Briefing Note

Our Reference: 23876.83876
Revision 0
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Nullamanna Feedlot Information Request Response

1. Background

DA-15/2016 seeks to increase the capacity of Nullamanna Station Feedlot to 3000 Standard Cattle Units. A Statement of Environmental Effects (SEE) was submitted to Inverell Shire Council for the proposed expansion. The SEE was referred to the Environmental Protection Agency (EPA) due to the licencing requirements of the *Protection of the Environment Operations Act 1997.*

The EPA has reviewed the Development Application (DA) and SEE and considers that the SEE has insufficient information to properly assess the environmental impacts of the proposal.

The DA and SEE were published for public review as a requirement of the application. Five letters were submitted to Inverell Shire Council which raised concerns or oppose the feedlot expansion. Responses to the NSW EPA and two cultural heritage letters are found within this briefing note.

This Briefing Note addresses the EPA's additional information requirements required for the assessment of the DA and SEE.

It is noted that, generally, the level of EPA query is not up to date with current practice, disproportionate to the size of the development and level of detail already provided, and risk presented by the development.

Paragraph no.	Statement	Comment
Attachment of Letter 1: NSW EPA – Michael Lewis		
1	The SEE does not identify the environmental values of Tumbledown Gully and Frazers Creek or the potential impact of the proposed development on the waterways. The EPA recommends that environmental values of Tumbledown Gully and Frazers Creek and the potential impact of the proposed development on the waterways are assessed.	Based on *Considering Environmental Values of Water when Issuing Prevention Notices* (NSW Department of Environment and Conservation, 2006), the following environmental values are identified for Tumbledown Gully: - Aquatic ecosystems - Livestock water supply The entire length of Tumbledown Gully is on Nullamanna Station. It flows into Frazers Creek on the western boundary of Nullamanna Station. Water from Tumbledown Gully is used for livestock water supply for grazing cattle on Nullamanna Station. Three protected aquatic species were listed in the fauna and flora assessment of the SEE (Appendix K). Tumbledown Gully was not found to provide adequate habitat for these species. Due to the lack of riparian vegetation, it is unlikely that it provides habitat for protected terrestrial species. The following environmental values have been identified for Frazers Creek: - Aquatic ecosystems - Visual amenity - Secondary contact recreation - Primary contact recreation - Livestock water supply - Irrigation water supply - Aquatic foods (to be cooked before eating) Frazers Creek flows alongside Nullamanna Station's western property boundary and receives water from Tumbledown Gully. The aquatic ecosystem of Frazers Creek is likely to harbour some protected species. Murray cod (*Maccullochella peelii*, vulnerable - commonwealth) and Booroolong frogs (*Litoria booroolongensis*, endangered – NSW and commonwealth) have been found further south near Inverell. Thus it is essential that runoff from the development is captured and maintained within the onsite wastewater system. Secondary contact recreation in Frazers Creek includes fossicking which is regularly conducted in the area, as well as fishing. It is also possible that aquatic foods (to be cooked before eating) are sourced from Frazers Creek: The water is also used for livestock and minor irrigation water supply. The potential impacts of the development area described in Section 4.1 (Waste Management) and Section 4.3 (Water Resources): Contamination of surface water may lead to toxic effects on the aquatic and riparian ecosystems downstream, as well as the people that use this water. This means that water quality should be maintained at a healthy level as much as possible upstream. The main potential source of surface water contamination from the feedlot is likely to be from offsite runoff during high rainfall events in the wet season. The construction phase will present the greatest risk for runoff, as

Paragraph no.	Statement	Comment
		this will remove vegetative cover and expose soil to the elements. This is controlled during construction by the Erosion and Sediment Control Plan (Appendix F of the Statement of Environmental Effects). During operation of the feedlot the pens and compost manure pad will form part of the controlled drainage area, which is sloped to the drains that lead to the wastewater ponds. The drains and sedimentation basins have been designed to cope with an average recurrence interval (ARI) of 20 years and the holding pond with a 1 in 20 year 24 hour storm. Contaminated Agricultural Runoff (CAR) dams will also be constructed below the silage pits and south of the feedlot road, where existing runoff was noted by the EPA on the site inspection. West of the new wastewater irrigation area, another CAR dam will be constructed to ensure that Tumbledown Gully is not subject to runoff from the irrigation areas.
2	The sustainability of the proposed effluent and manure solids reuse is not demonstrated. It is recommended that the proponent demonstrates the sustainability of the proposed effluent and manure solids reuse. Approaches should align with the recommendations of Development of indicators of Sustainability for Effluent Reuse in the intensive Livestock industries: Piggeries and Cattle Feedlots (McGahan and Tucker, 2003).	The *Development of indicators of Sustainability for Effluent Reuse in the intensive Livestock industries: Piggeries and Cattle Feedlots* (McGahan and Tucker, 2003) has been archived and superseded by the *Piggery Manure and Effluent Management and Reuse Guidelines* (2015) (Personal communication, Australian Pork, 2016). The National Guidelines for Beef Cattle Feedlots in Australia (MLA, 2012) is the current guideline for cattle feedlots, which has taken into account more recent research. Appendix E (Effluent and Manure Utilisation) of this guideline states: *"To avoid adverse environmental impacts, application rates should not exceed the rates at which constituents of the effluent and manure (water, nutrients – especially N and P – and salts_ are:* - *taken up by plants and removed from the site by harvesting* - *safely stored within the soil profile* - *released into the surrounding environmental in an acceptable form."* Appendix G (Soils Survey and Land Capability Assessment) of the SEE provides a nutrient balance that takes into account the expected effluent composition, soil type and suitability (leaching, phosphorus sorption, etc.), rainfall, and the irrigation methods (Section 3 3 -Land Capability and Crop Use). It is very conservative. This nutrient balance has very clear statements that do clearly enunciate the sustainability of the effluent reuse area. The effluent reuse area sustainability assessment shows that N, P and Na can be managed within the soil matrix and its crop uptake; and potassium may slowly increase, without subsequent management of gypsum or lime. Per the environmental assessment *Thus nutrient demand is expected to exceed the nutrient application from wastewaters and as such the irrigable area will require supplementing with composted manure or inorganic fertilisers. Degradation of land and the soils within the irrigable areas is not expected.* The NSW EPA's note is refuted accordingly. Manure solids will be spread on the same area as the treated wastewater on as an as needs basis (only); that is subject to soil testing and the soil condition and fertility requirements. Manure is a valuable soil ameliorant

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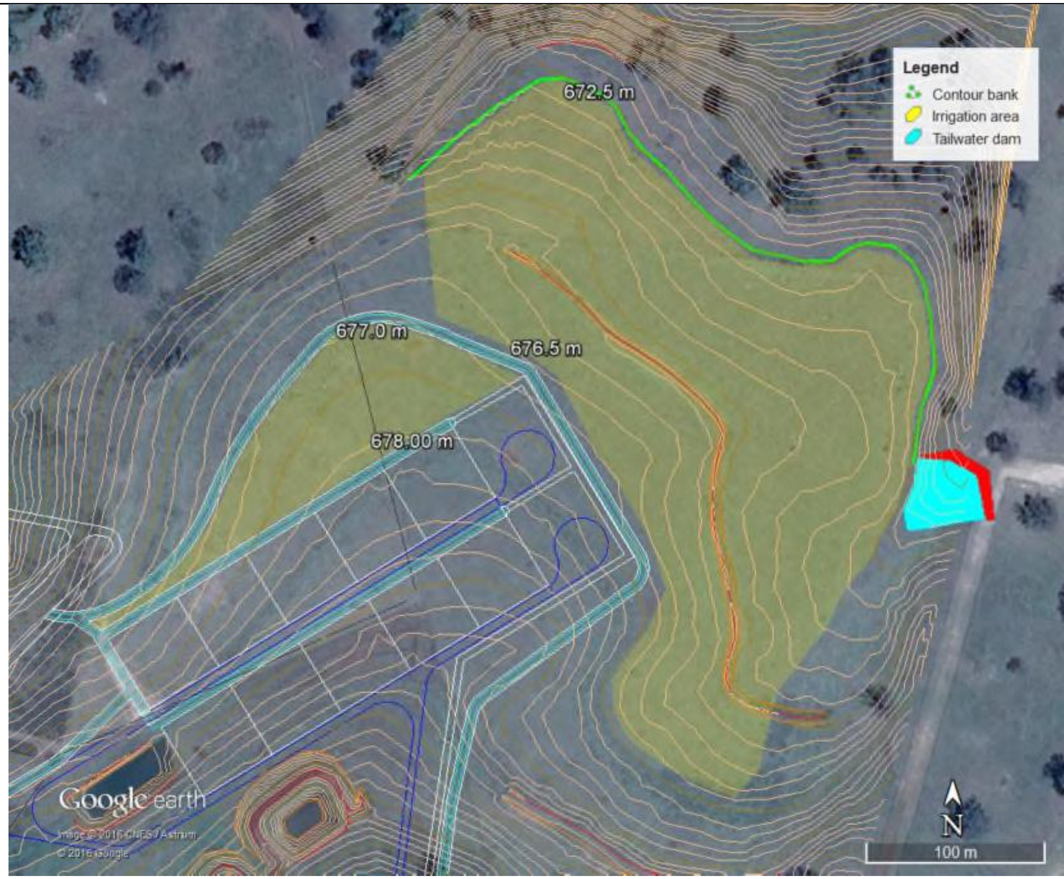
		and fertiliser. It is important that it is available to irrigable area to maintain soil health. Past practice on not allowing manure to be applied to waste water irrigation area is now understood to be out of date and to deliver poor agronomic and environmental outcomes (e.g. increased likelihood of soil degradation). Nullamanna Station has an additional 400 ha of crop lands for the application and use of manure, if the nutrient load of the irrigation areas becomes too high. Effluent and manure application areas will be cropped for hay, silage or forage to remove nutrients. Effluent reuse areas will be monitored annually, per the attached Environment Monitoring Plan (Attachment 4). The level of EPA query is not up to date with current practice, disproportionate to the size of the development and level of detail already provided, and risk presented by the development.
3	Specific information needed to demonstrate sustainability of effluent and manure solids reuse is detailed below. Suitability of effluent for irrigation The Australian and New Zealand Guidelines for Fresh and Marine Water Quality Volume 3: Primary industries - Rationale and Background Information (ANZECC, 2000) recommends that "In assessing the suitability of waters for irrigation use, water quality characteristics that affect agricultural production, catchment condition, and downstream water quality need to be evaluated." The expected quality of effluent from the proposed development has not been adequately characterised.	The Soils Survey and Land Capability Assessment (Attachment 5) provides the average quality of cattle feedlot effluent stored in retention ponds in Table 7. This was determined from a range of cattle feedlots tested and referenced in the Reference Manual for the Establishment of Beef Cattle Feedlots in Queensland (Skerman 2000). It provides conservative data for appropriate assessment of the development. (The existing waste waters would not be representative of expected waste water quality given changes in design and irrigation practice.)
4	The EPA notes that the SEE states that the expected electrical conductivity of the effluent will be 13.6 dS/cm*. ANZECC (2000) classes water with EC >8 dS/cm* as extremely saline and states that it is generally too saline to be used to irrigate crops.	It is noted that the values should be 13.6 dS/m and 8dS/m The ANZECC guidelines state: "*A preliminary water salinity rating can be assigned to irrigation waters based on EC (table 9.2.5). These ratings provide only a general guide and are not intended to be used on their own to define the suitability of irrigation water. As emphasised throughout this 9.2.3.2 Factors affecting irrigation salinity, other factors such as soil characteristics, climate, plant species and irrigation management must be considered.*" These factors have been discussed in Appendix G (Soils Survey and Land Capability Assessment). In this documentation it states: *"Given crop factors for improved pasture, the expected irrigation demand is in the order of 4-8ML/ha/ year.* *The 5.8 ML/yr of available treated wastewater when applied across 6.6 ha with an efficiency of 90 % will supply only 0.87 ML of water per ha per year. This is not sufficient to meet the irrigation demand for a fully irrigated improved pasture."* Since only 0.87ML/ha/yr (87mm/yr) will be wastewater, and a total of 4 – 8ML/ha/yr water is required to meet crop water demands, effluent concentration will be diluted to at least a quarter of its original strength prior to application. Thus the electrical conductivity of the treated wastewater effluent is likely to be applied to the crops at 1.5 – 3 dS/m, which requires only moderately tolerant to tolerant crops per the ANZECC guidelines.

Paragraph no.	Statement	Comment
5	The EPA recommends that the proponent either justify the use of industry data or sample effluent from the existing operation to provide an indicative characterisation of the expected effluent quality. The characterisation should inform the nutrient and salt balance assessments and calculation of the organic loading rate.	The industry data is drawn from and related to "Designing Better Feedlots" (Watts & Tucker 1994). It is referable data. See notes above. Effluent sampling for the existing facility will not provide accurate data as the facilities have not previous irrigated waste waters and simply used the holding ponds for evaporation. This may have concentrated some nutrient. Further it is expected that the large extraneous area directed to the holding pond will now significantly dilute the nutrient concentrations. The small amounts of existing wastewater will be managed within the new system and not expected to create any perturbation.
6	**Suitability of the proposed effluent reuse area** The EPA recommends that an assessment of the suitability of the proposed effluent reuse area and that the proponent provides a characterisation of soils in the proposed effluent reuse area is carried out to demonstrate their suitability, inform management of any potential limitations, and provide a monitoring baseline.	Additional soil tests have been undertaken in the effluent irrigation area. The Soil and Land Capability Assessment has been updated to include these results and can be found in Attachment 5. The soils are, generally, moderate clays with significant nutrient holding capacity. They are currently nutrient deficient. They present no chemical or structural risk to the project and will benefit greatly from effluent application and manure / compost applications as may be required.
7	It is recommended that the slope of the irrigation area is determined and the risk of excess runoff and erosion assessed. Consideration should be given to whether a terminal system is needed to collect and recycle irrigated effluent tail water and to manage contaminated stormwater runoff from the effluent irrigation area.	The irrigation area surrounded by the feedlot wastewater system runs roughly from the 678m to 677m contour (See Figure 1 below) and has a slope of 1-2%. Water from this irrigation area would run into the drain leading to the wastewater ponds directly downslope. This it is already contained; within the CDA. The irrigation area to the north of the feedlot area runs from the 676.5m contour to the 672.5m contour. This results in a 3%-4% slope. This is quite suitable with appropriate land management. A contour bank will be built along the 672.5m contour (approximate) to ensure that irrigation water does not run into the water supply. A lower contour bank has been added. It will be used to direct water to a terminal dam located in the gully below the entire feedlot complex. Water can be recycled to the irrigable area from this dam if required.

Paragraph no.	Statement	Comment
		 **Figure 1 Nullamanna Station irrigation areas**
8	**Nutrient, salt, and water balance assessments** It is recommended that a mass balance approach be used to calculate nutrient and salt loadings, in line with the recommendations of Development of indicators of Sustainability for Effluent Reuse in the intensive Livestock industries: Piggeries and Cattle Feedlots (McGahan and Tucker, 2003). If an alternative approach is used, the proponent should provide justification for this approach. The reuse area may need to be expanded and/or additional monitoring may be	BeefBal offers a mass balance method. The MEDLI model (McGahan and Tucker, 2003) uses the DAMP methods used in BeefBal; it is not calibrated in any fashion. At best it is a decision support tool. MEDLI has been found to deliver outcomes that diverge from actual outcomes “in the field”. Thus it is not considered to be an accurate predictor of nutrient budgets. Simple mass balance calculations using known quantities and nutrient concentrations of wastes applied to land, adsorbtion and then uptake provides more direct and far more useful means of identifying site and operational constraints. This is provided in Table 9 of the Soils Survey and Land Capability Assessment (Attachment 5).

<table>
<tr><th>Paragraph no.</th><th>Statement</th><th>Comment</th></tr>
<tr><td></td><td>necessary to manage the risk arising from uncertainty in the loading estimates.</td><td>The NSW EPA is directed to this table.

The FSIM model (Lott, 1998) used in the Hydrology Assessment (updated version found as Attachment 6) is the same model that was used to develop the National Guidelines for Beef Cattle Feedlots in Australia (MLA 2012). It is calibrated and verified and can be relied upon more than the MEDLI model.</td></tr>
<tr><td>9</td><td>It is recommended that the nutrient and salt balance assessments account for all nutrients and salts generated or applied on the premises and identify the fate of these. In particular, the sustainability of any proposed reuse of manure solids should be demonstrated. Any additional fertilisers applied should be included in nutrient balance assessments.</td><td>This is not an appropriate request. Fertiliser and ameliorants should only be added to attend to deficiencies and imbalances and thus the amounts to be applied cannot be predicted. Their use is a function of the Monitoring program and its data and assessment.</td></tr>
<tr><td>10</td><td>If composted manure solids reuse is proposed, the proponent should characterise the expected quality of the manure solids in terms of nutrients, salts, and organic content, and any other relevant characteristics in line with the recommendations of Development of indicators of Sustainability for Effluent Reuse in the intensive Livestock industries: Piggeries and Cattle Feedlots (McGahan and Tucker, 2003).</td><td>The Development of indicators of Sustainability for Effluent Reuse in the intensive Livestock industries: Piggeries and Cattle Feedlots (McGahan and Tucker, 2003) has been archived and superseded by the Piggery Manure and Effluent Management and Reuse Guidelines (2015) (Personal communication, Australian Pork, 2016).

The National Guidelines for Beef Cattle Feedlots in Australia (MLA, 2012) is the current guideline for cattle feedlots, which has taken into account more recent research.

A sample of manure from Nullamanna Station has been analysed, as shown in Table 1

Table 1 Manure composition collected from Nullamanna Station
<table>
<tr><th>Parameter</th><th>Unit</th><th>Manure composition</th></tr>
<tr><td>Moisture</td><td>%</td><td>7.2</td></tr>
<tr><td>pH - Water</td><td>pH units</td><td>7.94</td></tr>
<tr><td>Electrical Conductivity</td><td>dS/m</td><td>1.92</td></tr>
<tr><td>Nitrogen (Dry weight basis)</td><td>%</td><td>1.3</td></tr>
<tr><td>Calcium</td><td>%</td><td>2.3</td></tr>
<tr><td>Magnesium</td><td>%</td><td>0.88</td></tr>
<tr><td>Phosphorus</td><td>%</td><td>0.46</td></tr>
<tr><td>Potassium</td><td>%</td><td>1.3</td></tr>
<tr><td>Sulphur</td><td>%</td><td>0.43</td></tr>
<tr><td>Nitrate Nitrogen (Dry matter basis)</td><td>mg/kg</td><td><45</td></tr>
<tr><td>Chloride</td><td>%</td><td>0.435</td></tr>
</table>
</td></tr>
</table>

Paragraph no.	Statement	Comment
		Organic Carbon | % | 25.5 These values are less than those of the amounts cited. Thus all assessments are inherently conservative and over predictive.
11	It is recommended that a detailed description of the water balance modelling should be provided. This should identify and justify the model inputs and assumptions and provide model outputs. This information should include, but need not be limited to: - rainfall and evaporation depths and volumes; - runoff collected in the holding pond; - frequencies and volumes of any managed overflows and effluent reuse - volumes of evapotranspiration, runoff, and percolation from the reuse area.	A more detailed description of the water balance model and its parameters are provided in Attachment 6: Updated Hydrology Assessment.
12	It is recommended that the proponent reviews and amends the estimates of manure generation.	The dry scraped manure component generated per year will be approximately 4,320t/yr (6,170m^3). This is based on the QLD DAF manure removal rates of 1.44t/yr for one 600kg beast (1 SCU) (https://www.daf.qld.gov.au/environment/intensive-livestock/cattle-feedlots/managing-environmental-impacts/manure-production-data). Table 3 of Appendix I: Solid and Liquid Waste Management Plan (23876.82016) submitted as part of the SEE states that (up to) <15,000m^3 of manure/feedstock/sludge will be generated per year. These solids include compost derived from spill and spend feed and feedmill sold wastes (husks, unsuitable hay etc). It has been assumed that from time to time accumulated composted materials are applied on bulk for past and current periods. The approach is inherently conservative as an approach.
13	**Salt leaching** It is recommended that the proponent clarifies whether salts will be leached by rainfall and/or clean irrigation water, rather than by irrigated effluent, so as to prevent leaching of nutrients.	Effluent irrigation will not cause leaching due to the small volume of effluent added to the irrigation area (87mm/yr). Leaching will be driven by rainfall during peak rainfall events. More detail can be found in Attachment 5: Soils and Land Capability Assessment.
14	It is recommended that the proponent assesses the potential risk to surface waters posed by leached salts from the proposed reuse area.	A contour bank will be built to the north of the irrigation area to protect Tumbledown Gully. This contour bank will lead to a tailwater dam, as shown in Figure 1. Potential leaching is to the vadose zone which is substantial. There is no immediate nor apparent connection between the vadose zone and surface waters in the area. There is thus no apparent risk.
15	**Design standards** It is recommended that the proponent clarifies whether all components of the controlled drainage system will be designed and operated in accordance with the National Guidelines for Beef Cattle Feedlots in Australia 3rd Edition (MLA 2012).	As stated in Section 1.4 of Attachment 6: Hydrological Assessment, all components of the controlled drainage system will be designed and operated in accordance with the National Guidelines for Beef Cattle Feedlots in Australia 3rd Edition (MLA 2012).

Paragraph no.	Statement	Comment
16	**Monitoring** It is recommended that the proponent provides an operational monitoring plan. This should include details of and justification for the proposed monitoring program for soil characteristics, composted manure quality and quantity, effluent quality and quantity, surface water quality, and groundwater quality and, where relevant, should align with the recommendations of (McGahan and Tucker, 2003) and (DEC, 2004). Where there is disagreement between these documents, McGahan and Tucker (2003) should take precedence. The monitoring plan should provide details of the locations of all monitoring sites and the parameters that will be monitored. Consideration should be given to inclusion of upstream and downstream monitoring sites on Tumbledown Gully to improve the capacity to detect any impacts. Monitoring requirements can be reduced once the sustainability of the operation has been demonstrated.	An Environmental Monitoring Plan has been developed – refer to Attachment 4.
17	It is recommended that concentrations of nitrogen and phosphorus compounds be calculated based on their nitrogen and phosphorus content respectively (e.g. NOx-N, NH4-N, FRP-P).	
Letter 2: Anaiwan Local Aboriginal Land Council – Gregory Livermore		
1	I have some concerns and objections regarding the above mentioned development application currently before Council.	
2	These concerns regard the manner or lack of proper consultation with the local Aboriginal community including Anaiwan Local Aboriginal Land Council as well as the process of Due Diligence in respect of known Aboriginal sites in the area.	Refer to Attachment 3: Cultural Heritage Addendum.
3	After accessing the Statement of Environment Effects on Councils website and in particular page 23, Section 2.10 of this document entitled Archaeological and Heritage Matters" I read with interest that the author states; "A search of the Aboriginal Heritage Information System (AHIMS) found no aboriginal heritage sites on Lots 2, 10, 16, 17 and 18 DP 750112 (the areas involved in the expansion)"	
4	Experience has taught me that even if no Aboriginal Heritage Sites exist on the AHIMS Register good practise should always dictate that you undertake a wider AHIMS search of the area as well as undertake a survey on foot of the proposed area to be developed.	

Paragraph no.	Statement	Comment
5	On other developments proposals we have found on some areas where no Aboriginal Heritage Sites are registered on AHIMS that sites and objects do exist and would have been destroyed if no field surveys were carried out.	
6	Field Surveys or Aboriginal Cultural Heritage Assessments based on Landscape Modelling are not mentioned and local knowledge and other Aboriginal Cultural Heritage Survey Reports indicate that there are a number of sites in close proximity to the Nullamanna Feedlot Expansion area.	
7	Disappointingly no consultation with the local Aboriginal community is mentioned or offered but I read with interest that Landholders surrounding the proposed Nullamanna Feedlot Expansion were consulted and it seems that Aboriginal Cultural Heritage is of no value in this development.	
8	To remedy the lack of proper consultation with key local Aboriginal Stakeholders and so that the Proponents are reminded of their responsibilities and are seen to be conforming with the Due Diligence Code of Practice for the Protection of Aboriginal Objects in New South Wales to the satisfaction of the local Aboriginal community. I am offering the following recommendation; That a on ground Cultural Heritage Assessment of the proposed Nullamanna Feedlot Expansion area being Lots 2, 10, 16, 17 and 18 DP 750112 be conducted in consultation with and the involvement of the Anaiwan Local Aboriginal Land Council.	
	Letter 3	
1	Following consultation with members of the local Aboriginal community I am writing to you in regards to the above DA.	
2	While not objecting to the expansion, construction and / or operation of the feedlot per se, I am concerned with what I believe are some shortcomings within the Statement of Environmental Effects relating to the feedlot DA.	
3	1. On page 23 of the Statement of Environment Effects, Section 2.10 “Archaeological and Heritage Matters” the authors state: A search of the Aboriginal Heritage Information System (AHIMS) found no aboriginal (sic) heritage sites on Lots 2, 10, 16, 17 and 18 DP750112 (the areas involved in the expansion)”	Refer to Attachment 3: Cultural Heritage Addendum.

Paragraph no.	Statement	Comment
	I believe restricting an AHIMS search to such a very specific area (Lot and DP number) is neither within the spirit of Aboriginal Cultural Heritage investigation or legislative requirements. In support of my concerns I would point out that Requirement lb of the "General requirements applying to all archaeological investigations of the Code of Practice for Archaeological Investigation of Aboriginal Objects in NSW" (p.7) states: AHIMS searches must: • include an area larger than, and wholly containing, the subject area • include an area large enough to allow adequate landscape interpretation, and - if available - sites in large enough numbers to allow adequate understanding of the distribution of the sites within the landscape. On 17th Feb. 2016 I conducted an AHIMS search of an area 5kms x 5kms centred on the feedlot study area. This area was seen as "large enough to allow adequate landscape interpretation" and (identifying) sites in large enough numbers to allow adequate understanding of the distribution of the sites within the landscape. This search, of a compliant larger area, returned 3 Aboriginal sites within that area.	
4	2. Additionally an AHIMS search which the Statement of Environmental Effects is required to undertake is to: • include a search for any previous reports relevant to the subject area. Consulting the AHIMS "Previous Report" function, using the key word Nullamanna returns "An Investigation for Aboriginal Sites and Relics of a Proposed Optic Fibre Cable Route from Inverell to Nullamanna" undertaken by Terry Griffiths for Telstra Australia June, 1995. Report no. C-3456. No reference is made in the Statement of Environmental Effects to this extremely relevant localised report.	
5	3. The process of reviewing previous archaeological work is also seen as a component of the "General requirements applying to all archaeological investigations of the Code of Practice for Archaeological Investigation of Aboriginal Objects in NSW" (See 2.1 p.6 Reviewing Existing Knowledge) Would it not be correct to assume that the Griffiths report of 1995 also represents "previous archaeological work"?	

Paragraph no.	Statement	Comment
6	4. It appears that section 2.10 of the Statement of Environmental Effects; Archaeological and Heritage Matters" has been completed by desk top assessment only. The "Due Diligence Code of Practice for the Protection of Aboriginal Objects in New South Wales" clearly states on pages 12-13 that a desktop assessment should be supported by visual inspection "You must undertake a visual inspection of the area to see if Aboriginal objects can be identified or are likely to be present below the surface" No mention is made of field visit or landscape assessment in regards to Aboriginal Cultural Heritage.	
7	5. While Item 5 of the Due Diligence Code of Practice says "Consultation with the Aboriginal community is not a formal requirement (p.3), this is tempered by, Item 2b of the Due Diligence process that refers to". Are there any other sources of information of which a person is already aware?" Would not consultation with the local Aboriginal community be both a potential source of information and courteous? It appears that Table 7. (p.26 of the Statement of Environmental Effects) is more of a list of people who are neighbours rather than a consultation undertaken in the spirit of gaining knowledge re Aboriginal Cultural Heritage.	
8	6. In support of "other sources of information" (as mentioned above) several items of local information relative to the Nullamanna study area known to exist but are not mentioned in the Statement of Environmental Effects. These are extremely relative to the investigation and preservation specifically of Anaiwan Aboriginal Cultural Heritage-e.g. Collected between 1966-1969 from approximately 1-2km directly opposite this study site to the west, largely on the opposite side of Frazers Creek, 14 boxes of Aboriginal Cultural Heritage artefactual material was forwarded to the Australian Museum from at least 15 different but associated sites in this locale. One collected site was on the eastern side of Frazers Creek i.e. on Nullamanna Station, the site of this development. Each box was estimated at 40 lb weight (18kgs). Stone tools collected included backed blades, burins, cores, tula, elouera, muller, scrapers and microliths. A further 2 boxes were collected in 1970 and forwarded to the University of New England (UNE) Armidale.	
9	7. The proposed development site is some 800m north west of Frazers Creek (i.e. outside the preferred distance from water to	

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	indicate the likely existence of Aboriginal objects - see Due Diligence p.12) however, it is within 200m of the ephemeral water source Tumbledown Gully. Therefore given the proximity to known sites it is highly likely surface Aboriginal artefactual material could be present. It would therefore be prudent to undertake a survey “on foot, for the purposes of discovering Aboriginal objects” (See Code of I Practice for Archaeological Investigation of Aboriginal Objects in NSW - p.13). Such a survey should be conducted in consultation with and the involvement of the Local Anaiwan Aboriginal Community. The proponents should be aware of their responsibilities should it be necessary to apply for an Aboriginal Heritage Impact Permit (AHIP) and or Care Agreement given the potential for “discovering” of Aboriginal objects.	

2. Conclusion

EnviroAg concludes that the development should not produce undue environmental effects. Waste and wastewater from the feedlot can be used sustainably on the property. These results are based on referable scientific data and backed up by a monitoring plan to ensure that any effects are noticed and can be acted upon.

Cultural heritage should not be impacted by the development, as the development area has already been disturbed. The local Land Council has visited the site and confirmed that there is significant disturbance, but recommends that construction and operational workers should be made aware that cultural heritage artefacts may be found in the area. Workers will be made aware of the requirements and steps to be followed, if cultural heritage artefacts are found during construction or operation.

Signed: Date: 03/06/2016

Ryan Francis

Senior Environmental Scientist

EnviroAg Australia Pty Limited

References

NSW Department of Environment and Conservation (2006). Considering Environmental Values of Water when Issuing Prevention Notices. Available at: http://www.epa.nsw.gov.au/resources/mao/envvalueswater06171.pdf Accessed 21/3/2016.

Hernandez, Guillermo, et al. "Odor mitigation with tree buffers: Swine production case study." *Agriculture, Ecosystems & Environment* 149 (2012): 154-163.

Lott, S.C., (1998), *Feedlot hydrology*, PhD thesis, University of Southern Queensland, Toowoomba, Qld.

Trabue, Steven, et al. "Odor mitigation with tree buffers." *Biotechniques for Air Pollution Control: Proceedings of the 3rd International Congress on Biotechniques for Air Pollution Control. Delft, The Netherlands, September 28-30, 2009*. CRC Press, 2010.

Watts, P. & Tucker, R. (Eds). (1994). *Designing Better Feedlots*. Toowoomba, QLD: QLD Department of Primary Industries.

Attachment 1: NSW EPA Letter

NSW EPA

EF15/16945 -DOC16/76752-05

Mr Paul Henry
General Manager
Inverell Shire Council
PO Box 138
INVERELL NSW 2360

Attention: Chris Faley

Dear Mr Henry

Request to Stop the 'Deemed Development Clock' for proposed 3,000 Head Beef Cattle Feedlot at Nullamanna Station 1633 Nullamanna Road, Development Application - DA-15/2016

The Environment Protection Authority (EPA) refers to the development application and statement of environmental effects (SEE) received for the proposed 3,000 Head Feedlot at Nullamanna Station on 15 February 2016 from Inverell Shire Council (Council).

DA-15/2016 seeks to increase the capacity of the feedlot to 3,000 standard cattle units and was referred to the EPA as integrated development due to the licensing requirements of the *Protection of the Environment Operations Act 1997.*

Clause 110(2) of the *Environmental Planning and Assessment regulation 2000* provides that an approvals body can request additional information and stop the 'deemed development clock' within 25 days of receiving a matter referred to it by a consent authority.

The EPA has reviewed the development application and accompanying SEE and has found that it has insufficient information for the EPA to properly assess the environmental impacts of the proposal. In summary, the main information required by the EPA identified at this point in time relates to the following:

Water

Additional information is required to adequately consider potential water pollution risks.

The information requirement for the key point outlined above is discussed further in **Attachment 1**.

In light of the above request for additional information, the EPA notes that the deemed refusal clock will be stopped from the receipt of this letter until the information is provided. The EPA also requests that Council contact the Dubbo office of the EPA once the additional information has been received so that arrangements can be made regarding forwarding the information in a timely manner.

If you have any questions, or wish to discuss this matter further please contact Michelle Gibson in the Dubbo EPA office by telephoning 02 6883 5333.

Yours sincerely

15/3/16

MICHAEL LEWIS
A/Unit Head – Regional Operations
NSW Environment Protection Authority

Contac t officer: MICHELLE GIBSON
02 6883 5333

Enclosure: Attachment A

EPA comments and additional information requirements - DA-15/2016

The SEE does not identify the environmental values of Tumbledown Gully and Frazers Creek or the potential impact of the proposed development on the waterways. The EPA recommends that environmental values of Tumbledown Gully and Frazers Creek and the potential impact of the proposed development on the waterways are assessed.

The sustainability of the proposed effluent and manure solids reuse is not demonstrated. It is recommended that the proponent demonstrates the sustainability of the proposed effluent and manure solids reuse. Approaches should align with the recommendations of *Development of Indicators of Sustainability for Effluent Reuse in the Intensive Livestock Industries: Piggeries and Cattle Feedlots (McGahan and Tucker, 2003).*

Specific information needed to demonstrate sustainability of effluent and manure solids reuse is detailed below.

<u>Suitability of effluent for irrigation</u>
The *Australian and New Zealand Guidelines for Fresh and Marine Water Quality Volume 3: Primary Industries — Rationale and Background Information (ANZECC, 2000)* recommends that "In assessing the suitability of waters for irrigation use, water quality characteristics that affect agricultural production, catchment condition, and downstream water quality need to be evaluated." The expected quality of effluent from the proposed development has not been adequately characterised.

The EPA notes that the SEE states that the expected electrical conductivity of the effluent will be 13.6 dS/cm. ANZECC (2000) classes water with EC >8 dS/cm as extremely saline and states that it is generally too saline to be used to irrigate crops.

The EPA recommends that the proponent either justify the use of industry data or sample effluent from the existing operation to provide an indicative characterisation of the expected effluent quality. The characterisation should inform the nutrient and salt balance assessments and calculation of the organic loading rate.

<u>Suitability of the proposed effluent reuse area</u>
The EPA recommends that an assessment of the suitability of the proposed effluent reuse area and that the proponent provides a characterisation of soils in the proposed effluent reuse area is carried out to demonstrate their suitability, inform management of any potential limitations, and provide a monitoring baseline.

It is recommended that the slope of the irrigation area is determined and the risk of excess runoff and erosion assessed. Consideration should be given to whether a terminal system is needed to collect and recycle irrigated effluent tail water and to manage contaminated stormwater runoff from the effluent irrigation area.

<u>Nutrient, salt, and water balance assessments</u>

It is recommended that a mass balance approach be used to calculate nutrient and salt loadings, in line with the recommendations *of Development of Indicators of Sustainability for Effluent Reuse in the Intensive Livestock Industries: Piggeries and Cattle Feedlots (McGahan and Tucker, 2003)*. If an alternative approach is used, the proponent should provide justification for this approach. The reuse area may need to be expanded and/or additional monitoring may be necessary to manage the risk arising from uncertainty in the loading estimates.

It is recommended that the nutrient and salt balance assessments account for all nutrients and salts generated or applied on the premises and identify the fate of these. In particular, the sustainability of any proposed reuse of manure solids should be demonstrated. Any additional fertilisers applied should be included in nutrient balance assessments.

If composted manure solids reuse is proposed, the proponent should characterise the expected quality of the manure solids in terms of nutrients, salts, and organic content, and any other relevant characteristics in line with the recommendations of *Development of Indicators of Sustainability for Effluent Reuse in the Intensive Livestock Industries: Piggeries and Cattle Feedlots (McGahan and Tucker, 2003).*

It is recommended that a detailed description of the water balance modelling should be provided. This should identify and justify the model inputs and assumptions and provide model outputs. This information should include, but need not be limited to:

- rainfall and evaporation depths and volumes;
- runoff collected in the holding pond;
- frequencies and volumes of any managed overflows and effluent reuse
- volumes of evapotranspiration, runoff, and percolation from the reuse area.

It is recommended that the proponent reviews and amends the estimates of manure generation.

Salt leaching

It is recommended that the proponent clarifies whether salts will be leached by rainfall and/or clean irrigation water, rather than by irrigated effluent, so as to prevent leaching of nutrients.

It is recommended that the proponent assesses the potential risk to surface waters posed by leached salts from the proposed reuse area.

Design standards

It is recommended that the proponent clarifies whether all components of the controlled drainage system will be designed and operated in accordance with the *National Guidelines for Beef Cattle Feedlots in Australia 3rd Edition (MLA 2012).*

Monitoring

It is recommended that the proponent provides an operational monitoring plan. This should include details of and justification for the proposed monitoring program for soil characteristics, composted manure quality and quantity, effluent quality and quantity, surface water quality, and groundwater quality and, where relevant, should align with the recommendations of *(McGahan and Tucker, 2003) and (DEC, 2004).* Where there is disagreement between these documents, *McGahan and Tucker (2003)* should take precedence. The monitoring plan should provide details of the locations of all monitoring sites and the parameters that will be monitored. Consideration should be given to inclusion of upstream and downstream monitoring sites on Tumbledown Gully to improve the capacity to detect any impacts. Monitoring requirements can be reduced once the sustainability of the operation has been demonstrated.

It is recommended that concentrations of nitrogen and phosphorus compounds be calculated based on their nitrogen and phosphorus content respectively (e.g. NO_x-N, NH_4-N, FRP-P).

Attachment 2: Cultural Heritage Letters

ANAIWAN
LOCAL ABORIGINAL LAND COUNCIL

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FACSIMILE TRANSMISSION COVER SHEET

To: Paul Henry - Inverell Shire Council

Position: General Manager

Fax Number: 67288277

Subject: Nullamanna Feedlot Expansion DA 15/2016

Page(s): 3

Date: 15/03/2016

From: Greg Livermore

E-mail: anaiwanlalc@tingha.net

Message: Further to yesterday' e-mail

Cheers

Greg

ANAIWAN
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Phone (02) 6723 3022
Fax (02) 6723 3023

14th March 2016

Mr Paul Henry
General Manager
Inverell Shire Council
PO Box 138
Inverell NSW, 2360

Dear Paul,

Re: Nullamanna Feedlot Expansion DA 15/2016

I have some concerns and objections regarding the above mentioned development application currently before Council.

These concerns regard the manner or lack of proper consultation with the local Aboriginal community including Anaiwan Local Aboriginal Land Council as well as the process of Due Diligence in respect of known Aboriginal sites in the area.

After accessing the Statement of Environment Effects on Councils website and in particular page 23, Section 2.10 of this document entitled "Archaeological and Heritage Matters" I read with interest that the author states;

"A search of the Aboriginal Heritage Information System (AHIMS) found no aboriginal heritage sites on Lots 2, 10, 16, 17 and 18 DP 750112 (the areas involved in the expansion)"

Experience has taught me that even if no Aboriginal Heritage Sites exist on the AHIMS Register good practise should always dictate that you undertake a wider AHIMS search of the area as well as undertake a survey on foot of the proposed area to be developed.

On other developments proposals we have found on some areas where no Aboriginal Heritage Sites are registered on AHIMS that sites and

objects do exist and would have been destroyed if no field surveys were carried out.

Field Surveys or Aboriginal Cultural Heritage Assessments based on Landscape Modelling are not mentioned and local knowledge and other Aboriginal Cultural Heritage Survey Reports indicate that there are a number of sites in close proximity to the Nullamanna Feedlot Expansion area.

Disappointingly no consultation with the local Aboriginal community is mentioned or offered but I read with interest that Landholders surrounding the proposed Nullamanna Feedlot Expansion were consulted and it seems that Aboriginal Cultural Heritage is of no value in this development.

To remedy the lack of proper consultation with key local Aboriginal Stakeholders and so that the Proponents are reminded of their responsibilities and are seen to be conforming with the Due Diligence Code of Practice for the Protection of Aboriginal Objects in New South Wales to the satisfaction of the local Aboriginal community, I am offering the following recommendation;

That a on ground Cultural Heritage Assessment of the proposed Nullamanna Feedlot Expansion area being* Lots 2, 10, 16, 17 and 18 DP 750112 *be conducted in consultation with and the involvement of the Anaiwan Local Aboriginal Land Council.

If I can be of any further assistance to you regarding this matter please contact me on 6723 3022 during business hours.

Yours sincerely

Gregory T. Livermore
Chief Executive Officer
Anaiwan Local Aboriginal Land Council

Mr Paul Henry
General Manager
Inverell Shire Council.
8th March, 2016

Re: Nullamanna Feedlot Expansion DA 15/2016

Dear Paul,

Following consultation with members of the local Aboriginal community I am writing to you in regards to the above DA.

While not objecting to the expansion, construction and / or operation of the feedlot per se, I am concerned with what I believe are some shortcomings within the Statement of Environmental Effects relating to the feedlot DA.

1. On page 23 of the Statement of Environment Effects, Section 2.10 "Archaeological and Heritage Matters" the authors state:

   "A search of the Aboriginal Heritage Information System (AHIMS) found no aboriginal (sic) heritage sites on Lots 2, 10, 16, 17 and 18 DP750112 (the areas involved in the expansion)"

I believe restricting an AHIMS search to such a very specific area (Lot and DP number) is neither within the spirit of Aboriginal Cultural Heritage investigation or legislative requirements.

In support of my concerns I would point out that Requirement 1.b of the "General requirements applying to all archaeological investigations of the Code of Practice for Archaeological Investigation of Aboriginal Objects in NSW" (p.7) states:

AHIMS searches must:

- *Include an area larger than, and wholly containing, the subject area*
- *Include an area large enough to allow adequate landscape interpretation, and – if available – sites in large enough numbers to allow adequate understanding of the distribution of the sites within the landscape.*

On 17th Feb. 2016 I conducted an AHIMS search of an area 5kms x 5kms centred on the feedlot study area. This area was seen as *"large enough to allow adequate* *landscape interpretation" and (identifying) sites in large enough numbers to allow adequate understanding of the distribution of the sites within the landscape.*

This search, of a compliant larger area, returned 3 Aboriginal sites within that area.

2. Additionally an AHIMS search which the Statement of Environmental Effects is required to undertake is to:
    - *Include a search for any previous reports relevant to the subject area.*

Consulting the AHIMS "Previous Report" function, using the key word **Nullamanna** returns "An Investigation for Aboriginal Sites and Relics of a Proposed Optic Fibre Cable Route from Inverell to Nullamanna" undertaken by Terry Griffiths for Telstra Australia June, 1995. Report no. C-3456.

No reference is made in the Statement of Environmental Effects to this extremely relevant localised report.

3. The process of reviewing previous archaeological work is also seen as a component of the "General requirements applying to all archaeological investigations of the Code of Practice for Archaeological Investigation of Aboriginal Objects in NSW" (See 2.1 p.6 Reviewing Existing Knowledge)

Would it not be correct to assume that the Griffiths report of 1995 also represents "previous archaeological work"?

4. It appears that section 2.10 of the Statement of Environmental Effects; "Archaeological and Heritage Matters" has been completed by desk top assessment only. The "Due Diligence Code of Practice for the Protection of Aboriginal Objects in New South Wales" clearly states on pages 12-13 that a desktop assessment should be supported by visual inspection

    "You must undertake a visual inspection of the area to see if Aboriginal objects can be identified or are likely to be present below the surface"

No mention is made of field visit or landscape assessment in regards to Aboriginal Cultural Heritage.

5. While Item 5 of the Due Diligence Code of Practice says "Consultation with the Aboriginal community is not a formal requirement (p.3), this is tempered by, Item 2b of the Due Diligence process that refers to "Are there any other sources of information of which a person is already aware?"

Would not consultation with the local Aboriginal community be both a potential source of information and courteous? It appears that Table 7. (p.26 of the Statement of Environmental Effects) is more of a list of people who are neighbours rather than a consultation undertaken in the spirit of gaining knowledge re Aboriginal Cultural Heritage.

6. In support of "other sources of information" (as mentioned above) several items of local information relative to the Nullamanna study area known to exist but are not mentioned in the Statement of Environmental Effects. These are extremely relative to the investigation and preservation specifically of Anaiwan Aboriginal Cultural Heritage-

e.g. Collected between 1966-1969 from approximately 1-2km directly opposite this study site to the west, largely on the opposite side of Frazers Creek, 14 boxes of Aboriginal Cultural Heritage artefactual material was forwarded to the Australian Museum from at least 15 different but associated sites in this locale. One collected site was on the eastern side of Frazers Creek i.e. on Nullamanna Station, the site of this development.

Each box was estimated at 40lb weight (18kgs). Stone tools collected included backed blades, burins, cores, tula, elouera, muller, scrapers and microliths.

A further 2 boxes were collected in 1970 and forwarded to the University of New England (UNE) Armidale.

7. The proposed development site is some 800m north west of Frazers Creek (i.e. outside the preferred distance from water to indicate the likely existence of Aboriginal objects – see Due Diligence p.12) however, it is within 200m of the ephemeral water source Tumbledown Gully.

Therefore given the proximity to known sites it is highly likely surface Aboriginal artefactual material could be present. It would therefore be prudent to undertake a survey “on foot, for the purposes of discovering Aboriginal objects” (See Code of Practice for Archaeological Investigation of Aboriginal Objects in NSW – p.13)

Such a survey should be conducted in consultation with and the involvement of the Local Anaiwan Aboriginal Community. The proponents should be aware of their responsibilities should it be necessary to apply for an Aboriginal Heritage Impact Permit (AHIP) and or Care Agreement given the potential for “discovering” of Aboriginal objects.

Attachment 3: Addendum to Cultural Heritage Section

Addendum statement
Re: Aboriginal Cultural Heritage -
Statement of Environmental Effects Nullamanna Feedlot Expansion
EnviroAg Australia Pty Ltd
Report No. 23876.81916

Addendum completed by Tony Sonter "Artefact and Aspect"

May 2016

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All photos, figures and maps are photographed, prepared and designed by the report author unless otherwise noted.

Scales appearing in plates are: Red & white range pole in 20cm units;
Black & white IFRAO scale in 1cm units.

1. Background statement.

A “Statement of Environmental Effects” regarding the potential expansion of “Nullamanna Feedlot” was undertaken by EnviroAg Australia Pty Ltd (Report No. 23876.81916). This report was published on 3rd February 2016.

Following consultation regarding “Section 2.10 Archaeological and Heritage Matters”, this Addendum is provided to expand the knowledge base regarding Aboriginal Cultural Heritage in the vicinity of the planned expansion of the feedlot and associated infrastructure.

2. Executive Summary.

The western side of Frazers Creek which forms the south-western boundary of “Nullamanna Station” has revealed an extensive number of Aboriginal Cultural Heritage sites and artefacts during previous survey and historical collecting activities. A small amount of similar survey and collecting activity has also taken place on “Nullamanna Station”.

Although no direct evidence was found to indicate the likely presence of any Aboriginal Cultural Heritage material on the proposed feedlot and associated infrastructure development site, should any such objects or sites be uncovered during project development and construction, work should immediately stop and appropriate authorities notified. Appropriate authorities would include but not be limited to Anaiwan LALC (Tingha); Northern Tableland LLS (Inverell); Office of Environment and Heritage (Dubbo) and Inverell Police in the case of skeletal material.

Consideration should be given to an Aboriginal Cultural Heritage education and orientation program for all employees and contractors that are involved in the development and construction of the proposed feedlot and associated infrastructure. Such a program should involve the recognition of Aboriginal Cultural Heritage items in the field so that employees and contractors may act with due diligence.

3. Previous archaeological work.

Between 1966 and 1970, an amateur archaeologist and collector of Aboriginal Cultural Heritage material, a Mrs Muriel Baldwin of Gilgai, investigated and collected Aboriginal Cultural Heritage material from what she identified as at least 13 distinct but associated Aboriginal Cultural Heritage sites, 1-3km west of the planned location of the proposed feedlot and associated infrastructure expansion.

Mrs Baldwin removed at least 14 boxes of stone artefactual material. These boxes had an average weight of 40lb / 18kg. The majority of the artefacts were forwarded to the Australian Museum with some being forwarded to the University of New England (UNE) Armidale and some being put on display at the local museum, Inverell Pioneer Village. (See plates 1 and 2; 2a)

Mrs Baldwin’s activities were documented by Valerie Campbell, on behalf of New South Wales National Parks and Wildlife Service. (Report C-199- see note in Bibliography)

> *"On Tuesday 1st. September, 1970 I went to Gilgai to interview Mrs Baldwin and to inspect sites known to her. Mrs Baldwin and her mother have been keen collectors for many years and material has been sent to the Australian Museum. With one exception all artefacts (sic) have been collected from surface sites, generally located along the streams in the Inverell district."* (1970 p.1)

Campbell records activities by Mrs Baldwin in the Nullamanna areas specifically as:

> *"Mrs Baldwin reports sixteen distinct sites in an area of about one thousand acres / 400 hectares in the Nullamanna district. These appear to be concentrated along Frazer's Creek. She has given each place a number and has undertaken to provide both the University (New England) and the (Australian) Museum with a map with the numbers keyed in.* (See Figure 2)
>
> *Several boxes of material from these sites have been forwarded to the Australian Museum and some were given to the University. The latter contain quite a high proportion of cores in varying types of rock, and quite a number of flakes. Her own collection of material from this site includes several bifacially flaked axes about 4 inches / 10cms in length, as well as a large number of flakes.* (Campbell, 1970 p.2) (See plates 1 and 2; 2a)

Of the "sixteen distinct sites", sites numbered 3-15 were found on "Strathfillan" (except site 13) and represent the majority of the sites west of the proposed feedlot site (See Figure 2) One collected site was on the eastern side of Frazers Creek on Nullamanna Station (Site 13 – an eroded slope of 2 acres / approx. 0.8hectare)

Campbell additionally notes;

> *"More sites are known to exist both on "Strathfillan" and adjoining "Nullamanna Station" but no collections have been made of these"*

These sites were further examined by Michael Pearson while conducting Archaeological Research for his B.A. (Hons) Thesis "The Macintyre Valley – field archaeology and ethnohistory" (1973). Pearson described the area as an;

> "*Extensive area of surface site beside Frazer's Creek*" and suggested the "*size of sites and composition of artefacts (sic) suggests a quarry site*" (1973, Appendix "Surface Sites" unpaged)

This concentration of Nullamanna sites are recorded on the NSW Aboriginal Heritage Information Management System (A.H.I.M.S) as 11-6-31 dated 17th January, 1979.

4. Proposed feedlot location relative to known archaeology.

The proposed feedlot expansion is planned for a relatively gentle rolling hillcrest at approx. 690m ASL. This site is immediately to the north-west of the current farm and feedlot infrastructure. (See plate 3)

This hillcrest is a continuation of the same topographic unit that the current farm and existing feedlot infrastructure are sited on. To the west a maximal upper slope drops away to a simpler slope which adjoins Frazers Creek. It is this creek side simpler slope where Baldwin and Campbell (1970) have located Site 13.

Figures 3 and 3a have been constructed to show the relationship between the location of the proposed feedlot and associated infrastructure and known archaeology.

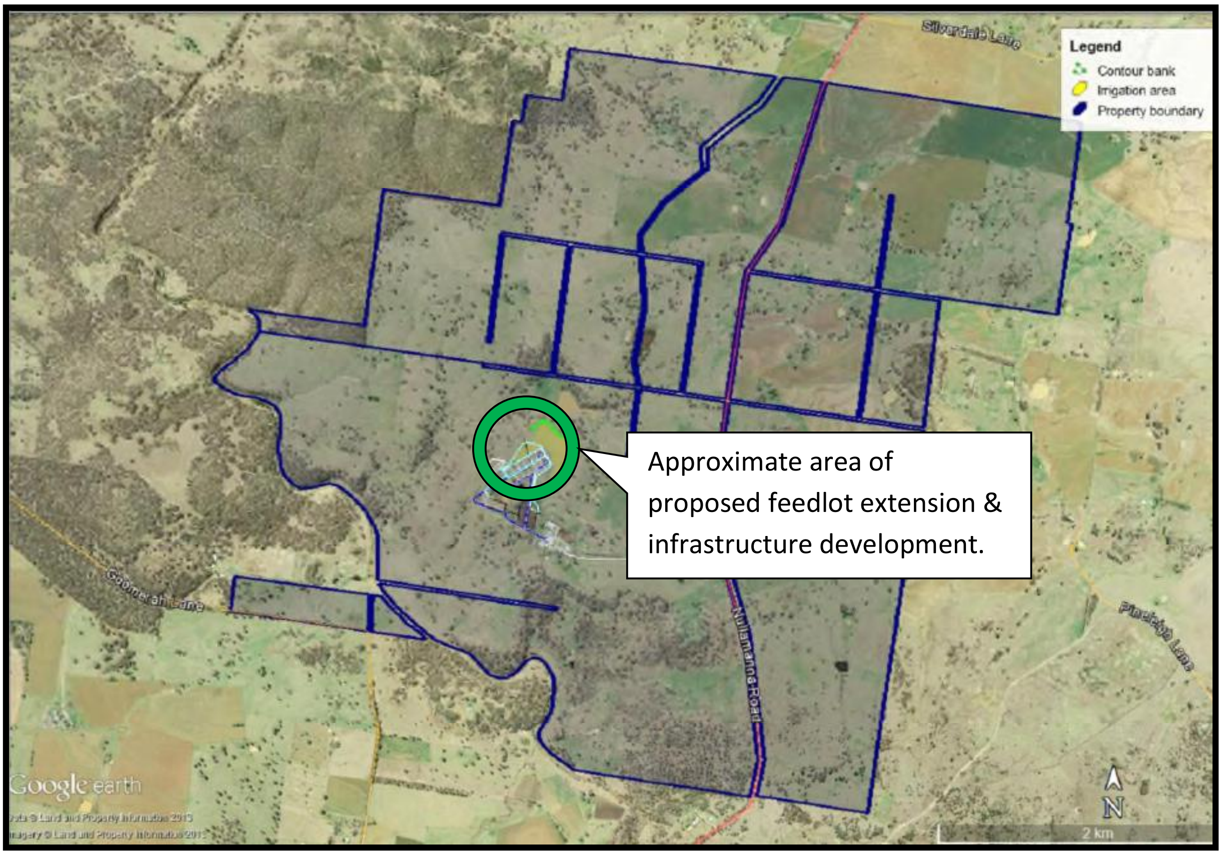

Figure 1. Aerial photomap of Nullamanna Station and area of proposed feedlot extension and infrastructure development. (Source: Lindi Olivier, EnviroAg Australia Pty Ltd., supplied 21st April 2016)

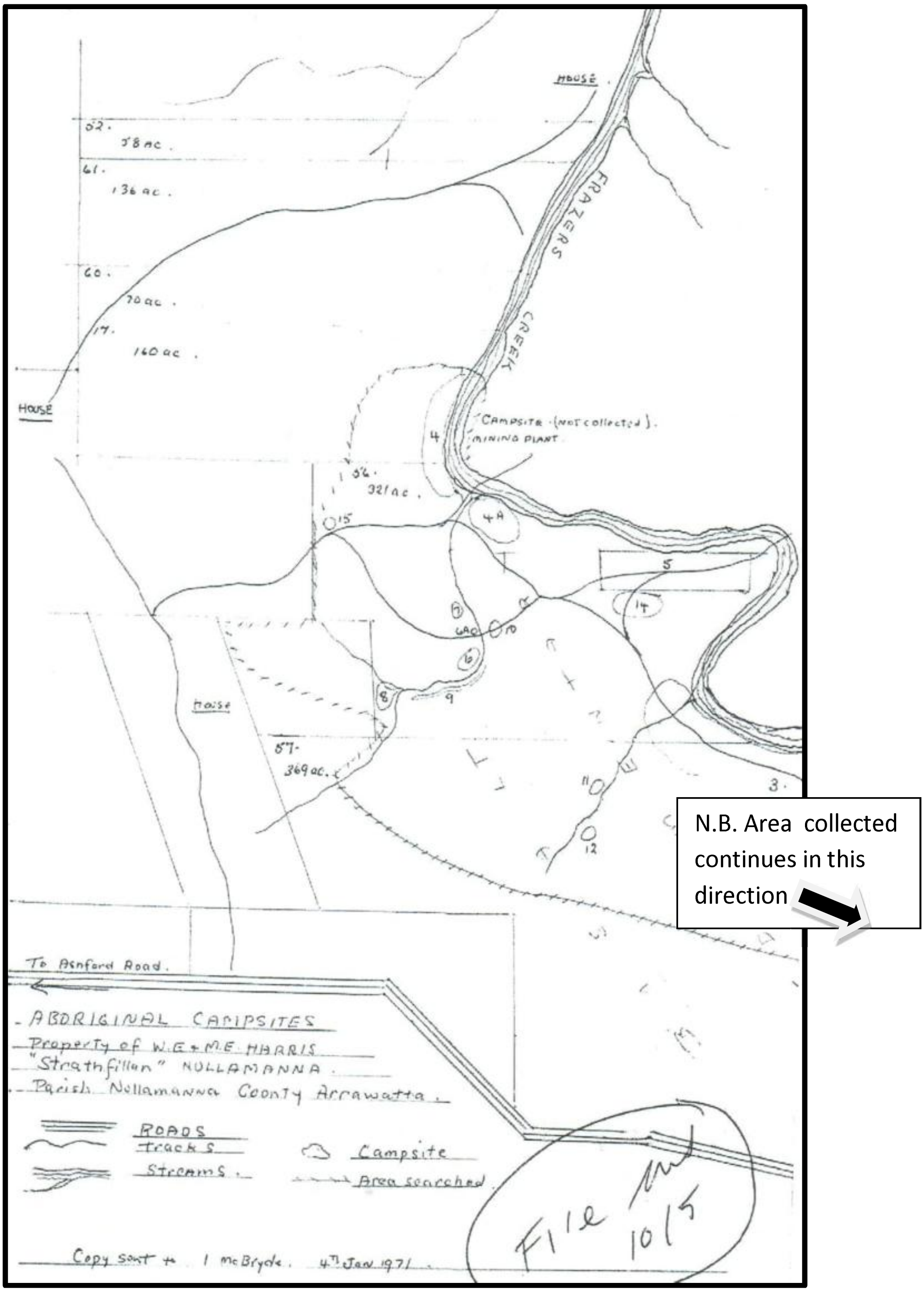

Figure 2. Area of "Aboriginal Campsites" west side of Frazers Creek, adjoining Nullamanna Station as mapped by Baldwin and recorded by Campbell. (1970)

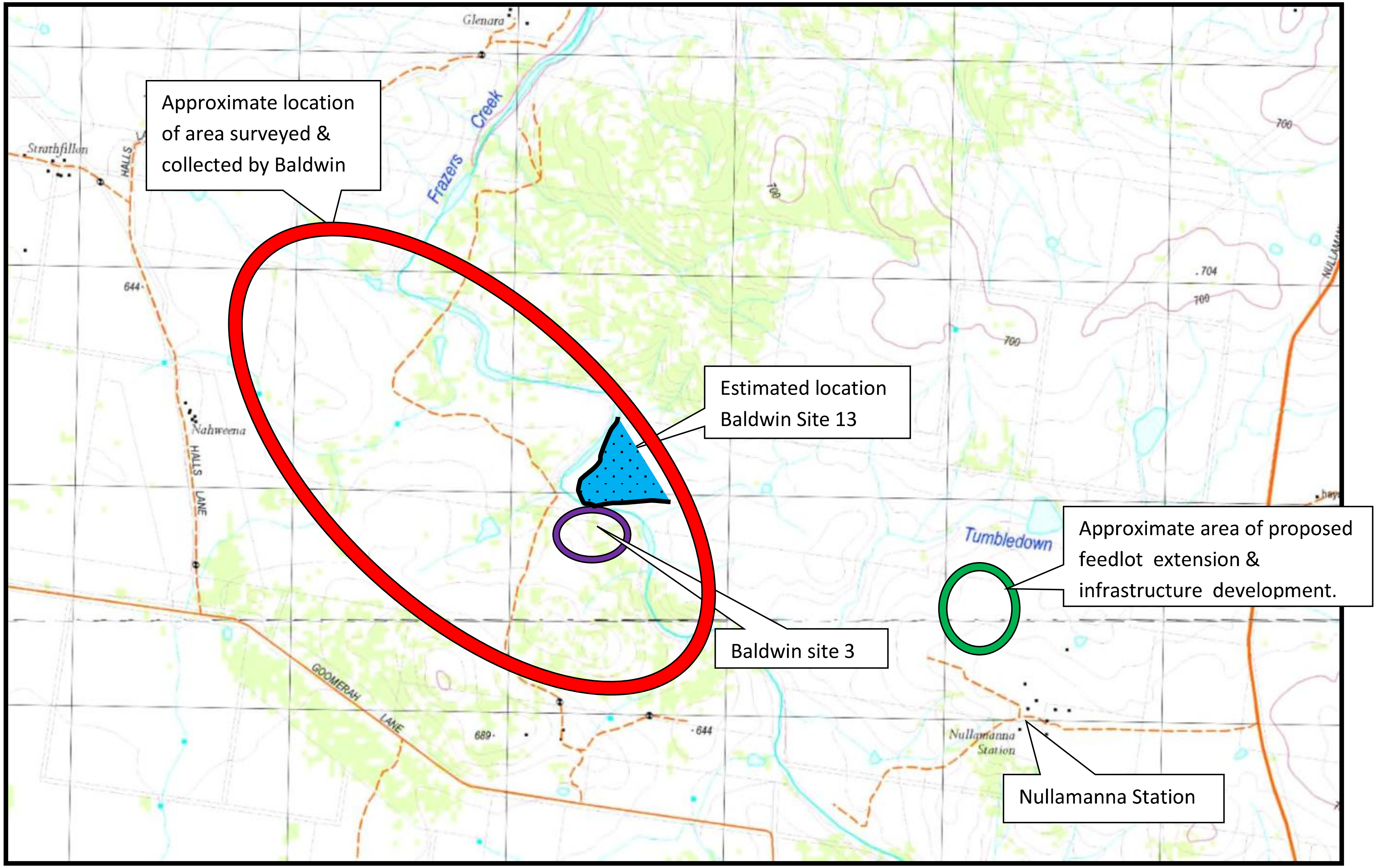

Figure 3. Composite overlay on topographic map base of Figs 1 & 2 showing proposed feedlot location relative to known archaeology.

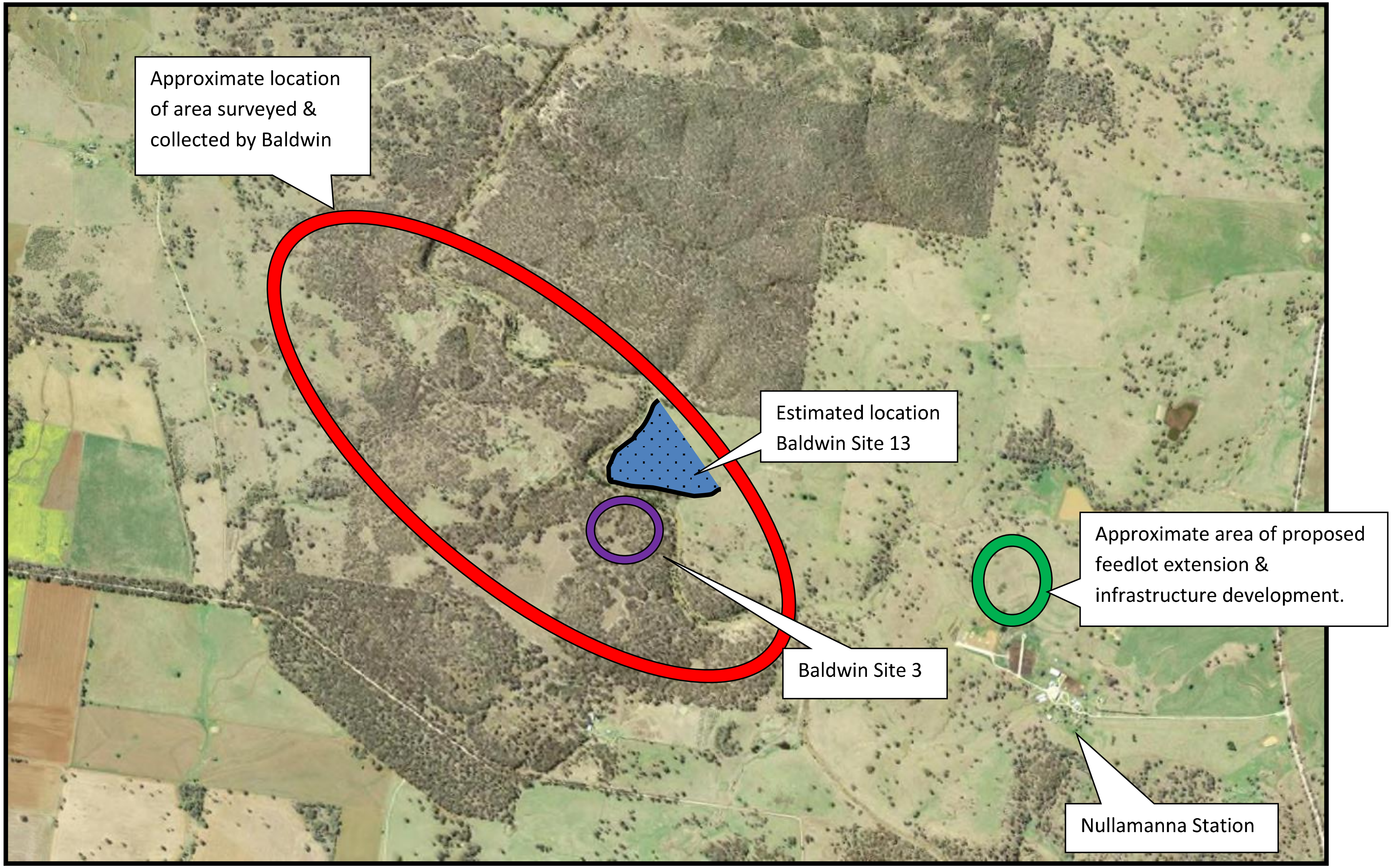

Figure 3a. Composite overlay on aerial photo base of Figs 1 & 2 showing proposed feedlot location relative to known archaeology.

5. Visual inspection and Site Prediction.

A site visit was undertaken on Thursday, 7th April 2016 by the report author in company with Mr Greg Livermore (CEO Anaiwan Land Council) and Mr Claude Livermore (Anaiwan Cultural Sites Officer). This visit was seen as a preliminary to investigate if Aboriginal objects could be identified or were likely to be present below the surface of the proposed feedlot and associated infrastructure site. Such an assessment was in compliance with the ”Due Diligence Code of Practice for the Protection of Aboriginal Objects in New South Wales” (pp. 12-13).

Normally such a site assessment would involve a survey “on foot, for the purposes of discovering Aboriginal objects” (See Code of Practice for Archaeological Investigation of Aboriginal Objects in NSW–p.13) Such a site survey was however, deemed unnecessary and impractical given the heavy vegetation cover (See Plates 4 and 5) and the hillcrest landform unit upon which the proposed feedlot and associated infrastructure was to be located.

Three prior studies of Aboriginal Cultural Heritage in the region have relevance to the location of this proposed development. They are Pearson (1981); Appleton (1990) and Kelton (1997).

Appleton, produced a survey strategy for predicting the location of surface archaeological material in areas too large to be intensely surveyed on the Western Slopes of NSW (1990 p.1) He concluded that stone artefacts will be distributed across the landscape in variable densities with the highest densities adjacent to creeks containing permanent water (wet creeks) and on ridges of the red brown soils that dominate the lower slopes. Most artefacts will be observable when ground cover is less than 10% and higher artefact scatters will be found near a raw material source. (1990, pp.164-16)

Kelton undertook an Aboriginal Cultural Heritage survey at Wandera, 7-8kms south west of the proposed development site, on behalf of Telstra in 1997. He constructed a predictive model for the presence of Aboriginal Cultural Heritage sites based on earlier work by Pearson (1981) that identified the following criteria as highly likely to predetermine the presence of sites:

- Accessibility to water
- Well drained level ground
- Elevation above cold air current and frost prone valley
- Good view of river flat and water source
- Sheltered from cold winter wind but with exposure to summer cooling breeze
- Adequate fuel supply

(Kelton, 1997, pp12-13)

Of these criteria “The Due Diligence Code of Practice” (2010 p.12) emphasises that the particular landscape features most likely to have Aboriginal objects associated with them is if they are on undisturbed land within 200m of water.

Given the proposed development site location as a hill crest a kilometre away from water in association with virtually nil surface visibility it is unlikely that any items of Aboriginal Cultural Heritage would be present or observable.

Conversely however, it is the reverse that probably allowed Baldwin (1966-1970) and Pearson (1973) to respectively survey and / or collect from the “erosion slope” on “Nullamanna Station” adjoining Frazers Creek. This site, recorded as Site 13, and the others in this concentration of Baldwin recorded sites (Numbers 3-15) confirm the important association between a ready water supply and Aboriginal Cultural Heritage sites.

6. Plates

Plate 1. Display cupboard of Aboriginal artefacts / stone tools as located at Inverell Pioneer Village, Tingha Rd. Inverell. Many of the stone artefacts are labelled Nullamanna with a site number as collected and “donated” by Mrs M. Baldwin in 1966-1969.

Plates 2 & 2a. Examples of artefacts in the display cupboard at Inverell Pioneer Village clearly labelled with a “Nullamanna” label and site number.

Plate 3. General view to the north-west looking over hillcrest which is the proposed site of the feedlot extension and infrastructure development. Middle ground ridgeline indicates maximal slope dropping towards Tumbledown Gully.

Plate 4. Development proponent, Mr Peter Lane (orange shirt) explains to Anaiwan representatives Mr Greg Livermore (CEO – on left) and Claude Livermore (Cultural Sites Officer – on right) aspects of the development proposal.

Plate 5. Site visibility showing 100% grass cover, at times up to 60cms tall over almost the total site proposed for development.

7. Bibliography

Appleton, J. 1990. A Survey Strategy for the Western Slopes – The Development of a Survey Technique and a Predictive Model for the Western Slopes of Northern NSW. Unpublished B.A. Hons. Thesis. UNE. Armidale.

Campbell, V. Report on Aboriginal Sites in Inverell District Located by Mrs Baldwin of Gilgai. NPWS Report C-199, 1/9/1970.

Note: This publication is unpaged or paged according to several sections that were probably written initially as "separate units" and later combined into the final report. Therefore most references from this publication are not page referenced.

Department Environment Climate Change and Water. Code of Practice for Archaeological Investigation of Aboriginal Objects in New South Wales. 2010.

Kelton, J. 1997. An Archaeological Survey for the Proposed Optic Fibre Cable Route Between Inverell and Bakkulla (sic), Northern NSW. Unpublished report 04387 NSW Office of Environment and Heritage.

Pearson, M. (1973) The MacIntyre Valley: A Field Archaeology and Ethnohistory. Unpublished B.A.Hons Thesis UNE. Armidale.

Pearson, M (1981) Seen Through Different Eyes: Changing Land Use and Settlement Patterns in the Upper Macquarie River Region of NSW From Prehistoric Times to 1860. Unpublished Ph.D Thesis Dept. Prehistory and Anthropology, ANU. Canberra.

State of NSW and the Department of the Environment, Climate Change and Water, "Due Diligence Code of Practice for the Protection of Aboriginal Objects in New South Wales" September 2010

8. Appendix

ANAIWAN
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5th May 2016

Tony Sonter

"Artefact and Aspect"

39 Brae Street

Inverell NSW 2360

Dear Tony,

Re: Proposed Nullamanna Feed Lot, Report No. 23876.81916

Further to a recent Cultural Heritage Assessment involving Anaiwan Local Aboriginal Land Council Cultural Heritage Officers at the proposed Nullamanna Feed Lot Expansion Site on Nullamanna Station, Emmaville Road, Nullamanna NSW 2360.

After reviewing your Addendum Statement Re: Aboriginal Cultural Heritage – Statement of Environmental Effects Nullamanna Feed Lot Expansion EnviroAg Australia Pty Ltd Report No. 23876. 81916 and having personnel physically on ground at the subject area the Anaiwan LALC is satisfied that all current Due Diligence procedures were followed.

I agree that a site survey was unnecessary and impractical due to the heavy vegetation cover and I also agree that the site of the proposed Feed Lot Expansion is outside the area where Aboriginal Cultural Heritage would be present or observable normally.

Anaiwan LALC endorses your Report and advice to EnviroAg Australia Pty Ltd and consistent with the recommendations already noted in your report the Anaiwan LALC has no objections with works proceeding on the proposed Nullamanna Feed Lot Expansion on Nullamanna Station.

If I am able to assist you further re this matter, please contact me at the Anaiwan LALC office on 0267233 022 during hours.

Regards

Gregory T. Livermore

Gregory T. Livermore
Chief Executive Officer
Anaiwan LALC

Attachment 4: Environmental Monitoring Plan

Environmental Monitoring Plan

Nullamanna Feedlot Expansion

Report Number 23876.85086

Prepared for

NULLAMANNA STATION

Nullamanna Station

1633 Nullamanna Road
Nullamanna NSW 2360
Telephone: 0428 539 163

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Document Status Record

Report Type:	Environmental Monitoring Plan
Project Title:	Nullamanna Feedlot Expansion
Client:	Nullamanna Station
Project.Document Number:	23876.85086
File Name:	Attachment 4 23876.85086_160517_Nullamanna Station_EMP_Rev0

Revision	Date of Issue	Author	Reviewed	Quality Assurance	Approved
0	03/06/2016	Erin Waller	Ryan Francis	B Calderwood	Simon Lott
Signatures					

Notes:

Rev 0: Final Report

Client

Company

Distribution:

Recipient	**No. Copies**
Nullamanna Station	1
EnviroAg Australia	1

This document provides information to address the intent of Project Number 23876 as agreed to by Nullamanna Station.

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Appendix D.	Historic Manure Sample Results	D-1

1. Introduction

1.1 Purpose

The Nullamanna Station feedlot is in the process of expanding from 1,000 SCU to 3,000 SCU. To ensure that the expansion does not cause environmental harm to surface water, groundwater and soil, an Environmental Monitoring Plan has been developed. The purpose of this plan is to detail the sample types, locations and analytes required to monitor the receiving environments around the feedlot. The monitoring will ensure that environmental impacts are recognised and remediation strategies can be implemented if required.

1.2 Project and location

The monitoring plan is for the expansion of the feedlot at “Nullamanna Station”, 1633 Nullamanna road, Nullamanna NSW. The expansion is from 1000SCU to 3000SCU, (1 SCU = one 600kg animal).

The feedlot development is situated 50 km west-north-west (WNW) of Glenn Innes; 17 km northeast of Inverell, and about 2.1 km north of the Nullamanna village. The location of the property is shown in Figure 1.

Properties immediately surrounding Nullamanna Station are used for grazing, croplands and hobby farming. The village of Nullamanna, 2.1 km south of the current feedlot area, is made up of rural residents.

The proposed general arrangement of the development layout is shown in Figure 2 below. This site was selected as it is immediately adjacent to the existing feedlot.

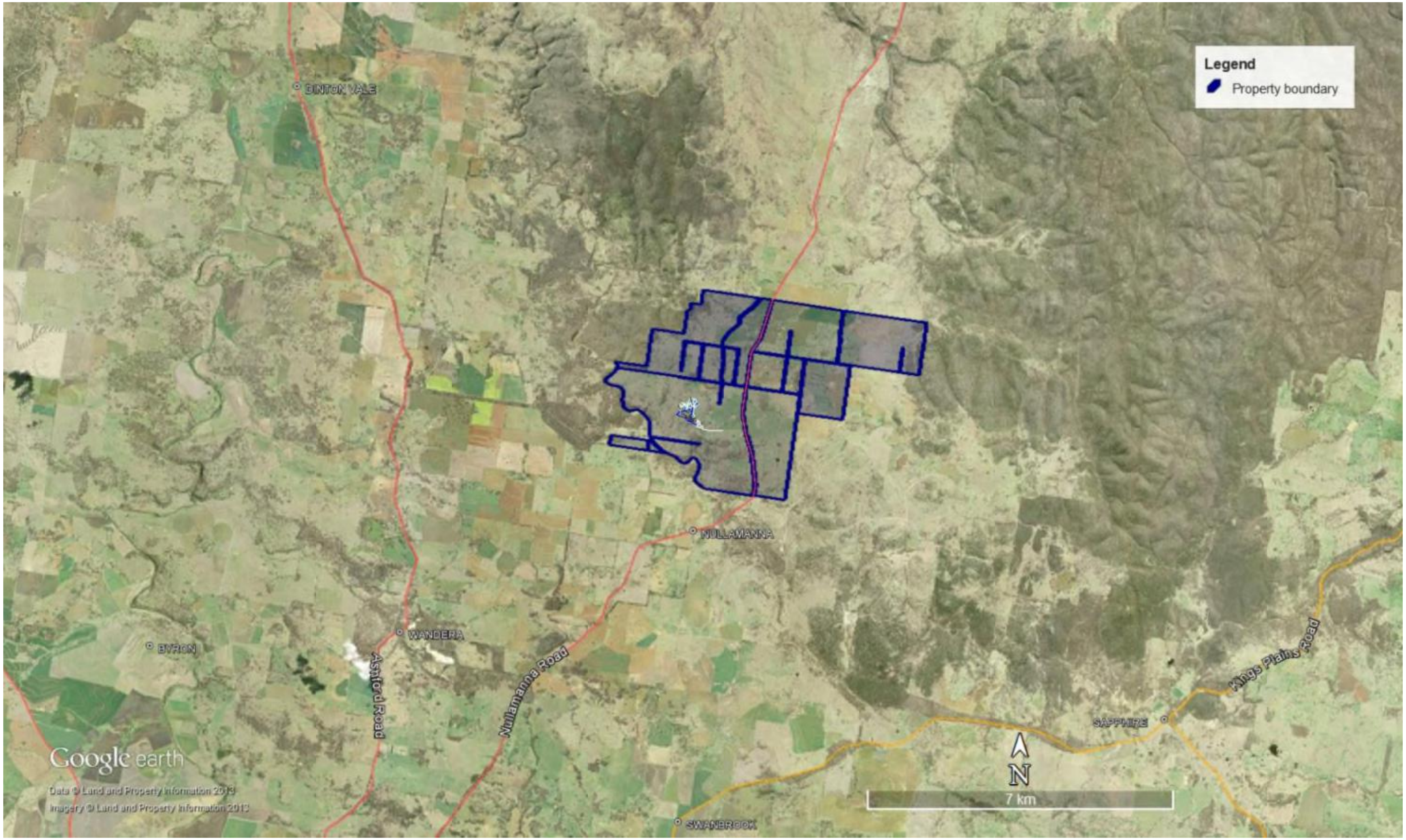

Figure 1 Location of Nullamanna Station

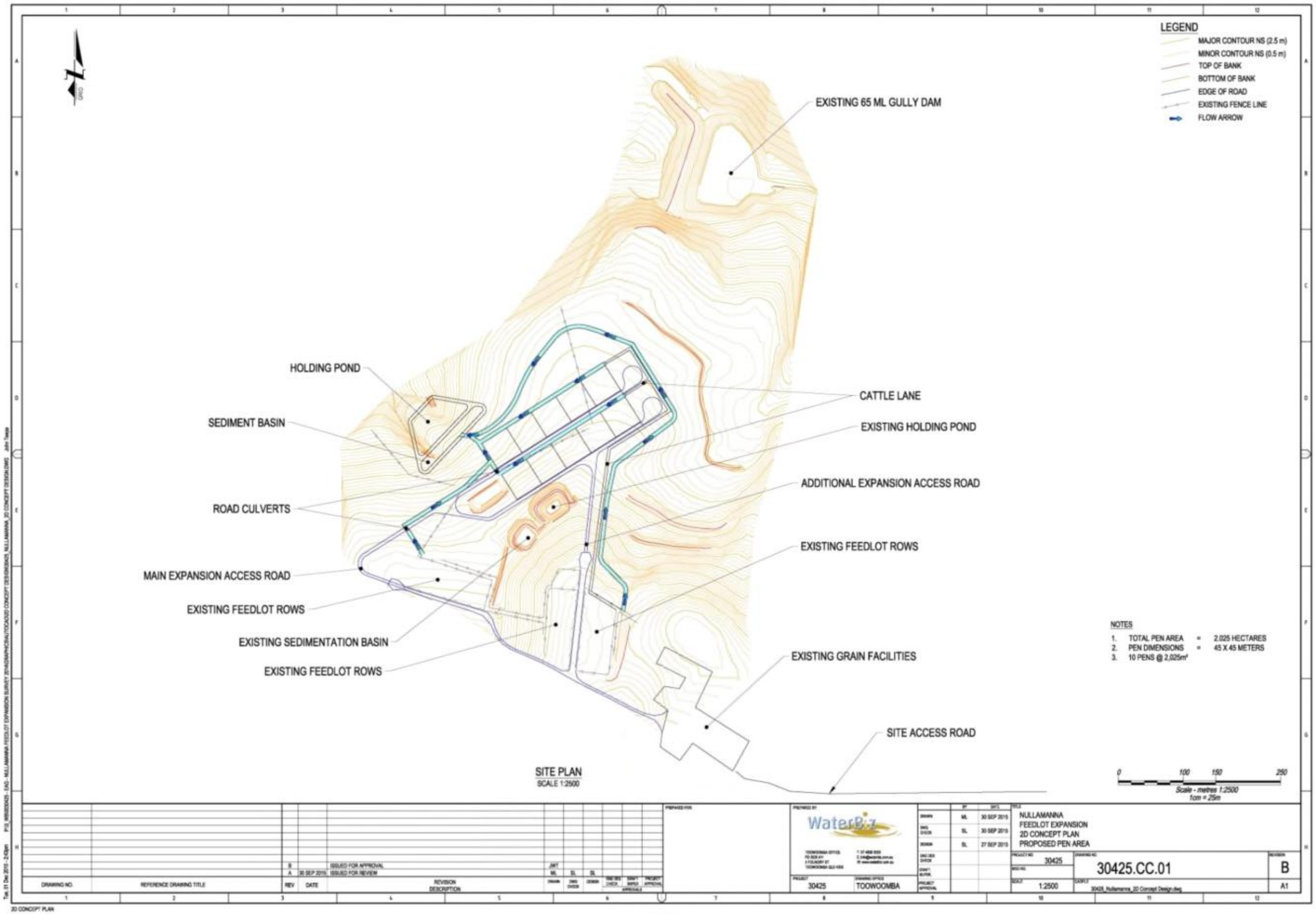

Figure 2 Conceptual design of the expanded feedlot

2. Environmental Monitoring

2.1 Surface Water Monitoring

Surface water will be monitored annually for three years to determine whether the feedlot expansion is impacting on the environmental values of Frazers Creek and Tumbledown Gully. The Monitoring Plan will be reviewed after three years to determine whether further monitoring is required. Surface water will be monitored yearly from the points shown in Table 1 and Figure 3. Two (2) sample locations have been chosen to establish if the feedlot is impacting Frazers Creek (SW FC) and Tumbledown Gully (SW TG). The other sampling location (SW FC Upstream) has been chosen as a reference site upstream of the feedlot to determine if the feedlot and Tumbledown Gully are impacting on Frazers Creek. The parameters and recommended trigger values for the surface water monitoring are shown in Table 2.

The results of the analysis will also be compared to the reference site to determine if any elevated results are due to the natural environment or operations upstream. Historic results for the Frazers Creek upstream sample site can be found in Appendix A.

Table 1 Coordinates of surface water monitoring points

Surface water monitoring point	Easting	Northing	Location
SW FC Upstream (reference)	-29.634698°	151.221158°	On Frazers creek upstream of the confluence with Tumbledown Gully
SW FC	-29.625584°	151.213525°	On Frazers creek downstream of the confluence with Tumbledown Gully
SW TG	-29.625595°	151.217313°	On Tumbledown Gully directly downstream of the feedlot

Table 2 Surface water quality parameters and trigger values

	Unit	Upland River Trigger Values (ANZECC & ARMCANZ 2000)	National Drinking Water Guidelines (NHMRC 2011)
pH	No unit	6.5-8	6.5-8.5 (aesthetic)
Electrical conductivity	µS/cm	350	-
Nitrate, NO_3 as NO_3	mg/L	-	50
Nitrite, NO_2 as NO_2	mg/L	-	3
Ammonia, NH3	mg/L	-	0.5 (aesthetic)
Total Kjeldahl Nitrogen	mg/L	-	-
Total Nitrogen (calc)	mg/L	0.25	-
Filterable Reactive Phosphorus	mg/L	-	-
Filterable Reactive Phosphorus as PO_4	mg/L	0.015	-
Total Phosphorus (Kjeldahl Digestion)	mg/L	-	-

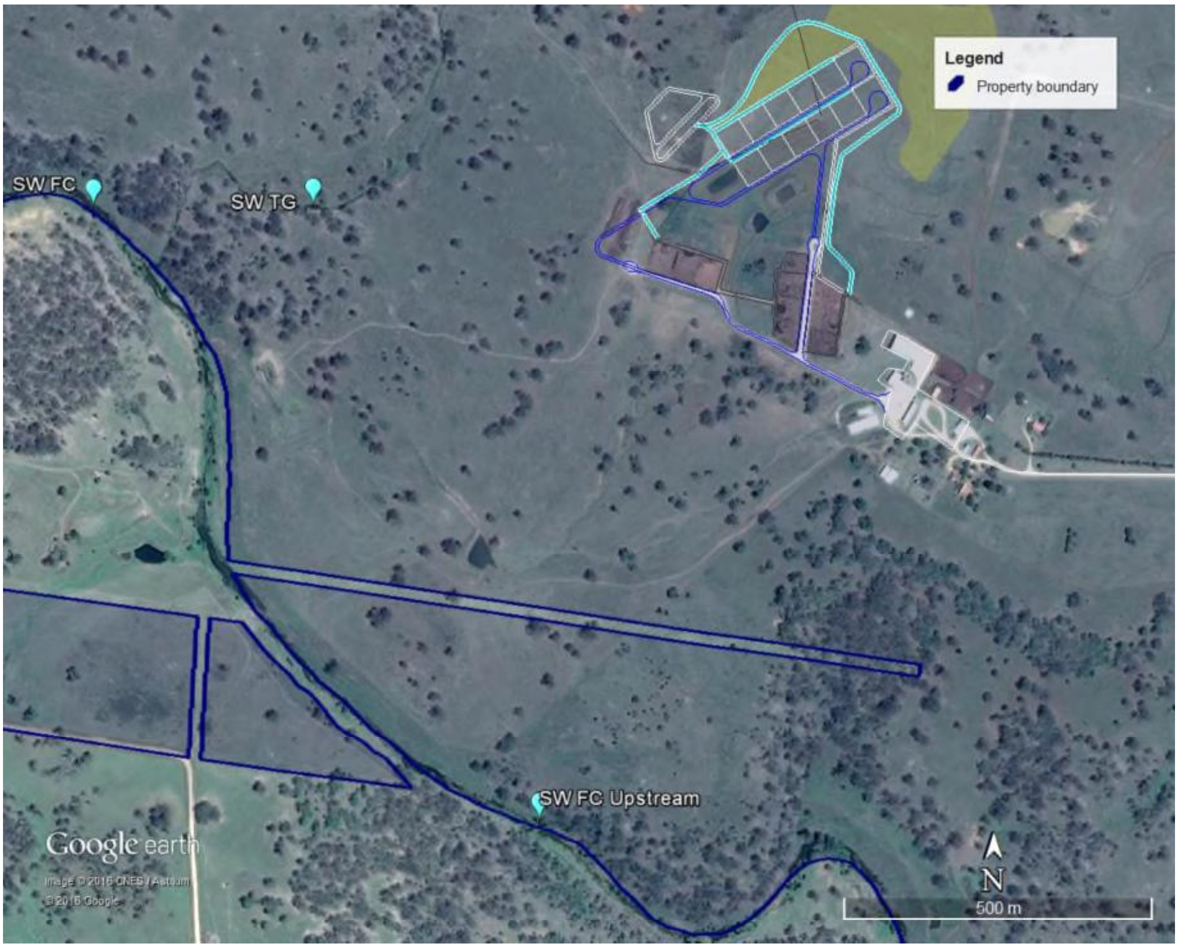

Figure 3 Map of surface water monitoring points

2.2 Groundwater Monitoring

Groundwater monitoring will be conducted annually for three years at two locations downhill of the feedlot and effluent irrigation area (Table 3 and Figure 4). The Monitoring Plan will be reviewed after three years to determine whether further groundwater monitoring is required. The parameters and recommended trigger values for the groundwater monitoring are shown in Table 4. The results will also be compared to the water quality results obtained from the existing Nullamanna Station bore to determine if any elevated results are due to the natural environment (results shown in Appendix B).

Table 3 Coordinates for groundwater monitoring points

Groundwater monitoring point	Easting	Northing	Location
GW1	-29.622178°	151.227598°	Downhill of Irrigation area
GW2	-29.623821°	151.223614°	Downhill of Feedlot and effluent ponds

Table 4 Groundwater quality parameters and trigger values

	Unit	Freshwater Guidelines (ANZECC & ARMCANZ 2000)	National Drinking Water Guidelines (NHMRC 2011)
pH	No unit	-	6.5-8.5 (aesthetic)
Electrical conductivity	µS/cm	-	-
Nitrate, NO_3 as NO_3	mg/L	0.7	50
Nitrite, NO_2 as NO_2	mg/L	-	3
Ammonia, NH3	mg/L	0.9	0.5 (aesthetic)
Total Kjeldahl Nitrogen	mg/L	-	-
Total Nitrogen (calc)	mg/L	-	-
Filterable Reactive Phosphorus	mg/L	-	-
Total Phosphorus (Kjeldahl Digestion)	mg/L	-	-
Sodium	mg/L		180 (aesthetic)
Chloride	mg/L		250 (aesthetic)

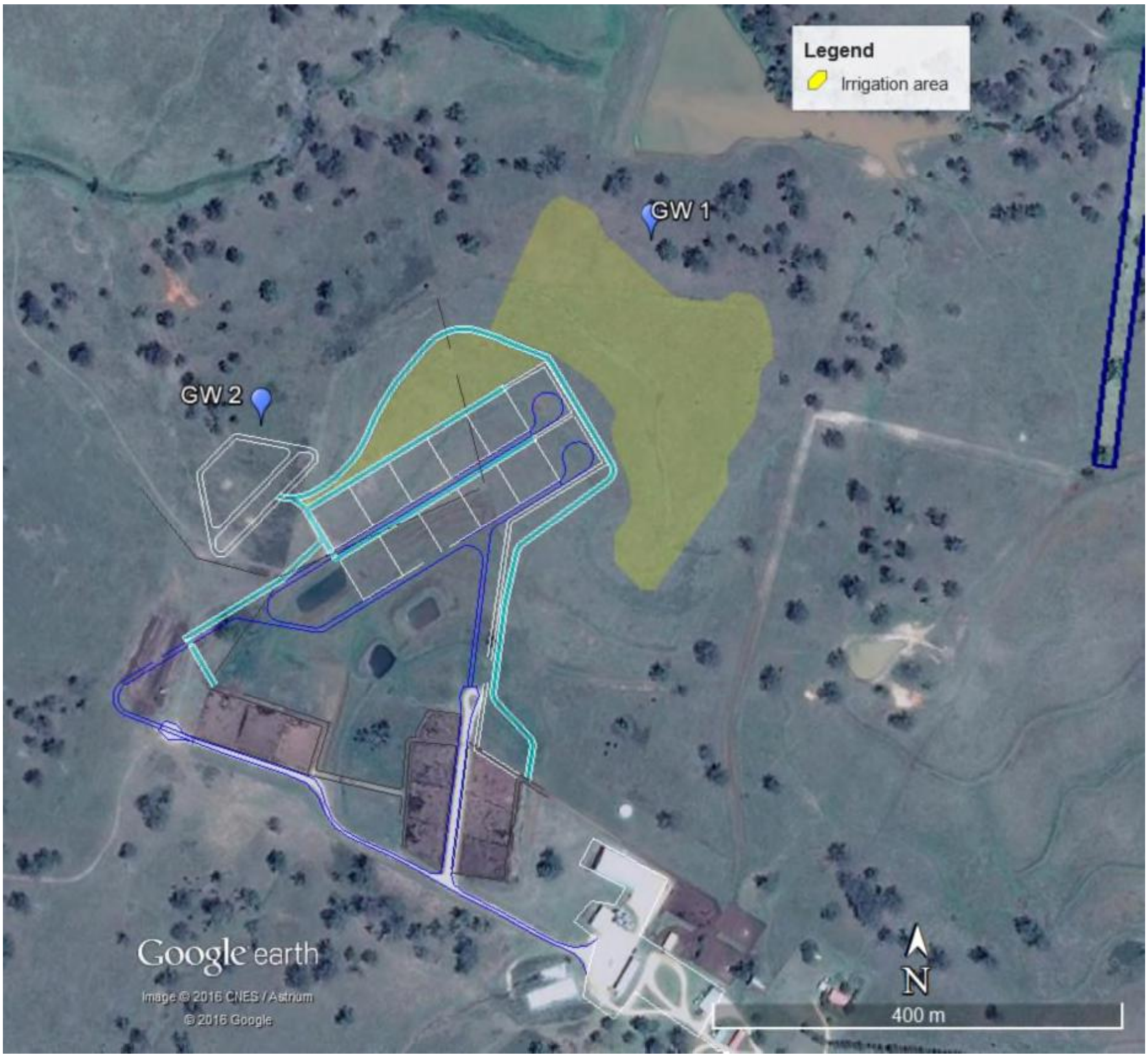

Figure 4 Map of groundwater monitoring points

2.3 Soil Monitoring

Soil will be monitored annually in the effluent irrigation areas to determine nutrient and salt loading levels. The soil monitoring points can be seen in Table 5 and Figure 5. A sample will be taken from two depths at each location – 0cm-30cm and 30cm-60cm. The parameters tested and soil limitations for wastewater irrigation are shown in Table 6. Historic results for the soil sample sites can be found in Appendix C.

Table 5 Soil monitoring coordinates

Monitoring points	Easting	Northing
Soil 1	-29.623350°	151.225522°
Soil 2	-29.622412°	151.226861°
Soil 3	-29.623405°	151.228268°

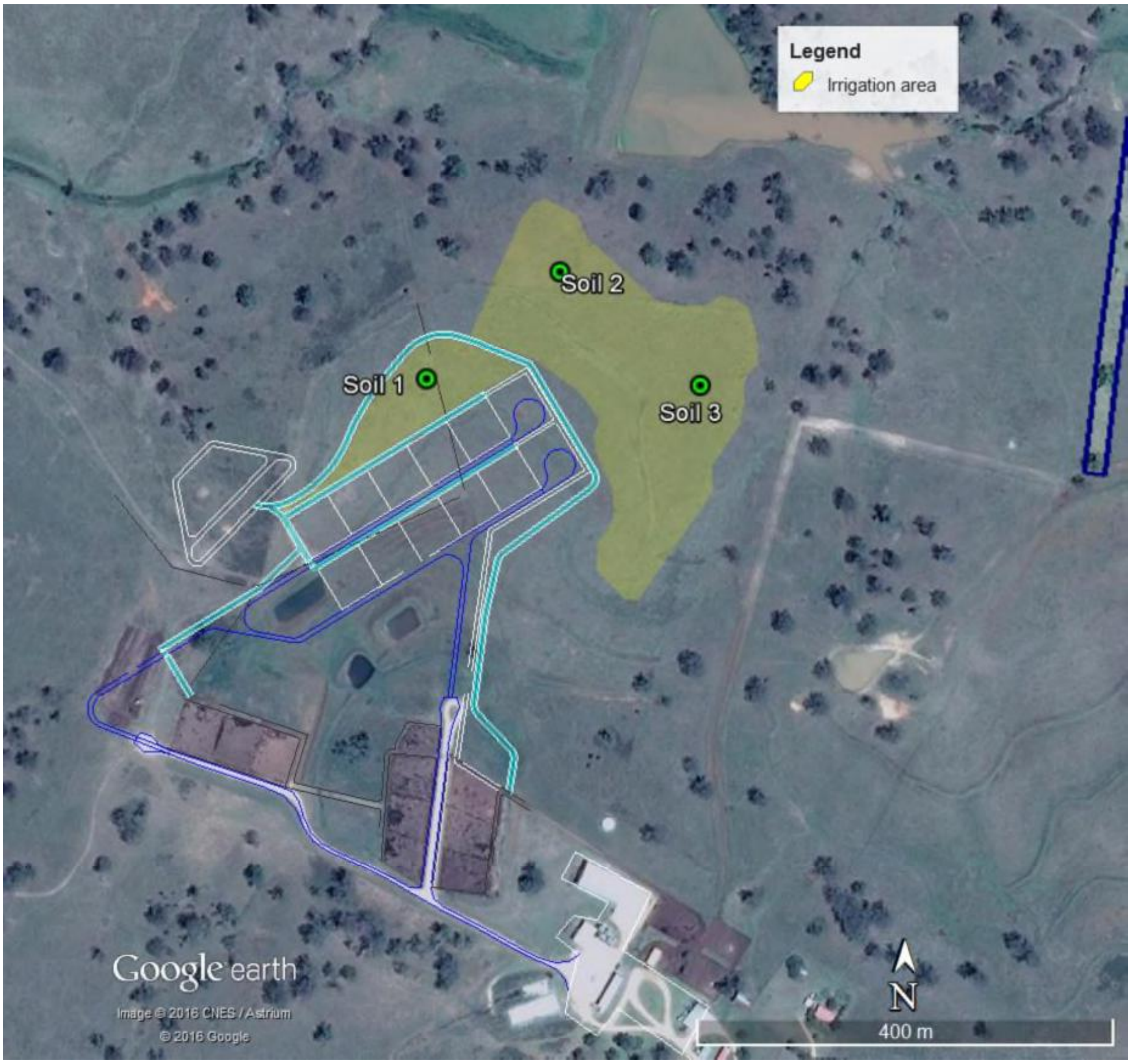

Figure 5 Map showing soil monitoring points

Table 6 Parameters and soil health values (DEC, 2004) for soil monitoring

		Soils limitation			
Parameter	**Unit**	**Nil-Slight**	**Moderate**	**Severe**	**Restriction**
Electrical conductivity	dS/m	<2	2 – 4	>4	Excess salt reduces plant growth
pH (0-30cm, pH_{CaCl2})	pH units	>6 – 7.5	3.5 – 6.0	<3.5	Reduces optimum plant growth
Cation Exchange Capacity	meq/100g	-	-	-	
Total phosphorus	mg/kg	-	-	-	
Phosphorus (Colwell)	mg/kg	-	-	-	
Phosphorus Buffering Index	mg/kg	-	-	-	
Total nitrogen	mg/kg	-	-	-	
Organic carbon	%	-	-	-	
Sulphur	%	-	-	-	
Zinc	mg/kg	-	-	-	
Manganese	mg/kg	-	-	-	
Iron	mg/kg	-	-	-	
Copper	mg/kg	-	-	-	
Chloride	mg/kg	-	-	-	
Sodium	mg/kg	-	-	-	
Potassium	mg/kg	-	-	-	
Aluminium	mg/kg	-	-	-	
Calcium exchange	%	-	-	-	
Potassium exchange	%	-	-	-	
Sodium exchange 0-30cm	%	0 – 5	5 – 10	<10	Structural degradation and waterlogging
Sodium exchange 30-60cm	%	<10	>10	-	Structural degradation and waterlogging
Magnesium exchange	%	-	-	-	

3. Manure and Effluent Monitoring

The manure and liquid effluent will be analysed annually for three years to help establish the source of contamination if it occurs. It will also help assist with nutrient and salt loading calculations and the application rates required for particular crops. The parameters tested for manure and effluent are shown in Table 7.

Table 7 Parameters for manure and effluent monitoring

Parameter	Unit	Notes
pH	pH Units	
Electrical conductivity	dS/m	
Total Dissolved Solids	mg/L	Effluent only
Total Alkalinity	mg/L	Effluent only
Chloride	mg/L	Effluent only
Nitrite	mg/L	Effluent only
Nitrate	mg/L	Effluent only
Sulfate	mg/L	Effluent only
Total nitrogen	%	Manure only
Nitrate nitrogen	mg/kg (Manure)	Manure only
Ammonia nitrogen	mg/kg (Manure)	
Aluminium	mg/kg (Manure) µg/L (Effluent)	
Boron	mg/kg (Manure) µg/L (Effluent)	
Calcium	mg/kg (Manure) µg/L (Effluent)	
Cobalt	mg/kg (Manure) µg/L (Effluent)	
Copper	mg/kg (Manure) µg/L (Effluent)	
Iron	mg/kg (Manure) µg/L (Effluent)	
Magnesium	mg/kg (Manure) µg/L (Effluent)	
Manganese	mg/kg (Manure) µg/L (Effluent)	
Molybdenum	mg/kg (Manure) µg/L (Effluent)	
Phosphorus	mg/kg (Manure) µg/L (Effluent)	
Potassium	mg/kg (Manure) µg/L (Effluent)	
Sodium	mg/kg (Manure) µg/L (Effluent)	
Sulfur	mg/kg (Manure) µg/L (Effluent)	
Zinc	mg/kg (Manure) µg/L (Effluent)	
Orthophosphate	mg/kg	Manure only
Organic carbon	%	Manure only

4. References

ANZECC & ARMCANZ (2000). *National water quality management strategy. Australian and New Zealand guidelines for fresh and marine water quality.* Australian and New Zealand Conservation Council & Agriculture, and Resource Management Council of Australia and New Zealand.

Department of Environment and Conservation (DEC) (2004). *Environmental Guidelines: Use of Effluent by Irrigation*. NSW Department of Environment and Conservation (NSW), Sydney.

NHMRC, NRMMC (2011) *Australian Drinking Water Guidelines Paper 6 National Water Quality Management Strategy.* National Health and Medical Research Council, National Resource Management Ministerial Council, Commonwealth of Australia, Canberra.

5. Appendices

Appendix A.	Historic Frazers Creek Water Analysis Results	A-1
Appendix B.	Historic Groundwater Analysis Results	B-1
Appendix C.	Historic Soil Analysis Results	C-1
Appendix D.	Historic Manure Sample Results	D-1

Appendix A. Historic Frazers Creek Water Analysis Results

SGS

ANALYTICAL REPORT

ilac-MRA

NATA

Accreditation No. 2562

CLIENT DETAILS

Contact	Lindi Oliver
Client	ENVIROAG AUSTRALIA PTY LTD
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Project	**Enviroag - Nullamanna Samples**
Order Number	**Enviroag - Nullamanna Samples**
Samples	2

LABORATORY DETAILS

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SGS Reference	**BE015493 R0**
Date Received	04 Jan 2016
Date Reported	07 Jan 2016

COMMENTS

Accredited for compliance with ISO/IEC 17025. NATA accredited laboratory 2562(20707/1706).

SIGNATORIES

CMcDermid

Caroline McDermid
Inorganics Supervisor

ANALYTICAL REPORT

BE015493 R0

Parameter	Units	LOR	BE015493.001	BE015493.002
Sample Matrix			Water	Water
Sample Date			31 Dec 2015	31 Dec 2015
Sample Name			Bore	Creek

pH in water Method: AN101 Tested: 4/1/2016

pH**	No unit	-	7.9	7.8

Conductivity and TDS by Calculation - Water Method: AN106 Tested: 4/1/2016

Conductivity @ 25 C	µS/cm	5	1800	350

Low Level Nitrate Nitrogen and Nitrite Nitrogen (NOx) by FIA Method: AN258 Tested: 5/1/2016

Nitrate, NO_3 as NO_3	mg/L	0.05	7.7	<0.05
Nitrite, NO_2 as NO_2	mg/L	0.05	<0.05	<0.05
Nitrite Nitrogen, NO_2 as N	mg/L	0.005	<0.005	<0.005
Nitrate Nitrogen, NO_3 as N	mg/L	0.005	1.7	<0.005

Ammonia Nitrogen by Discrete Analyser Method: AN280/WC250.19 Tested: 6/1/2016

Ammonia Nitrogen, NH_3 as N	mg/L	0.05	<0.05	<0.05
Ammonia, NH3	mg/L	0.05	<0.05	<0.05

TKN Kjeldahl Digestion by Discrete Analyser Method: AN281 Tested: 6/1/2016

Total Kjeldahl Nitrogen	mg/L	0.05	0.11	0.93

Calculated Nitrogen Forms - TN, organic N, inorganic N Method: AN281/292 Tested: -

Total Nitrogen (calc)	mg/L	0.05	1.9	0.94

Filterable Reactive Phosphorus (FRP) Method: AN278 Tested: 7/1/2016

Filterable Reactive Phosphorus	mg/L	0.002	0.046	0.033
Filterable Reactive Phosphorus as PO4	mg/L	0.02	0.14	0.10

Total Phosphorus by Kjeldahl Digestion DA in Water Method: AN279/AN293 Tested: 6/1/2016

Total Phosphorus (Kjeldahl Digestion)	mg/L	0.02	0.09	0.11

QC SUMMARY

MB blank results are compared to the Limit of Reporting
LCS and MS spike recoveries are measured as the percentage of analyte recovered from the sample compared the the amount of analyte spiked into the sample.
DUP and MSD relative percent differences are measured against their original counterpart samples according to the formula : *the absolute difference of the two results divided by the average of the two results as a percentage.* Where the DUP RPD is 'NA' , the results are less than the LOR and thus the RPD is not applicable.

Ammonia Nitrogen by Discrete Analyser   Method: ME-(AU)-[ENV]AN280/WC250.19

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Ammonia Nitrogen, NH_3 as N	LB023234	mg/L	0.05	<0.05	0 - 1%	85%	74%
Ammonia, NH3	LB023234	mg/L	0.05	<0.05			

Conductivity and TDS by Calculation - Water   Method: ME-(AU)-[ENV]AN106

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Conductivity @ 25 C	LB023216	µS/cm	5	<5	0%	103%

Filterable Reactive Phosphorus (FRP)   Method: ME-(AU)-[ENV]AN278

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Filterable Reactive Phosphorus	LB023272	mg/L	0.002	<0.002	0%	94%	90%
Filterable Reactive Phosphorus as PO4	LB023272	mg/L	0.02	<0.02	5%	94%	NA

Low Level Nitrate Nitrogen and Nitrite Nitrogen (NOx) by FIA   Method: ME-(AU)-[ENV]AN258

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Nitrate, NO_3 as NO_3	LB023237	mg/L	0.05	<0.05			
Nitrite, NO_2 as NO_2	LB023237	mg/L	0.05	<0.05			
Nitrite Nitrogen, NO_2 as N	LB023237	mg/L	0.005	<0.005	0%	105%	117%
Nitrate Nitrogen, NO_3 as N	LB023237	mg/L	0.005	<0.005			

pH in water   Method: ME-(AU)-[ENV]AN101

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
pH**	LB023216	No unit	-	5.8	0%	101%

TKN Kjeldahl Digestion by Discrete Analyser   Method: ME-(AU)-[ENV]AN281

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Total Kjeldahl Nitrogen	LB023225	mg/L	0.05	<0.05	2 - 3%	99 - 100%	97%

MB blank results are compared to the Limit of Reporting
LCS and MS spike recoveries are measured as the percentage of analyte recovered from the sample compared the the amount of analyte spiked into the sample.
DUP and MSD relative percent differences are measured against their original counterpart samples according to the formula : *the absolute difference of the two results divided by the average of the two results as a percentage.* Where the DUP RPD is 'NA' , the results are less than the LOR and thus the RPD is not applicable.

Total Phosphorus by Kjeldahl Digestion DA in Water   Method: ME-(AU)-[ENV]AN279/AN293

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Total Phosphorus (Kjeldahl Digestion)	LB023225	mg/L	0.02	<0.02	0 - 9%	90 - 104%	111%

METHOD	METHODOLOGY SUMMARY
AN101	pH in Soil Sludge Sediment and Water: pH is measured electrometrically using a combination electrode (glass plus reference electrode) and is calibrated against 3 buffers purchased commercially. For soils, an extract with water is made at a ratio of 1:5 and the pH determined and reported on the extract. Reference APHA 4500-H+.
AN106	Conductivity and TDS by Calculation: Conductivity is measured by meter with temperature compensation and is calibrated against a standard solution of potassium chloride. Conductivity is generally reported as µmhos/cm or µS/cm @ 25°C. For soils, an extract with water is made at a ratio of 1:5 and the EC determined and reported on the extract, or calculated back to the as-received sample. Total Dissolved Salts can be estimated from conductivity using a conversion factor, which for natural waters, is in the range 0.55 to 0.75. SGS use 0.6. Reference APHA 2510 B.
AN258	Nitrate and Nitrite by FIA: In an acidic medium, nitrate is reduced quantitatively to nitrite by cadmium metal. This nitrite plus any original nitrite is determined as an intense red-pink azo dye at 540 nm following diazotisation with sulphanilamide and subsequent coupling with N-(1-naphthyl) ethylenediamine dihydrochloride. Without the cadmium reduction only the original nitrite is determined. Reference APHA 4500-NO3- F.
AN278	Reactive Phosphorus by DA: Orthophosphate reacts with ammonium molybdate (Mo VI) and potassium antimonyl tartrate (Sb III) in acid medium to form an antimony-phosphomolybdate complex. This complex is subsequently reduced with ascorbic acid to form a blue colour and the absorbance is read at 880 nm. The sensitivity of the automated method is 10-20 times that of the macro method. Reference APHA 4500-P F
AN279/AN293	The sample is digested with Sulphuric acid, K_2SO_4 and $CuSO_4$. All forms of phosphorus are converted into orthophosphate. The digest is cooled and placed on the discrete analyser for colorimetric analysis.
AN280/WC250.19	A filtered water sample containing ammonia (NH_3) or ammonium cations (NH_4^+) is reacted with alkaline phenol and hypochlorite in a buffered solution to form the blue indophenol colour. The absorbance is measured at 630nm and compared with calibration standards to obtain the concentration of ammonia in the sample.
AN281	An unfiltered water or soil sample is first digested in a block digestor with sulfuric acid, K_2SO_4 and $CuSO_4$. The ammonia produced following digestion is then measured colourimetrically using the Aquakem 250 Discrete Analyser. A portion of the digested sample is buffered to an alkaline pH, and interfering cations are complexed. The ammonia then reacts with salicylate and hypochlorite to give a blue colour whose absorbance is measured at 660nm and compared with calibration standards. This is proportional to the concentration of Total Kjeldahl Nitrogen in the original sample.
AN281/292	Calculation of total nitrogen and organic nitrogen.

FOOTNOTES

IS	Insufficient sample for analysis.	LOR	Limit of Reporting
LNR	Sample listed, but not received.	↑↓	Raised or Lowered Limit of Reporting
*	NATA accreditation does not cover the performance of this service.	QFH	QC result is above the upper tolerance
**	Indicative data, theoretical holding time exceeded.	QFL	QC result is below the lower tolerance
		-	The sample was not analysed for this analyte
		NVL	Not Validated

Samples analysed as received.
Solid samples expressed on a dry weight basis.

Where "Total" analyte groups are reported (for example, Total PAHs, Total OC Pesticides) the total will be calculated as the sum of the individual analytes, with those analytes that are reported as <LOR being assumed to be zero. The summed (Total) limit of reporting is calcuated by summing the individual analyte LORs and dividing by two. For example, where 16 individual analytes are being summed and each has an LOR of 0.1 mg/kg, the "Totals" LOR will be 1.6 / 2 (0.8 mg/kg). Where only 2 analytes are being summed, the " Total" LOR will be the sum of those two LORs.

Some totals may not appear to add up because the total is rounded after adding up the raw values.

The QC criteria are subject to internal review according to the SGS QAQC plan and may be provided on request or alternatively can be found here: http://www.sgs.com.au/~/media/Local/Australia/Documents/Technical%20Documents/MP-AU-ENV-QU-022%20QA%20QC%20Plan.pdf

Appendix B. Historic Groundwater Analysis Results

SGS

ANALYTICAL REPORT

ilac-MRA

NATA

Accreditation No. 2562

CLIENT DETAILS

Contact	Lindi Oliver
Client	ENVIROAG AUSTRALIA PTY LTD
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Project	**Enviroag - Nullamanna Samples**
Order Number	**Enviroag - Nullamanna Samples**
Samples	2

LABORATORY DETAILS

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SGS Reference	**BE015493 R0**
Date Received	04 Jan 2016
Date Reported	07 Jan 2016

COMMENTS

Accredited for compliance with ISO/IEC 17025. NATA accredited laboratory 2562(20707/1706).

SIGNATORIES

Caroline McDermid
Inorganics Supervisor

ANALYTICAL REPORT

BE015493 R0

Parameter	Units	LOR	Sample Number: BE015493.001 Sample Matrix: Water Sample Date: 31 Dec 2015 Sample Name: Bore	Sample Number: BE015493.002 Sample Matrix: Water Sample Date: 31 Dec 2015 Sample Name: Creek
pH in water Method: AN101 Tested: 4/1/2016				
pH**	No unit	-	7.9	7.8
Conductivity and TDS by Calculation - Water Method: AN106 Tested: 4/1/2016				
Conductivity @ 25 C	µS/cm	5	1800	350
Low Level Nitrate Nitrogen and Nitrite Nitrogen (NOx) by FIA Method: AN258 Tested: 5/1/2016				
Nitrate, NO_3 as NO_3	mg/L	0.05	7.7	<0.05
Nitrite, NO_2 as NO_2	mg/L	0.05	<0.05	<0.05
Nitrite Nitrogen, NO_2 as N	mg/L	0.005	<0.005	<0.005
Nitrate Nitrogen, NO_3 as N	mg/L	0.005	1.7	<0.005
Ammonia Nitrogen by Discrete Analyser Method: AN280/WC250.19 Tested: 6/1/2016				
Ammonia Nitrogen, NH_3 as N	mg/L	0.05	<0.05	<0.05
Ammonia, NH3	mg/L	0.05	<0.05	<0.05
TKN Kjeldahl Digestion by Discrete Analyser Method: AN281 Tested: 6/1/2016				
Total Kjeldahl Nitrogen	mg/L	0.05	0.11	0.93
Calculated Nitrogen Forms - TN, organic N, inorganic N Method: AN281/292 Tested: -				
Total Nitrogen (calc)	mg/L	0.05	1.9	0.94
Filterable Reactive Phosphorus (FRP) Method: AN278 Tested: 7/1/2016				
Filterable Reactive Phosphorus	mg/L	0.002	0.046	0.033
Filterable Reactive Phosphorus as PO4	mg/L	0.02	0.14	0.10
Total Phosphorus by Kjeldahl Digestion DA in Water Method: AN279/AN293 Tested: 6/1/2016				
Total Phosphorus (Kjeldahl Digestion)	mg/L	0.02	0.09	0.11

MB blank results are compared to the Limit of Reporting
LCS and MS spike recoveries are measured as the percentage of analyte recovered from the sample compared the the amount of analyte spiked into the sample.
DUP and MSD relative percent differences are measured against their original counterpart samples according to the formula : *the absolute difference of the two results divided by the average of the two results as a percentage.* Where the DUP RPD is 'NA' , the results are less than the LOR and thus the RPD is not applicable.

Ammonia Nitrogen by Discrete Analyser Method: ME-(AU)-[ENV]AN280/WC250.19

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Ammonia Nitrogen, NH_3 as N	LB023234	mg/L	0.05	<0.05	0 - 1%	85%	74%
Ammonia, NH3	LB023234	mg/L	0.05	<0.05			

Conductivity and TDS by Calculation - Water Method: ME-(AU)-[ENV]AN106

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Conductivity @ 25 C	LB023216	µS/cm	5	<5	0%	103%

Filterable Reactive Phosphorus (FRP) Method: ME-(AU)-[ENV]AN278

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Filterable Reactive Phosphorus	LB023272	mg/L	0.002	<0.002	0%	94%	90%
Filterable Reactive Phosphorus as PO4	LB023272	mg/L	0.02	<0.02	5%	94%	NA

Low Level Nitrate Nitrogen and Nitrite Nitrogen (NOx) by FIA Method: ME-(AU)-[ENV]AN258

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Nitrate, NO_3 as NO_3	LB023237	mg/L	0.05	<0.05			
Nitrite, NO_2 as NO_2	LB023237	mg/L	0.05	<0.05			
Nitrite Nitrogen, NO_2 as N	LB023237	mg/L	0.005	<0.005	0%	105%	117%
Nitrate Nitrogen, NO_3 as N	LB023237	mg/L	0.005	<0.005			

pH in water Method: ME-(AU)-[ENV]AN101

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
pH**	LB023216	No unit	-	5.8	0%	101%

TKN Kjeldahl Digestion by Discrete Analyser Method: ME-(AU)-[ENV]AN281

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Total Kjeldahl Nitrogen	LB023225	mg/L	0.05	<0.05	2 - 3%	99 - 100%	97%

MB blank results are compared to the Limit of Reporting
LCS and MS spike recoveries are measured as the percentage of analyte recovered from the sample compared the the amount of analyte spiked into the sample.
DUP and MSD relative percent differences are measured against their original counterpart samples according to the formula : *the absolute difference of the two results divided by the average of the two results as a percentage.* Where the DUP RPD is 'NA' , the results are less than the LOR and thus the RPD is not applicable.

Total Phosphorus by Kjeldahl Digestion DA in Water   Method: ME-(AU)-[ENV]AN279/AN293

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Total Phosphorus (Kjeldahl Digestion)	LB023225	mg/L	0.02	<0.02	0 - 9%	90 - 104%	111%

METHOD	METHODOLOGY SUMMARY
AN101	pH in Soil Sludge Sediment and Water: pH is measured electrometrically using a combination electrode (glass plus reference electrode) and is calibrated against 3 buffers purchased commercially. For soils, an extract with water is made at a ratio of 1:5 and the pH determined and reported on the extract. Reference APHA 4500-H+.
AN106	Conductivity and TDS by Calculation: Conductivity is measured by meter with temperature compensation and is calibrated against a standard solution of potassium chloride. Conductivity is generally reported as µmhos/cm or µS/cm @ 25°C. For soils, an extract with water is made at a ratio of 1:5 and the EC determined and reported on the extract, or calculated back to the as-received sample. Total Dissolved Salts can be estimated from conductivity using a conversion factor, which for natural waters, is in the range 0.55 to 0.75. SGS use 0.6. Reference APHA 2510 B.
AN258	Nitrate and Nitrite by FIA: In an acidic medium, nitrate is reduced quantitatively to nitrite by cadmium metal. This nitrite plus any original nitrite is determined as an intense red-pink azo dye at 540 nm following diazotisation with sulphanilamide and subsequent coupling with N-(1-naphthyl) ethylenediamine dihydrochloride. Without the cadmium reduction only the original nitrite is determined. Reference APHA 4500-NO3- F.
AN278	Reactive Phosphorus by DA: Orthophosphate reacts with ammonium molybdate (Mo VI) and potassium antimonyl tartrate (Sb III) in acid medium to form an antimony-phosphomolybdate complex. This complex is subsequently reduced with ascorbic acid to form a blue colour and the absorbance is read at 880 nm. The sensitivity of the automated method is 10-20 times that of the macro method. Reference APHA 4500-P F
AN279/AN293	The sample is digested with Sulphuric acid, K2SO4 and CuSO4. All forms of phosphorus are converted into orthophosphate. The digest is cooled and placed on the discrete analyser for colorimetric analysis.
AN280/WC250.19	A filtered water sample containing ammonia (NH3) or ammonium cations (NH4+) is reacted with alkaline phenol and hypochlorite in a buffered solution to form the blue indophenol colour. The absorbance is measured at 630nm and compared with calibration standards to obtain the concentration of ammonia in the sample.
AN281	An unfiltered water or soil sample is first digested in a block digestor with sulfuric acid, K2SO4 and CuSO4. The ammonia produced following digestion is then measured colourimetrically using the Aquakem 250 Discrete Analyser. A portion of the digested sample is buffered to an alkaline pH, and interfering cations are complexed. The ammonia then reacts with salicylate and hypochlorite to give a blue colour whose absorbance is measured at 660nm and compared with calibration standards. This is proportional to the concentration of Total Kjeldahl Nitrogen in the original sample.
AN281/292	Calculation of total nitrogen and organic nitrogen.

FOOTNOTES

IS	Insufficient sample for analysis.	LOR	Limit of Reporting
LNR	Sample listed, but not received.	↑↓	Raised or Lowered Limit of Reporting
*	NATA accreditation does not cover the performance of this service.	QFH	QC result is above the upper tolerance
**	Indicative data, theoretical holding time exceeded.	QFL	QC result is below the lower tolerance
		-	The sample was not analysed for this analyte
		NVL	Not Validated

Samples analysed as received.
Solid samples expressed on a dry weight basis.

Where "Total" analyte groups are reported (for example, Total PAHs, Total OC Pesticides) the total will be calculated as the sum of the individual analytes, with those analytes that are reported as <LOR being assumed to be zero. The summed (Total) limit of reporting is calcuated by summing the individual analyte LORs and dividing by two. For example, where 16 individual analytes are being summed and each has an LOR of 0.1 mg/kg, the "Totals" LOR will be 1.6 / 2 (0.8 mg/kg). Where only 2 analytes are being summed, the " Total" LOR will be the sum of those two LORs.

Some totals may not appear to add up because the total is rounded after adding up the raw values.

The QC criteria are subject to internal review according to the SGS QAQC plan and may be provided on request or alternatively can be found here: http://www.sgs.com.au/~/media/Local/Australia/Documents/Technical%20Documents/MP-AU-ENV-QU-022%20QA%20QC%20Plan.pdf

SGS

CTW.2602214

Certificate of Analysis

This is to certify that the undermentioned sample(s) were analysed and this certificate was issued at SGS Agritech, 214 McDougall St., Toowoomba QLD 4350. Phone: 0011+61+7+46330599. NATA accredited laboratory 2120.

APPLICANT:	NULLAMANNA FEEDLOT PTY LTD NULLAMNNA STATION INVERELL NSW 2360		
SAMPLE NUMBER:	2006007049	**SAMPLE(S) RECEIVED:**	28 April 2006
COMMODITY:	Water	**CERTIFICATE ISSUED:**	10 May 2006
MARKINGS:			

TEST IDENTITY	RESULT	UNITS	METHOD
Total Dissolved Solids	1506.0	mg/L	TDS001
Chloride	358.73	mg/L	ANL001
Nitrate	12.37	mg/L	ANL001
Fluoride	0.34	mg/L	ANL001
Sulphate	33.33	mg/L	ANL001
Nitrite	<0.010	mg/L	ANL001
Phosphate	<0.010	mg/L	ANL001
pH	7.7	pH	WAT001
Electrical Conductivity	2473	µS/cm	WAT003
Total Nitrogen	4.4	mg/L	TOT001
Aluminium	<0.1	mg/L	MIN001
Boron	0.030	mg/L	MIN001
Calcium	87	mg/L	MIN001
Copper	<0.01	mg/L	MIN001
Iron	<0.01	mg/L	MIN001
Potassium	2.7	mg/L	MIN001
Magnesium	180	mg/L	MIN001
Manganese	<0.01	mg/L	MIN001
Molybdenum	<0.05	mg/L	MIN001
Sodium	310	mg/L	MIN001
Phosphorus	<1	mg/L	MIN001
Sulphur	14	mg/L	MIN001
Zinc	0.030	mg/L	MIN001
E coli in Water	<1	CFU/100mL	COL004
Total Kjeldahl Nitrogen	1.61	mg/L	

Note: < is Less Than.

Diana Abbott

Diana Abbott
Manager
For and on behalf of
SGS Australia Pty Ltd

The results apply only to the sample analysed. The sample on which the test was performed was not collected by or on behalf of SGS Agritech. This certificate is discrete and can only be reproduced in full. The analysis was performed between 28/04/2006 and 10/05/2006

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Certificate of Analysis

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APPLICANT: NULLAMANNA FEEDLOT PTY LTD
NULLAMNNA STATION
INVERELL NSW 2360

SAMPLE NUMBER: 2006007049 **SAMPLE(S) RECEIVED:** 28 April 2006

COMMODITY: Water **CERTIFICATE ISSUED:** 04 May 2006

MARKINGS:

TEST IDENTITY	RESULT	UNITS	METHOD
E coli in Water	<1	CFU/100mL	COL004

Note: < is Less Than.
CFU - Colony Forming Units.

Robert Lascelles
Chief Chemist
For and on behalf of
SGS Australia Pty Ltd

The results apply only to the sample analysed. The sample on which the test was performed was not collected by or on behalf of SGS Agritech. This certificate is discrete and can only be reproduced in full. The analysis was performed between 28/04/2006 and 4/05/2006

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Appendix C. Historic Soil Analysis Results

Report of Analysis

BA010829.001

Revision 1

Client:		**Job Number:**	BA010829
	ENVIROAG AUSTRALIA PTY LTD	**Report Date:**	24-05-2016
	PO BOX 1775	**Received:**	05-05-2016
	ARMIDALE NSW 2350	**Sampled:**	05-05-2016
		Sample Type:	
		Order Number:	Nullamanna Feedlot 23876

Description: Soil

Sample Identification: 10263

This document annuls and replaces any previous documents with the same number. The previous document should be destroyed or returned to the laboratory.

Analysis	Unit	Result	Method	Det.Lim.
ACIDITY				
pH - Water	pH units	5.93	SOL003/1/1	0.01
pH - CaCl2	pH units	5.38	SOL003/1/2	0.01
MAJOR ELEMENTS				
Nitrogen	mg/kg	<300	PRN002	300
Potassium	mg/kg	272	SOL060	1
Phosphorus - Colwell extr	mg/kg	25	SOL040/SOL090	1
SECONDARY ELEMENTS				
Calcium	mg/kg	2840	SOL060	1
Magnesium	mg/kg	1620	SOL060	1
Aluminium	mg/kg	<1	SOL061	1
Sulphur - KCl	mg/kg	7.4	SOL130	0.1
TRACE ELEMENTS				
Copper	mg/kg	2.8	SOL070	0.1
Zinc	mg/kg	1.1	SOL070	0.1
Manganese	mg/kg	140	SOL070	1.0
Iron	mg/kg	77	SOL070	1.0
ORGANIC MATTER				
Organic Carbon	%	0.7	SOL051	0.3
Organic Matter	%	1.4	SOL051	0.1
SALINITY				
Electrical Conductivity	dS/m	0.06	SOL007/2/2	0.01
Chloride	mg/kg	13	SOL012/SOL030	1
Sodium	mg/kg	176	SOL060	1
EXCHANGEABLE CATIONS				
Cation Exchange	meq/100g	29.2	SOL060	0.01
Exchangeable Sodium	meq/100g	0.76	SOL060	0.01
Exchangeable Sodium Percent	%	2.6	SOL060	0.1
Exchangeable Potassium	meq/100g	0.70	SOL060	0.01
Exchangeable Potassium Percent	%	2.4	SOL060	0.1
Exchangeable Calcium	meq/100g	14.2	SOL060	0.01
Exchangeable Calcium Percent	%	48.7	SOL060	0.1
Exchangeable Magnesium	meq/100g	13.5	SOL060	0.01
Exchangeable Magnesium Percent	%	46.3	SOL060	0.1
Exchangeable Aluminium	meq/100g	Not Applicable	SOL060	0.01
Exchangeable Aluminium Percent	%	Not Applicable	SOL060	0.1
Calcium/Magnesium Ratio		1.05	SOL060	0.01
OTHER				
Total Phosphorus	mg/kg	602	MIN001	1

Data Start/End Analysis : 05/05/2016 - 24/05/2016

Results are on an 'air dried' basis.

Revision issued due to addition of Phosphorus - Colwell extr.

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Mark Ayers - Production Supervisor

For and on behalf of SGS Australia Pty Ltd

Report of Analysis

BA010829.002

Revision 1

Client:		**Job Number:**	BA010829
	ENVIROAG AUSTRALIA PTY LTD	**Report Date:**	24-05-2016
	PO BOX 1775	**Received:**	05-05-2016
	ARMIDALE NSW 2350	**Sampled:**	05-05-2016
		Sample Type:	
		Order Number:	Nullamanna Feedlot 23876
Description:	Soil		
Sample Identification:	10264		

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Analysis	Unit	Result	Method	Det.Lim.
ACIDITY				
pH - Water	pH units	6.91	SOL003/1/1	0.01
pH - CaCl2	pH units	6.59	SOL003/1/2	0.01
MAJOR ELEMENTS				
Nitrogen	mg/kg	360	PRN002	300
Potassium	mg/kg	155	SOL060	1
Phosphorus - Colwell extr	mg/kg	<1	SOL040/SOL090	1
SECONDARY ELEMENTS				
Calcium	mg/kg	3560	SOL060	1
Magnesium	mg/kg	2450	SOL060	1
Aluminium	mg/kg	<1	SOL061	1
Sulphur - KCl	mg/kg	7.6	SOL130	0.1
TRACE ELEMENTS				
Copper	mg/kg	0.8	SOL070	0.1
Zinc	mg/kg	0.2	SOL070	0.1
Manganese	mg/kg	22	SOL070	1.0
Iron	mg/kg	19	SOL070	1.0
ORGANIC MATTER				
Organic Carbon	%	1.6	SOL051	0.3
Organic Matter	%	3.6	SOL051	0.1
SALINITY				
Electrical Conductivity	dS/m	0.09	SOL007/2/2	0.01
Chloride	mg/kg	54	SOL012/SOL030	1
Sodium	mg/kg	147	SOL060	1
EXCHANGEABLE CATIONS				
Cation Exchange	meq/100g	39.2	SOL060	0.01
Exchangeable Sodium	meq/100g	0.64	SOL060	0.01
Exchangeable Sodium Percent	%	1.6	SOL060	0.1
Exchangeable Potassium	meq/100g	0.40	SOL060	0.01
Exchangeable Potassium Percent	%	1.0	SOL060	0.1
Exchangeable Calcium	meq/100g	17.8	SOL060	0.01
Exchangeable Calcium Percent	%	45.3	SOL060	0.1
Exchangeable Magnesium	meq/100g	20.4	SOL060	0.01
Exchangeable Magnesium Percent	%	52.0	SOL060	0.1
Exchangeable Aluminium	meq/100g	Not Applicable	SOL060	0.01
Exchangeable Aluminium Percent	%	Not Applicable	SOL060	0.1
Calcium/Magnesium Ratio		0.87	SOL060	0.01
OTHER				
Total Phosphorus	mg/kg	230	MIN001	1

Data Start/End Analysis : 05/05/2016 - 24/05/2016

Results are on an 'air dried' basis.
Revision issued due to addition of Phosphorus - Colwell extr.

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Mark Ayers - Production Supervisor

For and on behalf of SGS Australia Pty Ltd

Report of Analysis

BA010829.003

Revision 1

Client:	**Job Number:** BA010829
ENVIROAG AUSTRALIA PTY LTD	**Report Date:** 24-05-2016
PO BOX 1775	**Received:** 05-05-2016
ARMIDALE NSW 2350	**Sampled:** 05-05-2016
	Sample Type:
	Order Number: Nullamanna Feedlot 23876

Description: Soil

Sample Identification: 10265

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Analysis	Unit	Result	Method	Det.Lim.
ACIDITY				
pH - Water	pH units	6.52	SOL003/1/1	0.01
pH - CaCl2	pH units	6.05	SOL003/1/2	0.01
MAJOR ELEMENTS				
Nitrogen	mg/kg	<300	PRN002	300
Potassium	mg/kg	225	SOL060	1
Phosphorus - Colwell extr	mg/kg	25	SOL040/SOL090	1
SECONDARY ELEMENTS				
Calcium	mg/kg	3710	SOL060	1
Magnesium	mg/kg	2570	SOL060	1
Aluminium	mg/kg	<1	SOL061	1
Sulphur - KCl	mg/kg	7.0	SOL130	0.1
TRACE ELEMENTS				
Copper	mg/kg	2.0	SOL070	0.1
Zinc	mg/kg	1.0	SOL070	0.1
Manganese	mg/kg	67	SOL070	1.0
Iron	mg/kg	44	SOL070	1.0
ORGANIC MATTER				
Organic Carbon	%	1.1	SOL051	0.3
Organic Matter	%	2.4	SOL051	0.1
SALINITY				
Electrical Conductivity	dS/m	0.07	SOL007/2/2	0.01
Chloride	mg/kg	11	SOL012/SOL030	1
Sodium	mg/kg	64	SOL060	1
EXCHANGEABLE CATIONS				
Cation Exchange	meq/100g	40.8	SOL060	0.01
Exchangeable Sodium	meq/100g	0.28	SOL060	0.01
Exchangeable Sodium Percent	%	0.7	SOL060	0.1
Exchangeable Potassium	meq/100g	0.58	SOL060	0.01
Exchangeable Potassium Percent	%	1.4	SOL060	0.1
Exchangeable Calcium	meq/100g	18.5	SOL060	0.01
Exchangeable Calcium Percent	%	45.4	SOL060	0.1
Exchangeable Magnesium	meq/100g	21.4	SOL060	0.01
Exchangeable Magnesium Percent	%	52.5	SOL060	0.1
Exchangeable Aluminium	meq/100g	Not Applicable	SOL060	0.01
Exchangeable Aluminium Percent	%	Not Applicable	SOL060	0.1
Calcium/Magnesium Ratio		0.87	SOL060	0.01
OTHER				
Total Phosphorus	mg/kg	539	MIN001	1

Data Start/End Analysis : 05/05/2016 - 24/05/2016

Results are on an 'air dried' basis.

Revision issued due to addition of Phosphorus - Colwell extr.

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Mark Ayers - Production Supervisor

For and on behalf of SGS Australia Pty Ltd

Report of Analysis

BA010829.004

Revision 1

Client:		**Job Number:**	BA010829
ENVIROAG AUSTRALIA PTY LTD		**Report Date:**	24-05-2016
PO BOX 1775		**Received:**	05-05-2016
ARMIDALE NSW 2350		**Sampled:**	05-05-2016
		Sample Type:	
		Order Number:	Nullamanna Feedlot 23876
Description:	Soil		
Sample Identification:	10266		

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Analysis	Unit	Result	Method	Det.Lim.
ACIDITY				
pH - Water	pH units	7.41	SOL003/1/1	0.01
pH - CaCl2	pH units	6.40	SOL003/1/2	0.01
MAJOR ELEMENTS				
Nitrogen	mg/kg	<300	PRN002	300
Potassium	mg/kg	151	SOL060	1
Phosphorus - Colwell extr	mg/kg	<1	SOL040/SOL090	1
SECONDARY ELEMENTS				
Calcium	mg/kg	3240	SOL060	1
Magnesium	mg/kg	2720	SOL060	1
Aluminium	mg/kg	<1	SOL061	1
Sulphur - KCl	mg/kg	2.9	SOL130	0.1
TRACE ELEMENTS				
Copper	mg/kg	0.8	SOL070	0.1
Zinc	mg/kg	0.2	SOL070	0.1
Manganese	mg/kg	21	SOL070	1.0
Iron	mg/kg	25	SOL070	1.0
ORGANIC MATTER				
Organic Carbon	%	0.9	SOL051	0.3
Organic Matter	%	1.9	SOL051	0.1
SALINITY				
Electrical Conductivity	dS/m	0.04	SOL007/2/2	0.01
Chloride	mg/kg	<1	SOL012/SOL030	1
Sodium	mg/kg	151	SOL060	1
EXCHANGEABLE CATIONS				
Cation Exchange	meq/100g	39.9	SOL060	0.01
Exchangeable Sodium	meq/100g	0.66	SOL060	0.01
Exchangeable Sodium Percent	%	1.6	SOL060	0.1
Exchangeable Potassium	meq/100g	0.39	SOL060	0.01
Exchangeable Potassium Percent	%	1.0	SOL060	0.1
Exchangeable Calcium	meq/100g	16.2	SOL060	0.01
Exchangeable Calcium Percent	%	40.6	SOL060	0.1
Exchangeable Magnesium	meq/100g	22.6	SOL060	0.01
Exchangeable Magnesium Percent	%	56.8	SOL060	0.1
Exchangeable Aluminium	meq/100g	Not Applicable	SOL060	0.01
Exchangeable Aluminium Percent	%	Not Applicable	SOL060	0.1
Calcium/Magnesium Ratio		0.71	SOL060	0.01
OTHER				
Total Phosphorus	mg/kg	209	MIN001	1

Data Start/End Analysis : 05/05/2016 - 24/05/2016

Results are on an 'air dried' basis.

Revision issued due to addition of Phosphorus - Colwell extr.

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Mark Ayers - Production Supervisor

For and on behalf of SGS Australia Pty Ltd

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Report of Analysis

BA010829.005

Revision 1

Client:		**Job Number:**	BA010829
ENVIROAG AUSTRALIA PTY LTD		**Report Date:**	24-05-2016
PO BOX 1775		**Received:**	05-05-2016
ARMIDALE NSW 2350		**Sampled:**	05-05-2016
		Sample Type:	
		Order Number:	Nullamanna Feedlot 23876
Description:	Soil		
Sample Identification:	10267		

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Analysis	Unit	Result	Method	Det.Lim.
ACIDITY				
pH - Water	pH units	6.19	SOL003/1/1	0.01
pH - CaCl2	pH units	5.37	SOL003/1/2	0.01
MAJOR ELEMENTS				
Nitrogen	mg/kg	<300	PRN002	300
Potassium	mg/kg	245	SOL060	1
Phosphorus - Colwell extr	mg/kg	16	SOL040/SOL090	1
SECONDARY ELEMENTS				
Calcium	mg/kg	3380	SOL060	1
Magnesium	mg/kg	2470	SOL060	1
Aluminium	mg/kg	1	SOL061	1
Sulphur - KCl	mg/kg	4.0	SOL130	0.1
TRACE ELEMENTS				
Copper	mg/kg	2.5	SOL070	0.1
Zinc	mg/kg	0.8	SOL070	0.1
Manganese	mg/kg	110	SOL070	1.0
Iron	mg/kg	74	SOL070	1.0
ORGANIC MATTER				
Organic Carbon	%	1.1	SOL051	0.3
Organic Matter	%	2.4	SOL051	0.1
SALINITY				
Electrical Conductivity	dS/m	0.04	SOL007/2/2	0.01
Chloride	mg/kg	18	SOL012/SOL030	1
Sodium	mg/kg	84	SOL060	1
EXCHANGEABLE CATIONS				
Cation Exchange	meq/100g	38.5	SOL060	0.01
Exchangeable Sodium	meq/100g	0.37	SOL060	0.01
Exchangeable Sodium Percent	%	1.0	SOL060	0.1
Exchangeable Potassium	meq/100g	0.63	SOL060	0.01
Exchangeable Potassium Percent	%	1.6	SOL060	0.1
Exchangeable Calcium	meq/100g	16.9	SOL060	0.01
Exchangeable Calcium Percent	%	43.9	SOL060	0.1
Exchangeable Magnesium	meq/100g	20.6	SOL060	0.01
Exchangeable Magnesium Percent	%	53.5	SOL060	0.1
Exchangeable Aluminium	meq/100g	Not Applicable	SOL060	0.01
Exchangeable Aluminium Percent	%	Not Applicable	SOL060	0.1
Calcium/Magnesium Ratio		0.82	SOL060	0.01
OTHER				
Total Phosphorus	mg/kg	595	MIN001	1

Data Start/End Analysis : 05/05/2016 - 24/05/2016

Results are on an 'air dried' basis.

Revision issued due to addition of Phosphorus - Colwell extr.

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Mark Ayers - Production Supervisor

For and on behalf of SGS Australia Pty Ltd

Report of Analysis

BA010829.006

Revision 1

Client:		**Job Number:**	BA010829	
	ENVIROAG AUSTRALIA PTY LTD	**Report Date:**	24-05-2016	**Page 11/12**
	PO BOX 1775	**Received:**	05-05-2016	
	ARMIDALE NSW 2350	**Sampled:**	05-05-2016	
		Sample Type:		
		Order Number:	Nullamanna Feedlot 23876	
Description:	Soil			
Sample Identification:	10268			

This document annuls and replaces any previous documents with the same number. The previous document should be destroyed or returned to the laboratory.

Analysis	Unit	Result	Method	Det.Lim.
ACIDITY				
pH - Water	pH units	6.72	SOL003/1/1	0.01
pH - CaCl2	pH units	6.54	SOL003/1/2	0.01
MAJOR ELEMENTS				
Nitrogen	mg/kg	<300	PRN002	300
Potassium	mg/kg	131	SOL060	1
Phosphorus - Colwell extr	mg/kg	1	SOL040/SOL090	1
SECONDARY ELEMENTS				
Calcium	mg/kg	3180	SOL060	1
Magnesium	mg/kg	3540	SOL060	1
Aluminium	mg/kg	<1	SOL061	1
Sulphur - KCl	mg/kg	2.3	SOL130	0.1
TRACE ELEMENTS				
Copper	mg/kg	1.0	SOL070	0.1
Zinc	mg/kg	0.2	SOL070	0.1
Manganese	mg/kg	57	SOL070	1.0
Iron	mg/kg	38	SOL070	1.0
ORGANIC MATTER				
Organic Carbon	%	0.9	SOL051	0.3
Organic Matter	%	2.1	SOL051	0.1
SALINITY				
Electrical Conductivity	dS/m	0.03	SOL007/2/2	0.01
Chloride	mg/kg	4	SOL012/SOL030	1
Sodium	mg/kg	274	SOL060	1
EXCHANGEABLE CATIONS				
Cation Exchange	meq/100g	46.9	SOL060	0.01
Exchangeable Sodium	meq/100g	1.19	SOL060	0.01
Exchangeable Sodium Percent	%	2.5	SOL060	0.1
Exchangeable Potassium	meq/100g	0.34	SOL060	0.01
Exchangeable Potassium Percent	%	0.7	SOL060	0.1
Exchangeable Calcium	meq/100g	15.9	SOL060	0.01
Exchangeable Calcium Percent	%	33.9	SOL060	0.1
Exchangeable Magnesium	meq/100g	29.5	SOL060	0.01
Exchangeable Magnesium Percent	%	62.9	SOL060	0.1
Exchangeable Aluminium	meq/100g	Not Applicable	SOL060	0.01
Exchangeable Aluminium Percent	%	Not Applicable	SOL060	0.1
Calcium/Magnesium Ratio		0.54	SOL060	0.01
OTHER				
Total Phosphorus	mg/kg	204	MIN001	1

Data Start/End Analysis : 05/05/2016 - 24/05/2016

Results are on an 'air dried' basis.

Revision issued due to addition of Phosphorus - Colwell extr.

This document annuls and replaces any previous documents with the same number. The previous document should be destroyed or returned to the laboratory.

The analyses presented in the report refer exclusively to the samples analysed.

The presented report can only be reproduced in its entirety.

Mark Ayers - Production Supervisor

For and on behalf of SGS Australia Pty Ltd

Appendix D. Historic Manure Sample Results

SGS

Certificate of Analysis

BA010830

Client:
ENVIROAG AUSTRALIA PTY LTD
PO BOX 1775
ARMIDALE NSW 2350

Order Number: Nullamanna Feedlot 23876
Report Date: 20-May-2016
Received Date: 05-May-2016

Analysis	Unit	BA010830.001 10269 Manure			
Nitrate Nitrogen	mg/kg	<45			
Chloride	%	0.435			
pH - Water	pH units	7.94			
Electrical Conductivity	dS/m	1.92			
Moisture	%	7.2			
Nitrogen	%	1.3			
Calcium	%	2.3			
Magnesium	%	0.88			
Phosphorus	%	0.46			
Potassium	%	1.3			
Sulphur	%	0.43			
Organic Carbon - Ignition	%	25.5			

Results are on a 'dry matter' basis.

Analysed Between 05/05/2016 - 20/05/2016

Method of Analysis

Analysis	Unit	Det.Lim.	Method
Moisture	%	0.1	MST001
pH - Water	pH units	0.01	SOL001/SOL002/SOL003
Electrical Conductivity	dS/m	0.01	SOL001/SOL002/SOL003
Nitrogen	%	0.1	PRN002
Calcium	%	0.01	MIN001
Magnesium	%	0.01	MIN001
Phosphorus	%	0.01	MIN001
Potassium	%	0.01	MIN001
Sulphur	%	0.01	MIN001
Nitrate Nitrogen	mg/kg	45	
Chloride	%	0.005	
Organic Carbon - Ignition	%	0.1	SOL050

Sample Method Summary

	Anions in manure, feeds and plants using Discrete Analyser
AMM001	Ammonia in Soild Samples Dry Matter (AMM001)
ANL006	Moisture and/or Ash by Leco TGA
MIN001	Minerals in Solid Sample (Feed/Silage/Hay etc.) Dry Matter (MIN001)
MST001	Two Stage Moisture Calculations
PRN002	Leco Nitrogen (PRN002)
SOL001/SOL002/SOL003	pH-EC in Solid Sample. (SOL001/SOL002/SOL003)
SOL050	Organic Matter Calculation by Ignition (SOL050)

Certificate of Analysis

BA010830

The analyses presented in the report refer exclusively to the samples analysed.

The presented report can only be reproduced in its entirety.

Mark Ayers - Production Supervisor

For and on behalf of SGS Australia Pty Ltd

Attachment 5: Updated Soil and Land Capability Assessment

~ Commercial-in-Confidence ~

Soils Survey and Land Capability Assessment

Nullamanna Feedlot Expansion

Report Number 23876.81961

Prepared for

NULLAMANNA STATION

Nullamanna Station

1633 Nullamanna Road
Nullamanna NSW 2360
Telephone: 0428 539 163

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Prepared by

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Document Status Record

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Client: Nullamanna Station

Project Document Number: 23876.81961

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Revision	Date of Issue	Author	Reviewed	Quality Assurance	Approved
1	03/02/2016	Lindi Olivier	Simon Lott	Barb Calderwood	Simon Lott
Signatures					

Notes:

Rev 1: Final Report

Distribution:

Recipient	No. Copies
Nullamanna Station	1
EnviroAg Australia	1

Client

Company

This document provides information to address the intent of Project Number 23876 as agreed to by Nullamanna Station.

Executive Summary

EnviroAg Australia Pty. Ltd. (EnviroAg) has been engaged by Messrs Peter and Mark Lane (the Client) to carry out a soils assessment for the property known as “Nullamanna Station” in Nullamanna NSW to determine its suitability for a feedlot expansion.

A total of eight test pits were excavated onsite. Soil samples collected during the survey were submitted for laboratory analysis. Analysis of bulk samples found that the soils in the feedlot expansion area are a Ferrosol on the upper slopes and Vertosol on the lower slope where gradients are flat.

The nutrient budget showed that the land in the irrigation area is deficient of nitrogen and phosphorus. However potassium and sodium will need to be managed.

Overall, this assessment found that sufficient land exists in the 6.6ha irrigation area to take up the wastewater. However, only a small volume of wastewater should be applied (0.87ML/ha across 6.6ha). The area of application should also be small, for example 2.2ha, and application areas should be rotated.

Glossary

The following tables set out key works with a definition and abbreviations and their full meaning.

Table 1 Definitions

Average recurrence interval	The average or expected value of the periods between exceedances of a given rainfall total accumulated over a given duration. It is implicit in this definition that the periods between exceedances are generally random.
Cation exchange capacity	The total capacity of a soil to hold exchangeable cations. CEC is an inherent soil characteristic and is difficult to alter significantly. It influences the soil's ability to hold onto essential nutrients and provides a buffer against soil acidification.
Land Capability	Assesses the limitations to land use imposed by the characteristics if the land and specifies management options.
Land classification	Land classification refers to land categories and assess quality classes, capability classes or grade, depending upon the characteristics of the land or its potential for agricultural use.
Land Cover	Represents the physical surface of the earth. It includes combinations of natural features such as vegetation, soil, exposed rocks, water bodies as well as anthropogenic (man-made) features such as agriculture and the built environment. Land cover classes can generally be identified by characteristic patterns using remote sensing.
Land Management Practice	Refers to the means by which the land management objective is achieved, that is the 'how' of land use (e.g. cultivation practices, cell grazing or broad acre grazing).
Land Suitability	Describes the fitness of a given area/type of land for a specified land use.
Land use	Refers to the purpose to which land is committed, that what the land manager wants to achieve (e.g. grazing on native or improved pastures).
Salinity	Soil salinity is the salt content in the soil. Salts occur naturally within the soils and water.
Sodicity	A term given to the amount of sodium held within the soil.
Sorption	The processes in which one substance takes up or holds another (via either absorption or adsorption) through a chemical process in which one substance permeates the other; a fluid permeates or is dissolved by a liquid or solid.
Standard Cattle Unit	One 600 kg animal

Table 2 Abbreviations

ARI	Average recurrence interval
CEC	Cation Exchange Capacity
COC	Chain of custody
EC	Electrical Conductivity
K	Potassium
N	Nitrogen
Na	Sodium
P	Phosphorus
pH	Potential Hydrogen
SCU	Standard Cattle Units

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1. Introduction

EnviroAg Australia Pty. Ltd. (EnviroAg) has been engaged by Messrs Peter and Mark Lane (the Client) to carry out a soils assessment for the property known as “Nullamanna Station” in Nullamanna NSW to determine its suitability for a feedlot expansion.

As part of the Statement of Environmental Effects, EnviroAg conducted a soil survey on the property with soil sampling undertaken on the 9^{th} of October 2015. The samples were analysed by Dr Simon Lott, a certified practicing soil scientist (Level 3), and registered professional engineer (agricultural, civil and environmental), and were then tested by a NATA accredited laboratory for their properties.

1.1 Project Description

Nullamanna Station is a feedlot situated north of Inverell NSW, which currently has the capacity to hold 1,000 Standard Cattle Units (SCU, where one SCU = one 600 kg animal). Nullamanna Station wishes to expand their feedlot capacity to 3,000 SCU.

1.2 Proposed Land Uses

It is proposed that the land be used for a feedlot and wastewater ponds. Importantly some land areas will be assigned to a controlled drainage area. These lands will be substantially modified with topsoils and subsoils being stripped from them and the areas made impervious.

1.3 Objectives of the Soil Survey

The objectives of this soil survey were to identify the soil types and profiles to assess constraints and benefits of the soil for the siting of the expanded feedlot, with consideration to site earthworks, borrow pits, crop irrigation and wastewater application. The soil survey covered both agronomic and geotechnical assessments.

The objective of the soil survey is to:

- Review existing mapping and land classifications for the site;
- Undertake a soil survey; and
- Test selected soil samples for their suitability for feedlot construction use; and,
- Methods

1.4 Introduction

The soil survey and its assessment included:

- Detailed assessment of available reference materials including ASRIS mapping and NSW Government soil reports in the area;
- Excavation of test pits;
- Lab testing (both agronomical and geotechnical tests); and,
- Data analysis and compilation.

1.5 Desktop Assessment

The desktop assessment undertook background research on the soils at the site and its surrounds.

1.6 Test Pits

The location of the pits for soils sampling was based upon mapping of the proposed land use areas. This was done so that the following could be determined:

- The structural integrity and quality of the soil for foundations and earthworks; and,
- The soil type and chemical characteristics for suitable qualities for irrigation and cropping.

On the 9th of October 2015 eight (8) test pits were dug using a backhoe (Figure 1). TP1, TP2, and TP3 were excavated to a depth of 3m, whilst TPA, TPB, TPC, TPD and TPE were excavated to a depth of 1.5m.

On the 29th of April 2016 a push tube was used to collect samples at three (3) sites in the irrigation area.

Each location was logged with a handheld GPS (accurate to <±3 m). The test pit locations selected for sampling are shown in Figure 2.

Soil profile characteristics were carefully logged. Each pit and its profile was measured and photographed. Disturbed soil samples were collected from each test pit and from each horizon. Samples collected were tagged and sealed in individual plastic bags and forwarded to a NATA certified laboratory in Brisbane for analysis. Physical attributes were identified and logged on site.

1.7 Laboratory Testing

Bulk soil samples from TP2 and TP3 were submitted to NATA accredited laboratories for geotechnical testing.

Soil samples from 0 – 30cm and 30 – 60cm deep were collected from the three site push tube sites and submitted to a NATA accredited laboratory for agronomic testing.

1.8 Data Management

The soils' physical characteristics were described and entered onto EnviroAg field soil logs with photographs and GPS locations collected for each test pit (Appendix A). This information was tabulated into spreadsheets for interpretation and collation with laboratory analysis data.

Samples were freighted to the Toowoomba office where they were prepared and forwarded to the relevant laboratory for analysis. This was carried out under Chain of Custody (COC) documentation.

Soil samples were air dried and are currently stored at EnviroAg facilities in Toowoomba QLD.

Figure 1 Excavation of test pits

Figure 2 Test pit and push tube locations

2. Soil Survey Results

2.1 Existing Soil Mapping

Based on ASRIS (2011) and NSW Office of Environment and Heritage (OEH, 2015) Australian Soil Classification (Isbell, 2002) mapping (Figure 3 and Figure 4 respectively), soil in the proposed feedlot area may include:

- Ferrosols – Well-drained soils with red or yellow-brown colour and have clay-loam to clay textures. Their B2 horizons are high in free iron oxide, and they lack strong texture contrast between A and B horizons.
- Chromosols – Have a strong texture contrast between A horizons and B horizons. The B Horizon is not strongly acid or strongly sodic.
- Rudosols – Usually young, poorly developed soils with negligible pedologic organisation. The component soils can vary widely in terms of texture and depth; many are stratified and some are highly saline. They generally have low fertility and low water-holding capacity.
- Rudosols and tenosols – Rudosols as described above. Tenosols are soils that generally have only weak pedologic organisation apart from the A horizons. It encompasses a diverse range of soils.

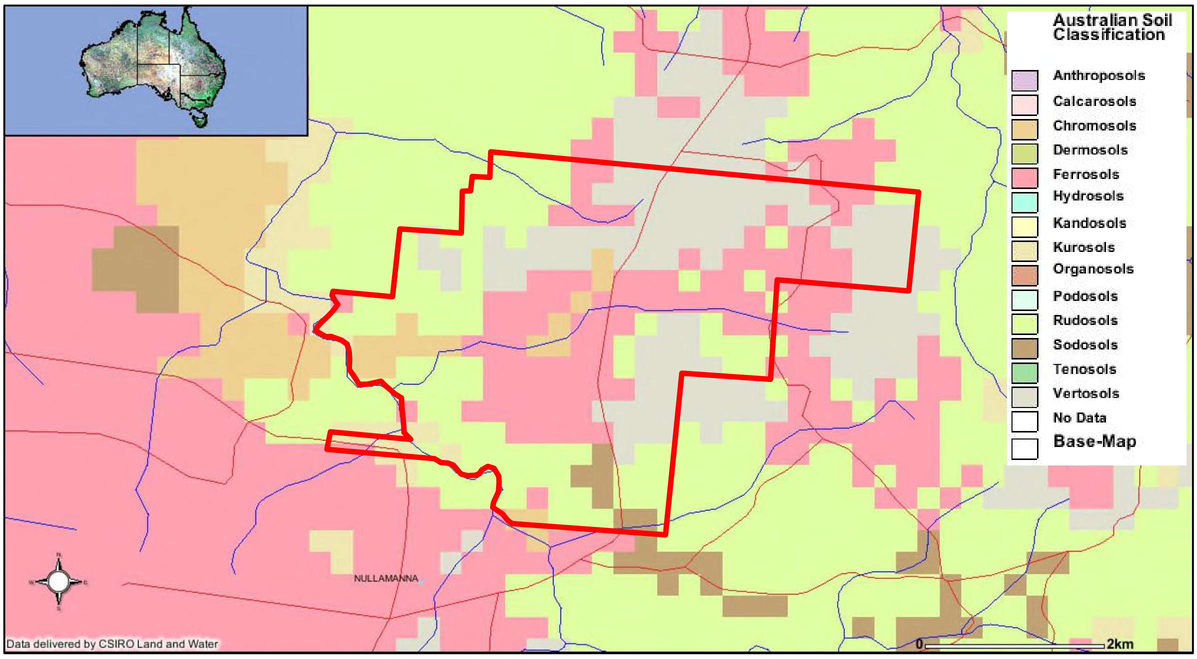


Figure 3 ASRIS soil national grid mapping

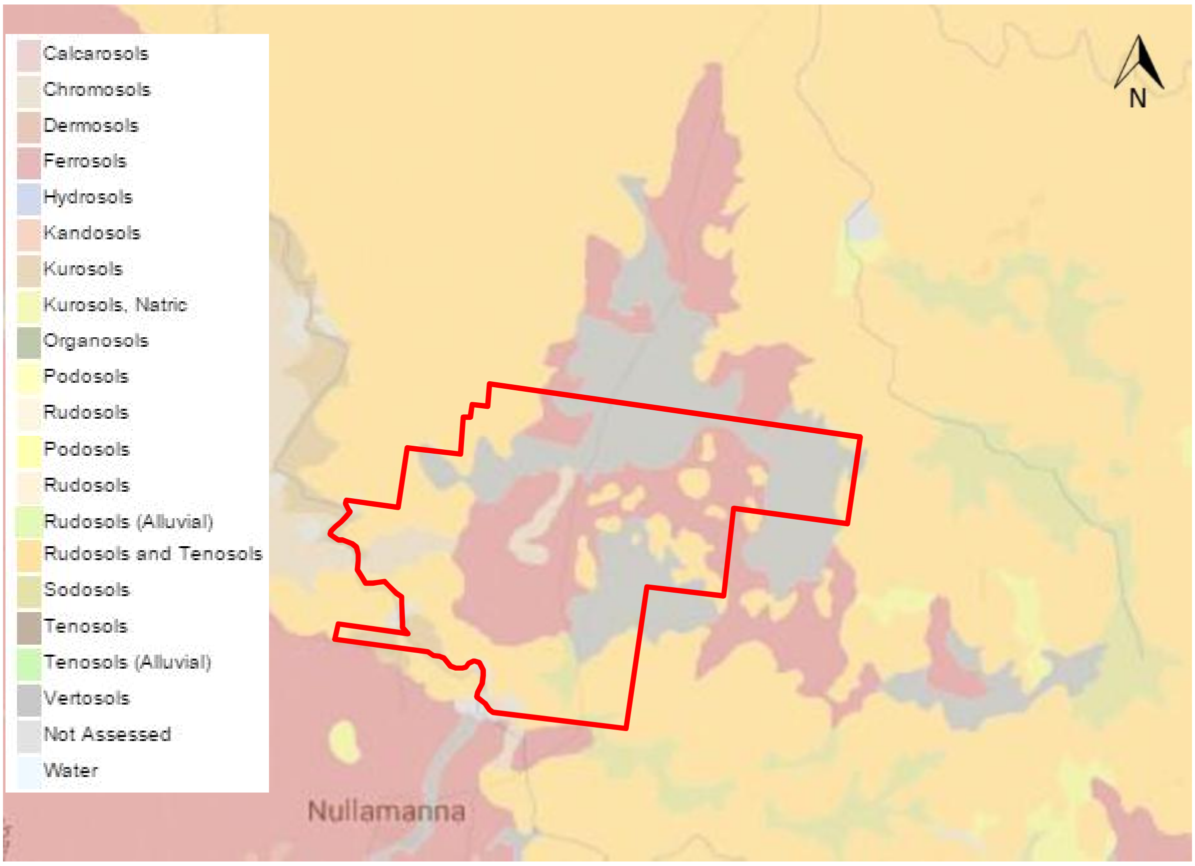


Figure 4 NSW OEH soil and land information mapping

2.2 Test Pits

As detailed in Section 1.6, a total of eight test pits were excavated. The location of the eight test pits is shown in Figure 2. The soil profile logs are included in Appendix A. Soil samples were collected from the test pits for geotechnical analysis. Refer Appendix A and Appendix B.

The field survey found that the soils in the feedlot expansion area are a Ferrosol on the upper slopes and Vertosol on the lower slope where gradients are flat.

2.3 General Properties of the Soils

The general properties of the soils are described by the stratigraphic summary in Table 3 (the pond area) and in Table 4 (the pen area) below. Figure 5 to Figure 12 show the profiles to the soil.

Generally the soil profile was shallow with the A horizon averaging to a depth of 0.31 m and the B horizon depth average of 1.42 m throughout the test pits. All horizons had an aspect of clay with varying levels of silt and/or sand. The C horizon typically had some gravel and saprolite.

Table 3 Typical soil profile from pond area (results noted from TP2)

Depth (m)	Horizon	Description
0 – 0.1	A1	Dark brown silty sandy clay with gravels to cobbles.
0.1-0.3	A2	Brown silty sandy clay with fine to course gravels.
0.3-1.0	B1	Strong brown clay with fine sand.
1.0-1.5	B2	Red brown clay with fine sand.
1.5-3.0	C1	Clayey sandy gravel with boulders, as well as saprolite sandstone/mudstone.

Table 4 Typical soil profile from pen area (results noted from TPD)

Depth (m)	Horizon	Description
0 – 0.1	A1	Very dark brown silty clay with traces of sand.
0.1-0.25	A2	Reddish brown silty sandy clay.
0.25-0.7	B1	Orange-red brown clay with traces of silt.
0.7-1.2	B2	Light brown clay with traces of silt and sand, as well as some gravels (deco basalt).
1.2-1.5	C1	Reddish orange brown clayey sandy gravel, with saprolite mafic basalt.

Figure 5 TP1 Profile

Figure 6 TP2 profile

Figure 7 TP3 profile

Figure 8 TPA profile

Figure 9 TPB profile

Figure 10 TPC profile

Figure 11 TPD profile

Figure 12 TPE profile

2.4 Landscape Features

2.4.1 Irrigation Area

The irrigable area is located on the large lower slope areas to the NE of the feedlot development. Soils in this area are generally deeper vertosols suitable for wastewater reuse.

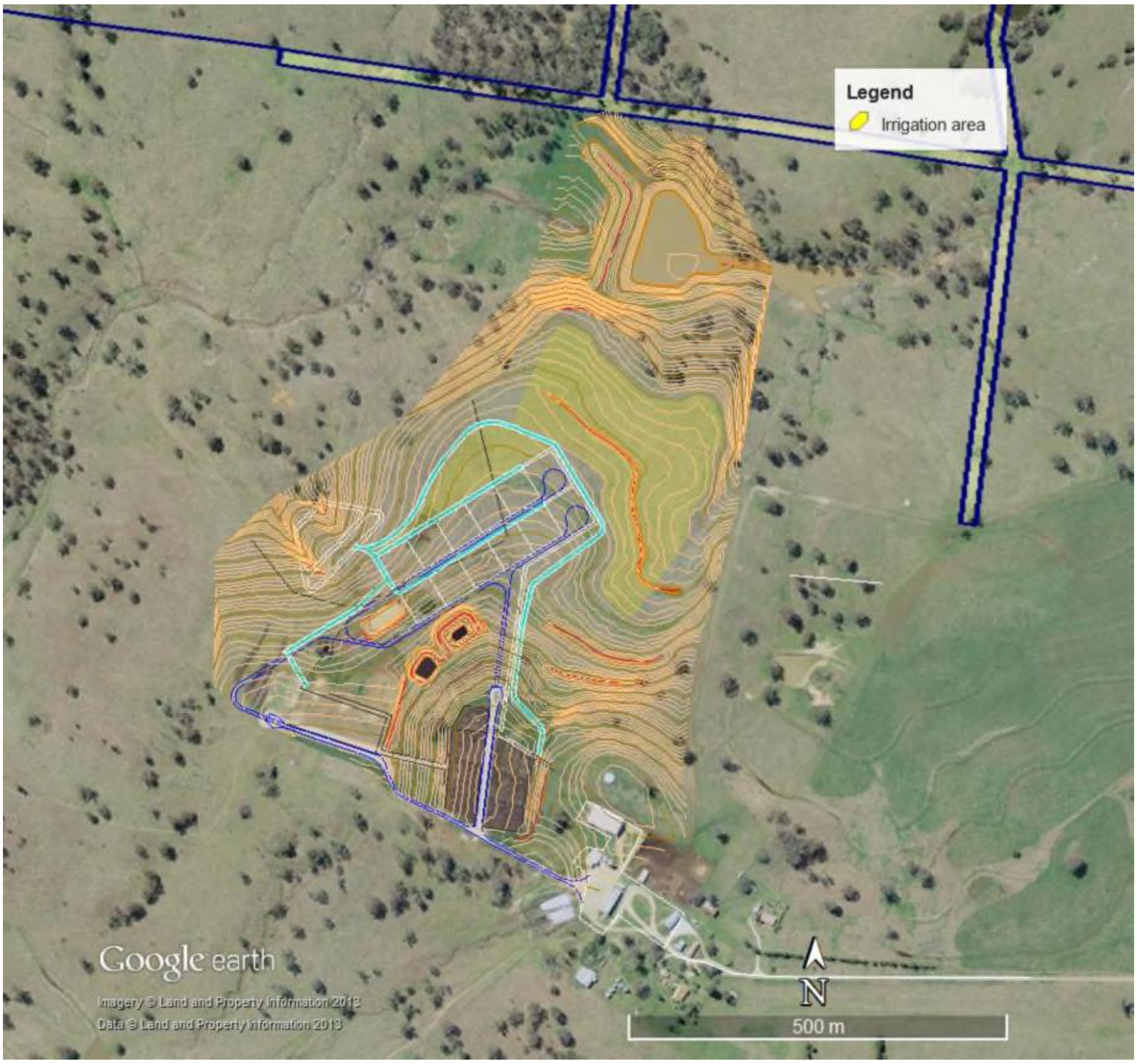


Figure 13 Feedlot conceptual design showing the location of the irrigation area

2.4.2 Controlled Drainage Area

The controlled drainage area of the development is well defined. It includes the existing and future pens, compost manure pad, drains and wastewater ponds. The storage capacity exceeds that required to hold rainfall runoff from a 1 in 10 year wet year.

The controlled drainage area is located upslope of the wastewater ponds. A topographic map from the Water storage facilities along the major drainage systems proposed to be developed is shown in Figure 13.

2.5 Soil Mapping

The NSW government mapping stated that for this area there was a low confidence in its mapping, whilst ASRIS had only mapped this area to a level 3, which means that each pixel on their map is a 3km mapping window. This also indicates that the mapping does not have a high level of precision.

The field survey found that the soils in the feedlot expansion area are a Ferrosol on the upper slopes and Vertosols on the lower slope where gradients are flat.

This is generally consistent with ASRIS and NSW OEH (2015) government mapping.

2.6 Soil Properties

Results from geotechnical analysis performed at the SoilTech Laboratory in Toowoomba QLD are noted in Table 5.

Permeability analysis was conducted on TP2 and TP3, which yielded a result of k(20) = 8.0 x 10^{-11} m/sec and k(20) = 3.4 x 10^{-10} m/sec respectively. A permeability of less than 1 x 10^{-9} m/s is advised for pen surfaces and sedimentation/holding ponds by the *National Guidelines for Beef Cattle Feedlots in Australia* (MLA 2012), as well as the NSW EPA (recommendations for the Statement of Environmental Effects).

Soil pH is neutral and soil conductivity is relatively low.

Table 5 Geotechnical analysis results

Sample ID	TP2	TP3
Sampling Date	9/10/2015	9/10/2015
Soil description	Red brown clay with fine sand	Strong brown clay with traces of sand
Permeability (m/s)	8.0 x 10^{-10}	3.4 x 10^{-10}
Liquid Limit %	67	82
Plastic Limit %	26	31
Plasticity Index	41	51
Linear Shrinkage %	18.0	19.0
19.00 mm		100
13.2 mm		93
9.50 mm	100	92
6.7 mm	100	92
4.75 mm	99	91
2.36 mm	97	91
1.18 mm	91	91
0.600 mm	85	89
0.425 mm	82	88
0.300 mm	80	88
0.150 mm	76	84
0.075 mm	73	76
pH	6.5	7.5
EC (µS/cm)	57	80

Agronomic soil testing has been undertaken in the irrigation area on Nullamanna Station as shown in Figure 2. The sample has been analysed for chemical and agronomic properties, the results of which are shown in Table 6.

As with the geotechnical sample results, these results show a pH that is slightly acidic to neutral and a low conductivity. They also show that cation exchange capacity increases or stays the same with depth.

In summary it is noted that:

- Conductivity levels are low throughout the profile and indicate non-saline conditions.
- Soil pH is slightly acidic to neutral throughout the profile. The soil will benefit from the application of lime and or gypsum.
- The cation exchange capacity of this soil is high in surface and subsurface soils. It should be able to hold plant nutrients well.
- Organic carbon levels are low in surface and subsoils. The soil may benefit significantly and positively from the application of composted manures.
- Total nitrogen, phosphorus and available (Colwell) phosphorus are low – the soil is deficient of phosphorus.
- The exchangeable sodium percentage of the soil is low throughout the profile, which means that the soil is non-sodic.
- Exchangeable potassium percent is low and exchangeable calcium percent is high.
- Calcium/magnesium ration is very low.

The soils indicate low fertility with fairly high cation exchange capacity in the surface soils. Nutrients, when applied, need to be applied frequently in low amounts to best meet plants needs. Organic matter contents need to be increased to assist in retention of soil moisture and nutrients.

Table 6 Chemical properties of push tube irrigation area samples

	Guidelines (DEC 2004) for soil with nil or slight limitations	Unit	PT1	PT1	PT2	PT2	PT3	PT3
			0 – 10cm	30 – 60cm	0 – 10cm	30 – 60cm	0 – 10cm	30 – 60cm
pH - Water	-	pH units	5.93	6.91	6.19	6.72	6.52	7.41
pH - $CaCl_2$	>6	pH units	5.38	6.59	5.37	6.54	6.05	6.40
Electrical Conductivity	<2	dS/m	0.06	0.09	0.04	0.03	0.07	0.04
Nitrogen	-	mg/kg	<300	360	<300	<300	<300	<300
Total Phosphorus	-	mg/kg	602	230	595	204	539	209
Phosphorus Colwell	-	mg/kg	25	<1	16	1	25	<1
Chloride	-	mg/kg	13	54	18	4	11	<1
Sodium	-	mg/kg	176	147	84	274	64	151
Potassium	-	mg/kg	272	155	245	131	225	151
Calcium	-	mg/kg	2840	3560	3380	3180	3710	3240
Magnesium	-	mg/kg	1620	2450	2470	3540	2570	2720
Cation Exchange Capacity	>15	meq/100g	29.2	39.2	38.5	46.9	40.8	39.9
Exchangeable Sodium	-	meq/100g	0.76	0.64	0.37	1.19	0.28	0.66
Exchangeable Sodium Percent	0 – 40cm depth: 0 – 5 40 – 100cm depth: <10	%	2.6	1.6	1.0	2.5	0.7	1.6
Exchangeable Potassium	-	meq/100g	0.70	0.40	0.63	0.34	0.58	0.39
Exchangeable Potassium Percent	-	%	2.4	1.0	1.6	0.7	1.4	1.0
Exchangeable Calcium	-	meq/100g	14.2	17.8	16.9	15.9	18.5	16.2
Exchangeable Calcium Percent	-	%	48.7	45.3	43.9	33.9	45.4	40.6
Exchangeable Magnesium	-	meq/100g	13.5	20.4	20.6	29.5	21.4	22.6
Exchangeable Magnesium Percent	-	%	46.3	52.0	53.5	62.9	52.5	56.8
Exchangeable Aluminium	-	meq/100g	N/A	N/A	N/A	N/A	N/A	N/A
Exchangeable Aluminium Percent	-	%	N/A	N/A	N/A	N/A	N/A	N/A
Calcium/Magnesium Ratio	-		1.05	0.87	0.82	0.54	0.87	0.71

	Guidelines (DEC 2004) for soil with nil or slight limitations	Unit	PT1	PT1	PT2	PT2	PT3	PT3
			0 – 10cm	30 – 60cm	0 – 10cm	30 – 60cm	0 – 10cm	30 – 60cm
Aluminium	-	mg/kg	<1	<1	1	<1	<1	<1
Sulphur - KCl	-	mg/kg	7.4	7.6	4.0	2.3	7.0	2.9
Organic Carbon	-	%	0.7	1.6	1.1	0.9	1.1	0.9
Organic Matter	-	%	1.4	3.6	2.4	2.1	2.4	1.9
Copper	-	mg/kg	2.8	0.8	2.5	1.0	2.0	0.8
Zinc	-	mg/kg	1.1	0.2	0.8	0.2	1.0	0.2
Manganese	-	mg/kg	140	22	110	57	67	21
Iron	-	mg/kg	77	19	74	38	44	25

3. Land Capability and Crop Use

3.1 Landscape Classification

The NSW OEH eSPADE NSW soil and land information mapping has mapped Nullamanna Station with the following land and soil capabilities:

2— Slight but significant limitations. Land capable of sustaining high impact land uses which can be managed by readily available, and easily implemented management practices.

3— Moderate limitations. Land capable of sustaining high impact land uses using more intensive, readily available and accepted management practices.

6— Very severe limitations. Land incapable of sustaining many land use practices (e.g. cultivation, moderate to high intensity grazing and horticulture). Highly specialised practices can overcome some limitations for some high value products. Land often used for low intensity land uses (low intensity grazing).

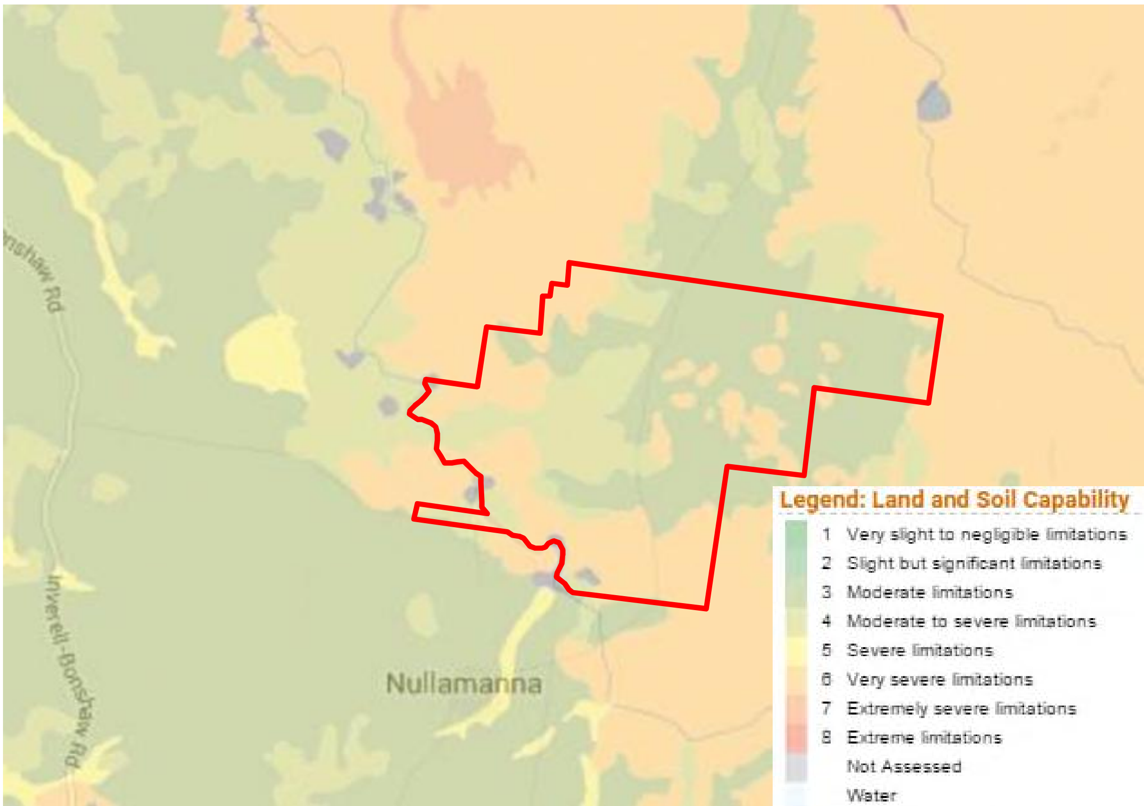


Figure 14 Land and soil capability of the Nullamanna area

3.2 Wastewater Application to Irrigable Area

Appendix D in the Statement of Environmental Effects presents the hydrological assessment of the proposed development. The modelling undertaken and described in the hydrological assessment shows that the annual average yield of wastewater from the facility is expected to be less than 20ML/year. The yield in the wettest year in 10 years is expected to be in the order of 30ML/year.

The total irrigable area proposed is 6.6 ha. The expected average nutrient content of the treated wastewater is shown in Table 7 below.

Table 7 Expected average nutrient content of treated wastewater

Attribute	pH	EC (dS/m)	TS (%)	TN (mg/L)	TP (mg/L)	K (mg/L)	Na (mg/L)
Average (Watts *et al.* 1994; Skerman 2000, ICIAI 1997)	7.43	13.6	0.25	720.55	103.76	2370	260
Average Annual WW Generation (ML)				5.782			
Mass (kg/ha)	NA	NA	2,190.15	631.25	90.9	2076.26	227.78
Losses in Wastewater (Wet Weather Storage) (kg/ha)	NA	NA	50%: 1095.08	40-70% (50%)^: 315.62	10-40 (25%)#: 22.73	10%: 207.63	-
Irrigation Application (kg/ha)	NA	NA	**1095.08**	**315.62**	**68.18**	**1868.64**	**227.78**

^ Volatilization (denitrification and evaporation)

Chemical precipitation and deposition in algae detritus (sludges)

3.3 Capability of Soils for Irrigation

3.3.1 Expected Leaching Fraction (LF)

The soils are vertosols. They deliver a useful soil to sustain irrigated agriculture. The wet season delivers a moisture surplus. This significant episodic event provides a leaching fraction.

The SALF program was used to assess the leaching fraction of the soil profile in the proposed irrigation area.

Parameters consistent with the soil profile as it is were used. Based on the model, the leaching fraction is estimated to be approximately 15.97mm/year (average). Peak deep drainage under wet seasons can be 5-10 times this amount. The model shows that this will adequately remove deleterious salts (sodium) from the soil profile so that they do not accumulate. The expected soil water concentration of the salts is also very low and no salinity impacts are expected.

Given the leaching fraction; ongoing careful management of potential loss of nitrogen and phosphorus is important. This is best achieved by:

- Frequent moderate applications of irrigation;
- Maintaining an active plant growth;
- Maximising organic matter content to maximise nutrient holding capacity;
- Management of soil meta-metal balances by application of gypsum/lime, and,
- Maximising nutrient recovery by crop harvest.

3.3.2 Expected Crop Production Capacity

Crop Type

Improved pasture will be grown in the irrigable area. It will be cut for hay. Forage sorghum, Lucerne and medics maybe under / over sown into the pasture from time to time.

Dry Matter Production

The dry matter production from improved pastures in the irrigable area is anticipated to be 10T DM/ha/year as hay through multiple cuts.

With a total annual DM harvest of 10T/ha, hay production will use about;

- 250 kg/ha of Nitrogen (N),
- 35kg/ha of phosphorus (P) and
- Over 300 kg/ha of potassium (K) each year.

3.3.3 Crop Water Requirements

The annual average rainfall for Inverell is 798.7 mm, whilst the annual average evaporation is 1603.1 mm (Table 8). Thus the average moisture deficit is in excess of 800 mm/year. This is equivalent to an annual average water deficit of 8ML/ha/year.

Table 8 Rainfall and evaporation data for Inverell Research Station (BOM 2015)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean rainfall (mm)	100.0	96.8	68.0	40.7	48.5	44.5	48.4	43.6	47.6	75.0	86.6	99.2	798.7
Mean monthly evaporation (mm)	207.7	168	161.2	114	83.7	60	62	86.8	117	158.1	180	204.6	1603.1

Crop water use is proportionate to the evaporation and consequent transpiration of the environment. A Crop Factor is applied to the evaporation to determine a transpiration rate. The Crop Factor considers soil and climatic factors to accurately determine the transpiration rates in different conditions.

Given the soil type, selected cropping regime, and considering the climatic data, a crop factor of 0.5 has been applied for all months. Given crop factors for improved pasture, the expected irrigation demand is in the order of 4-8ML/ha/ year.

The 5.8 ML/yr of available treated wastewater when applied across 6.6 ha with an efficiency of 90 % will supply only 0.87 ML of water per ha per year. This is not sufficient to meet the irrigation demand for a fully irrigated improved pasture.

3.4 Nutrient Management

3.4.1 Nutrient budget

A nutrient budget is provided in Table 7 above. It shows the input and outputs for the proposed irrigation area, given the proposed wastewater application rate and the crop production from the area.

Expected wastewater constituents are expressed in Table 9 (per the Hydrological Assessment report provided in Appendix D of the Statement of Environmental Effects). It is from these data that application rates can be calculated.

With the P sorption, evapotranspiration rates and the removal of nutrients through harvesting of the improved pasture for silage and hay, removal rates can be determined.

Table 9 Nutrient Budget (kg/ha/year)

	Total Solids kg/ha	N kg/ha	P kg/ha	K kg/ha	Na Kg/ha
Inputs					
Fertiliser	0	0	0	0	0
Wastewater	1095	315	68	1868	228
Outputs					
Runoff[(a)]	-	40	4	400	100
Loss from Field	500	158	0	0	0
LF[(b)] (allowable)	0	5	0.1	10	100
Harvest	10,000	250	35	300	2
Phosphorus Sorption	-	-	48[(c)]	-	-
Change	-9405	-138	-19	1158	28

(a) Annual average runoff will be ~40mm/ha or 0.4ML/ha. Runoff will carry some organics containing some nutrient, and, will preferentially dissolve and carry dissolvable ions especially potassium and sodium (that dissolve readily);

(b) LF = Leaching Fraction. Quantities based on concentrations in ANZECC guideline values for waters.

(c) Life of irrigable area 50years

The following assumptions were made in the preparation of Table 9:

- Composted manure is applied based on agronomic advices and if only a nutrient deficit exists;
- Harvest of pasture crops removes 10,000kg of dry matter per ha per year; and,
- The design life is 50 years (for exhaustion of P sorption in soils).

From Table 9 above it is concluded that:

- The application of wastewater to the wastewater utilisation areas will not result in excess nutrient availability (N and P);
- Some accumulation of K occurs and this is expected to be compensated by plant luxuriant uptake and,
- The health of the soil will be directly related to management of organic matter (to prevent a decline) and use of lime and gypsum to manage the cation exchange balance (K and Na).

Annual soil monitoring will be undertaken to check nutrient levels in the soil. The crop type and application rates can be adjusted accordingly.

3.4.2 Nutrient Management

This nutrient demand is expected to exceed the nutrient application from wastewaters and as such the irrigable area will require supplementing with composted manure or inorganic fertilisers. Degradation of land and the soils within the irrigable areas is not expected.

3.5 Land Management

3.5.1 Land and Soil Management

The irrigable area must be managed to ensure that soil health is maintained. Equally it must be managed so that it is as productive as possible. To achieve these outcomes the land area and its soils will be managed to:

- Minimise weed infestations by spraying out dense infestations and careful use of residual chemicals for ongoing control to allow pastures to establish and outcompete weed species; and,

- Minimise soil compaction by limiting traffic across the irrigation area when the soil is wet; and if necessary alleviation of compaction by deep ripping with appropriate implements (tines that do not disrupt the surface soil appreciably).

3.5.2 Soil Amelioration

The soils are only slightly acidic to neutral which will be beneficial in nutrient solubility and availability. The addition of agricultural lime and gypsum will assist in improving soil structure.

These soils will benefit from the application of wastewater irrigation and should provide a suitable soil base for the intended cropping regime.

Over time and in regard to agronomics the soils often need “corrective calcium” additions (gypsum/lime) to rebalance the cation exchange percentages between CA:Mg:K and Na and typically some boron and potentially zinc to realise the soil potential for plant growth.

Application of amendments in the form of agricultural lime will be required to allow for utilisation of the wastewater application for fodder crops under irrigation.

The application of composted manure would also assist in increasing the structure of the soil and carbon content.

3.5.3 Cultural practices

The improved pasture will be maintained by separating out undesirable grass species and resowing or oversowing the land areas with improved pasture seed. Where appropriate, hybrid forage species will be oversown to the pasture mix to increase dry matter production (forage sorghum / millets). Legumes such as clover and lucerne will be used when required to remove excess potassium from the soil profile

Irrigation will be limited and managed so that sufficient water is applied to prevent fertiliser burn but low enough to prevent significant leaching that would carry any excess nutrient below the root zone. Generally in this circumstance irrigation would be limited to 25-50mm per irrigation event.

4. Conclusion and Recommendations

Based on the findings reported above, the soil should be suitable for diluted effluent irrigation, provided that the recommendations below be followed.

4.1 Design

- Some land areas will be assigned to a controlled drainage area for the feedlot. These lands will be substantially modified with topsoils and subsoils being stripped from them and the areas made impervious to water.
- Wastewater should be irrigated on elevated area selected for the proposed irrigable areas; and
- Grass embankments should be built to hold the structure firm and alleviate erosion issues.

4.2 Management Practices

- Careful management of potential loss of nitrogen and phosphorus is important. This is best achieved by:
  - Frequent moderate applications of irrigation;
  - Maintaining an active plant growth;
  - Maximising organic matter content to maximise nutrient holding capacity; and,
  - Maximising nutrient recovery by pasture crop harvest.
- Manage the irrigable areas using the following:
  - Minimise weed infestations by spraying out dense infestations and careful use of residual chemicals for ongoing control to allow pastures to establish and outcompete weed species;
  - Minimise soil compaction by limiting traffic across the irrigation area when the soil is wet; and if necessary alleviation of compaction by deep ripping with appropriate implements (tines that do not disrupt the surface soil appreciably); and,
- Maintain the improved pastures by separating out undesirable grass species and resowing or oversowing of land areas with improved pasture seed. Where appropriate hybrid forage species will be added to the pasture mix to increase dry matter production (forage sorghum / millets).
- Application of amendments in the form of agricultural lime will be required to allow for utilisation of the wastewater application for fodder crops under irrigation

5. References

ASRIS. (2011). *ASRIS - Australian Soil Resource Information System.* Available at: http://www.asris.csiro.au. Accessed 7/11/2015.

Bureau of Meteorology (BOM) (2015). *Climate statistics for Australian locations: Inverell Raglan Street*. Available at http://www.bom.gov.au/climate/averages/tables/cw_056018.shtml. Accessed 15/10/2015.

Isbell, R.F. (2002). *The Australian Soil Classification* (2nd ed.). Collingwood, Victoria: CSIRO Publishing.

MLA (2012) *National Beef Cattle Feedlot Environmental Code of Practice* (2nd ed.). Sydney, Australia: MLA.

NSW Office of Environment and Heritage (OEH) (2015). *eSPADE soil and land information.* Available at: http://www.environment.nsw.gov.au/eSpadeWebApp/. Accessed 4/01/2015.

QLD Department of Agriculture and Fisheries (DAF) (2011). Manure production data. Available at: https://www.daf.qld.gov.au/environment/intensive-livestock/cattle-feedlots/managing-environmental-impacts. Accessed 19/10/2015.

Skerman, A. (2000). *Reference manual for the establishment and operation of beef cattle feedlots in Queensland.* Department of Primary Industries.

Watts, P., Tucker, R., Gardner, T., Casey, K. and Lott, S. (1994). Characteristics of Feedlot Waste, in "*Designing Better Feedlots*, eds. Watts, P. and Tucker, R. Queensland Department of Primary Industries, Toowoomba QLD.

6. Appendices

Appendix A.	Agronomic Soil Logs Sheets	A-1
Appendix B.	Laboratory Soil Testing Certificates	B-1

Appendix A. Agronomic Soil Logs Sheets

Form_06026_A | Agronomic Soil Sampling Report Sheet | EA Alliance

Client:	EAg	**Project No:**	40850/23876	GPS Zone	56	Easting:	328001.6
Property:	Nullamanna	Paddock:		GPS Datum:	WGS84	Northing:	6721485.7
Aspect:	West	Current land use:	Grazing	Vegetation:	Native grasses	BH or TP No:	TP 2 (3m)

Profile Description:

Sample No	Horizon	Horizon depth	Munsell Colour	Texture	Structure	Comments	pH	Mottles	Roots	Cracks
	A1	0-10 cm	Dark Brown	Silty Sandy Clay	Dry/Soft/Medium Dense	w/gravels to cobbles			Y	N
	A2	10-30cm	Brown	Silty Sandy Clay	Dry/Soft/Medium Dense	w/ fine to course gravels			Y	N
	B1	30-100cm	Strong Brown	Clay w/fine Sand	Dry/Firm/Medium dense			Trace	Y	
*	B2	100-150cm	Red Brown	Clay w/fine sand	Dry/Firm/Medium dense			Trace		
	B3									
*	C1	150 – 300cm	Light Yellow	Clayey Sandy Gravel w/ boulders	S-F/MD-L	Saprolite "rotten rock" sandstone/mudstone (to depth)				

Photo

Other comments:

Bulk Samples at 100cm

EOH sample at 3m

Parent material:	Mudstone/sandstone/meta morphosed
Surface drainage:	W – good
Surface slope:	3-4%
Photos:	
Collector Name:	OW
Signature:	
Date:	9/10/15

Form_06026_A — Agronomic Soil Sampling Report Sheet — EA Alliance

Client:	EAg	**Project No:**	40850/23876	GPS Zone	56	Easting:	327983.8
Property:	Nullamanna	Paddock:		GPS Datum:	WGS84	Northing:	6721517.4
Aspect:	West	Current land use:	Grazing	Vegetation:	Native grasses	BH or TP No:	TP 1 (3m)

Profile Description:

Sample No	Horizon	Horizon depth	Munsell Colour	Texture	Structure	Comments	pH	Mottles	Roots	Cracks
	A1	0-10 cm	Light Grey Brown	Silty Clay	Dry/Soft/ Medium Dense	w/course gravels			Y	N
	A2	10-50cm	Dark Grey Brown	Silty Clay	Dry/Soft/Loose to Medium Dense	w/ course gravels				
*	B1	50-120cm	Strong Brown	Clay w/ Sand	Dry/Firm/Medium dense	t/fine to course "deco" gravel				
	B2									
	B3									
	C1	120 – 300cm	Light Yellow	Clayey Sandy Gravel w/ boulders	S-F/MD-L	Saprolite "rotten rock" Sandstone/mudstone (to depth)				

Photo

Other comments:

Bulk Samples at 100cm

Parent material:	Mudstone/ sandstone/ metamorphosed
Surface drainage:	W – good
Surface slope:	3-4%
Photos:	
Collector Name:	OW
Signature:	
Date:	9/10/15

Form_06026_A	Agronomic Soil Sampling Report Sheet	EA Alliance

Client:	EAg	**Project No:**	40850/23876	GPS Zone	56	Easting:	328057
Property:	Nullamanna	Paddock:		GPS Datum:	WGS84	Northing:	6721545.3
Aspect:	West	Current land use:	Grazing	Vegetation:	Introduced grasses	BH or TP No:	TP 3 (3m)

Profile Description:

Sample No	Horizon	Horizon depth	Munsell Colour	Texture	Structure	Comments	pH	Mottles	Roots	Cracks
	A1	0-20 cm	Brown	Silty Clay	Dry/Soft/ Loose	t/gravels			Y	Trace
	A2	20-30cm	Dark Reddish Brown	Silty Clay	Dry/Soft/Loose	t/gravels			Y	Trace
*	B1	30-100cm	Dark Reddish Brown	Silty Clay	Moist/Soft/Loose	t/cobbles				
*	B2	100-200cm	Strong Brown	Clay t/sand	Moist/Firm/Medium dense	t/cobbles, plastic clay				
	B3									
*	C1	200 – 300cm	Light orangey grey	Clay w/ sand and gravel	S-F/MD-L	t/cobbles				

Photo

Other comments:

Bulk Samples at 100-200cm

Parent material:	Volcanics, basalt/andesite
Surface drainage:	W – good
Surface slope:	2-3%
Photos:	
Collector Name:	OW
Signature:	
Date:	9/10/15

Form_06026_A	Agronomic Soil Sampling Report Sheet	EA Alliance

Client:	EAg	**Project No:**	40850/23876	GPS Zone	56	Easting:	328135.7
Property:	Nullamanna	Paddock:		GPS Datum:	WGS84	Northing:	6721602.8
Aspect:	West	Current land use:	Grazing	Vegetation:	Native grasses	BH or TP No:	TP A (1.5m)

Profile Description:

Sample No	Horizon	Horizon depth	Munsell Colour	Texture	Structure	Comments	pH	Mottles	Roots	Cracks
	A1	0-20 cm	Dark Reddish Brown	Silty Clay	Dry/Firm/Medium Dense				Y	N
*	A2	20-30cm	Brown	Silty Clay	Dry/Firm/Medium Dense	Plastic			Y	N
*	B1	30-80cm	Red Brown	Clay t/silt and sand	Dry/Firm/Medium dense	Plastic			Y	
*	B2	80-120cm	Light Brown	Clay w/fine sand	Dry/Firm/Medium dense	w/course gravel to cobbles				
	B3									
	C1	120 – 150cm	Brown	Clayey Sandy Gravel w/ boulders	S-F/MD-L	Saprolite “rotten rock” mafic basalt (to depth)				

Photo

Other comments:

Parent material:	Volcanics, basalt/andesite
Surface drainage:	W – good
Surface slope:	2-3%
Photos:	
Collector Name:	OW
Signature:	
Date:	9/10/15

Form_06026_A	Agronomic Soil Sampling Report Sheet	EA Alliance

Client:	EAg	**Project No:**	40850/23876	GPS Zone	56	Easting:	328135.7
Property:	Nullamanna	Paddock:		GPS Datum:	WGS84	Northing:	6721602.8
Aspect:	NW	Current land use:	Grazing	Vegetation:	Native grasses	BH or TP No:	TP C (1.5m)

Profile Description:

Sample No	Horizon	Horizon depth	Munsell Colour	Texture	Structure	Comments	pH	Mottles	Roots	Cracks
	A1	0-20 cm	Brown	Silty Sandy Clay	Dry/Firm/Medium Dense				Y	Trace
	A2	20-30cm	Strong Brown	Silty Sandy Clay	Dry/Firm/Medium Dense				Y	Trace
*	B1	30-70cm	Light Brown	Silty Sandy Clay	Dry/hard/Dense	w/fine to course gravel				
*	B2 – C1	70-150cm	Red Brown	Silty Sandy Clay Gravel	Dry/Hard/dense	w/ Saprolite, mafic basalt (to depth)				

Photo

Other comments:

Bulk Samples at B1

Parent material:	Volcanics, basalt/andesite
Surface drainage:	NW – poor
Surface slope:	1%
Photos:	
Collector Name:	OW
Signature:	
Date:	9/10/15

Form_06026_A	Agronomic Soil Sampling Report Sheet	EA Alliance

Client:	EAg	**Project No:**	40850/23876	GPS Zone	56	Easting:	328231.3
Property:	Nullamanna	Paddock:		GPS Datum:	WGS84	Northing:	6721663.7
Aspect:	NW	Current land use:	Grazing	Vegetation:	Native grasses	BH or TP No:	TP D (1.5m)

Profile Description:

Sample No	Horizon	Horizon depth	Munsell Colour	Texture	Structure	Comments	pH	Mottles	Roots	Cracks
	A1	0-10 cm	Very Dark Brown	Silty Clay t/ sand	Dry/Firm/Medium Dense				Y	Trace
	A2	10-25cm	Reddish Brown	Silty Sandy Clay	Dry/Firm/Medium Dense				Y	Trace
*	B1	25-70cm	Orange-Red Brown	Clay t/ silt	Moist/Hard/Dense	Plastic			Trace	
*	B2	70-120cm	Light Brown (some red)	Clay t/ silt and sand	Moist/Hard/Dense	w/ gravels (deco basalt)				
	C1	120-150cm	Reddish/orange brown	Clayey Sandy Gravel	Dry/Firm/Loose	w/ Saprolite, mafic basalt (to depth)				

Photo

Other comments:

Bulk Samples at B1

Parent material:	Volcanics, basalt/andesite
Surface drainage:	NW – poor
Surface slope:	1%
Photos:	
Collector Name:	OW
Signature:	
Date:	9/10/15

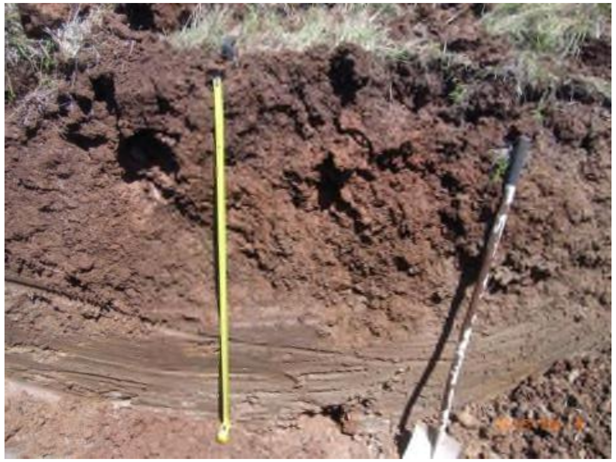
Form_06026_A	Agronomic Soil Sampling Report Sheet	EA Alliance

Client:	EAg	**Project No:**	40850/23876	GPS Zone	56	Easting:	328288.8
Property:	Nullamanna	Paddock:		GPS Datum:	WGS84	Northing:	6721600.5
Aspect:	N	Current land use:	Grazing	Vegetation:	Native grasses	BH or TP No:	TP E (1.5m)

Profile Description:

Sample No	Horizon	Horizon depth	Munsell Colour	Texture	Structure	Comments	pH	Mottles	Roots	Cracks
	A1	0-10 cm	Dark Brown	Silty Clay	Dry-Moist/Firm/Medium Dense				Y	Trace
	A2	10-30cm	Dark Reddish Brown	Silty Clay	Dry-moist/Firm/Medium Dense				Y	Trace
*	B1	30-80cm	Strong Brown	Clay t/ silt and sand	Dry/Hard/Dense					
	B2	80-140cm	Brown	Silty Sandy Clay	Dry/Hard/Dense	w/ gravels (deco basalt)				
	C1	140-150cm	Reddish brown	Clayey Sandy Gravel	Dry/Firm/MD-Loose	w/ Saprolite, mafic basalt (to depth)				

Photo



Other comments:

Parent material:	Volcanics, basalt/andesite
Surface drainage:	N – good
Surface slope:	2%
Photos:	
Collector Name:	OW
Signature:	
Date:	9/10/15

Form_06026_A	Agronomic Soil Sampling Report Sheet	EA Alliance

Client:	EAg	**Project No:**	40850/23876	GPS Zone	56	Easting:	328113.9
Property:	Nullamanna	Paddock:		GPS Datum:	WGS84	Northing:	6721428.8
Aspect:	N	Current land use:	Grazing	Vegetation:	Native grasses	BH or TP No:	TP B (1.5m)

Profile Description:

Sample No	Horizon	Horizon depth	Munsell Colour	Texture	Structure	Comments	pH	Mottles	Roots	Cracks
	A1	0-10 cm	Light Brown	Silty Sandy Clay	Dry/Firm/Medium Dense				Y	Trace
	A2	10-20cm	Brown	Silty Sandy Clay	Dry/Firm/Medium Dense				Y	Trace
*	B1	20-50cm	Brown	Clay t/ silt and sand	Dry/Firm/Dense					
*	B2 – C1	50-150cm	Yellow/brown/orange	Clayey Sandy Gravel	Dry/Firm/Loose	w/ deco basalt				

Photo

Other comments:

10 from holding dams to south and west

Bulk samples at B2 – C1

Parent material:	Volcanics, basalt/andesite
Surface drainage:	N – good
Surface slope:	2-3%
Photos:	
Collector Name:	OW
Signature:	
Date:	9/10/15

Appendix B. Laboratory Soil Testing Certificates

SOILTECH Testing Services Pty Ltd
1300 736 724
www.soiltech.com.au

Emerson Class Report

Client :	**Enviro Ag Australia Pty Ltd**	Report Number:	**15196 - 1/1**
Address :	**Po Box 1775, Armidale, QLD, 2350**	Report Date :	**14/12/2015**
Project Name :	**Nullamanna Feedlot**	Order Number :	**PEA0008880**
Project Number :	**15196**	Test Method :	**AS 1289.3.8.1**
Location:	**Nullamanna Station**		**Page 1 of 1**

Sample Number :	153863	153864		
Test Number :	TP2	TP3		
Sampling Method :	As Received	As Received		
Date Sampled :	10/12/2015	10/12/2015		
Date Tested :	11/12/2015	11/12/2015		
Material Type :	Soil	Soil		
Material Source :	Natural	Natural		
Lot Number :	-	-		
Sample Location :	Sample ID 9729 Test Pit 2 Depth 0.3m-1m	Sample ID 9732 Test Pit 3 Depth 1m-2m		
Primary Water Type :	Distilled Water	Distilled Water		
Primary Soil Description :	Brown Orange Slightly Sandy Silty Clay	Brown Silty Clay with a trace of Gravel		
Primary Temperature :	23	23		
Primary Emerson Class Number :	**Class 5**	**Class 5**		
Secondary Water Type :	-	-		
Secondary Soil Description :	-	-		
Secondary Temperature :	-	-		
Secondary Emerson Class Number :	**-**	**-**		
Remarks :				

NATA WORLD RECOGNISED ACCREDITATION

Accredited for compliance with ISO / IEC 17025
Laboratory Location:
194 Stephen Street,
Toowoomba, QLD, 4350

APPROVED SIGNATORY

Drew Obst - Senior Laboratory Manager
NATA Accreditation Number
2117

Trilab
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PERMEABILITY BY FALLING HEAD TEST REPORT

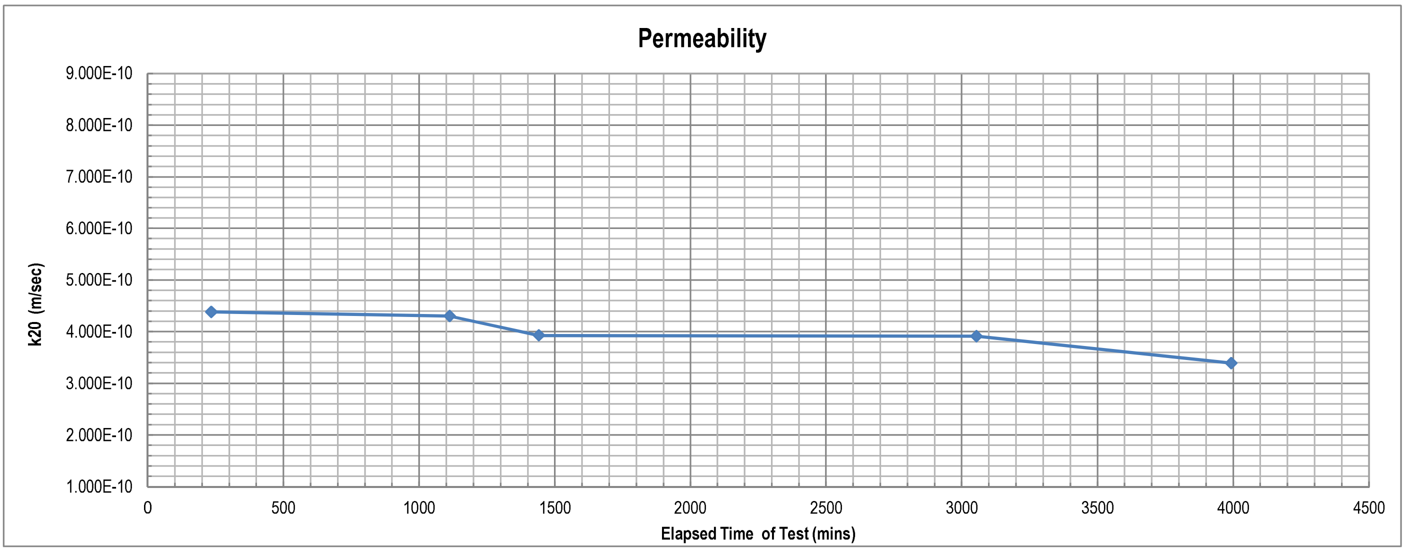
Test Method AS 1289 6.7.2, 5.1.1 , KH2 (Based on K H Head (1988) Manual of Laboratory Testing,10.7)

Client	Soiltech Testing Services Pty Ltd	**Report No.**	15120407-FHPT
Project	15196 Nullamanna Feedlot	**Test Date**	12/12/2015-17/12/2015
		Report Date	17/12/2015
Client ID	9732 - Test Pit 3	**Depth (m)**	1.00-2.00
Description	CLAY-brown	**Sample Type**	Remoulded Soil Specimen

RESULTS OF TESTING

Compaction Method	**AS1289.5.1.1 - Standard Compaction**		
Maximum Dry Density (t/m^3)	**1.34**	Hydraulic Gradient	**9.5**
Optimum Moisture Content (%)	**35.4**	Surcharge (kPa)	**2.9**
Placement Moisture Content (%)	**35.0**	Head Pressure Applied (kPa)	**10.84**
Moisture Ratio (%)	**98.9**	Water Type	**Deaerated**
Placement Wet Density (t/m^3)	**1.77**	Percentage Material Retained/Sieve Size (mm)	**0 % /9.5 mm**
Density Ratio (%)	**98.2**		

PERMEABILITY $k_{(20)} = 3.4 \times 10^{-10}$ **(m/sec)**



Remarks: The above specimen was remoulded to a target of 98% of Standard Dry Density and at 100% of Optimum Moisture Content.

Sample/s supplied by client The compaction data was supplied by the client.

Accredited for compliance with ISO/IEC 17025.
The results of the tests, calibrations, and/or measurements included in this document are traceable to Australian/National Standards.

Tested at Trilab Brisbane Laboratory.

Authorised Signatory

C. Channon

NATA ACCREDITED FOR TECHNICAL COMPETENCE

Laboratory No. 9926

Trilab
Soil Rock Calibration

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PERMEABILITY BY FALLING HEAD TEST REPORT

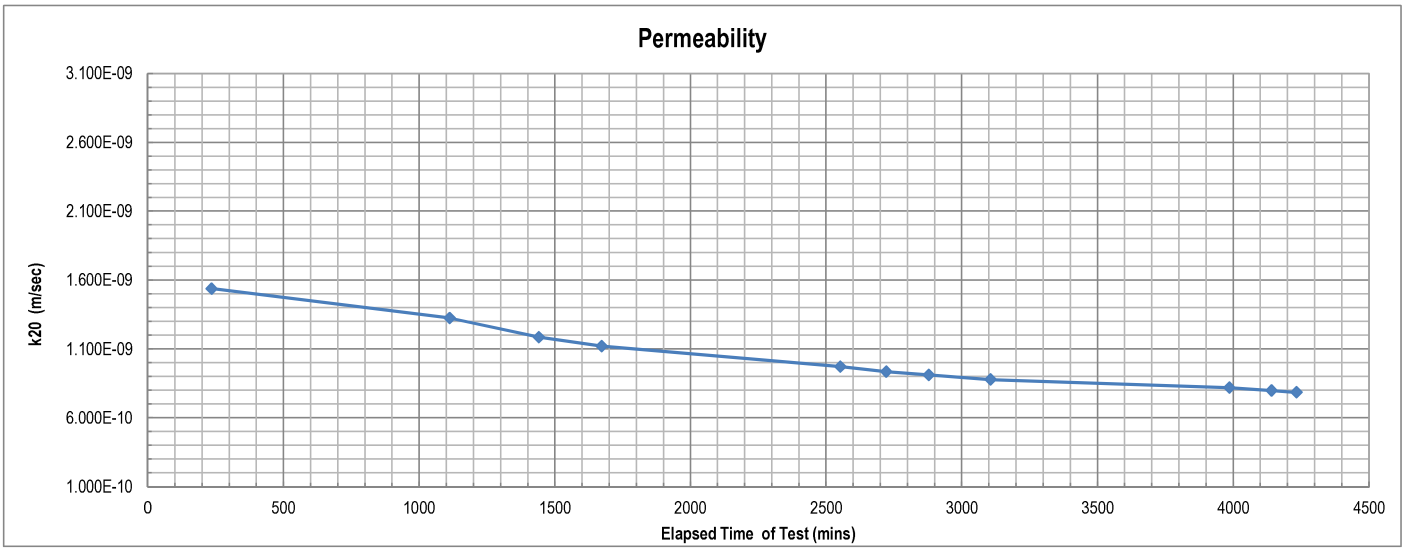
Test Method AS 1289 6.7.2, 5.1.1 , KH2 (Based on K H Head (1988) Manual of Laboratory Testing,10.7)

Client	Soiltech Testing Services Pty Ltd	**Report No.**	15120406-FHPT
Project	15196 Nullamanna Feedlot	**Test Date**	12/12/2015-18/12/2015
		Report Date	18/12/2015
Client ID	9729 - Test Pit 2	**Depth (m)**	0.30-1.00
Description	CLAY-red brown	**Sample Type**	Remoulded Soil Specimen

RESULTS OF TESTING

Compaction Method	**AS1289.5.1.1 - Standard Compaction**		
Maximum Dry Density (t/m^3)	**1.49**	Hydraulic Gradient	**9.4**
Optimum Moisture Content (%)	**25.3**	Surcharge (kPa)	**2.9**
Placement Moisture Content (%)	**25.9**	Head Pressure Applied (kPa)	**10.79**
Moisture Ratio (%)	**102.3**	Water Type	**Deaerated**
Placement Wet Density (t/m^3)	**1.83**	Percentage Material Retained/Sieve Size (mm)	**0 % /9.5 mm**
Density Ratio (%)	**97.5**		

PERMEABILITY $k_{(20)}$ = **8.0×10^{-10}** **(m/sec)**



Remarks: The above specimen was remoulded to a target of 98% of Standard Dry Density and at 100% of Optimum Moisture Content.

Sample/s supplied by client The compaction data was supplied by the client.

Accredited for compliance with ISO/IEC 17025.
The results of the tests, calibrations, and/or measurements included in this document are traceable to Australian/National Standards.

Tested at Trilab Brisbane Laboratory.

Authorised Signatory
C. Park

NATA
ACCREDITED FOR TECHNICAL COMPETENCE

Laboratory No. 9926

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EB1537519**	Page	: 1 of 2
Client	: **SOILTECH TESTING SERVICES PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: DREW OBST	Contact	: Customer Services EB
Address	: 19 POUND ROAD MILES QLD, AUSTRALIA 4415	Address	: 2 Byth Street Stafford QLD Australia 4053
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Telephone	: +61 07 462 7288	Telephone	: +61-7-3243 7222
Facsimile	: ----	Facsimile	: +61-7-3243 7218
Project	: 15196 Nullamanna Feedlot	QC Level	: NEPM 2013 B3 & ALS QC Standard
Order number	: PEA 0008880	Date Samples Received	: 11-Dec-2015 10:20
C-O-C number	: ----	Date Analysis Commenced	: 17-Dec-2015
Sampler	: ----	Issue Date	: 17-Dec-2015 12:57
Site	: ----		
		No. of samples received	: 2
Quote number	: ----	No. of samples analysed	: 2

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

NATA Accredited Laboratory 825

Accredited for compliance with ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Kim McCabe	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.

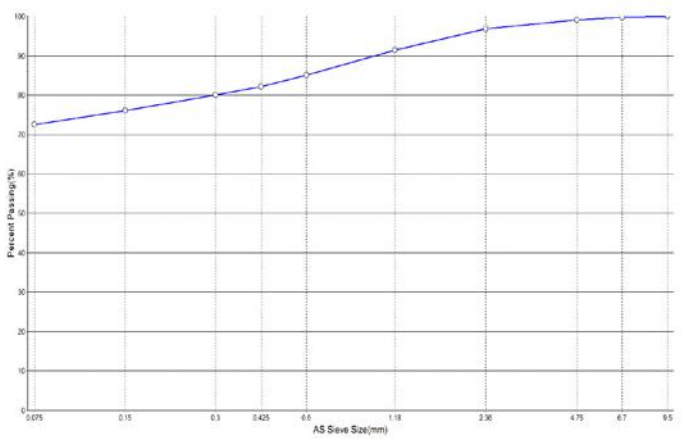
Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	9729 - Test Pit 2, 0.3m to 1.0m depth	9732 - Test Pit 3, 1.0m to 2.0m depth	----	----	----
			Client sampling date / time	[10-Dec-2015]	[10-Dec-2015]	----	----	----
Compound	CAS Number	LOR	Unit	EB1537519-001	EB1537519-002	--------	--------	--------
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	**6.5**	**7.5**	----	----	----
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	**57**	**80**	----	----	----

Quality of Materials Report

Client:	**Enviro Ag Australia Pty Ltd**	Report Number:	**15196 - 2/1**
Client Address:	**Po Box 1775 Armidale QLD 2350**		
Job Number:	**15196**	Report Date:	**15/12/2015**
Project:	**Nullamanna Feedlot**	Order Number:	**PEA0008880**
Location	**, Armidale**	**Page 1 of 2**	
Lab No:	**153863**	**Sample Location**	
Date Sampled:	**10/12/2015**	Sample ID 9729	
Date Tested:	**14/12/2015**	Test Pit 2	
Sampled By:	**Client**	Depth 0.3m-1m	
Sample Method:	**As Received**		
Material Source:	**Natural**	Spec Description:	-
For Use As:	**-**	Lot Number:	-
Remarks:	-	Spec Number:	-

Test Method: **AS1289.3.6.1**



A.S. Sieve Sizes	Specification Minimum	Percent Passing	Specification Maximum
75.00 mm			
53.00 mm			
37.50 mm			
26.50 mm			
19.00 mm			
13.2 mm			
9.50 mm		**100**	
6.7 mm		**100**	
4.75 mm		**99**	
2.36 mm		**97**	
1.18 mm		**91**	
0.600 mm		**85**	
0.425 mm		**82**	
0.300 mm		**80**	
0.150 mm		**76**	
0.075 mm		**73**	

AS1726 Soil Classification: -

Atterberg Tests	Test Method	Specification Minimum	Result	Specification Maximum
Liquid Limit (%)	**AS1289.3.9.2**		**67**	
Plastic Limit (%)	**AS1289.3.2.1**		**26**	
Plasticity Index	**AS1289.3.3.1**		**41**	
Linear Shrinkage (%)	**AS1289.3.4.1**		**18.0**	

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WORLD RECOGNISED ACCREDITATION

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Laboratory Location:
194 Stephen Street,
Toowoomba, QLD, 4350

Approved Signatory

Drew Obst - Senior Laboratory Manager

NATA Accred No:2117

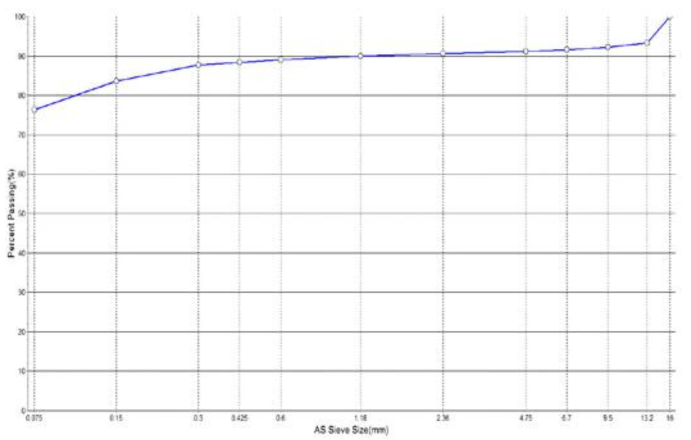
Form Number

AQUAL-REP-3

Quality of Materials Report

Client:	**Enviro Ag Australia Pty Ltd**	Report Number:	**15196 - 2/1**
Client Address:	**Po Box 1775 Armidale QLD 2350**		
Job Number:	**15196**	Report Date:	**15/12/2015**
Project:	**Nullamanna Feedlot**	Order Number:	**PEA0008880**
Location	**, Armidale**	**Page 2 of 2**	
Lab No:	**153864**	**Sample Location**	
Date Sampled:	**10/12/2015**	Sample ID 9732	
Date Tested:	**14/12/2015**	Test Pit 3	
Sampled By:	**Client**	Depth 1m-2m	
Sample Method:	**As Received**		
Material Source:	**Natural**	Spec Description:	-
For Use As:	**-**	Lot Number:	-
Remarks:	-	Spec Number:	-

Test Method: **AS1289.3.6.1**



A.S. Sieve Sizes	Specification Minimum	Percent Passing	Specification Maximum
75.00 mm			
53.00 mm			
37.50 mm			
26.50 mm			
19.00 mm		**100**	
13.2 mm		**93**	
9.50 mm		**92**	
6.7 mm		**92**	
4.75 mm		**91**	
2.36 mm		**91**	
1.18 mm		**90**	
0.600 mm		**89**	
0.425 mm		**88**	
0.300 mm		**88**	
0.150 mm		**84**	
0.075 mm		**76**	

AS1726 Soil Classification: -

Atterberg Tests	Test Method	Specification Minimum	Result	Specification Maximum
Liquid Limit (%)	**AS1289.3.9.2**		**82**	
Plastic Limit (%)	**AS1289.3.2.1**		**31**	
Plasticity Index	**AS1289.3.3.1**		**51**	
Linear Shrinkage (%)	**AS1289.3.4.1**		**19.0**	

SOILTECH Testing Services Pty Ltd

Shrink Swell Index Report

Client:	Enviro Ag Australia	**Report Number:**	15196 - 3
Client Address:	PO Box 1775, Armidale, NSW, 2350	**Report Date:**	15/12/2015
Job Number:	15196	**Test Method:**	AS1289.7.1.1
Project:	Geotechnical Testing	**Page:**	1 of 2
Location:	Nullamanna Feedlot		

Lab No:	153863	**Sample ID 9729**
Date Sampled:	10/12/2015	**Test Pit 2**
Date Tested:	14/12/2015	**Depth 0.3m - 1m**
Sampled By:	Client	
Sample Method:	U50 Tube	
Material Source:	Natural	
For Use As:	-	**Lot Number:** -
Remarks:	*Test specimen was remoulded using standard compaction at approximately the optimum moisture content*	**Item Number:** -

Shrinkage Moisture Content (%):	**25.1**	Swell MC Before (%):	**24.6**
Shrinkage (%):	**5.30**	Swell MC After (%):	**27.7**
Unit Weight (t/m3):	**1.937**	PP Before (kPa):	**-**
Swell (%):	**2.35**	PP After (kPa):	**-**
Shrink Swell Index (Iss%):	**3.6**		

Visual Classification:	Brown Orange Slightly Sandy Silty Clay
Inert Material Estimate (%):	2
Cracking:	Nil
Crumbling:	Nil

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SOILTECH Testing Services Pty Ltd

Shrink Swell Index Report

Client:	Enviro Ag Australia	**Report Number:**	15196 - 3
Client Address:	PO Box 1775, Armidale, NSW, 2350	**Report Date:**	15/12/2015
Job Number:	15196	**Test Method:**	AS1289.7.1.1
Project:	Geotechnical Testing	**Page:**	2 of 2
Location:	Nullamanna Feedlot		

Lab No:	153864	**Sample ID 9732**
Date Sampled:	10/12/2015	**Test Pit 3**
Date Tested:	14/12/2015	**Depth 1m - 2m**
Sampled By:	Client	
Sample Method:	U50 Tube	
Material Source:	Natural	
For Use As:	-	**Lot Number:** -
Remarks:	*Test specimen was remoulded using standard compaction at approximately the optimum moisture content*	**Item Number:** -

Shrinkage Moisture Content (%):	**34.4**	Swell MC Before (%):	**36.3**
Shrinkage (%):	**7.88**	Swell MC After (%):	**40.5**
Unit Weight (t/m3):	**1.842**	PP Before (kPa):	**-**
Swell (%):	**3.61**	PP After (kPa):	**-**
Shrink Swell Index (Iss%):	**5.4**		

Visual Classification:	Brown Silty Clay with a trace of Gravel
Inert Material Estimate (%):	2
Cracking:	Nil
Crumbling:	Nil

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APPROVED SIGNATORY

Paul Sheppard

NATA Accred No: 2117

Form Number

REP SS-1-1

Attachment 6: Updated Hydrology Assessment

Hydrological Assessment

Nullamanna Feedlot Expansion

Report Number 23876.81956

Prepared for

NULLAMANNA STATION

Nullamanna Station

1633 Nullamanna Road
Nullamanna NSW 2360
Telephone: 0428 539 163

ABN: 16 786 478 183

Prepared by

EnviroAg Australia

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Document Status Record

Report Type:	Hydrological Assessment
Project Title:	Nullamanna Feedlot Expansion
Client:	Nullamanna Station
Project Document Number:	23876.81956
File Name:	23876.81956_151126_Hydrology Assessment Nullamanna_Rev1

Revision	Date of Issue	Author	Reviewed	Quality Assurance	Approved
1	03/02/2016	Mark Lowry	Simon Lott	Barb Calderwood	Simon Lott
Signatures					

Notes:

Rev 1: Final Report

Client

Company

Distribution:

Recipient	No. Copies
Nullamanna Station	1
EnviroAg Australia	1

This document provides information to address the intent of Project Number 23876 as agreed to by Nullamanna Station.

Executive Summary

EnviroAg Australia Pty Ltd (EnviroAg) was engaged by Nullamanna Station to undertake a Hydrological Study at the proposed feedlot site in Nullamanna. The property is located at 1633 Nullamanna Road, Nullamanna NSW 2360.

Based on the hazards and risks associated with the movement of potential surface water pollutants into the general environment, a feedlot catchment is normally considered to consist of four (4) functional components: support infrastructure (access roads, hard stands), the feedlot itself and the ancillary facilities (feed mill, cattle handling and processing yards and manure stockpiles) servicing it, a wastewater utilisation area and a manure utilisation area.

The FSIM model (Lott, 1998) was used to model the hydrology of the feedlot controlled drainage area. It found that a storage capacity of 10ML will safely accommodate all but extreme wet years. This storage capacity delivers a spill frequency of 1 in 12 years which is substantially more conservative that than required for the site.

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1. Introduction

1.1 Site Description

EnviroAg Australia Pty Ltd (EnviroAg) was engaged by Messrs Peter and Mark Lane (the Client) to undertake a Hydrological Study at Nullamanna Station at 1633 Nullamanna Road, Nullamanna NSW 2360.

The site is located on the western slopes of the Northern Tablelands and is part of the Macintyre River Basin and the larger Border Rivers Catchment Area. Frazers Creek runs along the western boundary of the property and water onsite drains towards drainage areas that run into Frazers Creek. Frazers Creek starts at the town of Sapphire, runs along the eastern boundary of the property and into the Severn River, which then feeds into the Macintyre River.

The property is hilly and the proposed development site is on a relatively flat surface towards the top of a hill (Figure 2). This site has been cleared and ploughed, and is currently used for grazing stock. The development site drains towards a 1^{st} order stream to the northwest, which feeds into Frazers Creek.

1.2 Feedlot Land Use

The feedlot is characterised by several key land uses:

- Large areas of road and hard stand; and ancillary land uses;
- Open stock holding pen areas;
- Sedimentation basins and waste water holding ponds; and,
- Irrigable area.

Clean water from the rooves, roads and hard stands are diverted away from the operation areas of the feedlot where rainfall runoff can become contaminated.

1.3 Site Hydrology

The site of the expanded feedlot (approximately 676m AHD) is at a lower elevation to the current feedlot (eastern section 686m AHD, western section 681m AHD). It is on a hilltop with no area lying within a flood zone. The slope of the terrain causes water to flow towards dams or 1^{st} order streams and drainage areas which lead to Frazers Creek.

Feedlot areas will need to be in a well-controlled drainage area to ensure that water from the feedlot and associated infrastructure does not flow into Frazers Creek.

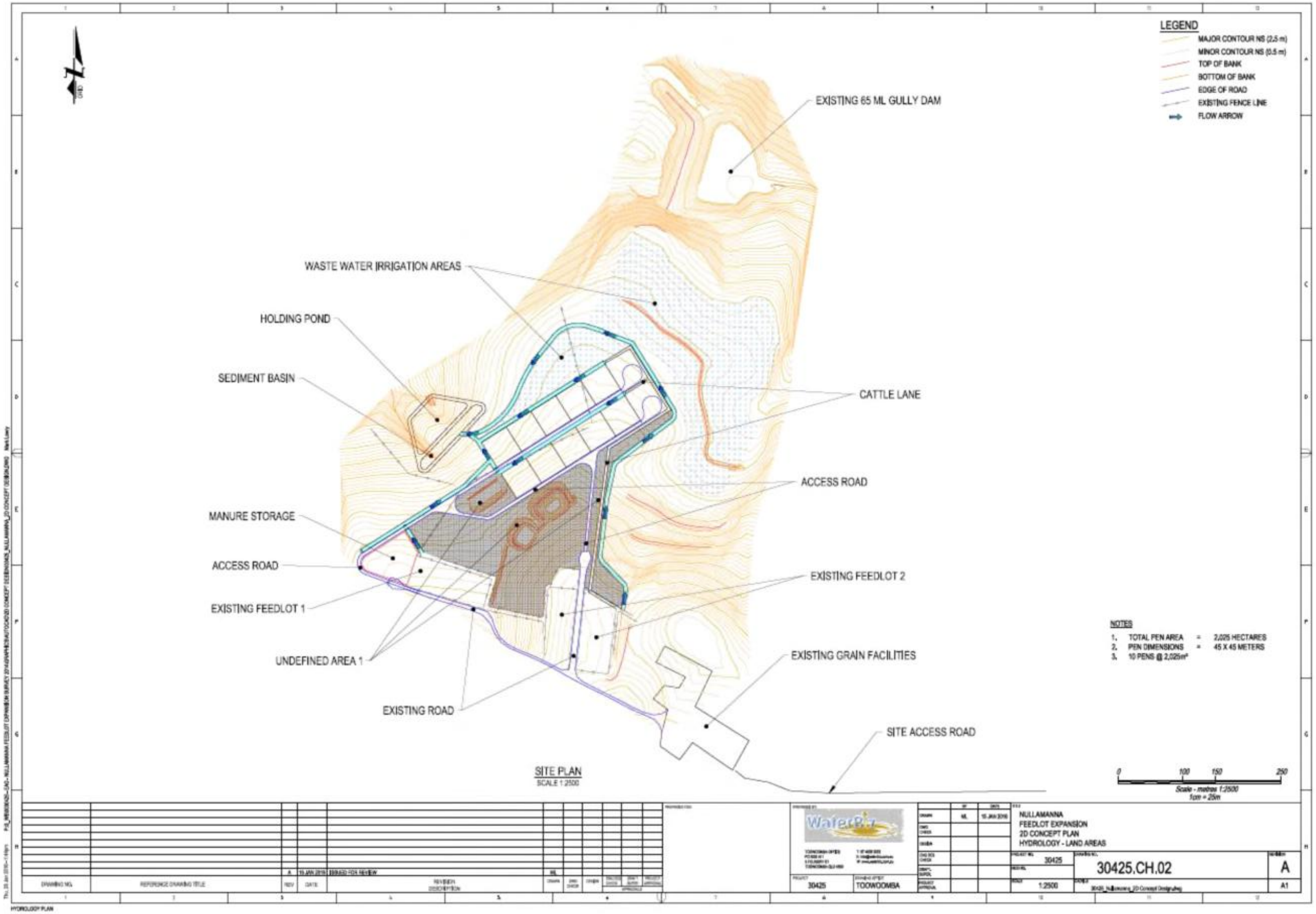


Figure 1 **Conceptual design of feedlot**

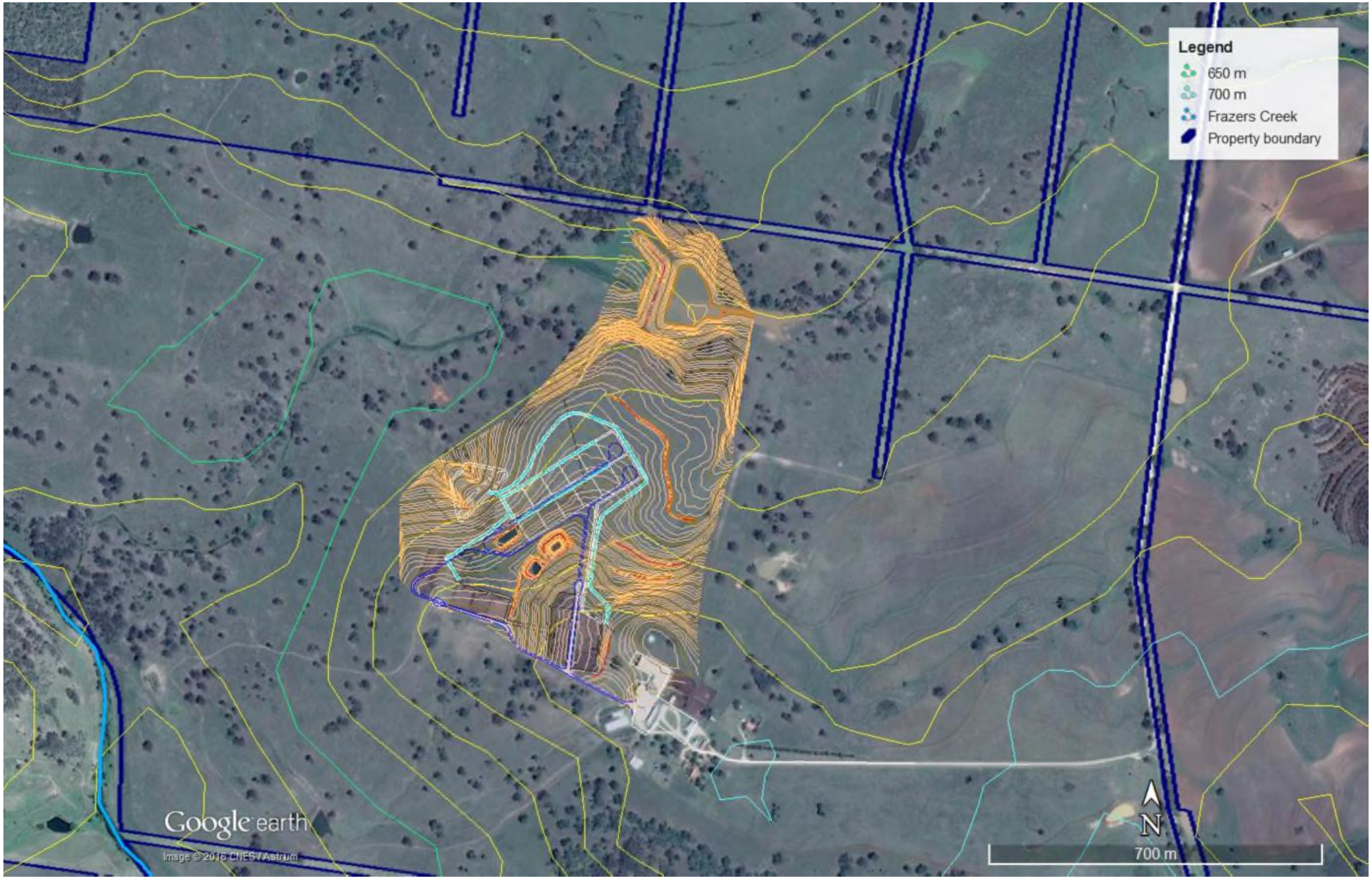


Figure 2 **Feedlot conceptual design and detailed topographic survey**

1.4 Design Guidelines

The pen areas are characterised by being areas of land that distinctively have manure as the principal form of "groundcover". Runoff from these areas typically carries quantities of dissolved nutrients and salts and may also entrain quantities of organic matter. If runoff containing these potential contaminants were to directly enter surface waters then pollution of that resource may result. Consequently, it is necessary for runoff to be adequately captured and safely stored. This typically involves the construction of runoff control structures and wastewater storages.

Guidelines exist that provide the design criteria for sizing runoff control structures in feedlots and, in particular, wastewater-holding ponds (Skerman, 2000; MLA, 2012). These guidelines have been based on research findings on the hydrology of feedlots under Australian climatic conditions. This research is described by Lott (1998). The research set out by Lott (1998) underpins current Australian National and State Government guidelines for the design and environmental management of the lot feeding industry.

The guidelines (MLA, 2012) can be applied to the hydrological assessment of the Nullamanna Station Feedlot.

2. Catchment Description and Characteristics

Based on the hazards and risks associated with the movement of potential surface water pollutants into the general environment, a feedlot catchment is normally considered to consist of four functional components: the support land uses (access roads, hardstands and buildings), the feedlot itself, and the ancillary facilities (cattle handling and processing yards and manure stockpiles) servicing it, a wastewater utilisation area, and a manure utilisation area.

The measures taken in each of these areas to address the hazards will be commensurate with the risks posed and varies between the four areas and are site and land-use management specific.

2.1 The Controlled Drainage Area

2.1.1 *Land Use in the Controlled Drainage Area*

The feedlot and its ancillary facilities typically pose the greatest risk to water quality in the external environment. To meet water quality objectives, uncontaminated runoff water from any areas upslope of the feedlot should be prevented from entering the feedlot facility or the associated land areas where waste may be collected, stored or treated.

This runoff is typically excluded from these “controlled” areas by an upslope “clean” water diversion bank. Concurrently, runoff from within these “controlled” areas needs to be adequately captured and safely stored.

The resultant, controlled drainage area (CDA) can therefore be described as the area in which all wastewaters and runoff are to be controlled, captured and stored. In practical terms it is the land area between any upslope clean water diversion banks (or in their absence the top of the catchment) and the downslope wastewater holding ponds and typically is further delineated by the areal extent of drains catching and conveying feedlot runoff to a primary treatment and wet weather storage (waste water holding ponds).

In a CDA the majority of the land is normally used for the feedlot pens. Other land uses in the CDA include, cattle processing facilities, roads and laneways, drains, manure stockpiles, hard stand areas and open or grassed areas between or around these facilities.

The layout of the proposed feedlot expansion is detailed in Figure 1 of this report. The relevant land use areas within the CDA of the proposed development are shown in Table 1. These areas were determined by using AutoCAD. The CDA of the feedlot compromises a catchment with a total area of 165,611m^2.

The layout of the feedlot expansion is to rows forming a contour layout. The natural fall of about 5% to the west and north east allows the feedlot to be designed with pens aligned in straight rows on a north east to south west axis. In this configuration each row of feedlots pens is separated from the adjacent row of pens on its lower or “back” side by a feed lane or alley.

A catch drain on the lower or “back” side separates the next row of pens. The catch drains will discharge to a main drain that runs down the slope at the western end of the feedlot. The natural fall to the west will result in a minor step down between each row of pens. It is expected that the pens will have a grade of 2.5-4.5%.

Table 1 Land uses by area

Controlled Discharge Areas			
Land Use	**Existing area (m^2)**	**Expanded area (m^2)**	**Total (m^2)**
Pen area		20,250	20,250
Cattle lanes		2,069	2,069
Drains		9,484	9,484
Manure storage		4,611	4,611
Roads		10,374	10,374
Existing pen area 1	7,056		7,056
Existing pen area 2	13,063		13,063
Undefined Area 1		46,750	46,750
Waste water irrigation area		66,157	66,157
Existing Road	4,421		4,421
Holding pond – internal area only		3,994	3,994
Sediment basin – internal area only		1,922	1,922
Total	24,540	165,611	**190,151**

2.1.2 *Runoff Control Structures*

The design principles of runoff control structures in feedlots are discussed in detail in Lott (1994), Lott & Skerman (1995), ICIAI (1997), SCARM (1997), Skerman (2000) and MLA (2012).

Drains

Runoff from the feedlot pen areas is to be collected in catch drains situated directly behind each pen. The pens are arranged in "front-to-back" rows (refer Figure 1, page 2). The configuration of the rows and the cross-slope gradient in the pens are designed to minimise the volume of runoff draining through adjoining pens.

The catch drains are also to serve as laneways providing access for cattle moving to and from the feedlot pens. The individual catch drains behind each row of pens are to discharge into main collection drains that will in turn discharge into a sedimentation system and ultimately the holding pond.

The catch drains and main drains need to be designed to both contain the flow volume and provide flow velocities that do not threaten channel stability at a peak flow rate equivalent to that from a design storm having an average recurrence interval (ARI) of 20 years (ICIAI, 1997, SCARM, 1997 and MLA, 2012). The maximum allowable flow velocity in channels is dependent on the characteristics of the material lining of the channel. High design velocities (>3 m/s) generally necessitate a concrete or masonry liner being applied. Where it is desirable to minimise any sedimentation of the entrained solids in the drains, minimum flow velocities (>0.3 – 0.5 m/s) may apply.

Sedimentation Basins

The aim of sedimentation system design is to provide flow velocities in the system low enough to allow for the settling of a minimum of 50% of the solids entrained in the CDA runoff in a design storm also having an ARI of 20 years (ICIAI, 1997 and SCARM, 1997). This level of sedimentation typically occurs when flow velocities are less than 0.005 m/s (Lott & Skerman, 1995). A performance standard requiring the settling of more than 50% of the entrained solids would require an exponential increase in detention time within the sedimentation system (as well as a correspondingly lower flow velocity) and therefore is generally impracticable and inefficient.

Peak Flow Velocities

To estimate the peak flow velocity in the catch drains, main drains and sedimentation systems it is necessary to determine the peak discharge of their respective catchments. The preferred method (ICIAI, 1997 and SCARM, 1997) for calculating the peak discharge of these catchments is the Rational Method as detailed by Pilgrim (2001). This methodology requires the prior estimation of the time of concentration of the catchments and the average rainfall intensity in the corresponding design storm.

Due to their relatively small size and the inability to derive observational data prior to construction, the Bransby Williams formula (Pilgrim, 2001) is often used to determine the time of concentration of feedlot catchments. This formula is given by:

Equation 1 Bransby Williams Formula

$$t_c = \frac{58L}{A^{0.1} S_e^{0.2}}$$

where t_c = time of concentration (min)

L = mainstream length (km)

A = area of catchment (km²)

S_e = equal area slope (m/km).

Rainfall Intensity and Design

The rainfall intensity, duration and frequency curves for the site are presented in Figure 3 and Figure 4. The 1 in 20 year 24 hour storm has an intensity of about 5.24mm/hr and a total of 126mm. Design storms of shorter durations are applicable for design of channels to accommodate peak flows from catchments inside the CDA.

Equation 2 Rational method formula

$$Q_y = 0.278\, C\ {}^{y}I_t\ A$$

where Q_y = peak volumetric flow (m³/s) having an ARI of y years,

C = runoff coefficient (typically 0.8),

${}^{y}I_t$ = rainfall intensity (mm/h) of design storm having duration tc, and

A = catchment area (km²).

Home | IFD Table | IFD Chart | Coefficients | ARI | Print IFD table | Help IFD table

Intensity-Frequency-Duration Table

Location: 29.625S 151.225E NEAR.. Nullamanna Feedlot Issued: 29/1/2016

Rainfall intensity in mm/h for various durations and Average Recurrence Interval

Average Recurrence Interval

Duration	1 YEAR	2 YEARS	5 YEARS	10 YEARS	20 YEARS	50 YEARS	100 YEARS
5Mins	73.7	96.9	129	150	178	218	251
6Mins	68.6	90.2	120	140	166	203	233
10Mins	56.0	73.5	97.6	113	135	164	189
20Mins	41.0	53.8	71.3	82.7	98.0	119	137
30Mins	33.2	43.6	57.7	66.8	79.1	96.4	111
1Hr	22.1	29.0	38.1	44.0	52.0	63.1	72.2
2Hrs	14.1	18.3	23.8	27.3	32.1	38.8	44.2
3Hrs	10.6	13.8	17.8	20.4	23.8	28.6	32.5
6Hrs	6.56	8.47	10.7	12.2	14.1	16.8	19.0
12Hrs	4.04	5.20	6.52	7.35	8.49	10.1	11.3
24Hrs	2.47	3.19	4.01	4.52	5.24	6.21	6.98
48Hrs	1.47	1.90	2.42	2.74	3.19	3.81	4.31
72Hrs	1.05	1.35	1.73	1.97	2.28	2.74	3.09

(Raw data: 29.97, 5.31, 1.38, 60.04, 9.47, 2.58, skew=0.32, F2=4.34, F50=16.31) © Australian Government, Bureau of Meteorology

Copy Table

Figure 3 Intensity frequency duration table

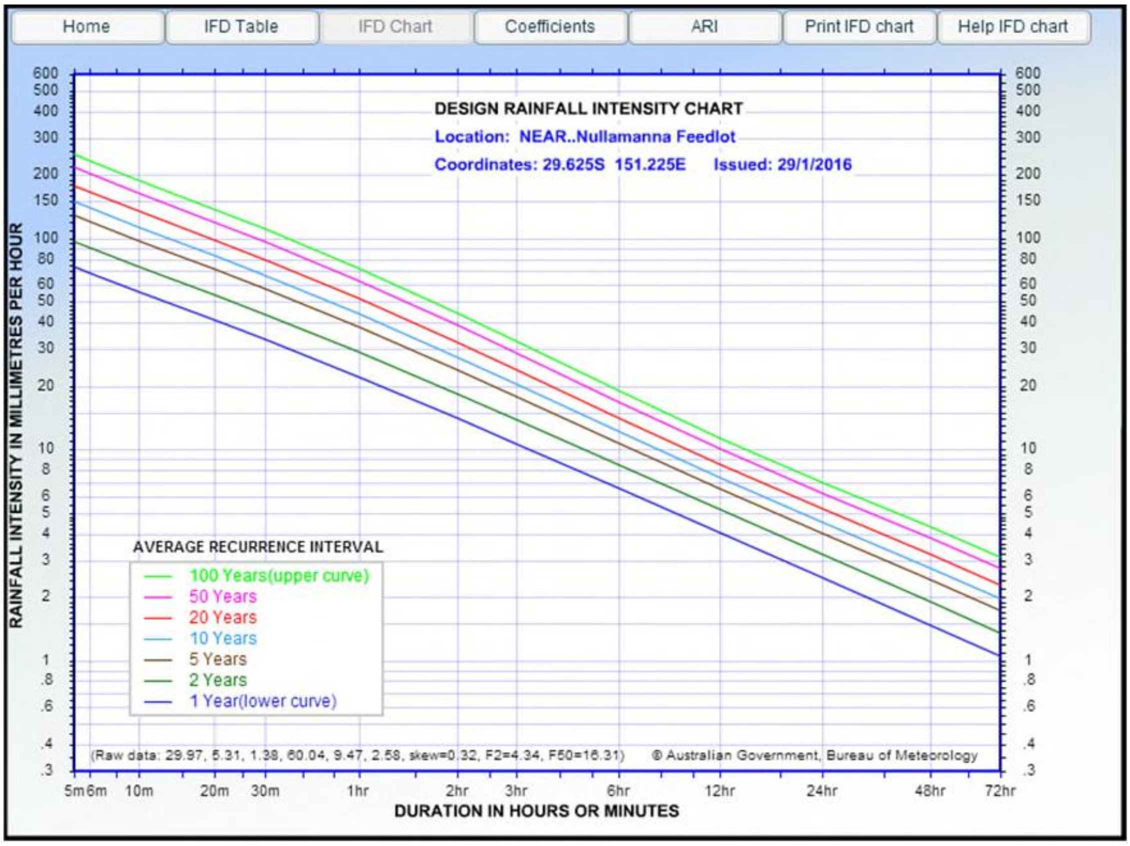


Figure 4 Design rainfall intensity

Manning's formulae can be used to calculate the runoff routing of a storm peak flow in a channel. The formulae are presented below.

Equation 3 Manning's formula

$$Q_y = \frac{\left[W \times d + \frac{d^2 \times (z_1 + z_2)}{2}\right]^{5/3} \times S^{1/2}}{\left[W + d \times \left(\sqrt{1 + z_1^2} + \sqrt{1 + z_2^2}\right)\right]^{2/3} \times n}$$

where Q_y = volumetric peak flow (m³/s) having an ARI of y years,

W = drain bed width (m),

d = drain flow depth (m),

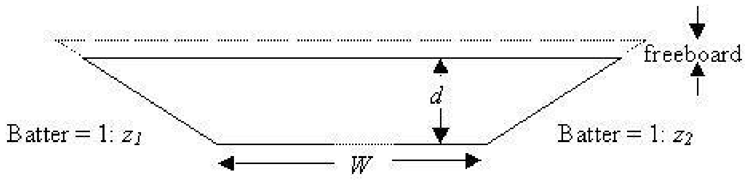
z_1 and z_2 are the batter grades (1: z horizontal) of the channel sides,

S = gradient of the channel bed slope (m/m), and

n = a Manning's roughness coefficient.

Equation 4 Manning's formula

$$V = \left[\frac{W \times d + \frac{d^2 \times (z_1 + z_2)}{2}}{W + d \times \left(\sqrt{1 + z_1^2} + \sqrt{1 + z_2^2}\right)}\right]^{2/3} \times \frac{S^{1/2}}{n}$$



Freeboard

Where embankments are necessary to form the drains (e.g. irrigation tail water drains), they need to be constructed to provide allowances for freeboard, settlement and minor undulations in addition to the calculated maximum drain flow depth. The degree of settlement will depend on soil type and the degree of compaction provided by construction equipment but can represent up to 20 to 25% reduction in finished embankment height (Skerman, 2000). An allowance of 0.15 m will normally account for undulations in most soil types (Skerman, 2000).

A suitable freeboard for feedlot drains is 0.5 metres (ICIAI, 1997). Side batter grades should less than 1:3 (ICIAI, 1997). Energy dissipaters may need to be placed where a catch drain terminates in the sediment basins and or main drain, so reducing the exit velocity from the channel (Lott, 1994). Design details for the catch and main drain are provided in Table 2.

Table 2 Design details of the feedlot pen catchments, main drains and tailwater drains

Parameter		CDA Main drain (Total Site)	CDA Typical catch drain
Mainstream length	L	0.444 km	0.196 km
Catchment area	A	0.13449 km^2	0.00337 km^2
Equal area slope	S_e	54.69 m/km	36.14 m/km
Time of concentration	t_c	14.1 min	9.8mins
Rational method formula			
Runoff coefficient	C	0.8	0.8
Rainfall intensity (20 yr ARI)	${}^yI_t$	115.7 mm/h	135.8 mm/h
Peak volumetric flow	Q_y	3.38 m^3/s	0.10 m^3/s
Manning's formula			
Lining	Material	Clay	Clay
Channel bed width	W	3	1.5
Upslope batter grade	z_1	0.25	0.33
Downslope batter grade	z_2	0.25	0.33
Channel bed gradient	S	0.054m/m	0.0237m/m
Manning's roughness coefficient	n	0.04	0.04
Channel flow depth	d	0.34 m	0.085 m
Channel flow velocity	v	2.27 m/s	0.683 m/s
Embankment height	$d + 0.5$	0.84 m	0.585 m

Sedimentation System Capacities

Sedimentation systems may be designed in the form of terraces, basins or ponds. These system types differ in respect to their aspect ratios and depth. Sedimentation terraces are shallow, relatively elongated structures with aspect ratios (*L*/*W*) of between 8:1 and 10:1. Sedimentation basins and ponds typically have similar aspect ratios (*L*/*W*) of between 2:1 and 3:1 but basins shallower (<1.5 m in depth) than ponds (>1.5 m in depth).

Both sedimentation terraces and basins are designed to drain freely after each runoff event so allowing the collected solids to be dried and removed at frequent intervals. Sedimentation ponds are designed to allow solids from a series of runoff events to accumulate with decanting of the captured solids typically occurring at intervals of one to five years. A scaling factor (λ) is applied to the design volume to account for the storage capacity required to store the solids captured in the various types of sedimentation system between decanting or cleaning operations. The required volume of sedimentation systems can be estimated using the formula provided by SCARM (1997) given by:

Equation 5 Required volume of sedimentation systems

$$V = Q_y \frac{L}{W} . \frac{\lambda}{v}$$

where V = sedimentation system volume (m³),

Q_y = volumetric peak flow (m³/s) having an ARI of y years,

L/W = aspect ratio of the system,

λ = a scaling factor, and

v = maximum design flow velocity (0.005 m/s).

The choice of sedimentation terrace, basin or pond is dependent upon factors such as available land areas, site topography and climate as well as the proximity of neighbours and other potential odour receptors. In this case the site of the proposed development *lends itself to the use of a sedimentation pond*

The design details for the pond are provided in Table 3. In a sedimentation pond the aspect ratio (*L*/*W*) is typically around 10:1 while the applicable scaling factor (λ) can be 1 (SCARM, 1997). The embankments of the sedimentation pond need to be constructed to provide an allowance for both freeboard and settlement. The minimum operational freeboard is 0.9 metres (ICIAI, 1997).

Table 3 Design details of sedimentation basin

Parameter	Unit	Sediment Basin
Sedimentation terrace formula		
Peak volumetric flow	Q_y	3.38 m^3/s
Aspect ratio	L/W	10
Scaling factor	λ	1
Maximum flow velocity	v	0.005 m/s
Design volume	V	6755 m^3
Surface area	A	6755 m^2
Depth	d	1.0 m
Minimum freeboard		0.9 m

Sediment Basin Discharge: Weir and Channels

Runoff discharged from the sedimentation terraces need to be released in a controlled manner by way of weirs. The required dimensions of the weirs should able to accommodate the peak volumetric flow from a 20 year ARI design storm (MLA, 2012) and can be estimated iteratively by solving for weir crest length (*b*) and hydraulic head (*H*) the following equation (Isrealsen & Hansen, 1962; Shaw, 1994 and Jenkins, 2001):

Equation 6 Determination of dimensions of a weir for peak volumetric flow - 20 year ARI storm

$$Q_y = C_d .bH^{3/2}$$

where Q_y = volumetric peak flow (m^3/s) having an ARI of y years,

C_d = a discharge coefficient,

b = weir crest length (m), and

H = hydraulic head of the approach flow (m).

A broad crested weir discharge coefficient (C_d) of 1.7, obtained from published values (Isrealsen & Hansen, 1962; Shaw, 1994 and Jenkins, 2001), can be considered suitable for preliminary design work such as this. The design dimensions for the weir are provided in Table 4.

Table 4 Design details for sedimentation pond weir

Parameter		Sediment Basin
Weir formula		
Peak volumetric flow	Q_y	3.38 m^3/s
Discharge coefficient	C_d	1.7
Weir crest length	b	5.6 m
Head of approach flow	H	0.5 m
Mean flow velocity	v	0.005 m/s

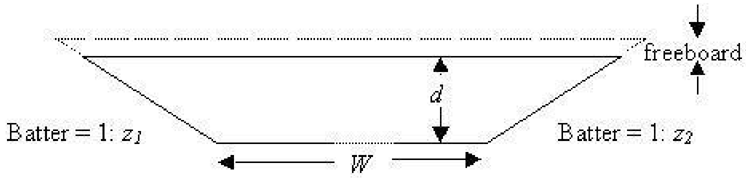
To reduce the likelihood of the weir being submerged due to subcritical flow conditions at the peak design discharge, the depth of the flow in the downstream channel at that time should generally be less than 80% or the hydraulic head of the approach flow in the sedimentation system (Isrealsen & Hansen, 1962 and WA Main Roads, 2004) and the spillway channel bed gradient should be greater than 0.5% (Schwab *et al*., 1971). Any part of the spillway below the weir likely to be exposed to supercritical flows under ordinary conditions (less than a 20 year ARI design storm) will need a concrete or masonry lining applied. Some form of energy dissipater or stilling basin may also be necessary.

More detailed engineering design for the weir and spillway structures (based on unit hydrographs) will be undertaken as part of the detailed design work to be carried out prior to construction of the feedlot.

The spillway channel below the weir is to be trapezoidal in cross section and vegetated (mown grass). A Manning's roughness coefficient of 0.04 (Shaw, 1994 and Loughlin & Robinson, 2001) and maximum permissible flow velocity of 1.5 m/s (ICIAI, 1997 and Skerman, 2001) are applicable in this instance. The requirement for the spillway channel allowing critical or supercritical flow over the weir under normal flow conditions is an additional design criterion. Using these criteria the design dimensions and design flow velocity in the spillway channel can be estimated iteratively using Equations 3 and 4 and are provided in Table 5.

Table 5 Design details for sedimentation pond spillway channel (Concrete lined)

Peak volumetric flow	Q_y	CDA Main drain
Manning's formula (F.3 & F.4)		
Channel bed width	W	3 m
Batter grade (1)	z_1	0.25
Batter grade (2)	z_2	0.25
Channel bed gradient	S	0.005 m/m
Manning's roughness coefficient	n	0.013
Channel flow depth	d	0.35 m
Mean flow velocity	v	2.20 m/s



2.1.3 *Primary Wastewater Pond*

The design principles of feedlot holding ponds (referred to as the Primary Wastewater Pond) are discussed in detail in Lott (1994), ICIAI (1997), SCARM (1997), Lott (1998) and Skerman (2000).

The principal design function of holding ponds is to store feedlot runoff until such time as the pond effluent can be safely used for irrigating the wastewater utilisation area. Depending on the time for which the runoff is stored in the holding pond, microbial degradation (principally anaerobic) of the entrained organic matter may occur, a portion of any mineralised nitrogen may be lost to volatilisation and denitrification processes and a proportion of the water will be lost to evaporation (Lott, 1994 and ICIAI, 1997). Some sludge build-up may also occur through settlement of the entrained solids (Lott, 1994).

Until comparatively recent times, a commonly utilised approach to holding pond design was to treat the holding ponds as short-term retention systems. The applicable design criteria were for the pond to be capable of retaining the runoff from a major storm event (1 in 20 year 24 hour storm). Typically runoff coefficients of 0.8 were used for feedlot pens, laneways and hardstand areas and 0.4 for grassed areas (ICIAI, 1997; SCARM, 1997; MLA, 2012). The required storage volume using the "major storm" concept can be determined using the following relationship:

Equation 7 Holding pond formula

$$V = [(A_h \times C_h) + (A_s \times C_s)] \times {}^{y}I_t / 100$$

where V = required storage volume (ML),

${}^{y}I_t$ = rainfall intensity (mm/h) of design storm having duration tc,

A_h = area of "hard" catchment (ha),

C_h = a hard catchment runoff coefficient,

A_s = area of "soft" catchment (ha), and

C_s = a soft catchment runoff coefficient.

An estimate of the required storage volume in the holding pond as determined using the "major storm" approach is shown in Table 6.

Table 6 Design details of holding pond (major storm event approach)

Parameter		Value
Holding pond formula		
1 in 20 yr 24 hour storm	${}^{y}I_t$	5.24 mm/h
"Hard" catchment area	A_h	7.26 ha
Runoff coefficient	C_h	0.8
"Soft" catchment	A_s	6.19 ha
Runoff coefficient	C_s	0.4
Storage volume	V	10.4Ml

The "major storm" design concept used above is based on the premise that holding ponds are only used for the short-term storage of runoff and that the pond contents can be fully utilised in the wastewater utilisation area between significant rainfall events. Unfortunately, major rainfall events are often associated with episodic periods of wetter than normal weather and seasonal and climatic factors may necessitate the long-term storage of runoff until such time as it can be safely assimilated in the wastewater utilisation area. Further, sludge build-up may also reduce the effective storage volume. Consequently, holding ponds designed on the above basis have often been found to have an unacceptably high frequency of "spill" or overflow events (more than an average of once every 10 years) due to the effective storage capacity being insufficient to accommodate the accumulated runoff in a 90 percentile wet year (Lott, 1998).

A more robust alternative to the major storm event approach is that carried out by undertaking a water balance for the entire feedlot catchment (controlled drainage area and wastewater utilisation area). This water balance needs to be modelled on at least a monthly step basis using site representative metrological data. Using this approach the required storage volume is that capable of preventing the holding pond from overflowing in a 90 percentile wet year (ICIAI, 1997 and SCARM, 1997). In determining this capacity consideration also needs to be given for the storage of accumulated solids.

The FSIM model (Lott, 1998) is a daily step model developed specifically for open cattle pens such as those used in the feedlot catchments. The FSIM model simulates the material balance of both water and nutrients within a feedlot catchment using distributed parameters to describe the relevant system processes. Catchment hydrology is modelled using separate algorithms for pen areas, “hard” surfaces such as roadways and “soft”, largely vegetated surfaces. The algorithms have been validated against standard methodologies used for catchment hydrology calculations (USDA, 1971 and Pilgrim, 1987). Model output has been verified by comparison with comprehensive hydrological measurements made in catchments within feedlots in southern Queensland. The design capacity of the holding ponds as determined using the FSIM model is detailed in Section 3 of this report.

Holding Pond Spillway

Irrespective of the design concept used, any holding pond is likely to spill or overflow following extraordinary rainfall events. Current guidelines (ICIAI, 1997 and SCARM, 1997) stipulate that the holding pond spillways be designed to handle a 1 in 50 year design storm. The volumetric peak flow resulting from a 50 year ARI design storm can be calculated using Equations 1 and 2. The design values determined using these equations are provided in Table 7.

Table 7 Peak volumetric peak flow (Q_p) from a 1 in 50 year design storm

Parameter		Value
Bransby Williams formula (F.1)		
Mainstream length	L	0.444 km
Catchment area	A	0.13449 km^2
Equal area slope	S_e	54.69 m/km
Time of concentration	t_c	14.1 mins
Rational method formula (F.2)		
Runoff coefficient	C	0.8
Rainfall intensity (50 yr ARI)	${}^{y}I_t$	145.55 mm/h
Peak volumetric flow	Q_y	4.35 m^3/s

The overflow from the primary holding pond needs to be released in a controlled manner by way of a weir. The required dimensions of a weir able to accommodate the peak volumetric flow from a 50 year ARI design storm (ICIAI, 1997) can be estimated by solving iteratively for weir crest length (b) and hydraulic head (H) the weir formula given in Equation 6. The resultant design details are provided in Table 8.

Constraints exist in terms of avoiding submergence of the weir due to subcritical flows at the peak design discharge apply. The extent of the spillway channel likely to be subjected to supercritical flows will need to be lined with a concrete or masonry liner. Again, more detailed engineering design for the weir and spillway structures will be undertaken as part of the detailed design work to be carried out prior to construction of the feedlot.

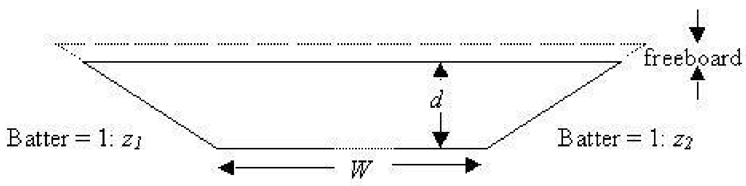
Table 8 Design details for Primary Pond Overflow Weir

Parameter		Value
Weir formula (F.6)		
Peak volumetric flow	Q_y	4.35 m^3/s
Discharge coefficient	C_d	1.7
Weir crest length	b	20 m
Head of approach flow	H	0.5 m
Mean flow velocity	v	0.947 m/s

The required dimensions of a trapezoidal spillway channel to carry the 50 year ARI peak flow can be determined iteratively by solving for various channel bed width and depth the Manning's formula equations (3 & 4). The holding pond spillway channel below the weir is to be trapezoidal in cross section and vegetated (mown grass). A Manning's roughness coefficient of 0.04 (Shaw, 1994 and Loughlin & Robinson, 2001) and maximum permissible flow velocity of 1.5 m/s (ICIAI, 1997 and Skerman, 2001) are applicable in this instance. The requirement for the spillway channel allowing critical or supercritical flow over the weir under normal flow conditions is an additional design criterion. The resultant design dimensions and design flow velocity of the spillway channel are provided in Table 9.

Table 9 Design details for holding pond spillway channel

Peak volumetric flow	Q_y	**Y m^3/s**
Manning's formula (F.3 & F.4)		
Channel bed width	W	20 m
Batter grade (1)	z_1	0.25
Batter grade (2)	z_2	0.25
Channel bed gradient	S	0.005 m/m
Manning's roughness coefficient	n	0.04
Channel flow depth	d	0.28 m
Mean flow velocity	v	0.736 m/s



2.2 Wastewater Irrigation Area

The runoff from a feedlot's controlled drainage area captured in the holding pond is to be irrigated on land adjacent to the feedlot complex where the nutrients and water can be utilised in plant production. The soil in the wastewater utilisation area provides a "sink" for the assimilation of applied nutrients.

The environmentally sustainable use of the wastewater utilisation area is directly related to the amount of nutrient applied to such areas, the amount of nutrient recovered in produce harvested or removed from the area and the amount of nutrient able to be safely stored in the soil. Some loss of nutrient (and salts) from the system will occur by way of leachate moving below the root zone of the crops and through processes such as erosive soil loss. It is also necessary for increased amounts of salt to be drained from the soil in the wastewater utilisation area by this means if salinization of the soil profile is to be avoided. This loss of nutrients and salts will not impact on the environmental value of any associated surface or groundwater resources.

Generally, one of the plant macronutrients (nitrogen, phosphorus or potassium), rather than either the hydraulic or the organic matter loading rate, is the limiting factor in determining the net annual application volume of wastewater in the utilisation area and, conversely, the required size of the utilisation area. The use of a source of "fresh" or "clean" irrigation water to supplement the applied wastewater will generally be necessary to help maximise crop yields and so maximise nutrient removal from the utilisation area. In the long term, rainfall, wastewater or irrigation water applications in excess of that utilised directly by the crops will be necessary to leach salts from the soil profile.

The amount and timing of both wastewater and fresh water applications will be largely determined by the irrigation requirement of the crops. In abnormally wet years or seasons, hydraulic loading may in the short term become the limiting factor on wastewater applications. Current guidelines (MLA, 2012) attempt to address this by stipulating that the wastewater utilisation area must be of sufficient size to allow wastewater irrigation in a 90 percentile wet year. Consistent with this, the FSIM model determines both the optimum size of the wastewater utilisation area and the optimum size of the holding pond necessary to provide sufficient storage capacity to safely store the wastewater in a 90 percentile wet year.

Equation 7 Terminal system formula

$$V = a + b$$

where V = volume of terminal system (m^3),

a = irrigation tailwater (m^3), and

b = stormwater runoff from the irrigation area (m^3).

Table 10 Design details for terminal system

Parameter		**Min Value (approx.)**
Terminal system formula		
Irrigation tailwater	a	0
Rainfall runoff	b	12mm
Area	A	6.6 ha
Terminal system capacity	V	792 m^3

3. Hydrological Modelling of the Nullamanna Feedlot

3.1 Introduction

The FSIM model (Lott, 1995 and Lott, 1998) simulates the hydrological mass balance of open cattle pens such as those in the feedlot complex with particular emphasis on the water balance of the pen surface. The model uses distributed parameters to describe the various aspects of the hydrological balance and has been developed to incorporate variables for factors such as land use and feedlot management practices.

Long-term daily climate data (precipitation and evaporation) for the site or a site representative station is a basic requirement. Output is in various forms and can be tailored to investigate the specific factors influencing the hydrology of the feedlot catchment. The model was developed using hydrological data collected in commercial feedlots. The FSIM model has been subsequently calibrated and the accuracy of its predictions of catchment conditions and rainfall runoff in feedlot catchments has been verified and tested (Lott, 1998).

The research data and model was used to derive the co-efficient used in the current State and National feedlot guidelines (MLA, 2012).

The FSIM model was used to simulate the hydrological performance of the Nullamanna Feedlot catchment including the holding pond and effluent utilisation area. This section of report discusses the principles underlying the FSIM model, the input data used in the model and presents the output predictions, comparing and contrasting them with those provided in the previous sections of the report.

3.2 Climatic Data

3.2.1 *Data Requirements*

The climate data required for a FSIM simulation are precipitation, temperature, humidity, radiation, and potential evaporation.

3.2.2 *Evaporation Data*

Evaporation can be demonstrated to be the most important climatic variable influencing the hydrological performance of the feedlot catchment, holding pond and wastewater utilisation area. To reliably model the hydrology of a feedlot, it is necessary to estimate, on a daily basis, the direct evaporation from the surface of the feedlot pen and the holding pond as well as the evapotranspiration from the wastewater utilisation area (Lott, 1998).

Lott & Skerman (1995) found hydrological balances based on daily variable evaporation estimates varied significantly from those based on monthly mean data with the two estimates of net annual evaporation varying by up to 30%. This has significant implications when issues such as the frequency of spill or overflow events are considered. Consequently, daily variable data is the preferred input for the FSIM model and should be used in preference to monthly mean data where available.

3.2.3 *Climate Datasets*

The site of the proposed development is located on the western slopes of the Northern Tablelands, NSW. The longitude and latitude of the site are respectively 151.225°E and 29.625°S.

Detailed climatic data is available for Bureau of Meteorology Inverell Research Station which is the nearest monitoring station to the Nullamanna Feedlot. Nullamanna’s climate data is similar to Inverell. Appendix A provides a summary of the Inverell climate.

The precipitation datasets for the other stations generally cover 100 years or more and are of reasonable quality (>99% original data & <1% patched data for missing values).

Given the intrinsic variability associated with climatic data, the length of the historical record used in the modelling of feedlot hydrology is an important consideration in determining the confidence that can be placed in modelled outcomes. This is particularly the case in determining the size of a holding pond and predicting the frequency of “spill” or overflow events.

Data records longer than 30 years are generally required to model spill events where the design criteria is a spill frequency less than one of 1 in 10 years. Ideally, more than 50 years of historical climate data should be used if available. To provide an acceptable level of accuracy and precision as well as conservative modelled outcomes representative of the development site, a composite meteorological dataset using precipitation data for 1889 through to 2015 was compiled for use in the FSIM modelling.

The 126 year dataset was obtained from the SILO enhanced climate database hosted by the Science Delivery Division of the Department of Science, Information Technology and Innovation (DSITI, August 2015). Of all the sites considered it provides the longest, most robust and conservative data set. The monthly averages for rainfall and evaporation used in the FSIM model are shown in Table 11. A snap shot of the header of the SILO dataset for climate data is shown in Figure 5 below (DSITI, 2015).

Table 11 SILO monthly average rainfall and evaporation depths

	Daily	
Month	**Rain (Ave)**	**Evaporation (Ave)**
January	3.07	6.87
February	2.97	6.20
March	2.13	5.37
April	1.35	3.86
May	1.44	2.52
June	1.63	1.92
July	1.61	2.01
August	1.42	2.78
September	1.50	4.04
October	2.17	5.14
November	2.70	6.09
December	3.01	6.86

```
latitude = -29.44   (DEG.MIN)
longitude = 151.44   (DEG.MIN)
Year     Day      Rain     Evap
                  (mm)     (mm/day)
```

Figure 5 Header of SILO dataset

3.2.4 *Runoff and Water Balance of a Manure Covered Pen*

The accumulated manure (faeces and urine) on the surface of feedlot pens acts as a significant store of water in the water balance of a pen area catchment. The characteristics of the manure also influence the volume of runoff from rainfall events, the amount of nutrients and organic matter entrained on the runoff and the amount of odour generated.

The mass of faeces voided by cattle each day is typically equivalent to between 5 and 6% of the body weight of the animals and has a wet basis moisture content greater than 80%. Voided urine typically constitutes around 30% of the manure produced each day. In contrast manure can be air dried to a wet basis moisture content of around 6% (Watts *et al*., 1994 and Sweeten & Lott, 1994). Given an average bulk density of 750 kg/m³, the above range of potential moisture contents equates to a capacity for 100 mm of dry, compacted manure to store up to 280 mm of water. Storage of this amount of water would be associated with substantial expansion of particulate matter in the manure and water filling all the voids between the manure particles such that 100 mm of dry manure would become 300 mm of wet manure.

Due primarily to compaction resulting from cattle trampling the manure pad on the surface of the pen, the manure develops a stratified profile that is generally found to consist of up to three layers.

Immediately above the soil surface in the pen, an interface layer 25 to 50mm deep develops. This layer consists of organic matter from the manure mixed with the soil fabric. The trampling of cattle facilitates the mixing and compacts the manure and soil particles in this layer, so increasing the bulk density and reducing the hydraulic conductivity. Significantly, the manure is also a significant source of the monovalent cation forms of sodium and potassium. Overrepresentation of these cations on colloidal matter in this interface layer causes dispersion of the colloidal material. This exacerbates the compaction caused by the cattle trampling the manure, further increasing bulk density and reducing hydraulic conductivity. In addition, microbial decomposition of the organic matter releases complex carbohydrates and organic molecules that fill the voids between particulate matter and occlude pores increasing bulk density and further reducing hydraulic conductivity. The net result of these influences is that this interface layer usually has a bulk density of between 1,000 and 1,700 kg/m³. By comparison, the manure above this layer typically has a bulk density of between 750 and 930 kg/m³ while the underlying soil may have a bulk density of 1,400 to 1,600 kg/m³ (Lott, 1998).

The hydraulic conductivity of the interface layer has been found to be in the range of 5×10^{-13} m/s and 3×10^{-12} m/s (Walker *et al*., 1979 and Southcott & Lott, 1997). Consistent with this Mazurak (1976), in a study undertaken in a Nebraska feedlot, found the hydraulic conductivity of the interface layer to be less than 4% that of the soil 100 mm deeper. These characteristics mean that the interface layer can be considered to effectively provide a barrier to water in the manure pad infiltrating into the underlying soil profile. Similarly, the interface barrier also prevents water borne pollutants directly entering the soil profile from the manure pad (Lott, 1998).

The condition of the manure above the interface layer varies with time and is dependent on factors such as rainfall, evaporation, stocking density, cattle trampling (which has different effects depending on the moisture content) and the manure management practices of feedlot pens. Lott (1994 & 1998) found that the condition of this manure could be reliably classified using one of the following descriptions:

(1) Powdery-smooth-dry,

(2) Smooth-compact-moist,

(3) Rough-wet (“puggy”), and

(4) Smooth-saturated.

Each condition depends on manure moisture content and mechanical disturbance of the surface manure by cattle movement. Importantly:

- Maximum runoff occurs in conditions 2 and 4,
- Maximum sediment erosion occurs in conditions 1 and 4,
- Maximum odour nuisance and least runoff occurs in condition 3, and
- Minimum odour and maximum runoff occurs in condition 2.

The rainfall-runoff relationship of surface of a manure covered pen is discussed in detail in Lott (1998). Figure 6 shows the conceptual water balance of a pen. It accounts for the gains and losses of moisture by the pen surface. The manure on the pen surface represents a store of water and its characteristics (slope and roughness) may influence its water balance and the rainfall-runoff process from the pen surface. The parameters of interest, when understanding the water balance of the manure are:

- Stored water,
- Infiltration,
- Depression storage,
- Temporary storage),

- Evaporation, and
- Surface runoff.

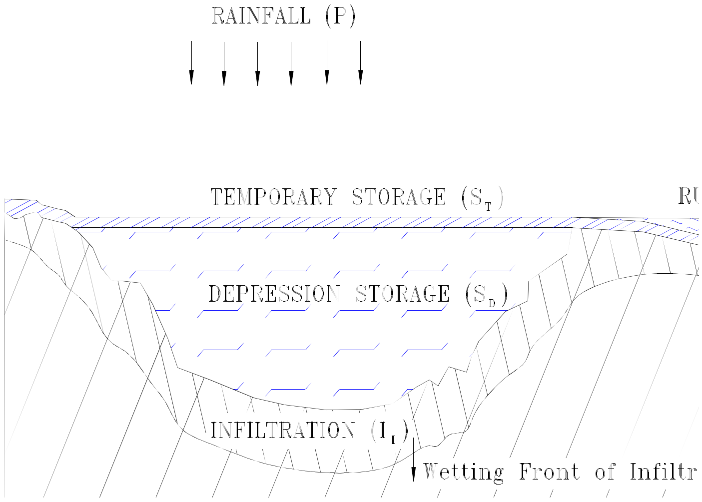


Figure 6 Conceptual model of the water balance of the cattle pen surface

Equation 8 Volume of Runoff

$$R = P - S_T - S_D - I - S_W - I_P$$

where R = runoff,

P = precipitation,

S_T = temporary storage,

S_D = depression storage,

I = infiltration,

S_W = stored water, and

I_P = percolation below the zone of stored water.

The FSIM model uses the four pen conditions (1 – 4) described above to characterise pen surface storage (*S*) and infiltration (*I*) in the above relationship.

A factor significantly impacting on the above relationship is the amount of water added to manure by the cattle (Watts, 1991). Cattle excrete faeces and urine that, when combined, have a mass equivalent to 5-6 % of the animal's body weight. It is anticipated that the mean live weight of cattle in the proposed feedlot will be about 450kg. An animal of this size can be estimated to produce about 25kg of manure (faeces and urine) per day. Of this, 28 kg is water and 4kg is dry matter. As a consequence, the amount of manure-derived water deposited on the pen surface can be seen to be dependent on the stocking density and the live-weight of the stock (refer Figure 7). The stocking density in the proposed feedlot is to be 15 m² per SCU. FSIM incorporates these additions when undertaking its daily step estimate of the pen surface water balance.

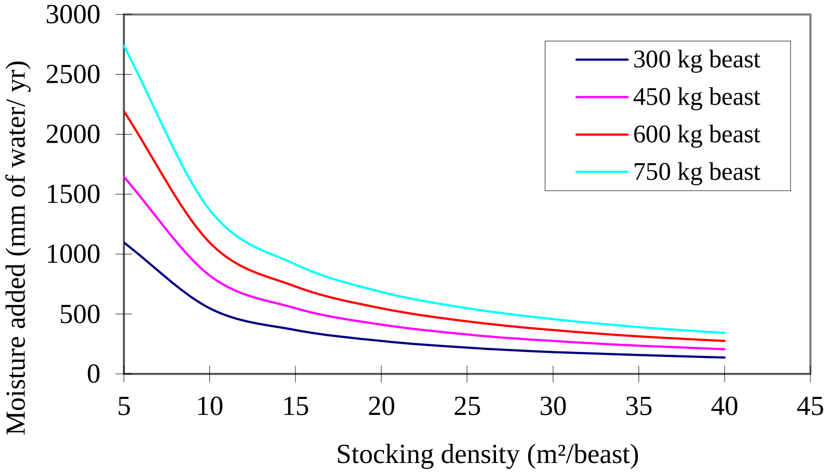


Figure 7 Moisture added to manure pad at various stocking densities of cattle of various live-weights (Sweeten & Lott, 1994)

The capacity of the pen surface to absorb water can vary with manure depth, manure condition and the gradient of the manure pad.

Empirically derived data on the rate of manure accumulation (Watts *et al*., 1994) is shown in Figure 8. At the proposed stocking density of 15 m^2 per head, the estimated rate of manure accumulation using this relationship is 130 mm/yr or 0.36mm/day (dry compact manure in pen condition 2). The amount of water able to be stored in the manure pad (S_w) increases with the mass of manure present on the pad. FSIM takes the accumulated depth of manure and its condition into consideration in undertaking the calculations for the pen surface water balance.

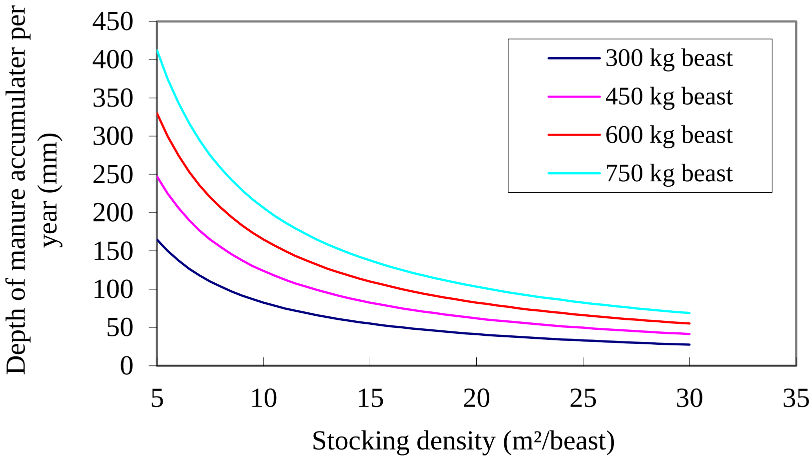


Figure 8 Depth of manure accumulated annually at various stocking densities of cattle of various live-weights (Watts et al., 1994)

Based on the above, at any given stocking density the amount of manure in the pens will be a function of the time since cleaning and the frequency of cleaning. This has implications for the condition of the manure in the pens. Lott (1998) found that compared to the regular intermittent cleaning of all of the pens, the continuous sequential cleaning of the pens reduces the incidence, extent and duration of pen condition 3 in the pen areas and the catchment that contributes to runoff to the waste water systems.

The depth of the manure and the moisture influences the amount of rainfall retained on the surface (S_T) and in depressions (S_D) in manure surface (Lott, 1994). This effect is not consistent across all pen conditions with manure depth being a significant influence on surface detention with pen condition 3 but not 1, 2 and 4. Condition3 is typified by "puggy" conditions where indentations made by the hooves of the cattle are more likely to form and persist on the surface of manure. Surface detention is also influenced by the gradient of the pen slope (Lott, 1994). However, this effect is least for pen condition 2 and 4.

Considering the above, it is evident that runoff from pens is determined by a multifarious relationship between factors as diverse as the live-weight of the cattle, climate, stocking density, the pen cleaning frequency and pen slope. A model such a FSIM allows all these factors to be integrated into the estimates of runoff from the cattle holding pens, so enhancing the precision and accuracy of the modelled outcomes.

It is important to note that most animals will be "empty" when they arrive and as such they are likely to void substantially less manure than shown in Figures 3 and 4. Consequently the FSIM model undertaken will be very conservative with regard to manure accumulations and characteristics.

3.3 Runoff from Other Land Uses Onsite

While the feedlot pens have the most variable runoff yield and comprise the largest land-use in the feedlot controlled drainage area, other portions of the catchment can contribute significant amounts of runoff and have a significant effect on the hydrology of the catchment, the wastewater holding ponds and the irrigation areas.

Roadways, laneways and other hard stands generate significant runoff. After an initial abstraction of around 5mm, the remainder of a rainfall event can be considered to contribute directly to runoff from these areas. Similarly, an initial abstraction of around 7 mm can be expected for the drainage system within the controlled drainage area (Lott, 1998).

Harvested manure in stockpiled areas has the capacity to store a substantial amount of rainfall. Lott (1998) found that an initial abstraction of around 25 mm was a reasonable approximation for windrowed manure. Hardstand areas with a compacted cover between the windrows can be expected to provide an initial abstraction of around 7 mm.

The runoff from grassed ("soft") areas and vegetated waterways within the catchment are able to be reliably determined using the approach used in USSCS model (USDA, 1971). This model assigns "k" values based on catchment condition and antecedent rainfall to the various areas within the catchment. These k values are then used to estimate runoff based on daily precipitation data.

3.4 Model Input Data

The values used for the major input variables in the FSIM model are provided in Table 12.

The data for the feedlot parameters were either design values discussed elsewhere in the SEE or derived from comparable production data. Catchment areas were obtained from CAD drawings of the site and the design of the expansion.

Table 12 Values for major input variables in the FSIM feedlot hydrology model

Parameter	Value	Notation
Feedlot parameters		
Feedlot capacity	3,000 SCU	
Occupancy	90%	
Mortality rate	0.3%	Industry standard mortality rate
Market type	Jap ox	Used heavy animal to ensure worst case scenario for SCU weight
Entry liveweight	450 kg	
Exit liveweight	750 kg	
Feeding period	178 days	
Liveweight gain	1.4 kg/d	
Dry matter intake	2.8% liveweight	
Pen capacity	200 head	
Stocking density	12.5 m^2/head	
Pen width	50 m	
Pen depth	50 m	
Pen slope	0.03 m/m (3%)	
Feedlot class	1	
Maximum manure depth	100 mm	
Cleaning frequency	4 times/yr	On average
Catchment characteristics		
Length feedlot drains	948.4 m	
Area feedlot drains	9 484 m^2	
Initial loss drains	7%	
Length roadways	1 675 m	
Area roadways	10 374 m^2	
Initial loss roadways	5%	
Area waterways	0 m^2	
Waterway K_1 K_2 K_3 values	35, 45, 55	
Area grass	46 750 m^2	
Grass K_1 K_2 K_3 values	45, 55, 75	
Manure stockpile area	4 611 m^2	
Manure bulk density	700 kg/m^3	
Maximum stockpile height	10 m	
Initial loss stockpile	25%	
Initial loss pavement	7%	
Sedimentation pond maximum surface area	1 922 m^2	
Sedimentation pond maximum depth	1 m	
Holding pond maximum surface area	3 994 m^2	
Holding pond maximum depth	4 m	
Terminal pond maximum surface area	1 267 m^2	
Terminal pond maximum depth	3 m	

3.5 FSIM Model Output - Results

3.5.1 *Holding Pond Capacity*

Iterations using the 126 year composite dataset discussed in Section 3.2.3 (page 18) found that the optimum capacity was found to be a total of about 10 ML.

With this configuration of holding pond volume and surface area, seven spill events were predicted occur the 126 year period of 1889 through to 2015 (less than 1 spill per 10 years).

The volume of wastewater stored in the holding pond each day over a 115 year runtime from 1990 to 2015 of the simulation (1889-2015) is shown in Figure 9 together with the spill events.

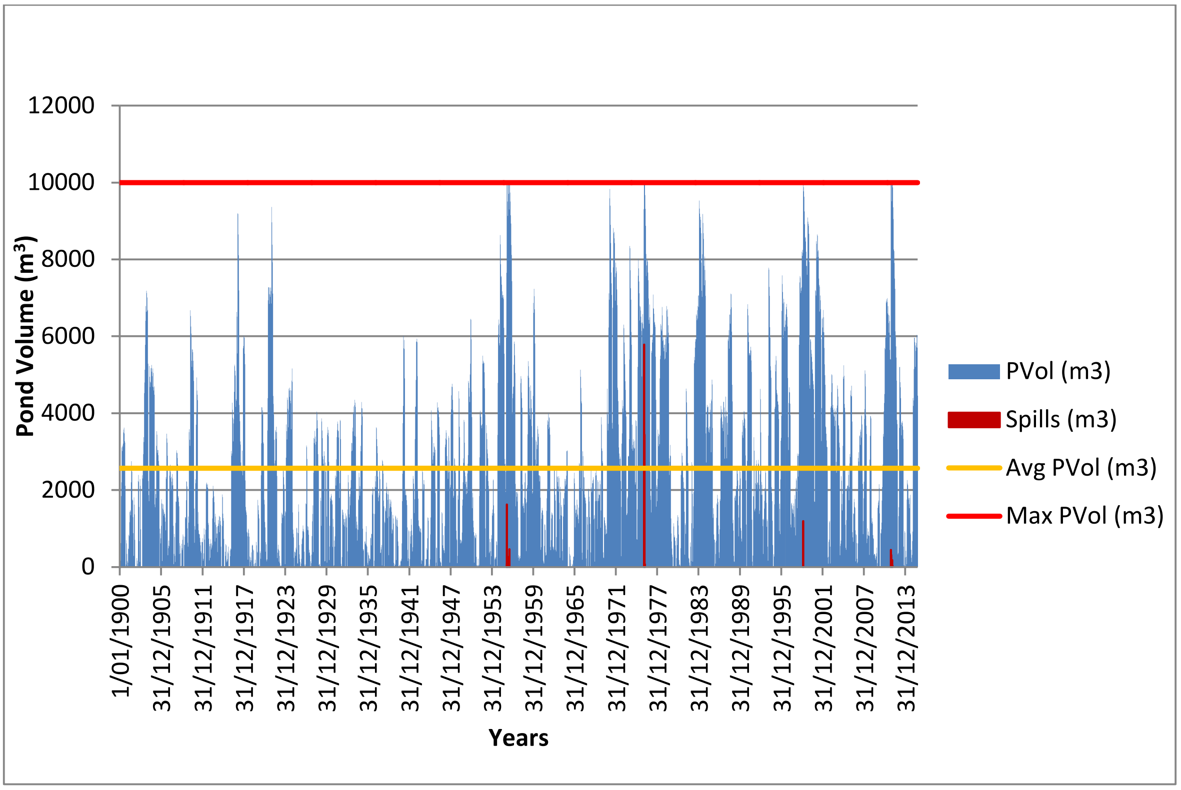


Figure 9 Volume of wastewater stored in the holding pond between 1900 to date in 2015

Figure 9 shows that the holding pond configuration spends much of its time containing less than 2.5 ML.

3.5.2 *Pond Spill Management*

Table 13 shows the number of spills. The data shows that only a few spills occur across the 126 year climate data set.

Table 13 FSIM Model Report on Spills (Nullamanna Feedlot)

Holding Pond Spill Data File				
Year	Day	Event Number	Holding Pond Spills	
			Vol(m3)	Cum. Vol(m3)
1894	139	1	172.05	172.1
1956	49	2	1628.23	1628.2
1956	51	2	6.2	1634.4
1956	54	2	76.78	1711.2
1956	122	3	265.34	265.3
1956	176	4	461.14	461.1
1956	193	5	7.4	7.4
1976	41	6	5785.58	5785.6
1976	42	6	87.59	5873.2
1976	56	7	3442.39	3442.4
1976	57	7	59.79	3502.2
1976	61	7	72.82	3575
1976	65	7	19.03	3594
1999	61	8	1196.08	1196.1
2011	329	9	446.62	446.6
2011	334	9	23.63	470.3
2011	339	9	66.78	537
2011	340	9	59.79	596.8
2011	341	9	9.7	606.5
2011	342	9	75.67	682.2
2011	343	9	147.16	829.3
2011	345	9	188.89	1018.2
2011	349	9	316.14	1334.4
2012	34	10	183.51	183.5
2012	41	11	28.68	28.7

These data show that the largest single spill even is some 5.7ML in 1976 which is at a time when the entire catchment is in significant flood. Indeed all spills occur at the peak of major floods in the region.

The model shows 11 spills occur across 126 years which is a frequency of less than 1 in 10 years. This is more conservative than the guideline criteria of 1 in 10 years.

3.5.3 *Sizing the Wastewater Irrigation Area*

The FSIM model provides output that allows the calculation of the average annual yield of runoff from the feedlot and the mean annual volume of wastewater available to irrigate the waste utilisation area.

These data have been used as input data into the nutrient balance. The results would suggest that an irrigation area cropped to improved pasture and tree irrigation would need to be 6.6 ha in size to enable wastewater applications to be sustainable from a nutrient balance viewpoint.

The interrelationship between the size of the wastewater irrigation area, the cropping program and the nutrient balance is discussed in detail in Section 3 of the Soils Survey and Land Capability Assessment. The FSIM model provides output that allows the calculation of the average annual yield of runoff from the feedlot and the mean annual volume of wastewater available to irrigate the waste utilisation area. These data have been used as input data into the nutrient balance.

Table 14 Values used in FSIM modelling of the wastewater irrigation area

Parameter	Value
Depth of Root Zone	0.9 m
Water holding capacity	300 mm/m
Plant available water	40 %
Total irrigable area	6.6 ha

The modelling was undertaken on the basis that 6.6 hectares of land was available for wastewater irrigation. This is based on utilising a sprinkler systems that will apply diluted wastewater to one area and then be moved to another area within the 6.6 ha.

4. General Civil Design Attributes of the Runoff Control Structures

4.1 Pens and Drains

The pens will be constructed of crushed and compacted gravelly-clays. The material has been shown to have permeability less than 1 x 10-9m/s when compacted to > 98% compaction (see Soils Survey and Land Capability Assessment, Appendix G of the Statement of Environmental Effects). This engineered surface will be essentially impermeable and resistant to traffic by cattle and machinery.

4.2 Sedimentation Ponds

The sediment basin will be constructed of clay. The design has been used elsewhere and had proven to be effective. The clay basin can be accessed in wet weather. Solids recovered from the basins are placed on a pad that drains back to the sedimentation basin.

4.3 Holding Pond

The holding pond will have compacted clay lining. The holding pond will be constructed with batters of a 33 degree angle and include a crest that can be accessed by a body truck so that sludges can be removed using a vacuums pump and/or front end loader. The primary treatment pond will be constructed so that it is cut below the natural surface and will have an embankment of about 2-3m above the surface.

5. Conclusion

The site of the Nullamanna Feedlot is above any flood level. Total holding pond capacity will be 10ML. The final design dimensions of the proposed feedlot catch and main drains and sedimentation, holding and terminal pond spillways channels will be determined using applicable components of the following guidelines (ICIAI, 1997 and SCARM, 1997).

6. References

Department of Science, Information Technology and Innovation (DSITI), (August 2015), *climatic dataset.* SILO enhanced climate database hosted by the Science Delivery Division Qld DSITI.

Canterford,R.P., Pescod, N.R., Pearce, H.J. and Turner, L.H., (2001),*Design intensity-frequency-duration rainfall,* in *'Australian Rainfall and Runoff',* ed. Pilgrim, D.H., Institution of engineers Australia, Barton, ACT.

ICIAI, (1997). *The New South Wales Feedlot Manual*, The Interdepartmental Committee on Intensive Animal Industries (Feedlot Section), NSW Agriculture, Orange, NSW.

Jenkins, A., (2001) *the sensitivity of headwater streams in the Hindu Kush Himalayas to acidification.* Water, Air and Soil Pollution, 2, 163-181.

Lott, S., (1994), *Drainage*, in '*Designing Better Feedlots*', eds. Watts, P. and Tucker, R., Queensland Department of Primary Industries, Toowoomba, Qld., pp. 5.5–37.

Lott, S.C. and Skerman, A.G., (1995), *Design of feedlot sedimentation systems*, in '*Proceedings of the Feedlot Waste Management Conference*', Ashmore, Queensland, Department of Primary Industries and University of Southern Queensland, Toowoomba, Qld.

Lott, S.C. and Skerman, A.G.,(1995), *Design of feedlot sedimentation systems,* in '*Proceeding of the Feedlot Waste Management Conference,'*, Ashmore Queensland, Department of Primary Industries and University of Southern Queensland, Toowoomba, Qld.

Lott, S.C., (1998), *Feedlot hydrology*, PhD thesis, University of Southern Queensland, Toowoomba, Qld.

Main Roads Western Australia (2004) *Environmental Guideline: Environmental Assessment and Approval*. Document No. 6707/001.

Mazurak A.P. and Mielke, L.N., (1976) *Infiltration of water on a cattle feedlot*. Trans. ASAE 19(2):341-344.

MLA (2012) *Lot feeding Brief: March 2012*. Meat and livestock Australia, Sydney.

Monteith, J.L., (1965), *Evaporation and environmental Physics*, 2nd Edition. Edward Arnold, London.

O'Loughlin, G.G and Robinson, D.K., (2001), *Urban stormwater drainage,* in '*Australian Rainfall and Runoff'* ed. Pilgrim, D.H., Institution of Engineers Australia, Barton ACT.

Penman, H.L., (1948), *Natural evaporation from open water, bare soil and grass.* Proceedings of the royal Society of London. Series A, Mathematical and Physical Sciences, Vol, 193, No.1032.

Pilgrim, D.H., ed., (2001), *Australian Rainfall and Runoff,* Institution of Engineers Australia, Barton, ACT.

SCARM (1997), *National guidelines for Beef Cattle Feedlots in Australia 2nd Edition,* Standing Committee on Agriculture and Resource Management, Collingwood, Victoria.

Schwab,G.O., Bamer, K.K., Frevert, R.K. and Edminter, T.W.,(1971) *Rainfall and Runoff,* In Elementary Soil and Water Engineering. John Wiley & Sons Inc., New York.

Israelsen, O.W., and Hansen V.E., (1962), Irrigation principles and practices, John Wiley and Sons, New York.

Shaw, E.M., (1994), *Hydrology in Practice*, 3rd Edition, Chapman and Hall, London.

Skerman, A., (2000), *Reference manual for the establishment and operation of beef cattle feedlots in Queensland,* Queensland Department of Primary Industries , Brisbane, Qld**.**

Southcott, P.H. and Lott, S.C., (1997), *Preliminary Results of Soil Permeability and Physical Characteristics of Feedlot Pens'*, 7th Australia, New Zealand Conference on '*Geomechanics: Geomechanics in a Changing* World',: Conference Proceedings.

Sweeten, J. M., and Lott S. (1994) *Dust management*. In Watts, P. and R. Tucker (eds.), Designing Better Feedlots. Toowoomba, Queensland, Australia. Queensland Department of Primary Industries. Conference and Workshop Series QC94002

Thornthwaite, C.W. (1948), *An Approach toward a rational classification of climate.* Geographical review 38.

Walker, K.F. (1979), *Regulated streams in Australia: the Murray Darling system*. In J.V Ward and J.A Stanford (eds), the Ecology of Regulated Streams, Plenum, N.Y:143-163.

Watts, P.J., Gardner, E.A., Tucker, R.W. & Casey K.D. (1994), *Mass-balance approach to design of nutrient management systems at cattle feedlots,* Proceedings of the Great Plains Animal Waste Conference on Confined Animal Production and Water Quality, Denver, Colorado, GPAC Publication 151, 27-33.

7. Appendices

Appendix A. Summary of Inverell's Climate A-1

Appendix A. Summary of Inverell's Climate

Summary of Inverell's Climate

Nullamanna Station is situated on the North West Slopes of NSW at an elevation of 650-740 m. The climate is best described as warm temperate. Table 1 provides average monthly and annual climate conditions as recorded at the nearest Bureau of Meteorology weather station 21km southwest of Nullamanna Station in Inverell (BOM 2015).

Rainfall in the area is variable with monthly averages ranging from approximately 40 mm in winter to 100 mm in summer. The wettest months of the year are November to February, with an average of Temperature also varies with averages of about 15 ºC to 28 ºC in summer and about 5 ºC to 15 ºC in winter.

Based on an annual average evaporation of 1603.1 mm and an annual average rainfall of 798.7 mm, the site generally has a moisture deficit on an annualised basis of approximately 804.4mm. The greatest deficit occurs through the winter/dry season. This is equivalent to 8ML/ha/year.

Table 1 Climate statistics for the nearest monitoring station, Inverell Research Station (BOM 2015)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean maximum temp (°C)	29.5	28.7	27.0	23.5	19.2	15.8	15.2	16.7	20.0	23.2	25.9	28.3	22.8
Mean minimum temp (°C)	16.4	16.2	14.4	11.0	7.5	4.8	3.6	4.4	7.0	10.3	12.8	15.0	10.3
Mean rainfall (mm)	100.0	96.8	68.0	40.7	48.5	44.5	48.4	43.6	47.6	75.0	86.6	99.2	798.7
Mean monthly evaporation (mm)	207.7	168	161.2	114	83.7	60	62	86.8	117	158.1	180	204.6	1603.1