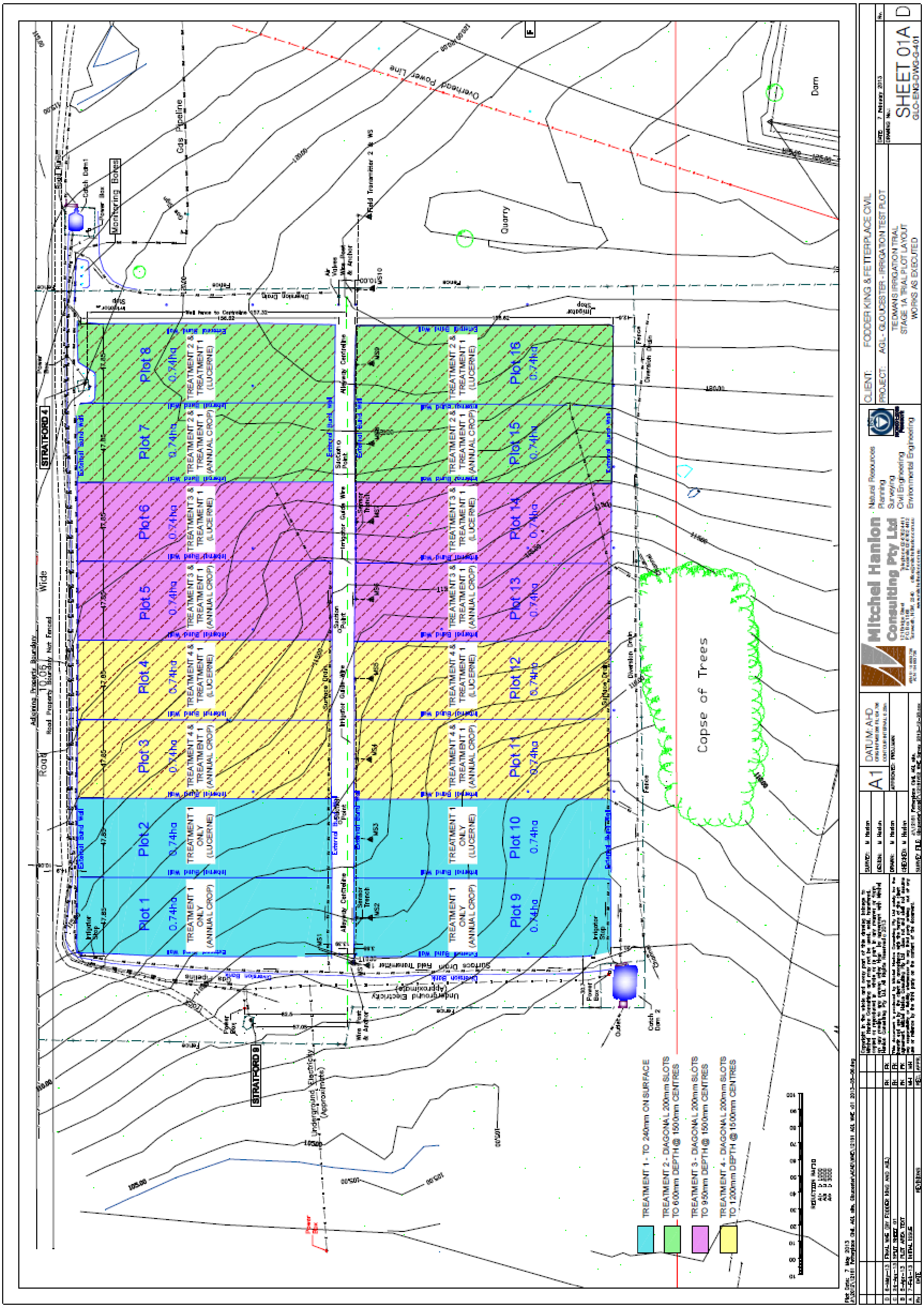


FK Report 2012 Figure 4: Stage 1A Trial Irrigation Area showing location of soil sampling site (CS), shallow *groundwater samplers (SP, piezometers) and soil moisture sensors (MS)*

Section 8 of FK 2012 concludes with the following statement that is very difficult to comprehend.

> By altering the soil characteristics and physical attributes the soil becomes more receptive to irrigation and as such the soil will be 'pre-habilitated'. Consequently, any subsequent measures that may be required to rehabilitate the soils resulting from the blended water quality profile are expected to be minimal.

The only interpretation of this can be that the soil is being used as a massive ‘sink’ for up to 10T salt/ha/yr.


Plot 1
Plot 2
Plot 3
Plot 4
Plot 5
Plot 6
Plot 7
Plot 8
Plot 9
Plot 10
Plot 11
Plot 12
Plot 13
Plot 14
Plot 15
Plot 16
0.74ha
Copse of Trees
Quarry
Dam
Overhead Power Line
Gas Pipeline
Monitoring Bores
STRATFORD 4
STRATFORD 8
Underground Electricity (Approximate)
TREATMENT 1 - TO 240mm ON SURFACE
TREATMENT 2 - DIAGONAL 200mm SLOTS TO 600mm DEPTH @ 1500mm CENTRES
TREATMENT 3 - DIAGONAL 200mm SLOTS TO 950mm DEPTH @ 1500mm CENTRES
TREATMENT 4 - DIAGONAL 200mm SLOTS TO 1200mm DEPTH @ 1500mm CENTRES
Mitchel Hanlon Consulting Pty Ltd
CLIENT: FODDER KING & FETTERPLACE CIVIL
PROJECT: AGL - GLOUCESTER - IRRIGATION TEST PLOT
TEDMANS IRRIGATION TRIAL
STAGE 1A TRIAL PLOT LAYOUT
WORKS AS EXECUTED
SHEET 01A
GLO-ENG-DWG-G-401

Collection of runoff

Section 5.1 of FK 20011 discussed how the required volume of the Catch Dams was determined but the calculations completely misuse the Rational Method because of how the rainfall intensity was calculated for the plots. A correct interpretation and calculation of rainfall intensity for the Rational Method formula involves the determination of a 'time of concentration' as discussed in the following extract from http://www.nrm.qld.gov.au/land/management/pdf/c6scdm.pdf .

> **6.3 Rainfall intensity**
>
> The average rainfall intensity for a design storm of duration equal to the calculated 'time of concentration' (tc) of a catchment is estimated using IFD (intensity, frequency, duration) information for the catchment.
>
> The catchment 'time of concentration' is the time estimated for water to flow from the most hydraulically remote point of the catchment to the outlet. The Rational Method assumes that the highest peak rate of runoff from the catchment will be caused by a storm of duration just long enough for runoff from all parts of the catchment to contribute simultaneously to the design point.
>
> The 'time of concentration' is calculated by summing the travel times of flow in the different hydraulic components. Those components may include overland flow, stream flow and/or flow in structures. Several flow paths may need to be assessed to determine the longest estimated travel time, which is then used to determine rainfall intensity.

The calculation in Section 5.1 uses a rainfall intensity of 11.7mm/hr which from the Report Table 4 page 10 is the average rainfall intensity for a storm lasting 24hour with a 1:100 year return period. That is, the FK 2012 report is suggesting that the time of concentration for the plots is 24hours and this is not correct.

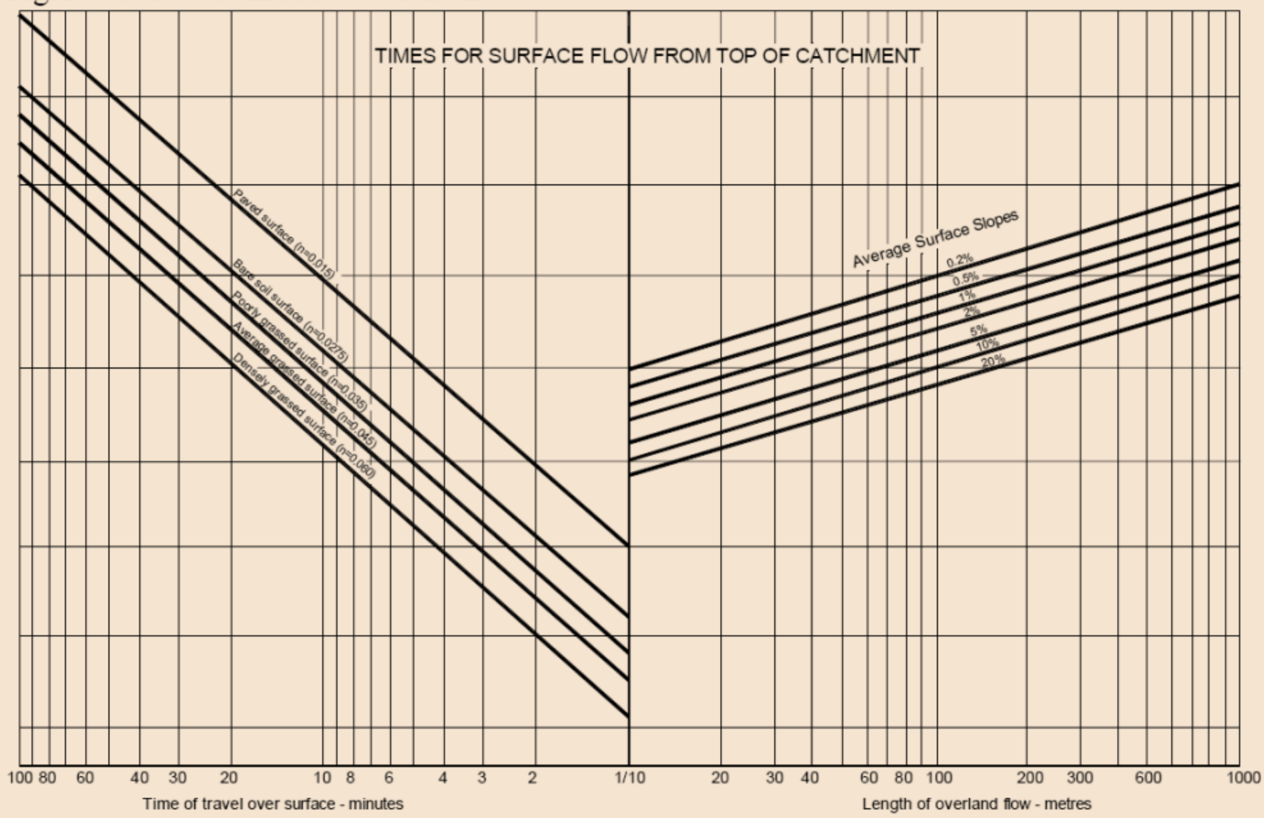
The above quoted nrm.qld.gov.au reference also provides a table (labelled Table 6.3) for calculating the time of concentration of plots and it is copied below.

Measurements for the plots at the Stage 1A site are 47m by 156m (FK 2013) so it can be estimated that the maximum length of overland flow will be about 160m. The land slope is approximately 2% and the surface is a moderately covered pasture. Therefore, the time of concentration for each plot would be about 22 minutes. The runoff is then channelled to the catch dam over a maximum distance of about 400m with a time of concentration of about 10minutes because at this stage it is channelised flow and has a greater velocity (say 0.7 m/s). This gives a total time of concentration of about 32 minutes for the trial area.

From the data in FK 2012 Table 4 the 32 minute rainfall intensity would be 100mm/hr for a 1:100 year rainfall event. That is, a depth of 100/2 or approximately 50mm total rain in the 32 minutes that the furthest runoff took to reach the catch dam. With a runoff coefficient of 0.2 used in the FK 2012 report this means that total runoff for the 12.32 ha will be 123,200m^2 x 0.2(coefficient) x 0.05m (rainfall) = 1232m^3 of water. This is 4 times the 310m^3 volume of runoff which the FK 2012 report calculates. The catch dams will overflow in a 1:100 year rainfall event and discharge polluted water into the surrounding land and watercourse

The pump on the catch dams has a capacity of 26L/s = 26/1,000 x 60 x 60 m^3/hr = 93.6 m^3 so it will take 3 hours to empty the dams and in the meantime 900m^3 of polluted water will have escaped.

Figure 6.3 Travel time for overland flow



Formula $t = \frac{107\, n\, \sqrt[3]{L}}{5\sqrt{s}}$

where
- t = time of travel over surface in minutes
- n = Horton's values for the surface
- L = Lenght of flow in metres
- s = slope of surface in %

Example

Length of overland flow 200m
Average slope of surface 5%
Densely grassed surface (n= 0.060)
Time of travel = 27.2 minutes

The whole calculation of volumes for the catch dams is flawed due to an incorrect use of the Rational Method. The FK 2012 report on page 11 contains the following paragraph that is meaningless.

> The pump rate is not designed to empty the catch dams at a rate equal to the runoff rate from a large storm event. It is designed to capture the "first flush" from the irrigation area based on a 1 in 1 year event (24.9 mm in 1 hour, refer Table 4). This is important because any excess overflow during large storm events (such as 11.7 mm/hr over 24 hours) will have similar characteristics to overland flow from natural surrounding areas. This will be monitored by the salinity loggers in the catch dams.

The concept that the "first flush" will be the only runoff that contains salt is also flawed. During a 1:100 year rain event, salt will be mobilised throughout the 32 minute rainfall period and all 1232m^3 of runoff water will be polluted. Therefore, all 900m^3 of water escaping from the 'trial' area will be polluted.

If the trial is about disposing of saline and polluted water in an environmentally safe and sustainable process then any runoff containing contaminants needs to be contained before it reaches the land or water bodies. The concept that "excess overflow during large storm events … will have similar characteristics to overland flow from natural surrounding areas" is false as the natural areas will not have been sprayed with polluted water via irrigation. This lack of logic adds to the poor design of the project to dispose of produced water from test wells.

Results after the first 6 months

Fodder King Compliance Report 2 (FK 2013) provides information on the soil testing at the completion of irrigating with "blended water" in the period 1st April to 39th June 2013. Crop growth and plant health were also monitored but no harvesting of fodder occurred during the period.

The FK report also provides information on the treatments actually applied as follows:

> Due to the selection of a centre feed linear move irrigator as the method for applying irrigation water, each treatment and crop combinaton was split evenly on either side of the centreline of the linear irrigator, resulting in 8 plots (Plots 1-8) under the northern leg of the irrigator and 8 plots (Plots 9-16) under the southern leg of the irrigator.
>
> This accommodated the need for 2 crop types and 4 treatment depths on either side of the cart track.

This is a major design fault as the water requirements of the various crops sown (see below) will vary substantially at any time of the year. A realistic design would have enabled the amount of irrigation water to be varied between plots to allow for the variable soil and crop treatments.

> The crop types being trialled for the 18 month trial are:
> - Perennials (lucerne) – 8 plots x 4 treatment depths
> - Annuals - 8 plots x 4 treatment depths
>   - winter forage cereals, eg oats, barley, triticale
>   - followed by summer forages, eg millet, forage sorghum
>
> The winter annual chosen for the period April to October 2013 was triticale.

In this 'trial' the water requirement is calculated from the average soil moisture data across all 16 plots so there is no allowance for different soil amelioration effects, crop requirements, evaporation rates due to plant height or density, or soil surface slope and its effect on infiltration. There is no ability in this 'trial' to assess soil treatment or crop type differences or interactions between these and/or soil moisture. The use of 8 treatments and 2 replications is at best wasted and at worst it makes it impossible to sensibly interpret the data.

> During the reporting period 16% of the water received by the trial area came from blended water while 84% came from rainfall. See Table 3.1.

Table 3.1 Rainfall and irrigation for the period – Stage 1A

Units	Rainfall for the period	Irrigation for the period	Total
Mm	205.8	39.0	244.8
Megalitres	24.7	4.66	29.36
%	84	16	100

> Irrigation of blended CSG water occurred in late April - May 2013 only. The DID, cumulative DID and soil moisture indicated that during this time was the only opportunity to irrigate. Approximately 4.66 ML of blended CSG water was applied to the Stage 1A area during the period.

Therefore, there were only 2 irrigations in the reporting period (30th April 8mm and 7th May 31mm). This was because rainfall was reasonable and evapotranspiration was low during the period meaning that the

Daily Irrigation Deficit (DID) was above zero indicating that the soil could not absorb more water without saturating the root zone and/or creating runoff.

Irrigation water quality

The following information on water quality is extracted from FK 2013.

Table 3.2 summarises water quality of the blended CSG water prior to irrigation to Stages 1A and 1B

Table 3.2: Water quality of the blended CSG water prior to irrigation

Parameter	Units	Value
Electrical Conductivity (EC)	µS/m	1380
pH	no units	9.28
Chloride (Cl)	mg/L	218
Sodium (Na)	mg/L	200
Sodium Adsorption Ratio (SAR)	-	14.5
Adjusted SAR	-	4.4
Total Alkalinity	mg $CaCO_3$/L	303
Bicarbonate Alkalinity (HCO_3)	mg $CaCO_3$/L	194
Carbonate Alkalinity (CO_3^-)	mg $CaCO_3$/L	109
Calcium Carbonate Saturation Index	-	9.4
Hardness	mg $CaCO_3$/L	36
Aluminium (Al)	mg/L	0.04
Boron (B)	mg/L	0.16
Calcium (Ca)	mg/L	6
Copper (Cu)	mg/L	0.002
Fluoride (F)	mg/L	0.2
Iron (Fe)	mg/L	0.54
Magnesium (Mg)	mg/L	5
Manganese (Mn)	mg/L	0.009
Nitrate nitrogen (NO_3)	mg/L	<0.01
Total Phosphorus (P)	mg/L	0.39
Orthophosphate (PO_4^{3-})	mg/L	<0.01
Potassium (K)	mg/L	160
Sulfur (S)	mg/L	27
Zinc (Zn)	mg/L	0.012
Total Dissolved Solids (TDS)	mg/L	924
Total Organic Carbon (TOC)	mg/L	14

This list does not contain all of the heavy metals such as cadmium, chromium, boron and arsenic that are included in other AGL ground and surface water testing. It is important to test for these as they are taken up from the soil by crops such as triticale. Nor is there any testing for hydrocarbons and BTEX chemicals.

The blended water had an EC < 1500 µS/cm which was the mixing-model design objective for water quality prior to irrigation. The elevated pH (9.3) is of minor concern to site soils at these EC values as the pH can be attributed to carbonate interactions in the blended water. The blended irrigation water had elevated sodium and low calcium and magnesium and this has the potential to cause problems in association with the high alkalinity. The blended irrigation water was generally low in nutrients (nitrate and ortho-phosphate) however at a pH of 9.3 all phosphorous was in the bound form. Adjustment of the pH to around 7.5 would eliminate any alkalinity issues and release phosphorous for crop assimilation. Sodium, nutrients and Total Organic Carbon (TOC) values will be discussed further in section 3.5 with respect to mass balance results and potential impacts on site soils.

For unexplained reasons the FK 2013 report provides information on a mass balance for sodium (Na) rather than for salt which would be better related to electrical conductivity as measured. Unfortunately Table 3.3 states the mg of Na applied per kg of soil to a depth of 333mm. This is nonsense as the 333mm is a very artificial depth with no physical, practical or logical basis. There is no process in this trail of determining what soil characteristics are changing with in the slots or at various widths and depths from the slots. There is no possible basis for suggesting that the soil will be equalising across its entire mass.

3.5.1. Stage 1A

The mass of soil in Stage 1A was calculated as:

11.94 ha = 119,400 m^2 x 0.333 m (average treatment depth) x 1200 kg/m^3 (bulk density of the soil)

= 47,712,240 kg of soil in Stage 1A.

Table 3.3 provides a summary of mass balances for sodium, nitrate nitrogen, total phosphorous and total organic carbon

Table 3.3: Summary of mass balances for sodium, nitrate nitrogen, total phosphorous and total organic carbon

	Dam WQ	Irrigation	Total Applied	Site soil mass	Total Applied
	(mg/L)	(ML)	(mg)	(kg)	(mg/kg)
Sodium (Na)	200	4.66	932,000,000	47,712,240	19.5
Nitrate nitrogen (NO_3^-)	0.01	4.66	46,600	47,712,240	0.001
Total Phosphorus (P)	0.39	4.66	1,817,400	47,712,240	0.038
Total Organic Carbon (TOC)	14	4.66	65,240,000	47,712,240	1.367

This is absolutely meaningless information. The use of average treatment depth for soil mass is nonsense.

For example, 19.5 mg/kg of sodium has been applied during the period. Soil analysis over this period (discussed in Section 4) indicated that Na ranged from approximately 75 mg/kg (10cm depth) to 375 mg/kg (at 40 cm depth). Coupled with excess rainfall and saturated soils the 19.5 mg/kg applied during this period is not likely to significantly increase sodium in the soil profile.

The last sentence above is unbelievable. Firstly, the rainfall was not excess; the table below from FK 2013 indicates that rainfall was 8mm above average which is about 4%. Secondly, there should be information on the actual sodium change in the profile over depth not a statement about it being “not likely to significantly increase” or even decrease.

Table 6.1 - Key weather and irrigation information

Key information	April	May	June	Total for the period
Rainfall				
AGL weather stn	52.0mm	61.6mm	92.2mm	**205.8mm**
Bureau of Meteorology Gloucester Post Office	61.6mm	55.8mm	59.4mm	**176.8mm**
Mean monthly rainfall at Gloucester Post Office	77.3mm	68.0mm	68.4mm	**213.60mm**

The FK 2013 Report on Baseline 3 data for January to June 2013 only presents average values over the 16 plots for Stage 1A and some extracts are copied below on page 15. Pages 3-4 contain extracts of the Baseline 2 data. The Report also has some brief comments on trends in soil properties as copied below.

4.7. Key findings – Baseline 3 (irrigated soils) vs Baseline 2 (pre-irrigated soil)

The changes in average values between Baseline 3 and Baseline 2 are shown in Attachment 4. In addition, Baseline 3 is compared against Baseline 1 (parent soil) values.

Salinity (Ec)

As discussed in Report 1, the salinity 'spike' resulting from the use of compost and the mixing of layer 3 of the parent soil has subsided. Further decreases are expected to be reflected in the Baseline 4 results.

Sodium and Exchangeable Sodium Percentage (ESP)

The sodium values have decreased. As a result the exchangeable sodium percentages have also decreased and currently sit at a desirable level of less than 6% to 80cm depth. See Figure 4.1.

The comments are hard to follow as different soil depth ranges are used and in some cases different units are used. It is unacceptable to include gratuitous comments such as "further decreases are expected" without any explanation.

The implication above is that salinity (EC) has decreased over the time period. However the average EC for 1-10cm depth in Baseline 2 was 0.06 dS/m and for Baseline 3 in 2013 it was 0.32dS/m. This is a substantial increase over the period so the statement in the 2013 report is incorrect. For the minimum value data presented the increase is fourfold from 0.04 to 0.17dS/m in the surface soil. For the maximum value data presented the increase is sevenfold from 0.08dS/m in 2011 to 0.59dS/m in 2013. Therefore, according to the data in the report Annexes, there is an increase in surface soil salinity, as measured by EC, during the time when saline irrigation water was applied

In 2012 the Baseline 2 sodium value in the 0-10cm layer was 0.39meq/100g as an average of the 16 sample sites and the value in 2013 for Baseline 3 was to 0.558 meq/100g. This is an increase; not a decrease as stated in the Report section 4.7. The minimum value for sodium in Baseline 2 was 0.08 meq/100g and in Baseline 3 (2013) it had increased to 0.32 meq/100g.

The problem with all of these results is that the sample size is inadequate and the volume of saline blended irrigation water has been too small to cause any meaningful change in any direction.

Some Baseline 3 Soil Test Results from FK 2013

AVERAGE N =	Depth cm	EC (1:5) dS/m	pH CaCl2	NO3 mg/kg	Org-C %	K meq/100g	Ca meq/100g	Mg meq/100g	Na meq/100g
16	0-20	0.32	6.64	44	3.1	0.961	14.875	5.661	0.558
12	20-40	0.30	6.02	29	2.1	0.688	10.448	6.588	0.665
12	40 - 60	0.25	5.31	24	1.7	0.549	6.913	7.275	0.788
8	60 - 80	0.20	4.80	18	1.2	0.435	5.363	8.495	0.955
4	80 - 100	0.14	4.24	8	0.6	0.270	2.210	10.520	1.295
3	100 - 120	0.25	4.29	6	0.4	0.235	1.845	9.730	1.340

Maximum N =	Depth cm	EC (1:5) dS/m	pH CaCl2	NO3 mg/kg	Org-C %	K meq/100g	Ca meq/100g	Mg meq/100g	Na meq/100g
16	0-20	0.59	7.04	88	5.21	2.36	23.00	10.50	0.90
12	20-40	0.57	6.98	79	4.07	1.55	18.60	10.00	0.97
12	40 - 60	0.52	6.92	62	3.18	1.38	15.60	11.40	1.08
8	60 - 80	0.28	6.95	45	1.88	0.64	13.90	12.50	1.40
4	80 - 100	0.14	4.43	12	0.70	0.28	2.35	12.50	1.50
3	100 - 120	0.36	4.44	11	0.46	0.25	2.20	11.50	1.51

Minimum N =	Depth cm	EC (1:5) dS/m	pH CaCl2	NO3 mg/kg	Org-C %	K meq/100g	Ca meq/100g	Mg meq/100g	Na meq/100g
16	0-20	0.17	6.13	17.4	1.97	0.4	10.3	3.14	0.32
12	20-40	0.13	4.42	8.4	1.02	0.23	5.04	3.12	0.35
12	40 - 60	0.11	4.33	2.8	0.62	0.19	2.36	2.28	0.34
8	60 - 80	0.13	4.05	2.3	0.46	0.23	1.79	3.13	0.45
4	80 - 100	0.13	4.05	2.9	0.5	0.26	2.07	8.54	1.09
3	100 - 120	0.14	4.14	2	0.39	0.22	1.49	7.96	1.17

Standard Deviation N =	Depth cm	EC (1:5) dS/m	pH CaCl2	NO3 mg/kg	Org-C %	K meq/100g	Ca meq/100g	Mg meq/100g	Na meq/100g
16	0-20	0.13	0.26	21.2	0.87	0.57	3.92	1.94	0.18
12	20-40	0.13	0.86	22.2	1.05	0.35	4.41	2.41	0.19
12	40 - 60	0.12	1.02	18.0	0.81	0.34	4.26	2.79	0.25
8	60 - 80	0.05	0.98	15.4	0.51	0.14	3.93	2.74	0.28
4	80 - 100	0.01	0.27	6.5	0.14	0.01	0.20	2.80	0.29
3	100 - 120	0.16	0.21	6.3	0.05	0.02	0.50	2.50	0.24