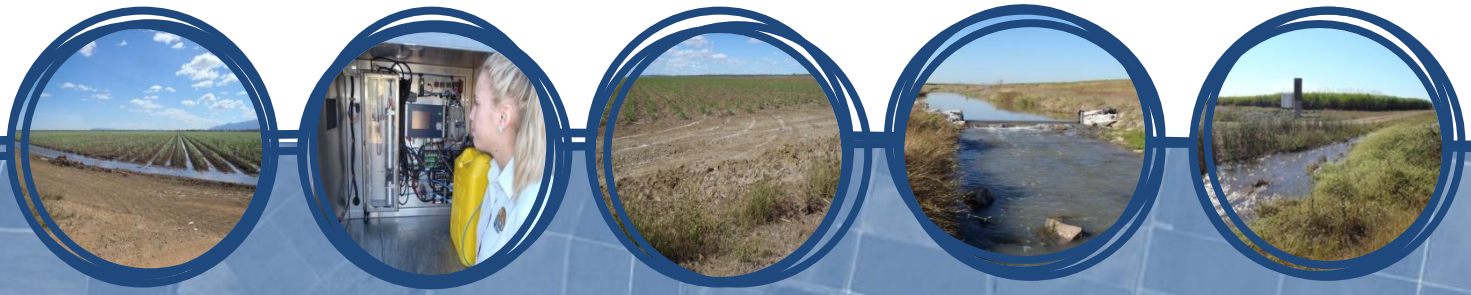
A SUB CATCHMENT ADAPTIVE MANAGEMENT APPROACH TO WATER QUALITY IN SUGARCANE

Burdekin Bowen Integrated Floodplain Management Advisory Committee Inc.



AUGUST 2014

BBIFMAC

NQ DRY TROPICS

Queensland Government

A Sub Catchment Adaptive Management Approach

To Water Quality in Sugarcane

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The study was undertaken by
Burdekin Bowen Integrated Floodplain Management Advisory Committee (BBIFMAC)

with funding from the Department of Environment and Heritage Protection Reef Water Quality Science Program and the NQ Dry Tropics Reef Rescue Program 2014

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ABSTRACT

This report describes an adaptive management approach to improve water quality in the downstream ecosystems of the Lower Burdekin Irrigation Area. The sugarcane farmers in a selected sub-catchment were supported to assess their farm management practices against the quality of the water leaving their farms. The collaborating sub-catchment farmers were able to directly relate management practices they were using on their farms to the water quality results in their adjacent drainage system, and this provided them with the catalyst to take ownership of the water quality issues.

The key water quality parameters of nitrate - N (NO_3-N), total suspended solids (TSS), chemical oxygen demand (COD), electrical conductivity (EC) and flow volume were collected by specialized instrumentation and conveyed via telecommunication to a purpose-built, password protected web site. This water quality information, collected hourly and displayed in 'real-time', was reviewed by project staff and any anomalies (spikes) in any of the key parameters were relayed back to the sub-catchment farmers for their information, thus providing them with an opportunity to relate their recent farm management activities with the water quality results.

Total fluxes from the sub-catchment over the 12-month monitoring period are reported, as well as selected individual irrigation and rainfall events. Despite the fact that the nitrate - N concentrations in the irrigation events were higher than in the rainfall events, it was found that the total flux of nitrates from the sub-catchment were largely attributable to rainfall events. This was due to the large runoff volumes from wet season rainfall events, compared to the relatively small volumes from irrigation driven events.

The use of this or similar instrumentation, which can provide quality water quality information in 'real time', plus the willingness and collaboration of the sub-catchment farmers, proved to be the key elements of the projects success. The project demonstrates an effective adaptive management approach to improving water quality in the sugarcane industry in the Lower Burdekin. It is very likely that there is real potential that this approach could be further extended in this region, as well as to other regions where water quality issues are associated with agricultural enterprises.

1.0 INTRODUCTION

The Burdekin River Irrigation area in the dry tropics of North Queensland is a highly productive agriculture area. Sugar cane production and to a lesser extent horticulture and grains are grown under irrigation on the soils of the Delta and in the Burdekin River floodplain on both banks of the river.

Surface drainage or runoff water leaves the farm lands into a system of purpose-built drains or directly into natural creeks, which either feed back into the Burdekin River or into coastal wetlands. These wetlands are either RAMSAR listed or are of national significance. Inevitably, this runoff water enters the marine environment including marine national parks and the Great Barrier Reef lagoon.

Concern for the health of the Great Barrier Reef (GBR) has led to an increased awareness of the need for more efficient management of the water resources, and safeguard water quality. Agriculture, and especially sugarcane production, is a major land use in GBR catchments and has been identified as an important source of diffuse pollution. Changes to on-farm management practices will be required to improve this situation.

Extensive water quality monitoring by various agencies have determined that the runoff water from farmlands frequently carry significant loads, both nutrients and pesticides. This is a major concern to government and conservation agencies such as the Great Barrier Reef Marine Park Authority (GBRMPA). Numerous reports have been produced detailing the concentration and loads moving into the aquatic environment from the irrigated farmlands.

Recent efforts have been made to engage growers, and to alert the industry to the serious nature of the situation. The industry at farm level has largely not accepted the challenge by taking ownership of the issues. The reason for this are many and varied, but generally farmers do not read nor do they fully believe information gathered and reported by scientists, who are funded and influenced by government or conservation organisations.

The adaptive management approach using technologically advanced instrumentation was trialled in a sub-catchment in the Burdekin Haughton Water Supply Scheme area of North Queensland. The Burdekin River catchment has been identified as one of the catchments, which poses a threat to the Great Barrier Reef.

Adaptive management emerged as a scientific response to managing complex systems in the 1970s. An adaptive management approach involves adjusting actions in response to feedback from progress towards management objectives, as well as responding to contextual changes (anticipated or not) that may arise.

The combination of being able to use the adaptive management approach, and the ability to monitor the key water quality parameters in ‘real–time’, has proven to be an effective means of engaging growers. The Sub Catchment Adaptive Management Approach to Water Quality in Sugarcane program is described below, with the engagement process and results documented.

2.0 AIMS & OBJECTIVES

This study aims to make a direct connection between paddock and stream by intensively monitoring, in 'real time', the runoff at the downstream end of a sub-catchment stream/drain, and tracking any spikes or anomalies in concentration of nutrients and pesticides back to the farm and paddocks. The contributing management practices can then be quickly identified and modified, or alternative practices discussed with the farmer.

The objectives of the program include:

- Increasing farmer awareness, understanding and acceptance of ownership of nutrients in runoff from their enterprises through direct involvement in water quality monitoring. We plan to do this by providing evidence of a direct link between farming activities and nutrient loads in the farm runoff.
- Over the course of the project gain an understanding of how well the engagement process is working. We will do this by documenting attitudinal change and actual changes in management in response to the projects activities.

The Sub Catchment Adaptive Management Approach to Water Quality in Sugarcane is supported by a combination of:

1. Establishing intensive, real-time water quality testing/monitoring at downstream end of sub-catchment
2. Identifying spikes in pollutants and track back to specific farm management practices on an individual farm
3. Supporting grower involvement in measuring water quality, collecting spatial data records and providing information needed for them to identify the links between inputs and pollutant losses from their farms to increase adoption of management practices that are known to reduce losses
4. Communicating results of the water quality monitoring data to the farm managers and prompting a response from them as a result of the information they received
5. Establishing the direct linkage between farm management practices and water quality
6. Improving water quality in aquatic ecosystems by raising grower awareness of best farm management practices for water quality outcomes.

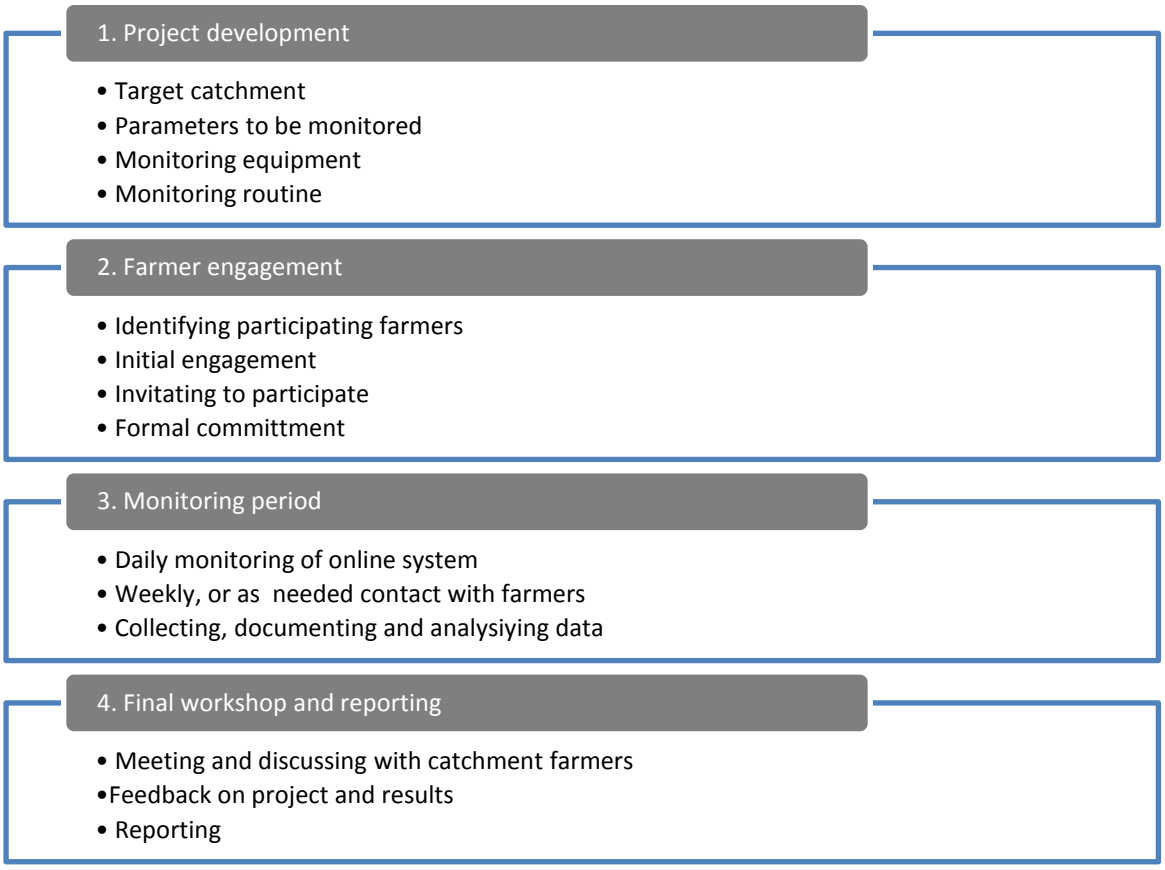
The adaptive management approach underpins the overall success of the study. The five interconnected elements that make up the approach - Learn - Plan - Do - Check - Act - are applied rigorously and continually to all aspects of the study.

The essence of adaptive management is that action can seldom be postponed until there is 'enough' information to fully understand the situation. Through ‘real-time’ information, this study eliminates the encumbrance of waiting for laboratory results and promotes a proactive response to water quality variation in the sub-catchment. This allows for early action to monitor and evaluate the results and derive 'lessons learned' that will improve responses to the issue.

Not only does this lead to improved understanding of ways of dealing with natural resource management issues, it also encourages growers to take direct ownership of their contributions to the catchment processes.

3.0 METHODOLOGY

The simple flow chart below demonstrates the general approach adopted in undertaking this project, agreed at inception between BBIFMAC and participating growers.



3.1 Overview

The combination of being able to develop the adaptive management approach, plus the ability to monitor the key water quality parameters in 'real–time', has shaped the foundation of the following methodologies.

The study targeted a complete sub-catchment, where runoff was monitored at a catchment level as well as at individual farm level. Direct measurements of water quality were taken and aligned with farm management practices at a paddock scale.

A systematic approach to adaptive management was adopted as follows:

1	**Monitor**	Monitor the online AgDat website daily, to identify any spikes or anomalies in the catchment's water quality
2	**Contact**	Contact growers to link in-stream water quality with on-farm practices and discuss implications
3	**Inspect**	Inspect the catchment, documenting runoff, stream volumes and water quality – direct measurements of nutrient and pesticide flux from paddocks and from sub-catchment are measured
4	**Document**	Runoff and water quality results are directly related to farm management practices at an individual farm level and variations documented – volumes are measured in each case to provide flux of the contaminant (flux = concentration x volume of event)
5	**Discuss**	Discuss with growers and suggest the impacts of their particular farming practices

3.2 Parameters

Parameters measured in stream include:

- Catchment flow (ML)
- Nitrate-N (NO_3-N)
- Electrical conductivity (EC)
- Chemical oxygen demand (COD)
- Total suspended solids (TSS)
- Temperature (C^0)

Parameters measured at farm level include:

- Approximate event discharge (L/s)
- Nitrate-N (NO_3-N)
- Chemical oxygen demand (COD)
- Total suspended solids (TSS)

Farm management factors

- Area under cropping
- Fertilizer applied (mixture, rate)
- Irrigation applied
- Cultural operations
- Timing of operations

3.3 Instrumentation

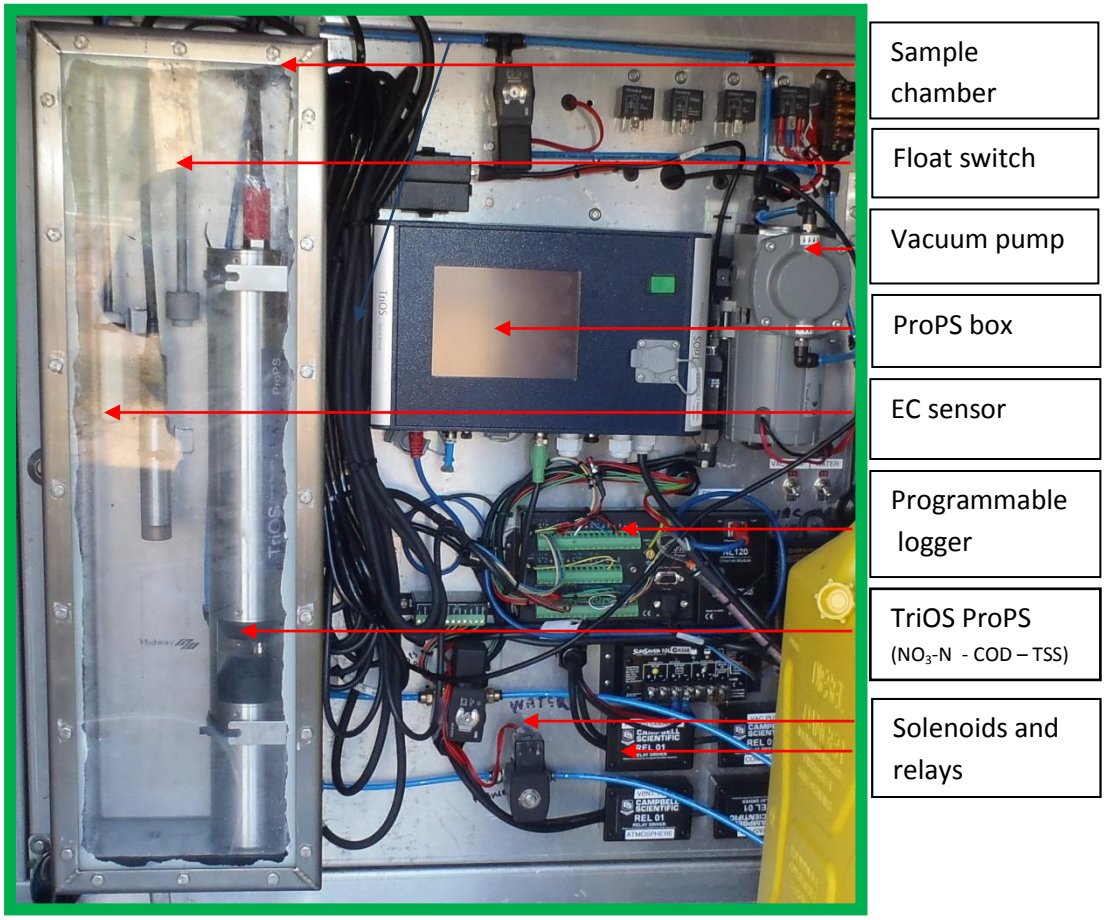


Figure 1 - Instrumentation Box.

The instrumentation as pictured above contains the following main components -:

1. Flow cell chamber containing the following instruments / components:
    - TriOS – ProPS submersible hyperspectral UV transmissiometer
    - Campbell Scientific Australia CS547A EC sensor
    - Campbell Scientific Australia OB S 300 turbidity sensor
    - Two stage electronic float switch
2. TriOS TriBox2 control system & digital display
3. Campbell Scientific Australia CR 1000 programmable logger
4. Thomas 12V Model 107CDC20 vacuum pump
5. ARB Model 1043301524V compressor and pressure accumulator
6. Intercell Modem transmitter
7. Solenoid valves and ball valves (multiple)
8. 12V relays (multiple)

External to the instrument box other components included:

- 50 Watt Solar array with regulator
- 4 X 70 Amp Hour 12V battery bank
- Campbell Scientific Australia CS 456 L pressure sensor in stream
- Sample delivery manifold and tube lines

3.4 Online Web Based System

The real-time data is communicated and stored on an online system, which makes it directly available via web site. The online AgTrix database is developed by Agtrix Harvest Management System, an Australian company providing sophisticated technology solutions for the agricultural sector.

The real-time data exchange system promotes ease of access to the on-farm catchment monitoring system.

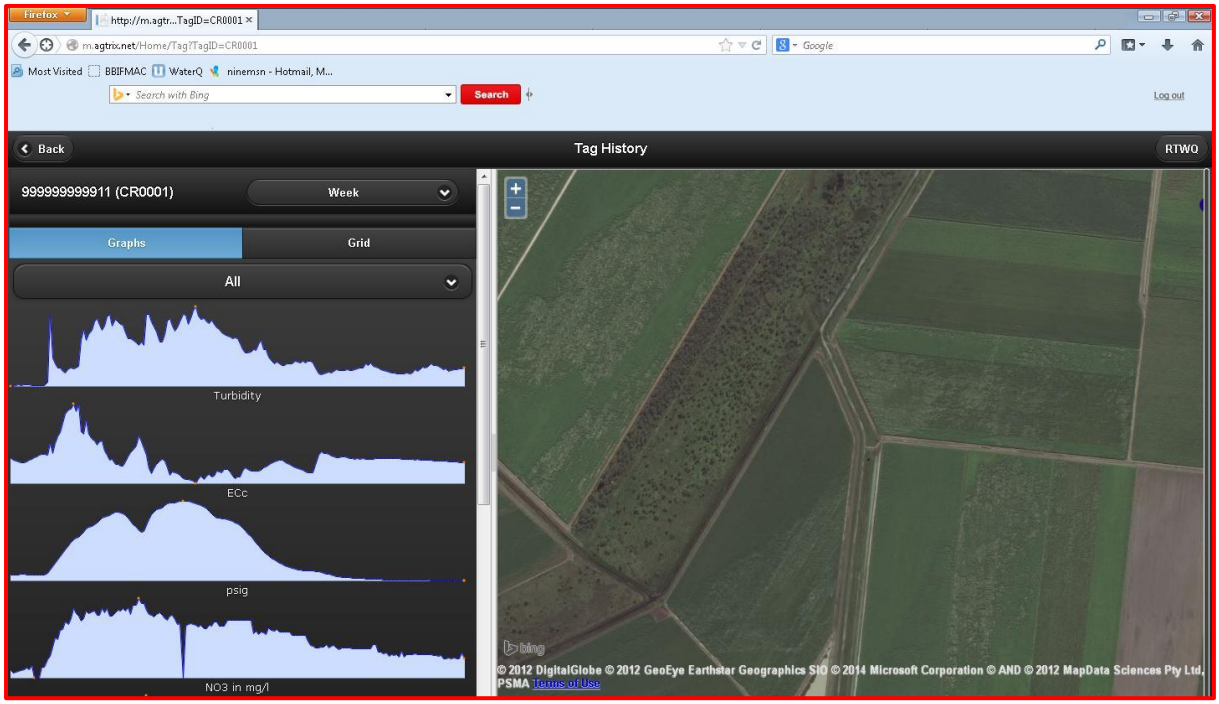


Figure 2 - Online Agtrix monitoring system

Throughout the course of the study, the Agtrix system displayed on the web site has been providing daily data to the BBIFMAC project officers. The day-to-day recording and assessment of data allows a quick response to any events that may be occurring.

3.5 Engagement Process

The Great Barrier Reef is equally important to growers and the wider community. Communication and engagement is an integral part of the approach to meeting water quality targets. The project relies heavily on a trusting relationship between the project staff and the collaborating farmers. This trust was evident throughout the project and was a major factor in its success.

Initial engagement:

- Catchment selected for its location having close proximity to Barratta Creek and the number of growers in the catchment (3)
- Meeting on-site with target catchment growers to explain the project's intent.
- Growers in the catchment agreed to collaborate
- Documentation of farm management practices and paddock runoff locations

On-going engagement:

- Weekly calls to growers to identify their irrigation and application practices
- Monitor online system and document water quality results
- Contact growers to acknowledge any changes in water quality
- Establish the foundation of water quality anomalies and document them
- Provide support and advice to growers
- Project team meetings to discuss progress and issues that may have arisen.

Figure 3 - Catchment farmers with Project Officer, Eleisha Burton

3.6 Data Validation

In order to validate the accuracy of the real time water quality data, samples were periodically taken and forwarded to an accredited lab for analysis. This procedure gave us confidence that the data produced and shared with the sub-catchment farmers was a true reflection of that was actually happening in the sub-catchment.

Since the monitoring site is at the bottom of the sub-catchment, in a drain having multiple inlets there was a need to identify the source of the contributing flow of runoff. This was achieved by communicating with the sub-catchment farmers on a regular basis (at least weekly). Knowing when the farmer is irrigating allows us to determine when his runoff is contributing to catchment flows.

To more specifically track any anomalies (spikes) in water quality, the project team would visit the site, and noting which farms the runoff was coming from, we would take a 20 litre drum of runoff water and analyse it through the on-site instrumentation. This was done by manually triggering the instrumentation to analyse the content of the drum. This further allows us to accurately identify the source of the water quality anomaly.

Figure 4. BBIFMAC project officer Dennis Stubbs samples farm runoff from an inflow point into the sub-catchment drainage system to validate the integrity of water quality information measured downstream automatic water quality monitoring site.

4.0 EXTENSION / COMMUNICATION

This section details methods of communication and extension to participating growers.

Refer to **Appendix 1.** for a comprehensive work plan developed for the program.

Throughout the course of the program, growers were provided with ongoing extension to communicate the progress and outcomes of the monitoring plan. The three (3) participating growers are proactive in terms of observing their on-farm practices and potential impacts on the adjoining catchment. The growers understand the relationship between their paddock and the Great Barrier Reef, and each link in between.

Fundamental to the success of the project was the willingness of the sub-catchment growers to share data and ownership of the issues as they arose. The data sharing outside the group was focused on promoting the concept, and good news as it applied to improved water quality outcomes.

Results of the project were attained and communicated to catchment growers through:

- farm management practices of sub catchment farmers by spatial database
- water quality monitoring data by farmers and project staff loaded onto database
- results and achievements on BBIFMAC website
- specially convened meetings and regular industry meetings

Results of the project were communicated to the extension community via newsletters, field days, public meetings, reports, meetings and personal contact.

The participating growers were actively contacted on a recurring basis to identify any on-farm works or irrigation events. The growers were also notified of any spikes in data and collaborated approach was taken to track down the offending management practice.

BBIFMAC staff Tom McShane and Eleisha Burton, have presented the project operations, results and practice changes at numerous meetings over the past year. Those attending the meetings included industry, growers, and other community members.

The project ensures information is provided to the grower community through the following extension products as appropriate:

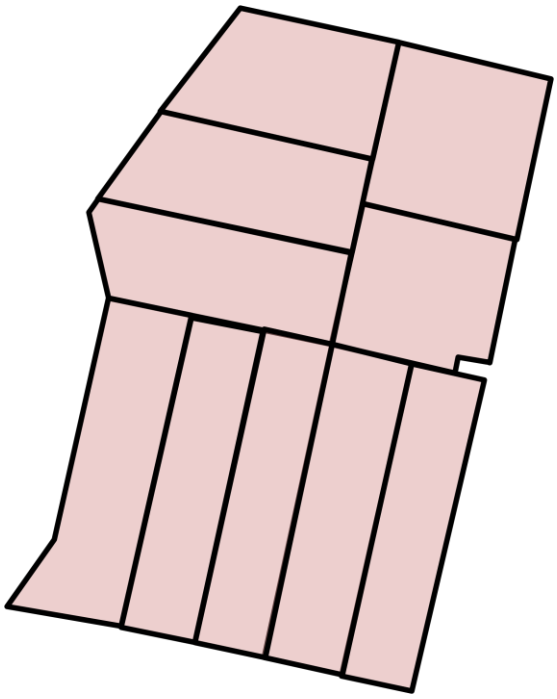
- fact sheets
- simple language report
- simple language presentation (e.g. PowerPoint, workshop poster)
- spatial layer/maps with user guide
- electronic media files.

BBIFMAC has produced a short film (viewable at http://www.bbifmac.org.au/projects/sub-catchment-adaptive-management-approach/), which presents the aims and objectives of the project and the ideal outcomes that may arise.

The following grower information was collected in mid - 2013 for the 2013 cropping season.

4.1 Sub-Catchment Grower Information

Grower A



Grower A is located at the downstream end of the subject catchment, within meters of the monitoring site.

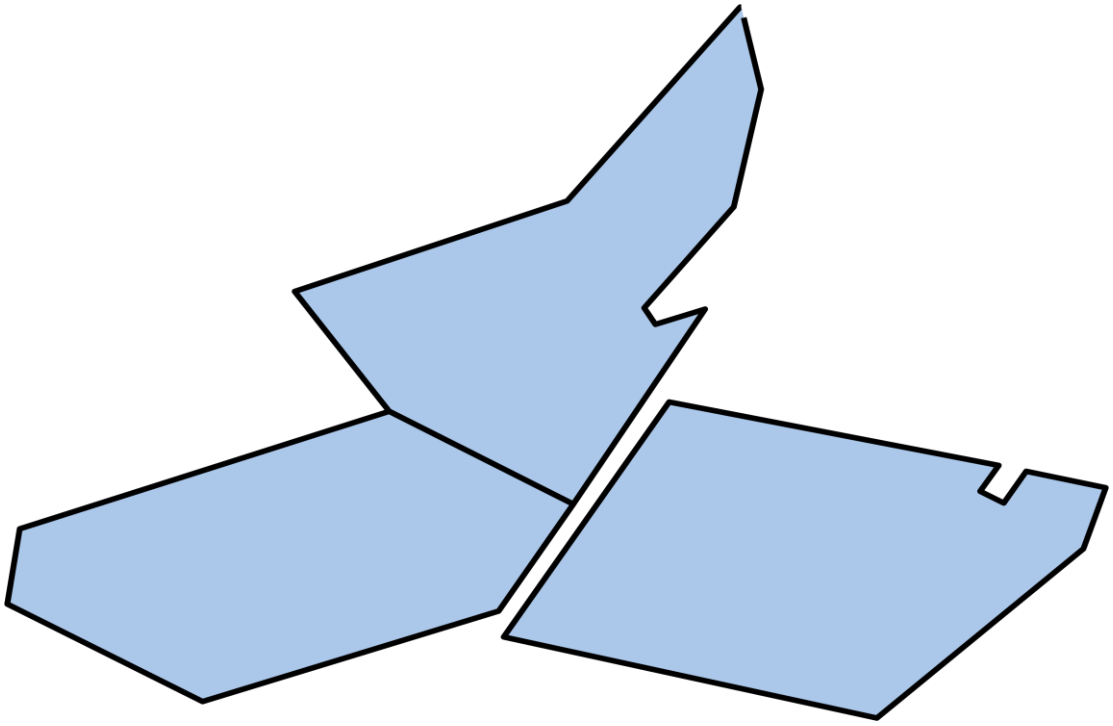
Grower A has two (2) farms, divided into ten (10) blocks:

F209	F222
Block 1	Block 1
Block 2	Block 2
Block 3	Block 3
Block 4	Block 4
Block 5	Block 5

For the 2013/2014 cropping season, information on planting and nutrient application was documented.

		Planting	Nutrient Application
F209	Block 1	Late Plant (Q183) Plant Source HWT Yr: 2011 Double disc opener - dual	09/09/13 - 210 kg of N in centre of stool Directly behind the harvester
	Block 2	First Ratoon	09/09/13 - 210 kg of N in centre of stool Directly behind the harvester
	Block 3	Third Ratoon	30/08/13 - 190 kg of N in centre of stool Directly behind the harvester
	Block 4	*Fallow*	
	Block 5	Second Ratoon	25/06/13 - 240 kg of N in centre of stool Directly behind the harvester
F222	Block 1	Late Plant (Q247 & Q183) Plant Source HWT Yr: 2011 Double disc opener - dual	13/09/13 - 210 kg of N in centre of stool Directly behind the harvester
	Block 2	First Ratoon	25/08/13 - 240 kg of N in centre of stool Directly behind the harvester
	Block 3	*Fallow*	
	Block 4	Third Ratoon	Unknown - 190 kg of N in centre of stool Directly behind the harvester
	Block 5	Second Ratoon	25/08/13 - 240 kg of N in centre of stool Directly behind the harvester

Grower B

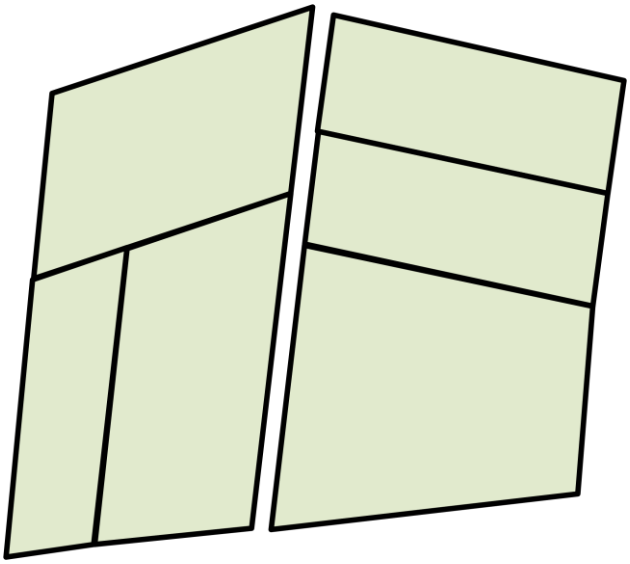


Grower B is located between 200 and 2,000 metres from the monitoring site.

For the 2013/2014 cropping season, information on planting, ameliorant application, and nutrient application was documented.

	Planting	Ameliorant Application	Nutrient Application
MP40 L	*Fallow*		
MP40 R	Plant Cane (Q208)	06/04/2013 30/05/2013 25/06/2013	@ Planting - 250 kg/ha of DAP side dressed with side splitter and rate controller
MP46	Plant Cane (Q183)	15/06/2013 03/10/2013 04/11/2013	@ Planting - 250 kg/ha of DAP side dressed with side splitter and rate controller
MP47	First Ratoon	30/07/2013 14/08/2013	After planting (three leaf spike) 780 kg/ha of CB 82414 in centre of stool with rate controller
MP49 L	Fourth Ratoon	01/11/2013 29/11/2013	After planting (three leaf spike) 780 kg/ha of CB 82414 in centre of stool with rate controller
MP49 R	*Fallow*		

Grower C



Grower C is located at the top of the catchment, approximately 2,000 metres from the monitoring site.

Grower C has four (4) farms, divided into six (6) blocks.

For the 2013/2014 cropping season, information on planting, ameliorant application, and nutrient application was documented.

	Planting	Nutrient Application
C3	Plant Cane (KQ183 & Q240) 3 bed - 6 row planter with 2.4 metre row spacing	Unknown
C4 North	Third Ratoon (Q183)	24/07/2013 - 700 kg Leichardt S After first irrigation - post harvest Stool split in centre of stool
C4 South	Second Ratoon (KQ228)	24/07/2013 - 700 kg Leichardt S After first irrigation - post harvest Stool split in centre of stool
C5 East	*Fallow*	
C5 West	Third Ratoon (Q183)	18/07/2013 - 700 kg Leichardt S After first irrigation - post harvest Stool split in centre of stool
C6	Third Ratoon (Q183)	29/09/2013 - 700 kg Leichardt S After first irrigation - post harvest Stool split in centre of stool

5.0 RESULTS

The catchment was monitored for a period of one year, which included mid-year 2013 to mid-year 2014. The instrumentation was programmed to take samples every hour, and over one year this meant that over 8,500 samples were taken and analysed, providing a robust dataset for interpretion and use by the sub-catchment farmers. The monitoring time frame basically covered a full season of a sugarcane crop from planting and ratooning to harvest.

The parameters of most interest were Nitrate-N, Turbidity and Electrical Condictivity, with nitrate-N of particular interest in this environment and catchment. The concentrations and fluxes of nitrate-N will be presented and discussed in the following section, whereas a couple of examples of events relating to EC and turbidity will be presented with some comment in a later section.

5.1 Nitrate-N Concentration

Full details of the years result are available in **Appendix 2.** The data includes both height over the wier and nitrate-N concentrations. High flow events and increased nitrate-N events can be easily identified from the subject appendice, and are displayed in Figure 5 below.

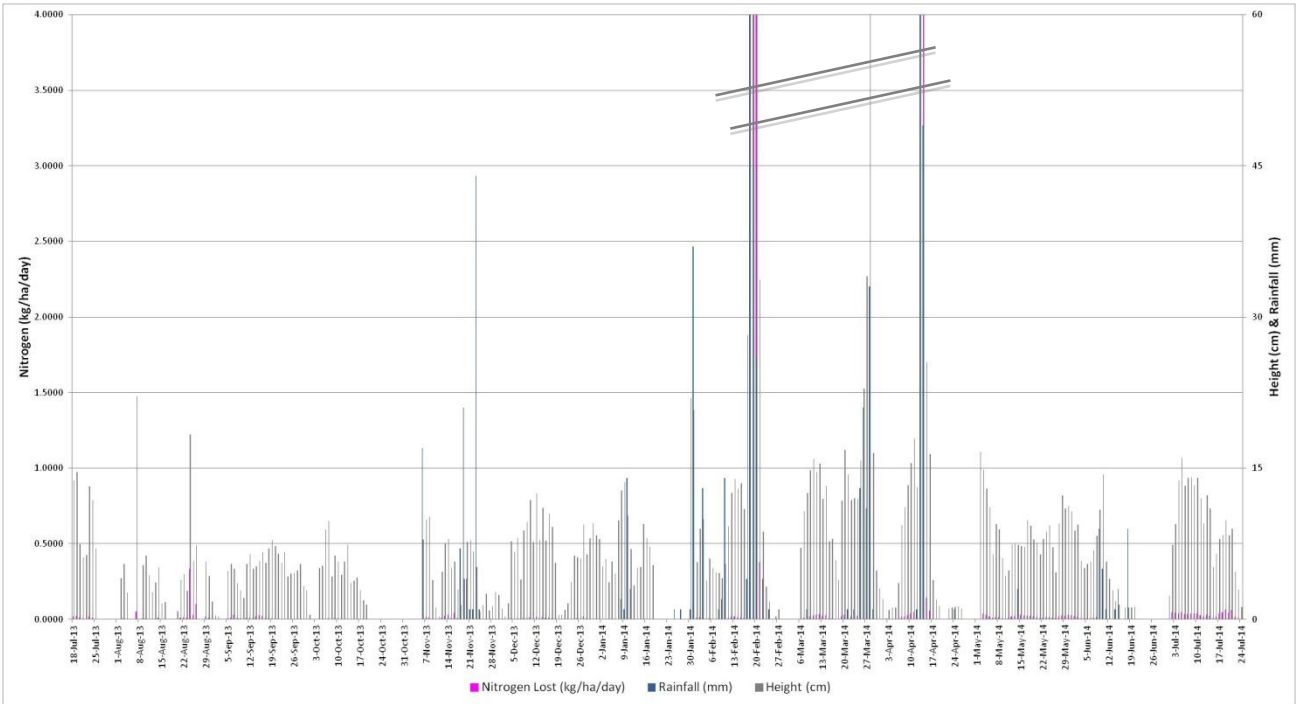


Figure 5 – Monitoring Results (07/13 – 07/14)

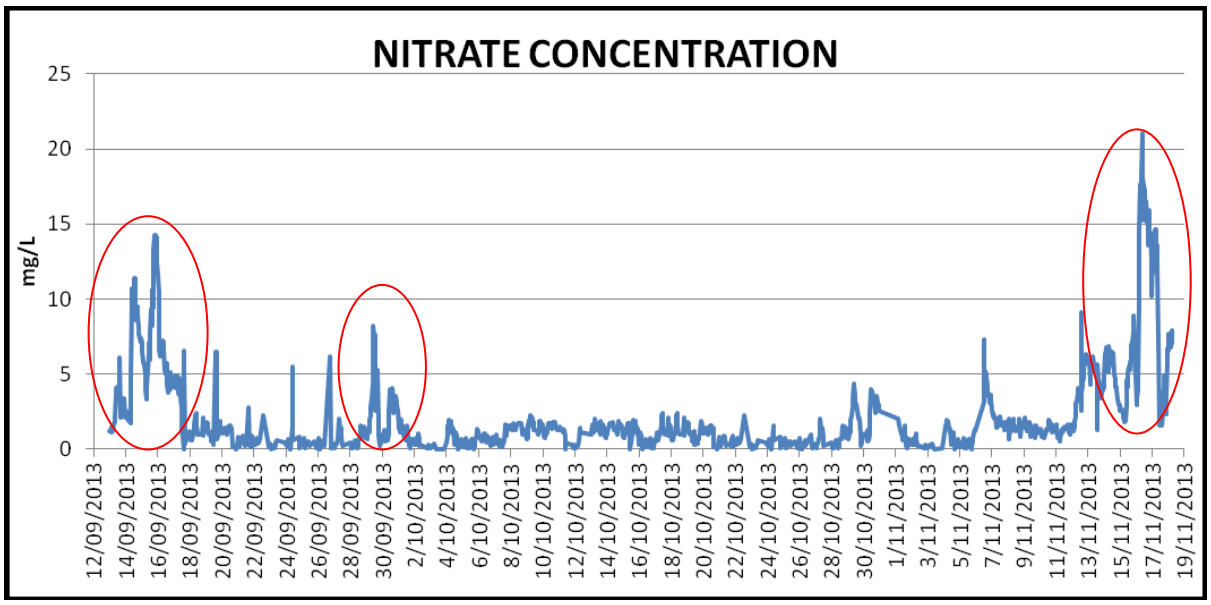


Figure 6: Nitrate-N concentration (mg/L) over time at the monitoring site weir.

- Event 1. First irrigation following nutrient application directly behind harvester Stool split – centre of stool with B5422 (N31.9, P4, K9, S0.3).
- Event 2. Fertilizer applied after second irrigation following harvesting. Stool split – centre of stool (rate controller) with Leichhardt-S
- Event 3. 40kg of fertiliser added to 2 drills (20kg each) to 'green up'

Details of selected significant events for both rainfall and irrigation are included below:

Date	Event	Details	Volume (ML/event)	Nitrogen Lost (kg/ha)
16/09/13	Irrigation Event	First irrigation following nutrient application directly behind the harvester (Figure 4)	3.56	0.0378
29/09/13	Irrigation Event	Harvested → Irrigated → Fertilised →Irrigated	3.88	0.0168
16/11/13	Irrigation Event	Added fertiliser to two (2) rows - missed during fertiliser application - to 'green up (Figure 5)	2.38	0.0467
11/01/14	Rainfall Event	Approximately 20mm of rainfall + irrigations	6.16	0.0718
31/01/14	Rainfall Event	Approximately 40mm of rainfall	11.63	0.0739
17/02/14	Rainfall Event	Approximately 140mm of rainfall over three (3) days (Figure 6)	1,221.48	6.6869
25/03/14	Rainfall Event	Approximately 78mm of rainfall over four (4) days	840.21	2.4248
13/04/14	Rainfall Event	Approximately 122mm over two (2) days	1,120.74	3.3638
14/05/14	Irrigation Event	Irrigations over two and a half (2.5) days	9.70	0.0704
01/07/14	Irrigation Event	Irrigations over two (2) days	11.88	0.1373
17/07/14	Irrigation Event	Irrigations over five (5) days (Figure 7)	24.75	0.2143

Given the large amount of data documented over the last cropping season, a number of events have been extracted to demonstrate in graph form for ease of viewing. For a full year's results refer to **Appendix 2**.

Two irrigation driven events and one rainfall event are presented below in the following graphs, accompanied with some background information and comments regarding concentrations and flow volumes.

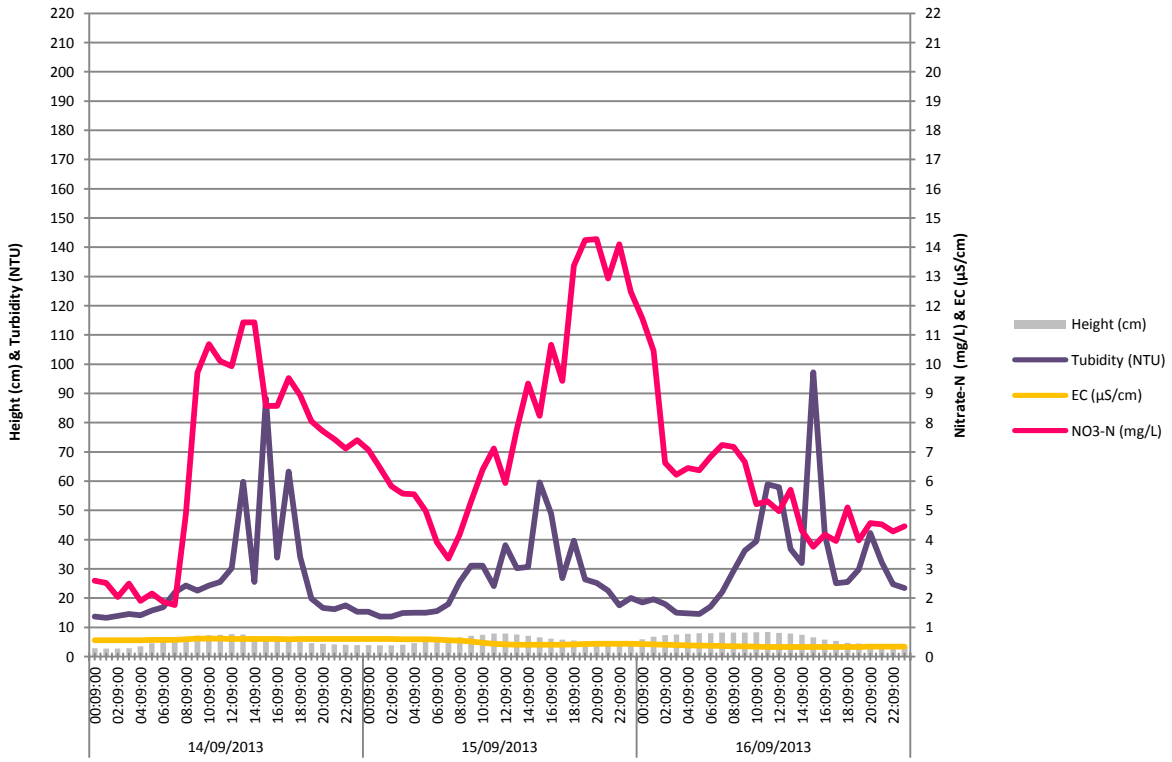


Figure 7 - Irrigation Event (14/09/13 - 16/09/13)

This event took place between 14 September 2013 and 16 September 2013, aligning with the first irrigation following nutrient application directly behind the harvester. Details of application are as follows:

- Stool split - centre of stool with 730 kg/ha of B5422 (N31.9 - P4 - K9.3 - S0.3)

The volume of water running off the farm was steady, with an average flow of 34.08 L/sec. The event lasted for approximately 30 hours and had an average nitrate-N concentration of 9.25 mg/L. From this we have calculated that 0.0378 kg of nitrogen/ha (total farmed area in the catchment is 866.27 ha) was lost to the catchment as part of this event.

Between 12.00AM and 06.00AM on 14 September 2013, nitrate-N concentrations are determined to be 'background' (ca. 1.5 to 2.5 mg/L), which is the base concentration of catchment without farm runoff. In the next hour nitrate-N concentrations jump to 10 mg/L, varying over the next two days.

Although only a low flow event, nitrate-N concentrations are still considerable.

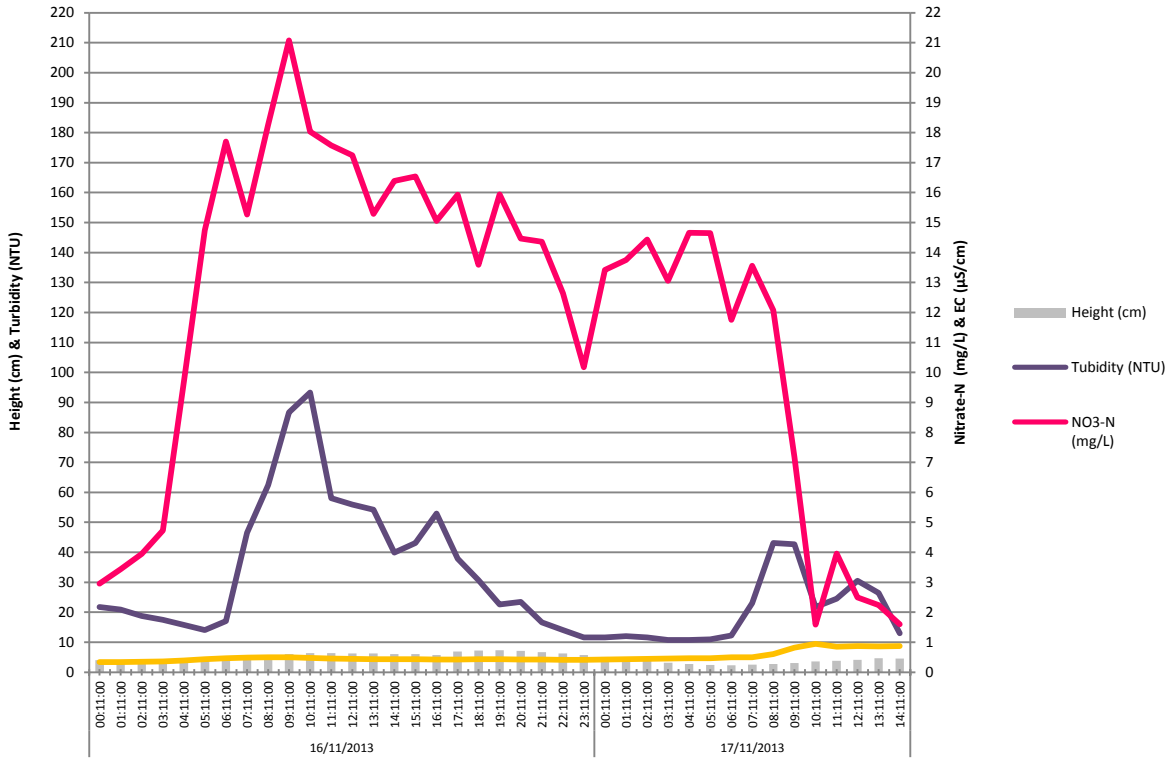


Figure 8 - Irrigation Event (16/11/13 - 17/11/13)

This event took place during 16 November 2013 and 17 November 2013, occuring as a result of:

- An incidental application of 20 kg of fertiliser added to two drills that were missed during initial fertiliser application

The fertiliser was surface applied and was only done because of a real need to 'green up' the missed rows. This was atypical of the farmer's normal practice in applying fertilizer, but it did show the farmers how easily the nitrogen is lost from the field if not applied subsurface. The event also demonstrated how effective the monitoring capabilities are in tracing anomolies in water quality.

Note that the axes have been maintained for comparison with other events. Similar to the previous event, the volume of water running off the farm was steady, with an average flow of 22.80 L/sec; there was also 20 mm of rainfall during this time. Although the event only lasted for approximately 29 hours, the levels of nitrate-N are generous. The average nitrate-N concentration during the event was 17 mg/L, meaning that the extent of nitrogen lost during the event equated to 0.0467 kg/ha.

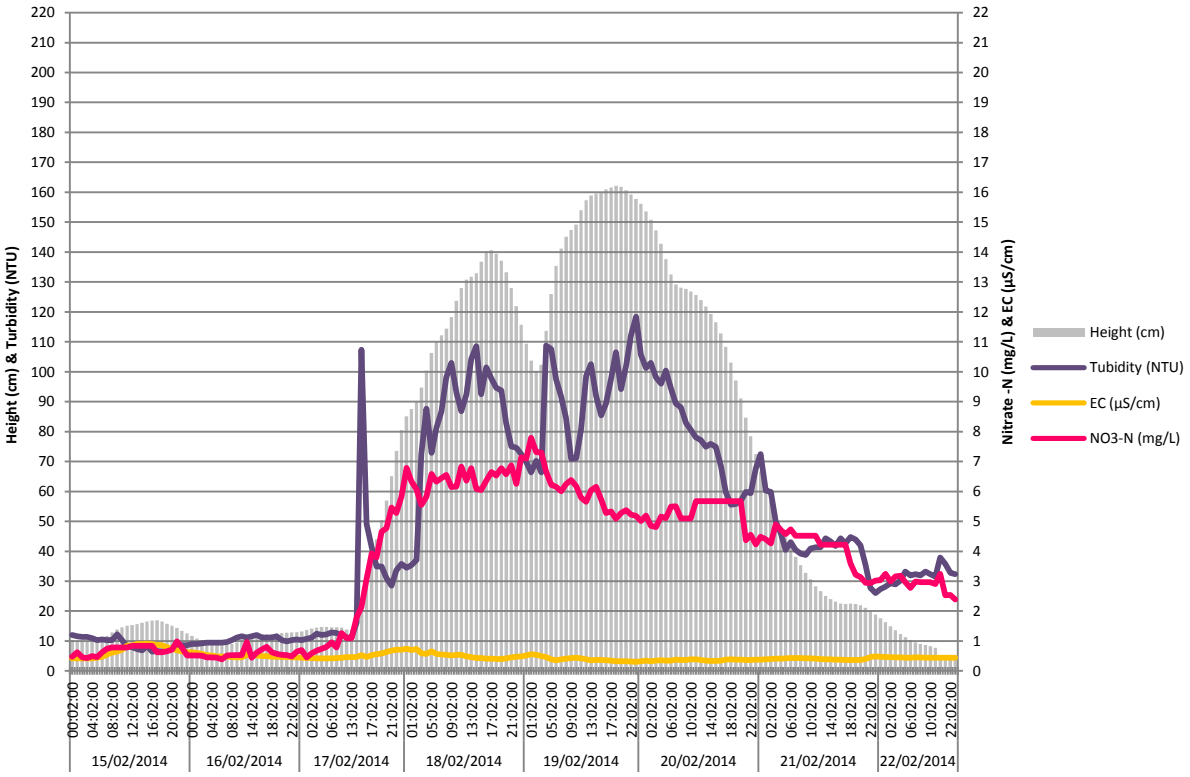


Figure 9 - Rainfall Event (15/02/14 - 22/02/14)

Observations of the above figure indicate a significant rainfall event. This event began on 15 February 2014, with significant flows staring on 17 February 2014.

Again note that the axes have been maintained for comparison with other events.

This event occured as a result of 140 mm of rainfall over three (3) days. Although it had been months since fertiliser application on the catchment farms, there is still nutrient runoff taking place.

Given the size of this event the average flow leaving the catchment was calculated at 2,610 L/sec. The measured nitrate-N concentration was approximately 6 mg/L. However due to the extensive event volumes, the amount of nitrogen lost was calculated at 6.69 kg/ha.

Figure 10 - Typical Irrigation Event

Figure 11 - High Rainfall Event

The figures above demonstrate the extremity of the rainfall event compared to a typical irrigation event in the subject catchment.

5.2 Nitrate-N Flux

Rainfall vs. irrigation events

Based on the daily data from the parameters measured, the total flux from the system can be calculated using the formulae FLUX = CONCENTRATION X VOLUME.

Appendix 3 details the daily data of flow, volume and nitrogen capacity.

The calculations include:

- stream flow (L/sec)
- volume (ML/day)
- nitrogen lost (kg/ha/day)

Figure 12 illustrates the amount of nitrogen lost (kg) per hectare per day. The six largest portions of the graph have been defined as rainfall events, ranging from 26mm to 73mm. From the full year of monitoring the subject catchment, more than three-quarters of the nitrogen lost to runoff was from rainfall events.

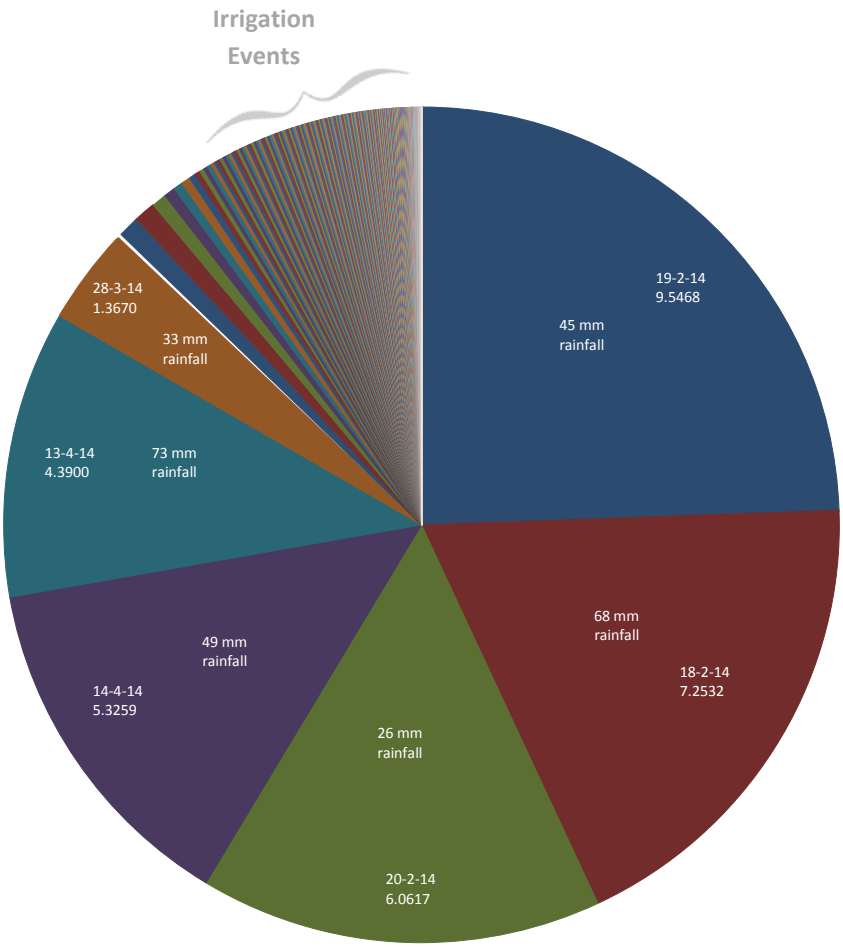


Figure 12 – Nitrogen Lost (kg/ha/day) between July 2013 and July 2014

5.3 Electrical Conductivity

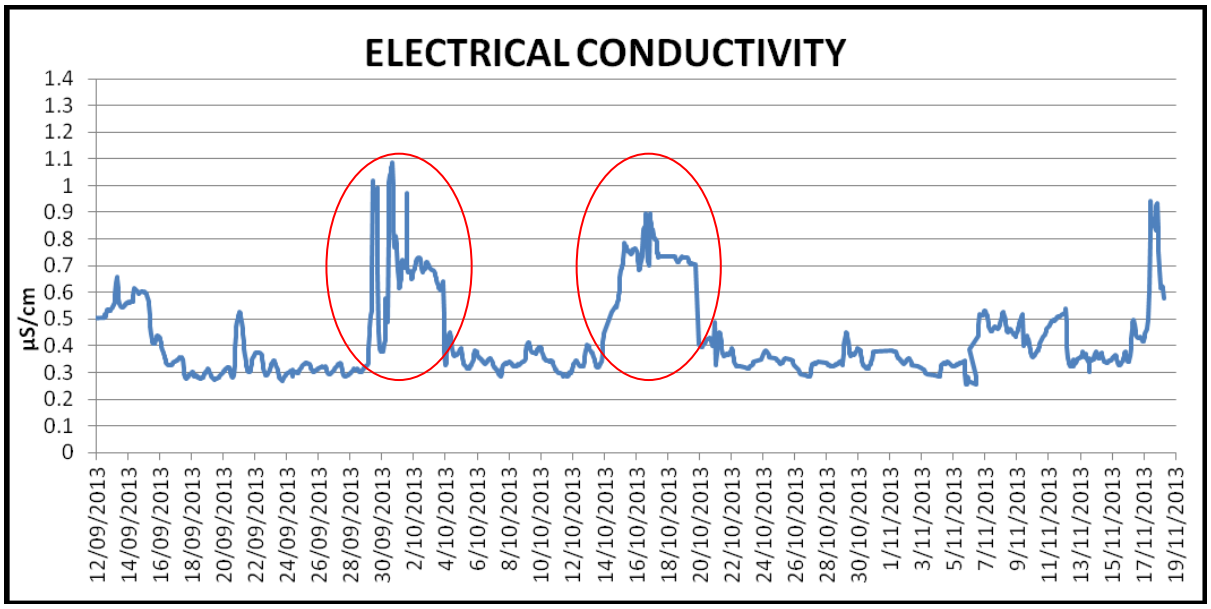


Figure 13: Electrical conductivity (µS/cm) over time at the monitoring site weir

While the majority of the land in the sub-catchment is irrigated with surface water from the irrigation scheme, there are two farmers who occasionally use ground water pumps to supplement their surface water supplies.

The figure above demonstrated the capacity to effectively trace irrigation water sources through electrical conductivity. This capacity could prove invaluable in the future in being able to identify the contribution from rising ground water tables to the base flow in the drainage systems.

5.4 Turbidity

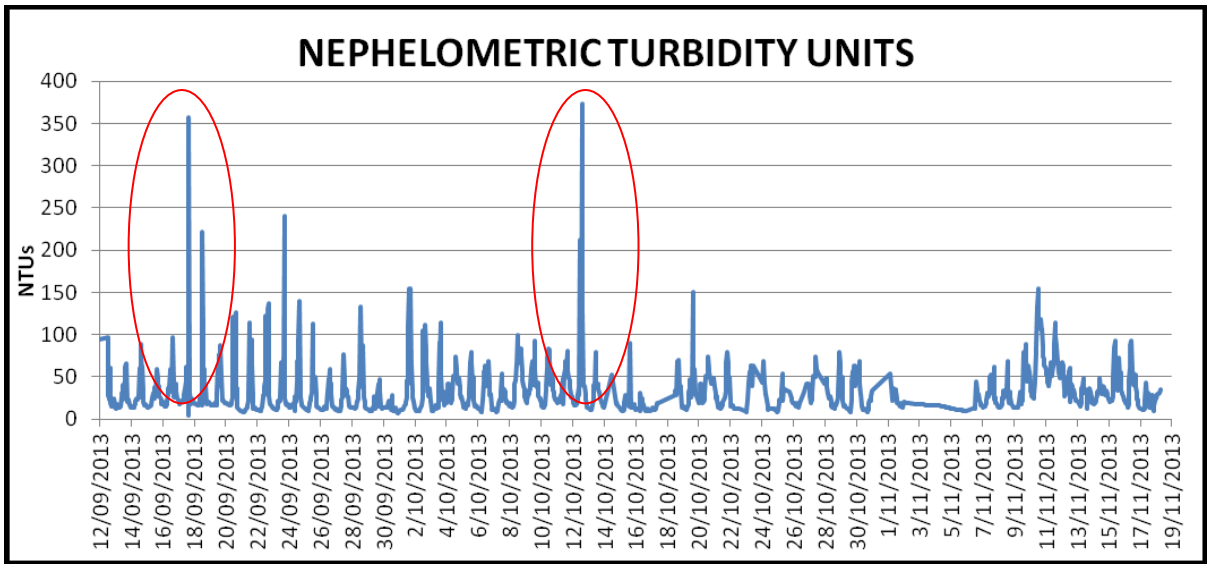


Figure 14: Turbidity units (NTUs) over time at the monitoring site weir

The turbidity of runoff water leaving the sub-catchment farms is generally very low, due to the low grades associated with the irrigated land and the low inflow rates associated with irrigation in the Burdekin River Irrigation Area . In spite of this, the data consistently showed a spike in turbidity every night, and this was somewhat of a mystery to the project team. In an effort to understand the reason for the nightly spike, an early morning visit found that there was an accumulation of aquatic bird life (ducks) in the drain at night. The bird numbers were estimated to be in the order of several thousand in the drainage system of the sub-catchment. The reason for this was thought to be the abnormally dry period in western Queensland, which resulted in a migration of ducks to the wetter coastal areas. The duck moved out of the drains around daybreak resulting in the water in the system becoming less turbid through the day. Again this example demonstrated the capacity of the real time water quality monitoring system to provide data that prompts enquiry to understand what was causing the water quality anomoly in the drainage system.

6.0 GROWERS FEEDBACK

The participating farmers' responses to the project were captured and documented throughout the program and also at a final workshop, which included presentation of the results and successes thus far, discussion based on the program, and a feedback questionnaire.

Feedback at the end of the program identified that the participants are keen to improve their understanding and knowledge of water quality in their catchment. They all found the subject matter interesting, and this was the main driver for their proactive participation.

When asked, all the participant farmers considered the project to be a success with regard to improving awareness of water quality issues from agriculture. Their views were collated during the plenary session at the final workshop. The questionnaire contained the following with responses:

1. Do you believe that there are water quality issues in the downstream environment, and that agriculture is in some way contributing?
    - *1 – YES; 2 – UNDECIDED*
    - *Comment – "Need to be more specific about 'issues' ".*
    - *Comment - "I wouldn't know. I have not seen the information".*
    - *"My commitment is to minimize man-made chemicals leaving my farm".*
2. Do you agree with the statement, '*If there is to be an improvement in downstream water quality, it will only occur when land managers accept and take ownership of the issues*'?
    - *2 – YES; 1- UNDECIDED.*
    - *Comment – "Include city dwellers".*
    - *Comment – "If there is a demonstrated unacceptable problem, those responsible for creating it MUST take responsibility for it, and take whatever action is required to stop it".*
3. Do you understand what the project is attempting to achieve?
    - *3 – YES.*

4. Were you satisfied with how project staff engaged with yourself during the course of the project?
    - *3 – YES.*
5. Can you offer any suggestions as to how to improve the engagement / consultation process?
    - *1 – YES, 2 –No.*
    - *Comment – "We need to be keeping a log of significant events to correlate with project data".*
6. Are you satisfied with the quality/credibility of the data being collected?
    - *3 – YES.*
7. Can you see that there is a relationship between what is happening on your farm and sub-catchment water quality?
    - *2 - YES; 1 – UNSURE.*
8. Have you or would you or consider making adjustments to farm practices based on the feedback from the water quality results (i.e. Recycling runoff water, Changes to irrigation and/or nutrient management practices, Use of alternative products)?
    - *3 – YES.*
    - *Comment – "Absolutely; this project will be invaluable in assessing best practice".*
9. Are you willing to be kept involved in the project for another two seasons under a similar or improved engagement process?
    - 3 – YES.

It is fair to say there is still a fair bit of scepticism from growers on the links between practices and impacts on the reef. Growers acknowledged they have an impact, yet are still questioning the magnitude of the impact and contribution from other sources. Overall, the participating growers are keen to keep the program going and improve its capability in their catchment.

6.1 Management Changes

Although only operating for one year, the project has already stimulated changes to farm management practices by the catchment farmers.

- Change to delaying fertilizer application until after first irrigation.
- Two farmers have increased their capacity to trap and recycle water.
- Adjust placement of fertilizer in beds to make sure it is effectively accessed by plants.
- Modified bed shape and configuration so that fertilizer is ideally located in the bed.

7.0 CONCLUSIONS

Overall conclusions:

- The Burdekin sugarcane farmers are strongly focused on maintaining productivity to remain financially viable and sustainable.
- In the last few years the farmers in this area are increasingly aware of the water quality issues and their obligation to minimize losses to the environment.
- Farmers generally are not familiar with the processes of the loss mechanisms, and without receiving support struggle to address them.
- The information provided to the collaborating farmers through this project was well accepted by them, and raised awareness of the mechanism of loss from the farming system.
- This information and process of engagement stimulated the thoughts of the farmers about the relationship between their farm practises and water quality leaving their farm.
- The catchment farmers have already implemented changes or are contemplating changes to their practices, which will reduce the losses from their farms as a result of the project.
- Significantly, none of the farmers has considered reducing rates of fertiliser applied as a means of reducing losses from their systems.
- All farmers indicated their willingness to continue to participate in this or a similar project, and are keen to achieve good water quality outcomes.

8.0 RECOMMENDATIONS

- This project produced one year's data and, ideally, this should be supported by further periods of monitoring to confirm results obtained so far.
- The findings from the project could be extended to the whole of the sugarcane industry, especially in the Burdekin.
- The adaptive management approach supported by high quality data for meaningful parameters has proved a successful approach in engaging farmers in water quality issues.
- The 'real time' component for data collection adds credibility to the data; this is a significant factor when attempting to engage farmers.
- The project's data suggests that there is significant nitrogen available for loss in runoff several months after application of fertiliser.
- More experimental and monitoring work should be undertaken to quantify the availability of nitrogen for loss by any mechanism throughout the cropping season.

ACKNOWLEDGEMENTS

The BBIFMAC project team would like to acknowledge the funding agencies NQ Dry Tropics and Queensland Government Department of Environment and Heritage's for their foresight in funding this project and their faith in believing BBIFMAC could deliver to achieve sound outcomes.

Other local personnel who have assisted in the activity include Evan Shannon (Farmacist), who helped identify and select the site for the monitoring, and was willing to provide advice whenever required. Steve Attard (Agri Tech Solutions) also assisted in developing the project plan and budget.

We would especially like to thank the sub catchment farmers for their trust and collaboration, and their willingness to honestly share their farm management activities with us, throughout the course of the project. Obviously, without this trust and collaboration we would have failed to achieve the project's objectives.

APPENDIX 1

A SUB CATCHMENT ADAPTIVE MANAGEMENT APPROACH TO WATER QUALITY IN SUGARCANE

WORK PLAN

One-Time Tasks:

- Contact Farmacist – re: farm maps and training
- Farm details from collaborating growers
    - Harvest dates
    - Crop varieties
    - Crop class
        - Fertiliser application – Dates / Rates / Methods
    - Irrigation timing and volume
- Calibration of weir height
- Nitrate-N reading comparisons
    - TRIOS analysis
    - BBIFMAC Lab analysis
    - HORTUS analysis
- Video production

Daily Tasks:

- Inspection of the website
- Check grower details from bi-weekly engagement

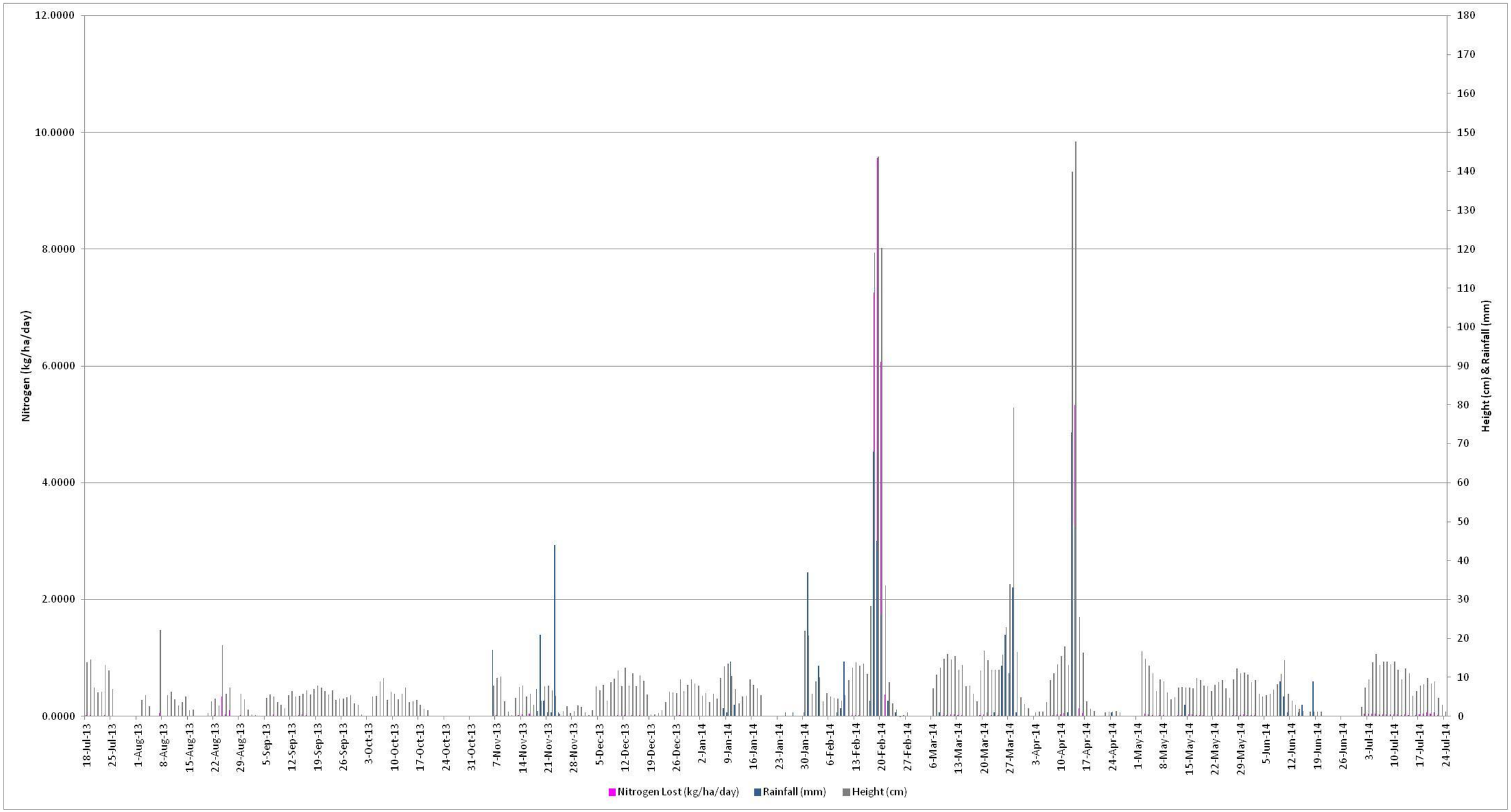
Weekly Tasks:

- Site inspection
    - Measure stream height above the constructed weir (in cm)
    - Time the flow speed over a 5m distance that is marked (in sec/5m)
    - Calculate volume = 5 x 4 (width) x weir height (m) x 1000 / flow speed (cm)
    - Record TriOS readings – NO_3, COD and TSS
    - Drive up the catchment, noting any flows
    - Estimate flow volume and collect sample in bucket
    - Take photos at each inlet point
    - Record a manual TriOS reading for each sample – NO_3, COD and TSS
- Instrumentation clean and service
- Manage database
- Contact growers for practices – Monday and Thursday
    - Irrigation?
    - Applying nutrients/pesticides/herbicides?
    - Management practices?
    - Other?

Monthly Tasks:

- Provide growers with formal analysis and interpretation of results
- Monitor milestones

APPENDIX 2


Nitrogen (kg/ha/day)
Height (cm) & Rainfall (mm)
12.0000
10.0000
8.0000
6.0000
4.0000
2.0000
0.0000
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
18-Jul-13
25-Jul-13
1-Aug-13
8-Aug-13
15-Aug-13
22-Aug-13
29-Aug-13
5-Sep-13
12-Sep-13
19-Sep-13
26-Sep-13
3-Oct-13
10-Oct-13
17-Oct-13
24-Oct-13
31-Oct-13
7-Nov-13
14-Nov-13
21-Nov-13
28-Nov-13
5-Dec-13
12-Dec-13
19-Dec-13
26-Dec-13
2-Jan-14
9-Jan-14
16-Jan-14
23-Jan-14
30-Jan-14
6-Feb-14
13-Feb-14
20-Feb-14
27-Feb-14
6-Mar-14
13-Mar-14
20-Mar-14
27-Mar-14
3-Apr-14
10-Apr-14
17-Apr-14
24-Apr-14
1-May-14
8-May-14
15-May-14
22-May-14
29-May-14
5-Jun-14
12-Jun-14
19-Jun-14
26-Jun-14
3-Jul-14
10-Jul-14
17-Jul-14
24-Jul-14
Nitrogen Lost (kg/ha/day)
Rainfall (mm)
Height (cm)

APPENDIX 3

	Rainfall (mm)	Height (m)	Height (cm)	Nitrate-N (mg/L)	Flow (L/sec)	Volume (ML/day)	Nitrogen Lost (kg/day)	Nitrogen Lost (kg/ha/day)
18-Jul-13	0	0.14	13.8	1.26	160.43	13.86	17.4636	0.0202
19-Jul-13	0	0.15	14.62	1.2	179.33	15.49	18.588	0.0215
20-Jul-13	0	0.07	7.41	1.81	49.72	4.3	7.783	0.0090
21-Jul-13	0	0.06	6.13	1.28	35.35	3.05	3.904	0.0045
22-Jul-13	0	0.06	6.35	0.95	37.67	3.25	3.0875	0.0036
23-Jul-13	0	0.13	13.21	1.32	147.48	12.74	16.8168	0.0194
24-Jul-13	0	0.12	11.84	0.89	119.65	10.34	9.2026	0.0106
25-Jul-13	0	0.07	7.04	0.81	45.38	3.92	3.1752	0.0037
26-Jul-13	0	0	0	1.58	2.58	0.22	0.3476	0.0004
27-Jul-13	0	0	0	0.97	2.58	0.22	0.2134	0.0002
28-Jul-13	0	0	0	0.8	2.58	0.22	0.176	0.0002
29-Jul-13	0	0	0	1.97	2.58	0.22	0.4334	0.0005
30-Jul-13	0	0	0	2.06	2.58	0.22	0.4532	0.0005
31-Jul-13	0	0	0	3.75	2.58	0.22	0.825	0.0010
01-Aug-13	0	0	0	4.36	2.58	0.22	0.9592	0.0011
02-Aug-13	0	0.04	4.09	2.09	17.83	1.54	3.2186	0.0037
03-Aug-13	0	0.05	5.49	1.78	29.16	2.52	4.4856	0.0052
04-Aug-13	0	0.03	2.64	1.45	9.4	0.81	1.1745	0.0014
05-Aug-13	0	0	0	0.92	2.58	0.22	0.2024	0.0002
07-Aug-13	0	0.22	22.11	1.23	401.59	34.7	42.681	0.0493
09-Aug-13	0	0.05	5.38	1.81	28.22	2.44	4.4164	0.0051
10-Aug-13	0	0.06	6.31	1.42	37.26	3.22	4.5724	0.0053
11-Aug-13	0	0.04	4.35	1.76	19.69	1.7	2.992	0.0035

12-Aug-13	0	0.03	2.71	2.23	9.7	0.84	1.8732	0.0022
13-Aug-13	0	0.04	3.62	2.7	14.76	1.28	3.456	0.0040
14-Aug-13	0	0.05	5.11	3.32	25.79	2.23	7.4036	0.0085
15-Aug-13	0	0.02	1.56	3.36	5.26	0.45	1.512	0.0017
16-Aug-13	0	0.02	1.72	3.55	5.77	0.5	1.775	0.0020
17-Aug-13	0	0	0.03	3.46	2.59	0.22	0.7612	0.0009
18-Aug-13	0	0	0	3.15	2.58	0.22	0.693	0.0008
19-Aug-13	0	0	0	3.2	2.58	0.22	0.704	0.0008
20-Aug-13	0	0.01	0.82	6.17	3.5	0.3	1.851	0.0021
21-Aug-13	0	0.04	3.9	6.59	16.57	1.43	9.4237	0.0109
22-Aug-13	0	0.04	4.48	7.66	20.68	1.79	13.7114	0.0158
23-Aug-13	0	0.03	2.83	9.03	10.29	0.89	8.0367	0.0093
24-Aug-13	0	0.18	18.35	12.03	278.93	24.1	289.923	0.3347
25-Aug-13	0	0.06	5.8	8.95	32.12	2.77	24.7915	0.0286
26-Aug-13	0	0.07	7.33	20.39	48.86	4.22	86.0458	0.0993
29-Aug-13	0	0.06	5.7	6.4	31.15	2.69	17.216	0.0199
30-Aug-13	0	0.04	4.33	5.77	19.55	1.69	9.7513	0.0113
31-Aug-13	0	0.02	1.78	3.35	5.95	0.51	1.7085	0.0020
01-Sep-13	0	0	0.4	3.09	2.89	0.25	0.7725	0.0009
02-Sep-13	0	0	0.25	3.04	2.74	0.24	0.7296	0.0008
05-Sep-13	0	0.05	4.77	2.85	22.97	1.98	5.643	0.0065
06-Sep-13	0	0.06	5.5	4.2	29.31	2.53	10.626	0.0123
07-Sep-13	0	0.05	5.03	12.76	25.08	2.17	27.6892	0.0320
08-Sep-13	0	0.04	3.58	5.89	14.52	1.25	7.3625	0.0085
09-Sep-13	0	0.03	2.86	4.81	10.45	0.9	4.329	0.0050
10-Sep-13	0	0.02	2.12	5.71	7.16	0.62	3.5402	0.0041

11-Sep-13	0	0.05	5.48	3.64	29.07	2.51	9.1364	0.0105
12-Sep-13	0	0.06	6.42	2.28	38.43	3.32	7.5696	0.0087
13-Sep-13	0	0.05	5.02	2.57	25.06	2.17	5.5769	0.0064
14-Sep-13	0	0.05	5.26	6.62	27.14	2.34	15.4908	0.0179
15-Sep-13	0	0.06	5.78	8.27	31.92	2.76	22.8252	0.0263
16-Sep-13	0	0.07	6.65	5.83	40.9	3.53	20.5799	0.0238
17-Sep-13	0	0.06	5.61	1.93	30.25	2.61	5.0373	0.0058
18-Sep-13	0	0.07	7.05	1.15	45.5	3.93	4.5195	0.0052
19-Sep-13	0	0.08	7.87	1.46	55.52	4.8	7.008	0.0081
20-Sep-13	0	0.07	7.26	0.91	47.93	4.14	3.7674	0.0043
21-Sep-13	0	0.06	6.47	0.56	38.98	3.37	1.8872	0.0022
22-Sep-13	0	0.06	5.63	0.28	30.51	2.64	0.7392	0.0009
23-Sep-13	0	0.07	6.68	0.12	41.25	3.56	0.4272	0.0005
24-Sep-13	0	0.04	4.26	0.64	19.03	1.64	1.0496	0.0012
25-Sep-13	0	0.05	4.51	0.26	20.89	1.8	0.468	0.0005
26-Sep-13	0	0.05	4.59	0.39	21.55	1.86	0.7254	0.0008
27-Sep-13	0	0.05	4.85	0.43	23.59	2.04	0.8772	0.0010
28-Sep-13	0	0.05	5.47	0.62	29	2.51	1.5562	0.0018
29-Sep-13	0	0.03	3.29	2.99	12.76	1.1	3.289	0.0038
30-Sep-13	0	0.03	2.88	2.3	10.57	0.91	2.093	0.0024
01-Oct-13	0	0	0.43	0.95	2.93	0.25	0.2375	0.0003
02-Oct-13	0	0	0	0.22	2.58	0.22	0.0484	0.0001
03-Oct-13	0	0	0.03	0.06	2.59	0.22	0.0132	0.0000
04-Oct-13	0	0.05	5.08	0.89	25.56	2.21	1.9669	0.0023
05-Oct-13	0	0.05	5.31	0.43	27.52	2.38	1.0234	0.0012
06-Oct-13	0	0.09	8.94	0.56	70.43	6.09	3.4104	0.0039

07-Oct-13	0	0.1	9.76	0.75	82.99	7.17	5.3775	0.0062
08-Oct-13	0	0.04	4.26	1.39	19.06	1.65	2.2935	0.0026
09-Oct-13	0	0.06	6.31	1.45	37.24	3.22	4.669	0.0054
10-Oct-13	0	0.06	5.72	1.42	31.38	2.71	3.8482	0.0044
11-Oct-13	0	0.04	4.4	0.39	20.06	1.73	0.6747	0.0008
12-Oct-13	0	0.06	5.71	0.83	31.21	2.7	2.241	0.0026
13-Oct-13	0	0.07	7.36	0.05	49.2	4.25	0.2125	0.0002
14-Oct-13	0	0.04	3.57	0	14.46	1.25	0	0.0000
15-Oct-13	0	0.04	3.83	0	16.05	1.39	0	0.0000
16-Oct-13	0	0.04	4.13	0	18.1	1.56	0	0.0000
17-Oct-13	0	0.03	2.87	0	10.52	0.91	0	0.0000
18-Oct-13	0	0.02	1.9	0	6.36	0.55	0	0.0000
19-Oct-13	0	0.01	1.47	0	5	0.43	0	0.0000
06-Nov-13	17	0.08	7.92	2.47	56.23	4.86	12.0042	0.0139
07-Nov-13	0	0.1	9.87	1.77	84.78	7.33	12.9741	0.0150
08-Nov-13	0	0.1	10.19	1.49	89.99	7.77	11.5773	0.0134
09-Nov-13	0	0.04	3.89	1.41	16.51	1.43	2.0163	0.0023
10-Nov-13	0	0.01	1.14	1.29	4.15	0.36	0.4644	0.0005
11-Nov-13	0	0	0.28	1.24	2.77	0.24	0.2976	0.0003
12-Nov-13	0	0.05	4.74	3.9	22.74	1.97	7.683	0.0089
13-Nov-13	0	0.07	7.48	4.72	50.63	4.37	20.6264	0.0238
14-Nov-13	0	0.08	7.95	5.28	56.59	4.89	25.8192	0.0298
15-Nov-13	0	0.05	5.08	4.58	25.56	2.21	10.1218	0.0117
16-Nov-13	0	0.06	5.74	13.54	31.53	2.72	36.8288	0.0425
17-Nov-13	0	0.03	2.92	7.34	10.76	0.93	6.8262	0.0079
18-Nov-13	7	0.01	1.37	9.81	4.74	0.41	4.0221	0.0046

19-Nov-13	21	0.04	3.98	12.85	17.07	1.47	18.8895	0.0218
20-Nov-13	4	0.08	7.7	12.65	53.42	4.62	58.443	0.0675
21-Nov-13	1	0.08	7.87	4.9	55.63	4.81	23.569	0.0272
22-Nov-13	1	0.07	6.72	2.01	41.74	3.61	7.2561	0.0084
23-Nov-13	44	0.05	5.19	3.22	26.52	2.29	7.3738	0.0085
24-Nov-13	1	0.01	0.72	2.18	3.34	0.29	0.6322	0.0007
25-Nov-13	0	0.01	1.42	2.36	4.88	0.42	0.9912	0.0011
26-Nov-13	0	0.03	2.5	1.81	8.76	0.76	1.3756	0.0016
27-Nov-13	0	0.01	0.84	1	3.55	0.31	0.31	0.0004
28-Nov-13	0	0.01	1.3	1.3	4.54	0.39	0.507	0.0006
29-Nov-13	0	0.03	2.72	1.4	9.79	0.85	1.19	0.0014
30-Nov-13	0	0.02	2.41	1.29	8.34	0.72	0.9288	0.0011
01-Dec-13	0	0.01	1.02	1.22	3.9	0.34	0.4148	0.0005
02-Dec-13	0	0	0.3	1.25	2.79	0.24	0.3	0.0003
03-Dec-13	0	0.02	1.58	1.24	5.34	0.46	0.5704	0.0007
04-Dec-13	0	0.08	7.76	1.04	54.17	4.68	4.8672	0.0056
05-Dec-13	0	0.07	6.66	0.78	41.05	3.55	2.769	0.0032
06-Dec-13	0	0.08	8.1	1.01	58.57	5.06	5.1106	0.0059
07-Dec-13	0	0.04	3.95	1.14	16.86	1.46	1.6644	0.0019
08-Dec-13	0	0.09	8.79	0.79	68.13	5.89	4.6531	0.0054
09-Dec-13	0	0.1	9.64	0.93	80.98	7	6.51	0.0075
10-Dec-13	0	0.12	11.81	1.17	119.16	10.3	12.051	0.0139
11-Dec-13	0	0.08	7.68	0.8	53.19	4.6	3.68	0.0042
12-Dec-13	0	0.12	12.5	1.06	132.71	11.47	12.1582	0.0140
13-Dec-13	0	0.08	7.83	1.14	55.05	4.76	5.4264	0.0063
14-Dec-13	0	0.11	11.03	1.4	104.57	9.04	12.656	0.0146

15-Dec-13	0	0.08	7.78	1.72	54.38	4.7	8.084	0.0093
16-Dec-13	0	0.1	10.44	1.51	94.23	8.14	12.2914	0.0142
17-Dec-13	0	0.09	9.13	0.72	73.22	6.33	4.5576	0.0053
18-Dec-13	0	0.06	5.58	1.29	29.97	2.59	3.3411	0.0039
19-Dec-13	0	0	0.47	1.39	2.98	0.26	0.3614	0.0004
20-Dec-13	0	0	0.45	0.94	2.95	0.26	0.2444	0.0003
21-Dec-13	0	0.01	0.9	1.07	3.65	0.32	0.3424	0.0004
22-Dec-13	0	0.02	1.59	2.29	5.35	0.46	1.0534	0.0012
23-Dec-13	0	0.04	3.68	2.05	15.12	1.31	2.6855	0.0031
24-Dec-13	0	0.06	6.32	0.92	37.33	3.23	2.9716	0.0034
25-Dec-13	0	0.06	6.11	1.69	35.22	3.04	5.1376	0.0059
26-Dec-13	0	0.06	6.02	0.37	34.24	2.96	1.0952	0.0013
27-Dec-13	0	0.09	9.41	2.4	77.4	6.69	16.056	0.0185
28-Dec-13	0	0.06	6.46	1.79	38.88	3.36	6.0144	0.0069
29-Dec-13	0	0.08	8.01	0.74	57.47	4.97	3.6778	0.0042
30-Dec-13	0	0.1	9.54	0.51	79.51	6.87	3.5037	0.0040
31-Dec-13	0	0.08	8.32	0.45	61.62	5.32	2.394	0.0028
01-Jan-14	0	0.08	7.96	0.17	56.77	4.91	0.8347	0.0010
02-Jan-14	0	0.05	5.23	0.49	26.85	2.32	1.1368	0.0013
03-Jan-14	0	0.06	5.96	1.07	33.64	2.91	3.1137	0.0036
04-Jan-14	0	0.04	3.67	0.74	15.05	1.3	0.962	0.0011
05-Jan-14	0	0.06	5.72	0.48	31.34	2.71	1.3008	0.0015
06-Jan-14	0	0.05	4.52	0.29	21.01	1.82	0.5278	0.0006
07-Jan-14	0	0.1	9.82	0.49	83.84	7.24	3.5476	0.0041
08-Jan-14	2	0.13	12.79	3.05	138.76	11.99	36.5695	0.0422
09-Jan-14	1	0.14	13.59	1.65	155.85	13.47	22.2255	0.0257

10-Jan-14	14	0.1	10.27	1.21	91.37	7.89	9.5469	0.0110
11-Jan-14	3	0.07	6.96	1.1	44.39	3.84	4.224	0.0049
12-Jan-14	0	0.03	3.36	0.84	13.17	1.14	0.9576	0.0011
13-Jan-14	0	0.05	5.05	0.89	25.3	2.19	1.9491	0.0022
14-Jan-14	0	0.05	5.2	0.44	26.56	2.29	1.0076	0.0012
15-Jan-14	0	0.09	9.46	0.56	78.19	6.76	3.7856	0.0044
16-Jan-14	0	0.08	8.02	0.74	57.55	4.97	3.6778	0.0042
17-Jan-14	0	0.07	7.21	0.38	47.41	4.1	1.558	0.0018
18-Jan-14	0	0.05	5.36	0.43	27.96	2.42	1.0406	0.0012
19-Jan-14	0	0	0	1.37	2.58	0.22	0.3014	0.0003
20-Jan-14	0	0	0	0.45	2.58	0.22	0.099	0.0001
21-Jan-14	0	0	0	0.88	2.58	0.22	0.1936	0.0002
22-Jan-14	0	0	0	0.8	2.58	0.22	0.176	0.0002
23-Jan-14	0	0	0	0.16	2.58	0.22	0.0352	0.0000
24-Jan-14	0	0	0	0.47	2.58	0.22	0.1034	0.0001
25-Jan-14	1	0	0	0.15	2.58	0.22	0.033	0.0000
26-Jan-14	0	0	0	0.24	2.58	0.22	0.0528	0.0001
27-Jan-14	1	0	0	0.31	2.58	0.22	0.0682	0.0001
28-Jan-14	0	0	0	0.4	2.58	0.22	0.088	0.0001
29-Jan-14	0	0	0	0.51	2.58	0.22	0.1122	0.0001
30-Jan-14	1	0.22	21.95	1.23	395.71	34.19	42.0537	0.0485
31-Jan-14	37	0.21	20.74	4.95	354.22	30.6	151.47	0.1749
01-Feb-14	0	0.06	5.69	3.02	31.06	2.68	8.0936	0.0093
02-Feb-14	0	0.09	8.99	1.92	71.13	6.15	11.808	0.0136
03-Feb-14	13	0.1	9.93	2.31	85.64	7.4	17.094	0.0197
04-Feb-14	0	0.04	3.83	1.43	16.1	1.39	1.9877	0.0023

05-Feb-14	0	0.06	6.02	1.41	34.23	2.96	4.1736	0.0048
06-Feb-14	0	0.05	5.05	1.37	25.27	2.18	2.9866	0.0034
07-Feb-14	0	0.05	4.64	1.43	21.93	1.89	2.7027	0.0031
08-Feb-14	1	0.05	4.59	1.42	21.56	1.86	2.6412	0.0030
09-Feb-14	2	0.04	4.07	1.56	17.68	1.53	2.3868	0.0028
10-Feb-14	14	0.05	5.46	0.97	28.9	2.5	2.425	0.0028
11-Feb-14	0	0.09	9.21	0.66	74.47	6.43	4.2438	0.0049
12-Feb-14	0	0.13	12.51	1.11	132.86	11.48	12.7428	0.0147
13-Feb-14	0	0.14	13.89	1.03	162.42	14.03	14.4509	0.0167
14-Feb-14	0	0.13	12.92	1	141.4	12.22	12.22	0.0141
15-Feb-14	0	0.13	13.48	0.69	153.34	13.25	9.1425	0.0106
16-Feb-14	0	0.11	10.92	0.59	102.62	8.87	5.2333	0.0060
17-Feb-14	4	0.28	28.25	2.08	649.8	56.14	116.7712	0.1348
18-Feb-14	68	1.19	119.12	6.42	11327.46	978.69	6283.19	7.2532
19-Feb-14	45	1.44	143.73	5.81	16474.72	1423.42	8270.07	9.5468
20-Feb-14	26	1.2	120.31	5.26	11554.39	998.3	5251.058	6.0617
21-Feb-14	0	0.34	33.66	4.12	918.68	79.37	327.0044	0.3775
22-Feb-14	4	0.09	8.69	2.93	66.83	5.77	16.9061	0.0195
23-Feb-14	0	0.03	3.25	2.25	12.53	1.08	2.43	0.0028
24-Feb-14	1	0.02	1.78	2.01	5.97	0.52	1.0452	0.0012
25-Feb-14	0	0	-0.26	1.78	2.5	0.22	0.3916	0.0005
26-Feb-14	0	0	0.26	1.81	2.76	0.24	0.4344	0.0005
27-Feb-14	0	0.01	1.01	1.93	3.87	0.33	0.6369	0.0007
06-Mar-14	0	0.07	7.11	0.3	46.13	3.99	1.197	0.0014
07-Mar-14	0	0.11	10.7	0.9	98.75	8.53	7.677	0.0089

08-Mar-14	1	0.13	12.53	1.06	133.39	11.52	12.2112	0.0141
09-Mar-14	0	0.15	14.79	0.99	183.47	15.85	15.6915	0.0181
10-Mar-14	0	0.16	15.9	1.2	211.13	18.24	21.888	0.0253
11-Mar-14	0	0.15	14.61	1.66	179.16	15.48	25.6968	0.0297
12-Mar-14	0	0.15	15.41	1.81	198.61	17.16	31.0596	0.0359
13-Mar-14	0	0.12	11.92	1.68	121.2	10.47	17.5896	0.0203
14-Mar-14	0	0.13	13.23	1.65	148.02	12.79	21.1035	0.0244
15-Mar-14	0	0.08	7.71	1.25	53.59	4.63	5.7875	0.0067
16-Mar-14	0	0.08	7.96	0.82	56.74	4.9	4.018	0.0046
17-Mar-14	0	0.06	5.83	0.77	32.4	2.8	2.156	0.0025
18-Mar-14	0	0.04	3.9	1.15	16.57	1.43	1.6445	0.0019
19-Mar-14	0	0.12	11.75	1.5	117.86	10.18	15.27	0.0176
20-Mar-14	0	0.17	16.79	1.31	234.71	20.28	26.5668	0.0307
21-Mar-14	1	0.14	14.34	1.53	172.75	14.93	22.8429	0.0264
22-Mar-14	0	0.12	11.85	1.68	119.82	10.35	17.388	0.0201
23-Mar-14	1	0.12	11.99	1.77	122.47	10.58	18.7266	0.0216
24-Mar-14	0	0.12	11.92	1.76	121.22	10.47	18.4272	0.0213
25-Mar-14	13	0.16	15.76	1.68	207.53	17.93	30.1224	0.0348
26-Mar-14	21	0.23	22.89	1.9	429.68	37.12	70.528	0.0814
27-Mar-14	11	0.34	34.04	2.36	939.26	81.15	191.514	0.2211
28-Mar-14	33	0.79	79.19	2.73	5020.37	433.76	1184.165	1.3670
29-Mar-14	1	0.17	16.5	2.16	226.79	19.59	42.3144	0.0488
30-Mar-14	0	0.05	4.84	1.59	23.5	2.03	3.2277	0.0037
31-Mar-14	0	0.03	3.05	2.13	11.42	0.99	2.1087	0.0024
01-Apr-14	0	0.02	1.99	2.35	6.7	0.58	1.363	0.0016
02-Apr-14	0	0	0.12	2.14	2.64	0.23	0.4922	0.0006

03-Apr-14	0	0.01	0.94	2.13	3.73	0.32	0.6816	0.0008
04-Apr-14	0	0.01	1.19	2.15	4.28	0.37	0.7955	0.0009
05-Apr-14	0	0.01	1.19	2.05	4.27	0.37	0.7585	0.0009
06-Apr-14	0	0.04	3.57	1.87	14.42	1.25	2.3375	0.0027
07-Apr-14	0	0.09	9.31	1.64	75.91	6.56	10.7584	0.0124
08-Apr-14	0	0.11	11.1	1.77	105.84	9.14	16.1778	0.0187
09-Apr-14	0	0.13	13.33	1.8	150.22	12.98	23.364	0.0270
10-Apr-14	0	0.15	15.49	1.86	200.52	17.33	32.2338	0.0372
11-Apr-14	0	0.18	17.94	1.92	266.9	23.06	44.2752	0.0511
12-Apr-14	1	0.13	13.11	1.9	145.33	12.56	23.864	0.0275
13-Apr-14	73	1.4	139.89	2.82	15608.4	1348.57	3802.967	4.3900
14-Apr-14	49	1.48	147.69	3.07	17393.6	1502.81	4613.627	5.3259
15-Apr-14	0	0.26	25.53	2.67	532.48	46.01	122.8467	0.1418
16-Apr-14	0	0.16	16.4	2.49	224.23	19.37	48.2313	0.0557
17-Apr-14	0	0.04	3.86	2.09	16.27	1.41	2.9469	0.0034
18-Apr-14	0	0.02	1.95	2.25	6.56	0.57	1.2825	0.0015
19-Apr-14	0	0.01	1.35	2.26	4.67	0.4	0.904	0.0010
20-Apr-14	0	0	0	2.23	2.58	0.22	0.4906	0.0006
21-Apr-14	0	0	0	2.23	2.58	0.22	0.4906	0.0006
22-Apr-14	0	0.01	1.03	2.28	3.92	0.34	0.7752	0.0009
23-Apr-14	0	0.01	1.19	2.28	4.29	0.37	0.8436	0.0010
24-Apr-14	1	0.01	1.2	2.3	4.3	0.37	0.851	0.0010
25-Apr-14	0	0.01	1.27	2.41	4.47	0.39	0.9399	0.0011
26-Apr-14	0	0.01	1.07	2.31	4	0.35	0.8085	0.0009
02-May-14	0	0.17	16.61	0	229.62	19.84	0	0.0000
03-May-14	0	0.15	14.82	2.13	184.12	15.91	33.8883	0.0391

04-May-14	0	0.13	12.92	2.01	141.48	12.22	24.5622	0.0284
05-May-14	0	0.11	11.11	1.83	106.07	9.16	16.7628	0.0194
06-May-14	0	0.06	6.43	2.18	38.52	3.33	7.2594	0.0084
07-May-14	0	0.09	9.45	2.03	78.07	6.75	13.7025	0.0158
08-May-14	0	0.09	8.91	2.01	69.93	6.04	12.1404	0.0140
09-May-14	0	0.06	6.07	1.96	34.83	3.01	5.8996	0.0068
10-May-14	0	0.04	4.33	2.2	19.56	1.69	3.718	0.0043
11-May-14	0	0.05	4.82	2.37	23.36	2.02	4.7874	0.0055
12-May-14	0	0.07	7.41	3.82	49.72	4.3	16.426	0.0190
13-May-14	0	0.07	7.49	4.57	50.71	4.38	20.0166	0.0231
14-May-14	3	0.07	7.37	5.6	49.26	4.26	23.856	0.0275
15-May-14	0	0.07	7.28	5.94	48.17	4.16	24.7104	0.0285
16-May-14	0	0.07	7.19	5.47	47.13	4.07	22.2629	0.0257
17-May-14	0	0.1	9.79	2.89	83.48	7.21	20.8369	0.0241
18-May-14	0	0.09	9.27	3.03	75.27	6.5	19.695	0.0227
19-May-14	0	0.08	7.89	3.44	55.89	4.83	16.6152	0.0192
20-May-14	0	0.08	7.63	2.35	52.56	4.54	10.669	0.0123
21-May-14	0	0.06	6.43	1.98	38.52	3.33	6.5934	0.0076
22-May-14	0	0.08	7.99	2.08	57.15	4.94	10.2752	0.0119
23-May-14	0	0.09	8.7	2.07	66.86	5.78	11.9646	0.0138
24-May-14	0	0.09	9.36	2.07	76.65	6.62	13.7034	0.0158
25-May-14	0	0.07	7.16	2.04	46.78	4.04	8.2416	0.0095
26-May-14	0	0.05	4.68	2.39	22.22	1.92	4.5888	0.0053
27-May-14	0	0.09	9.49	2.34	78.64	6.79	15.8886	0.0183
28-May-14	0	0.12	12.28	1.91	128.35	11.09	21.1819	0.0245
29-May-14	0	0.11	11	2.31	104.03	8.99	20.7669	0.0240

30-May-14	0	0.11	11.23	2.67	108.16	9.35	24.9645	0.0288
31-May-14	0	0.11	10.68	2.58	98.38	8.5	21.93	0.0253
01-Jun-14	0	0.09	8.83	3.37	68.74	5.94	20.0178	0.0231
02-Jun-14	0	0.09	9.37	2.11	76.83	6.64	14.0104	0.0162
03-Jun-14	0	0.06	5.81	2.09	32.17	2.78	5.8102	0.0067
04-Jun-14	0	0.05	5.07	2.18	25.46	2.2	4.796	0.0055
05-Jun-14	0	0.05	5.48	2.01	29.06	2.51	5.0451	0.0058
06-Jun-14	0	0.06	5.73	2.07	31.46	2.72	5.6304	0.0065
07-Jun-14	0	0.07	6.86	2.21	43.31	3.74	8.2654	0.0095
08-Jun-14	0	0.08	8.27	2.03	60.86	5.26	10.6778	0.0123
09-Jun-14	9	0.11	10.85	2.2	101.25	8.75	19.25	0.0222
10-Jun-14	5	0.14	14.37	2.24	173.56	15	33.6	0.0388
11-Jun-14	1	0.06	5.73	1.83	31.4	2.71	4.9593	0.0057
12-Jun-14	0	0.04	4.03	1.53	17.46	1.51	2.3103	0.0027
13-Jun-14	0	0.03	2.86	2.33	10.45	0.9	2.097	0.0024
14-Jun-14	1	0.02	1.82	2.32	6.1	0.53	1.2296	0.0014
15-Jun-14	3	0.01	1.43	2.34	4.91	0.42	0.9828	0.0011
16-Jun-14	0	0	0	2.39	2.58	0.22	0.5258	0.0006
17-Jun-14	0	0.01	1.14	2.34	4.16	0.36	0.8424	0.0010
18-Jun-14	9	0.01	1.15	2.3	4.19	0.36	0.828	0.0010
19-Jun-14	0	0.01	1.18	2.36	4.26	0.37	0.8732	0.0010
20-Jun-14	0	0.01	1.22	2.42	4.35	0.38	0.9196	0.0011
01-Jul-14	0	0.02	2.35	2.28	8.12	0.7	1.596	0.0018
02-Jul-14	0	0.07	7.37	9.4	49.3	4.26	40.044	0.0462
03-Jul-14	0	0.09	9.47	5.6	78.37	6.77	37.912	0.0438
04-Jul-14	0	0.14	13.79	2.37	160.35	13.85	32.8245	0.0379

04-Jul-14	0	0.13	12.8	2.63	138.87	12	31.56	0.0364
05-Jul-14	0	0.16	16.03	2.26	214.46	18.53	41.8778	0.0483
06-Jul-14	0	0.13	13.24	2.26	148.11	12.8	28.928	0.0334
07-Jul-14	0	0.14	14.04	2.06	165.83	14.33	29.5198	0.0341
08-Jul-14	0	0.14	14.1	2.23	167.29	14.45	32.2235	0.0372
09-Jul-14	0	0.13	13.3	2.43	149.4	12.91	31.3713	0.0362
10-Jul-14	0	0.14	14.03	2.22	165.76	14.32	31.7904	0.0367
11-Jul-14	0	0.12	11.99	2.1	122.6	10.59	22.239	0.0257
12-Jul-14	0	0.1	9.5	2.29	78.89	6.82	15.6178	0.0180
13-Jul-14	0	0.12	12.29	2.22	128.51	11.1	24.642	0.0284
14-Jul-14	0	0.11	11	2.24	103.93	8.98	20.1152	0.0232
15-Jul-14	0	0.05	5.21	2.39	26.63	2.3	5.497	0.0063
16-Jul-14	0	0.07	6.51	4.43	39.36	3.4	15.062	0.0174
17-Jul-14	0	0.08	7.96	6.56	56.8	4.91	32.2096	0.0372
18-Jul-14	0	0.08	8.3	7.39	61.28	5.29	39.0931	0.0451
19-Jul-14	0	0.1	9.79	7.68	83.43	7.21	55.3728	0.0639
20-Jul-14	0	0.08	8.35	6.46	62.06	5.36	34.6256	0.0400
21-Jul-14	0	0.09	8.98	8.95	70.97	6.13	54.8635	0.0633
22-Jul-14	0	0.05	4.71	8.59	22.46	1.94	16.6646	0.0192
23-Jul-14	0	0.03	2.96	7.13	10.98	0.95	6.7735	0.0078
24-Jul-14	0	0.01	1.22	5.55	4.34	0.38	2.109	0.0024