ON-SITE WASTEWATER TREATMENT AND WATER RECYCLING AT A MUSIC FESTIVAL VENUE

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Woodfordia Site

- Festival event site in Queensland, Australia
- Holds the largest festival event in the Southern Hemisphere
  - The Woodford Folk Festival
- Between 1987 and 2008 all wastewater trucked off-site to centralised STP's
- Trucking became unfeasible
  - Cost, Insurance, Town-Planning Permits, and Green House Gas Emissions
- Pipeline to nearest centralized STP quoted at 20 million dollars
- Multiple quotes for decentralized solutions
  - Issues with intermittent production of wastewater
  - All looked at storage and daily treatment of small volumes of effluent
- Arris proposed a batching treatment facility
  - Constructed in 2009

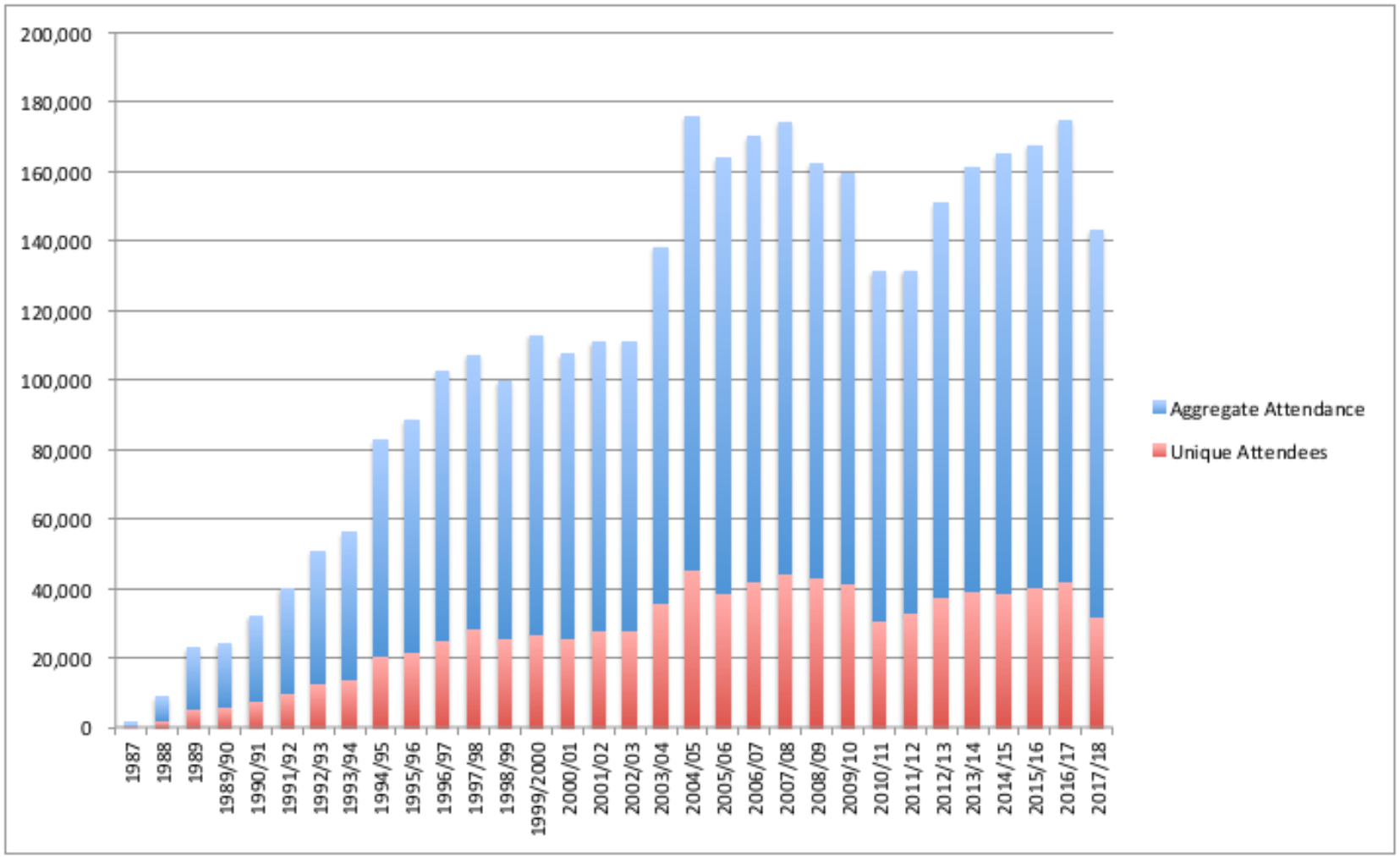
Woodfordia Decentralized Water System

- Potable Water System
  - 16 ML storage dam
  - 1.3 ML a day treatment capacity
  - 5 ML main storage tank + 1 ML of smaller tanks
- 50 permanent amenities blocks
  - Depending on the event additional facilities are hired
- Gravity and Pressure Sewer Reticulation System
  - Approximately 30 kilometres
- Pump stations deliver water to the STP (no gravity fed to STP)
- STP treatment capacity of 1.5 ML/day
- All treated water recycled on-site

Types of Festivals

- Woodford Folk Festival
  - 26 December to 1st of January
- The Planting Festival
  - May Day Long Weekend
- Splendour in The Grass
  - Held in 2010 and 2011
  - Up to 50 000 people a day on-site
- Dreaming Festival
  - Indigenous festival
  - Currently not running
- Tough Mudder
  - Obstacle course/Fun Run

Attendance at the Woodford Folk Festival

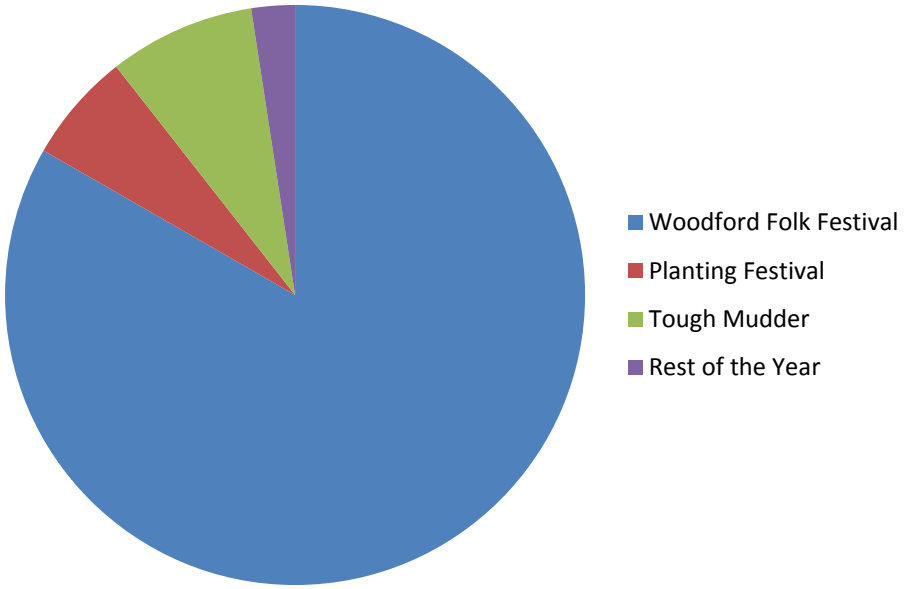


Wastewater Volumes Treated per day 2017/2018 Woodford Folk Festival

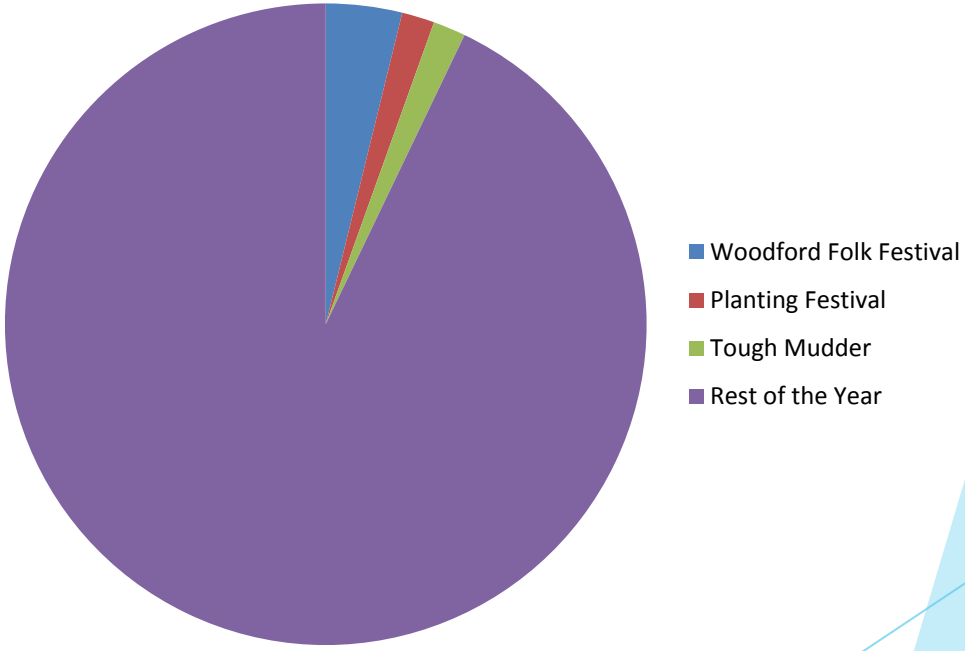
26/12/17	730 kL
27/12/17	390 kL
28/12/17	680 kL
29/12/17	1115 kL
30/12/17	1110 kL
31/12/17	1390 kL
1/01/18	975 kL
2/01/18	505 kL
3/01/18	340 kL
4th to 19th Jan/18	1145 kL
Total (treated)	**8380 kL (2 213 762 gallons)**

Volume and Time Comparison 2017/2018

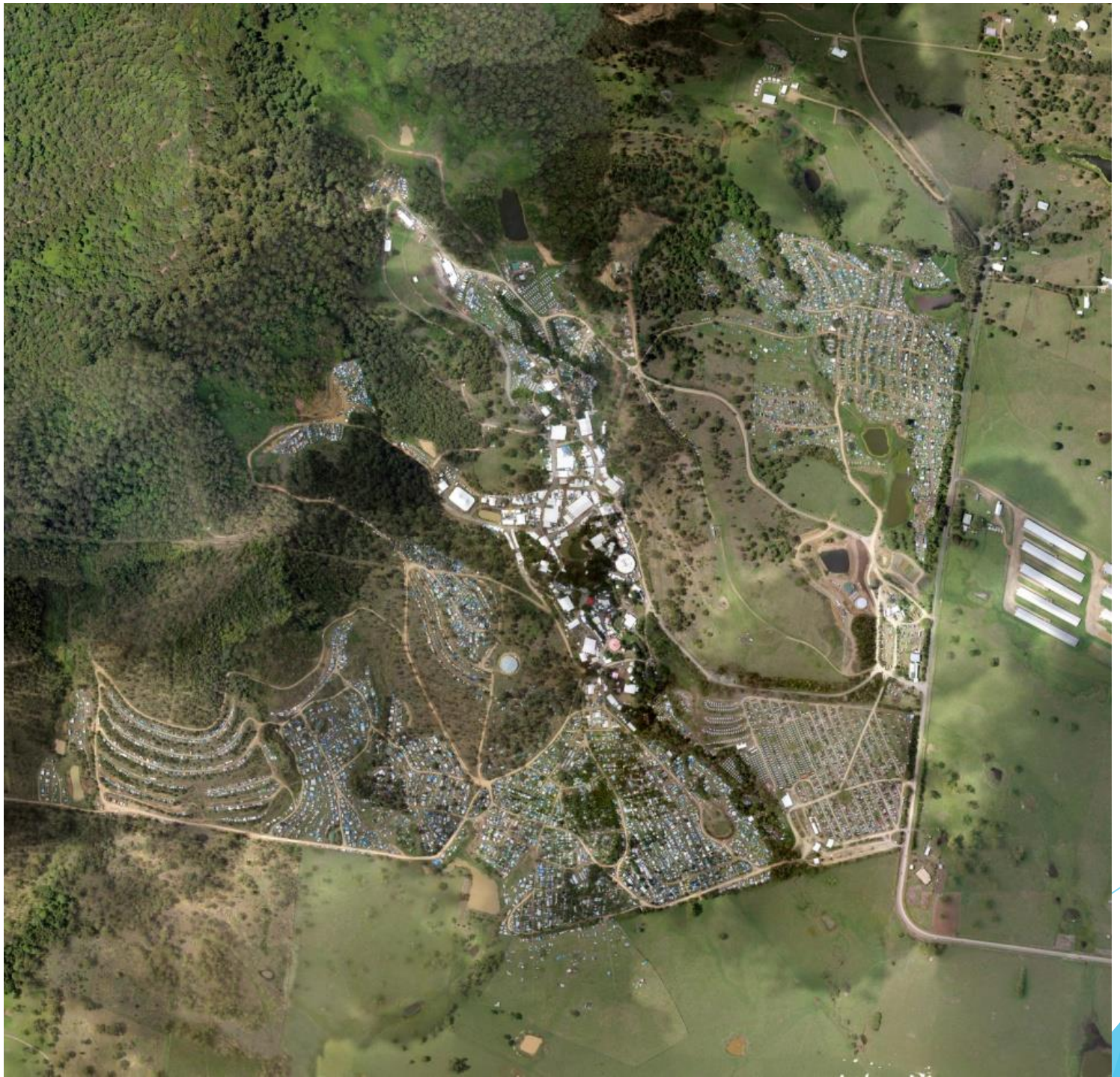
Wastewater Volume kL



Number of Days

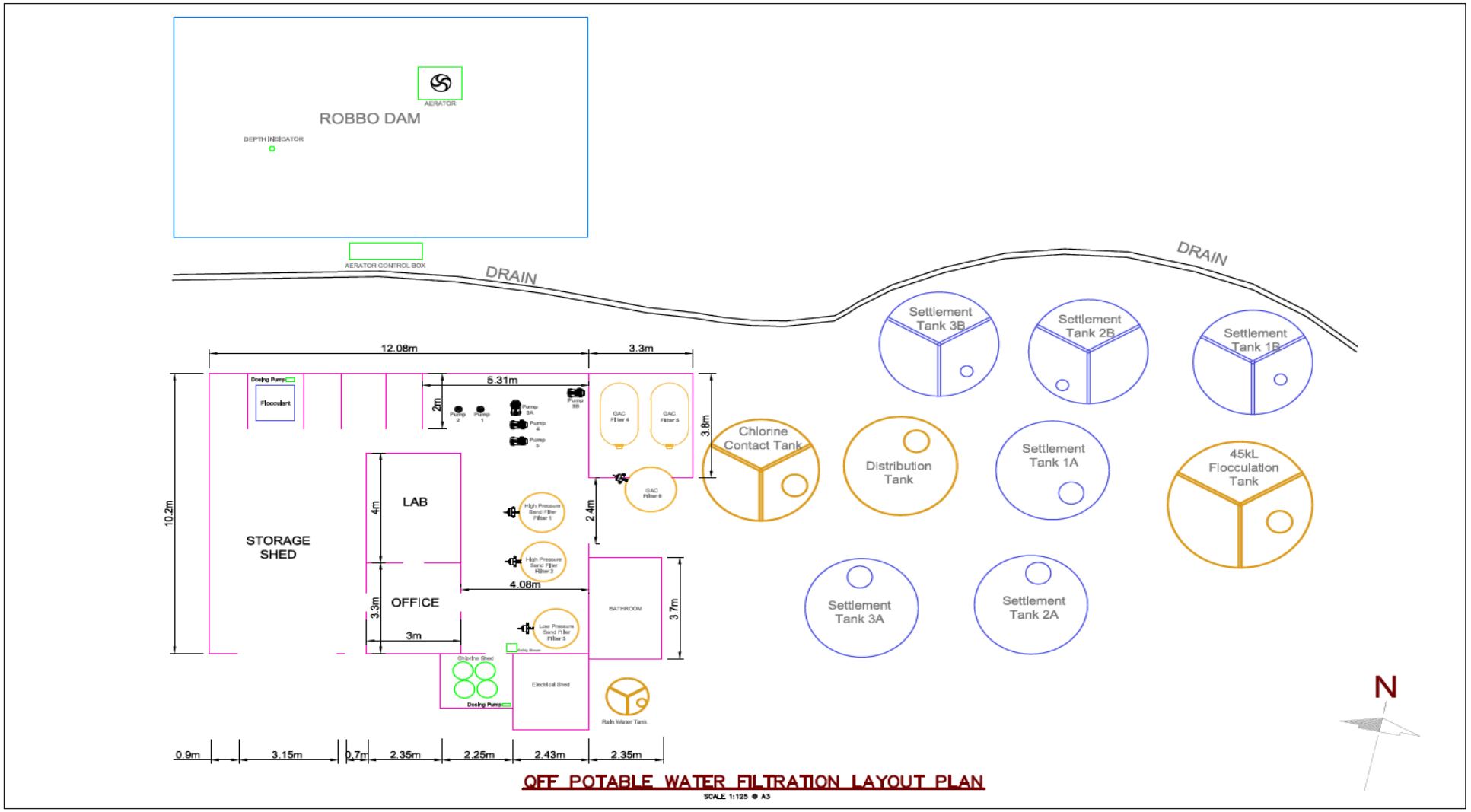



Wright Rd
Pratt Rd
Woodrow Rd
Image © 2010 GeoEye
© 2010 Cnes/Spot Image
© 2010 Whereis® Sensis Pty Ltd
©2010 Google
26°54'28.85" S 152°44'57.80" E elev 308 m
Eye alt 2.62 km



Potable Water

Potable Water Treatment



QFF POTABLE WATER FILTRATION LAYOUT PLAN

SCALE 1:125 @ A3

LEGEND:

- Backwash Line
- Building
- Pond/Dam
- Drain
- Water Line
- Filter
- Water Tank
- Settlement Tank
- Flow Direction
- Basket Filter
- Non-return Valve
- Valve
- Flow Meter

NOTE:

1. Subject to changes
2. All measurements in metres

arris water treatment & technology

AS BUILT ISSUE

REV.	DATE	DESCRIPTION	DRAFT	ENG.	CHKD
0		AS BUILT			

QFF Potable Water Filtration
Arris Water - QFF

A3

DRAWING NUMBER: Job Number 00 | Sheet No. 01 | Rev. 0

Design BK | Drawn AR

Batching Treatment Process

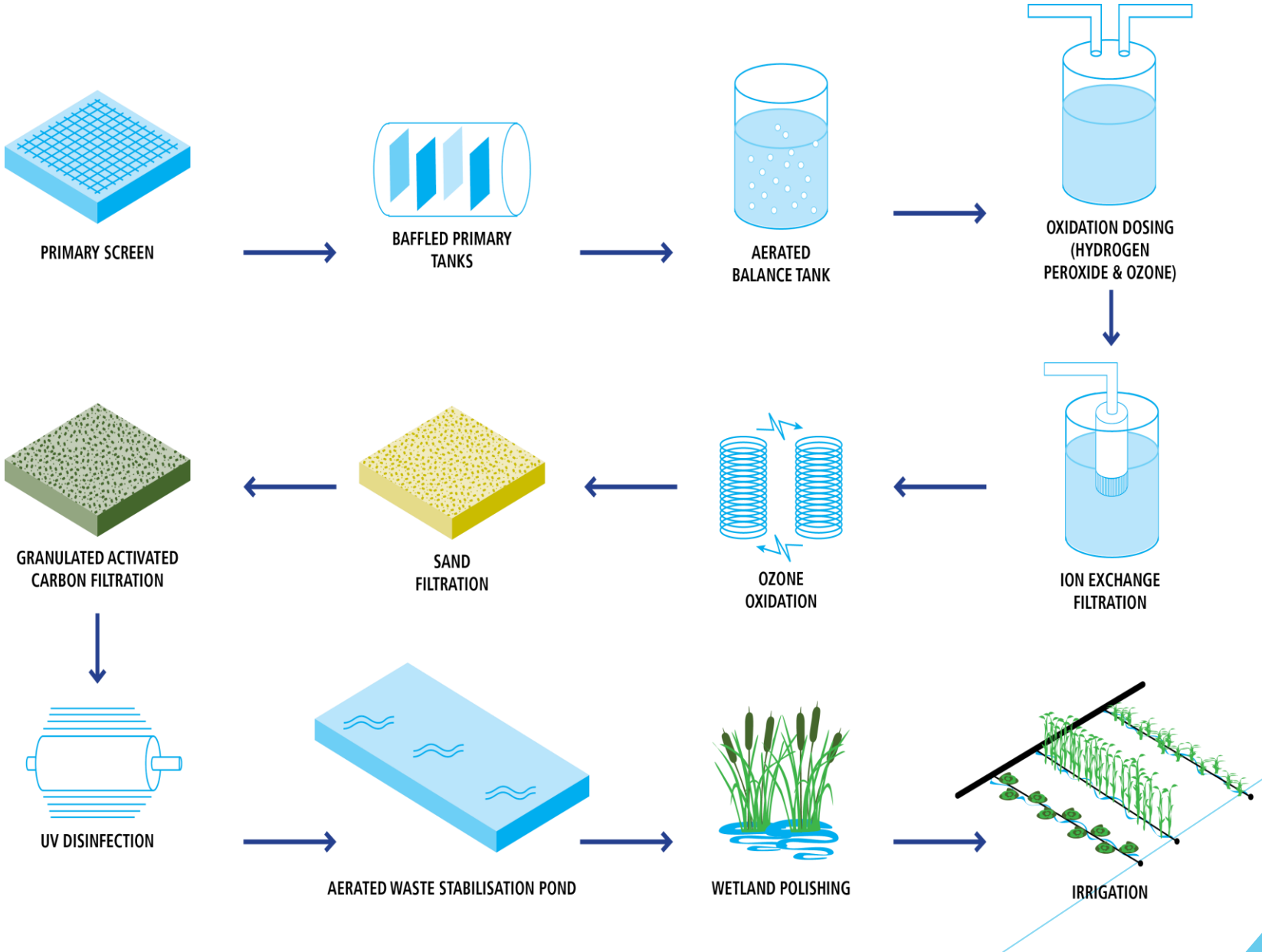
- Beneficial Bacteria of limited use due to the intermittent flow
  - Negates the use of many traditional technologies
  - Still may be beneficial, but can't be relied upon
- Physical separation of solids
- Chemical oxidation via hydrogen peroxide and ozone
- Ion exchange media to reduce certain contaminants of concern
- Adsorption media to adsorb pollutants
- Multiple barrier approach to disinfection
- Aeration to prevent anaerobic odors
- Sufficient Balance Tank Capacity & Treated Water Storage
- Must meet regulatory limits for treated water
- 100% water recycling on-site

Regulatory Process

- Bespoke treatment plant design approved by the State Government
- Design incorporated into a Site Based Management Plan
  - Water volumes, Treated Water Quality, Maintenance Plan, & Irrigation Design
  - Risk Assessment
- Licence granted by the State Government
  - Annual licence fee
    - $24 000 per annum
    - Based on the daily treatment capacity of the STP
  - Testing of the treated water quality for each event
  - Groundwater testing under the aquifers
  - Testing of the soils in the irrigation area (sodicity impacts)
  - Annual report
    - Water volumes
    - Water quality tests
  - Audit visits approximately once every 5 years

Woodfordia STP

Treatment Chain

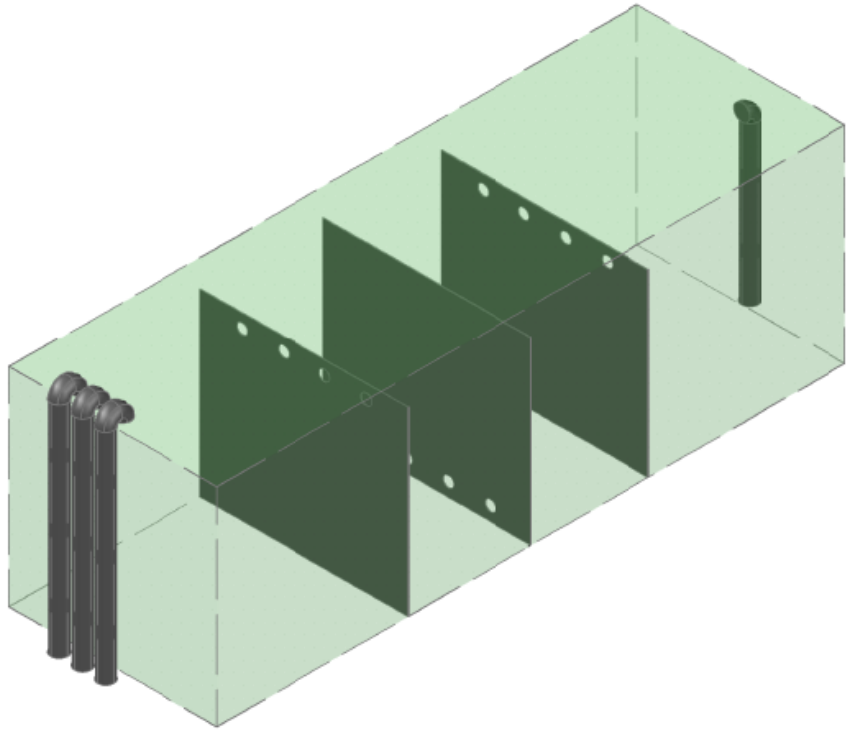


Primary Screen

- Retro-fit to the treatment chain
- Minimise the impact of wet wipes
- Reduce the hydraulic surge from pump-out trucks delivering to the STP
  - Approximately 1.3 Megalitres
  - High Sludge Content
- Modified 40 foot shipping container
- 2 sets of screens
- Elevated outlet
- Controlled dispersal

Primary Treatment Tanks

- Pump stations deliver directly to these tanks
- 4 tanks with a combined capacity of 600 kL
  - Additional capacity would be beneficial
  - Minimal beneficial bacteria treatment
- Tanks are baffled to aid sludge deposition
- Tanks were originally the holding tanks at the site
- Must be desludged yearly
- Steel tanks so corrosion control is important



Odor Control

- Prevailing wind blows across the STP into the Festival Precinct
- All tanks must have odor control vents
- No uncovered tanks
- Hydrogen Peroxide & Ozone also assist with odor control

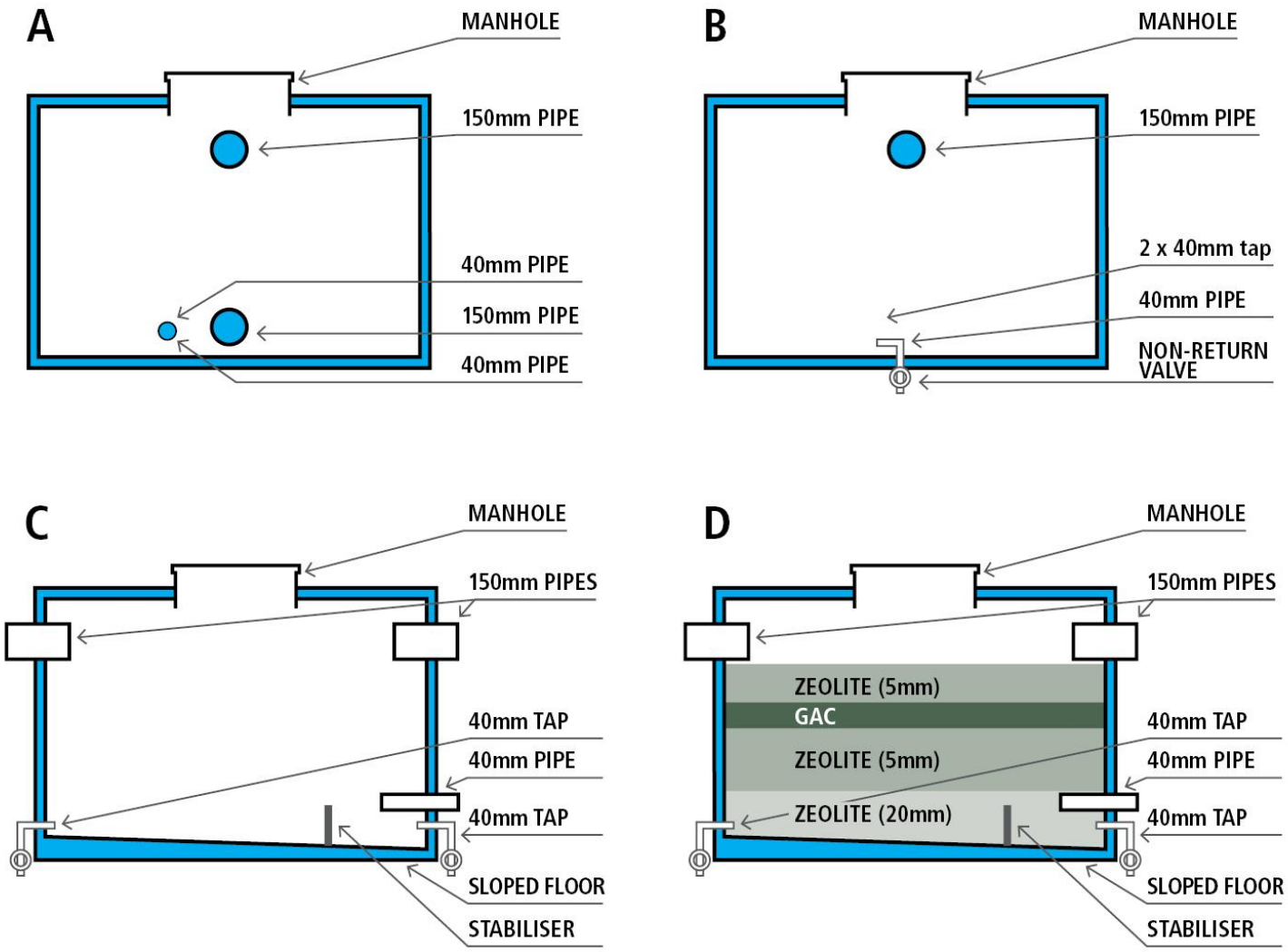
Aerated Balance Tank

- 1.5 MegaLitre Capacity
  - 1.3 ML Active Volume
- Panel tank with liner
- Gravity-fed from Primary Tanks
- Aeration
  - Compressed Air & Diffusion Discs
- Odor Control units on vents
- Corrosion Control Important
- Requires desludging every 2 years

Hydrogen Peroxide Dosing & Ion Exchange

- Hydrogen Peroxide
  - Chemical oxidation
  - BOD/COD reduction
  - Disinfection
  - Odor & Color Control
- Ion Exchange & Adsorption
  - Sodium Adsorption Ratio reduction via IEX
  - Nitrogen reduction via IEX
  - Metal reduction via IEX
  - Phosphorus reduction via adsorption
  - Physical filtration
  - Minimum 20 minutes contact time
  - Requires regeneration
    - Starvation cycle

Ion Exchange and Adsorption



Ion Exchange: SAR reduction

Sample/Analysis	Na mg/L	K mg/L	Mg mg/L	Ca mg/L	SAR	EC µS/cm	pH
Untreated Average	74.3	17.4	2.1	4.5	7.3	993	7.5
Pump-well 1	72.5	14.3	1.8	3.2	8	1001	7.7
Zeolite filter 1	33.6	2.3	6.5	20.5	1.7	465	7.4
Zeolite filter 2	29.6	1.9	5.9	17.6	1.6	510	7.3
Zeolite filter 3	36.0	2.3	8.2	21.1	1.7	515	7.4
Zeolite filter 4	24.9	4.6	7.2	19.7	1.2	423	7.4
Zeolite filter 5	38.1	1.2	7.1	20	1.9	403	7.2
Zeolite filter 6	31.2	1.5	7.1	21.5	1.5	469	7.3
Average Zeolite Filter	32.2	2.3	7.0	20.1	1.6	464	7.33
Zeolite Standard Deviation	4.7	1.2	0.8	1.9	0.2	45	0.1
Pump-well 2	32	1.9	7.5	20	1.5	487	7.4

Ozonation

Ozonation

- Retro-fit to System
- Aim is to reduce consumption of hydrogen peroxide
- Modern Ozone systems produce ozone from the atmosphere
- Reduces the delivery of dangerous goods to site
- Able to increase/decrease ozonation rate in real time in relation to the water quality
- Additional disinfection barrier
- Reduces color and odors
- Reduces backwashes of sand and carbon filters

Sand & Granulated Activated Carbon Filtration

- Sand is physical filtration
- Pre-treatment for UV disinfection
- Backwash returns to Balance Tank
- Granulated Activated Carbon (GAC)
  - Adsorption media
  - Pharmaceuticals and personal care products
  - Colors & odor reductions
- Minimum of 15 minutes contact time
- Requires replacement every 5 years
  - Starvation cycle

Ultraviolet Disinfection

- Final Disinfection Technology
  - Water has lowest turbidity at this point
- Effective against bacteria, viruses, and protozoa
- Maintenance more frequent as equipment is dry for the majority of the year

Waste Stabilisation Pond

- 14 MegaLitre Capacity
- Compacted Clay Liner
- Beneficial Microorganisms
- Bunded against stormwater intrusion
- Aerated:
  - Compressed Air & Diffusers
  - Floating Aerator
- Water can be sent to:
  - Wetlands
  - Irrigation
- Good Biodiversity

Aeration: Waste Stabilisation Pond

Constructed Wetland

- 2 constructed wetlands installed
- One deep and one variable depth
- Typically receives ‘new’ water 4 times a year
- No release
- Combined capacity of 3 Megalitres
  - Additional storage
- Biodiversity changing overtime
- Enables water polishing
- Maintenance part of training program

Treated Water Quality Requirement

Parameter	Units	Limit/Guideline	Monitoring Freq.
Fecal Coliforms	cfu/500 ml	<1000	**Monthly**
Virus and/or Protozoa	log reduction	5 log reduction	**Yearly**
Biological Oxygen Demand	mg/L	<10	**Monthly**
Total Nitrogen	mg/L	<10	**Monthly**
Ammonia	mg/L	<1	**Monthly**
Total Phosphorus	mg/L	<10	**Monthly**
Total Suspended Solids	mg/L	<30	**Monthly**
Electrical conductivity	µS/cm	<1000	**Monthly**
Sodium Absorption Ratio		<6	**Monthly**
pH		6-8.5	**Continuous**
Turbidity	NTU	<5	**Continuous**

pH Results

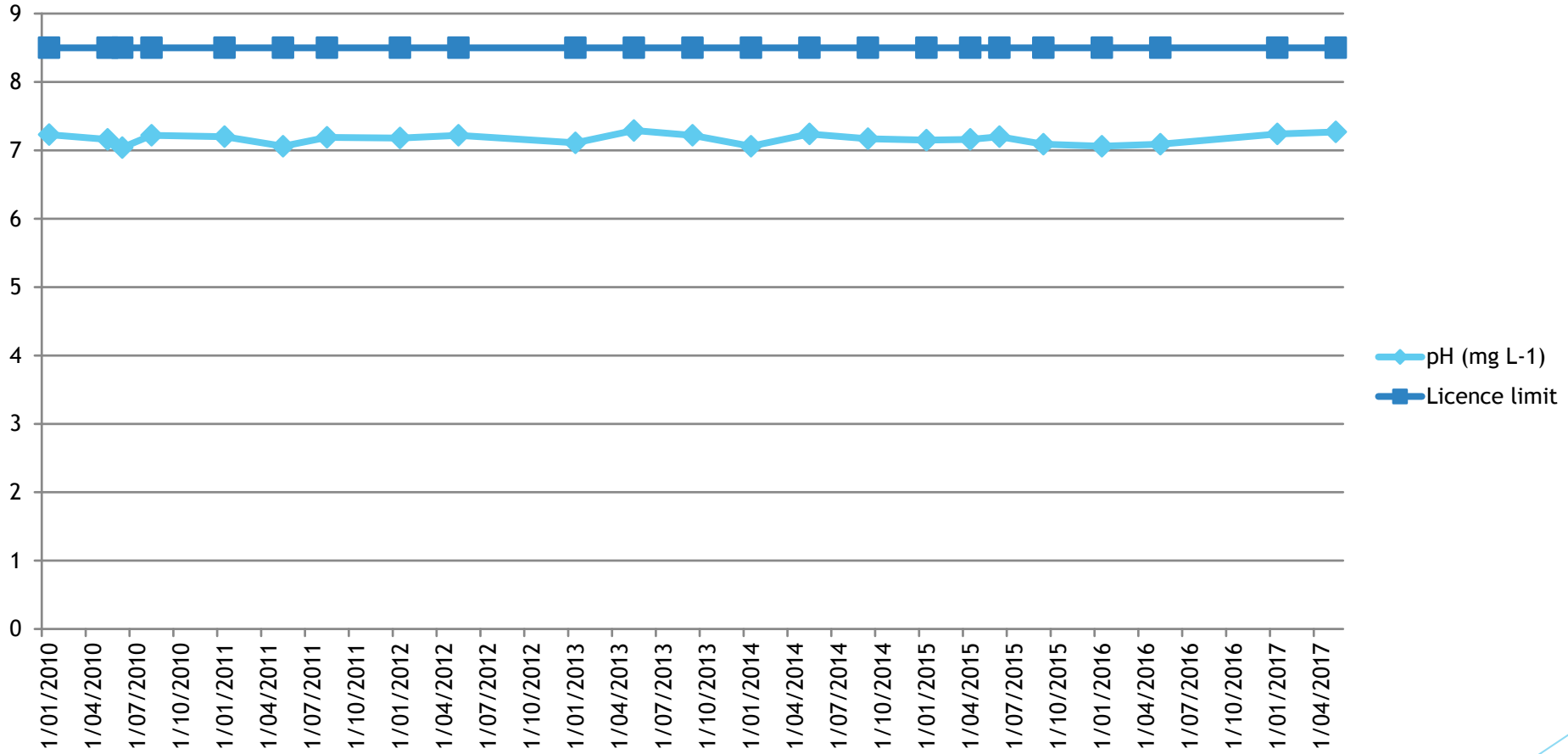


Figure: pH results of Woodfordia STP Treated Water

Fecal Coliforms

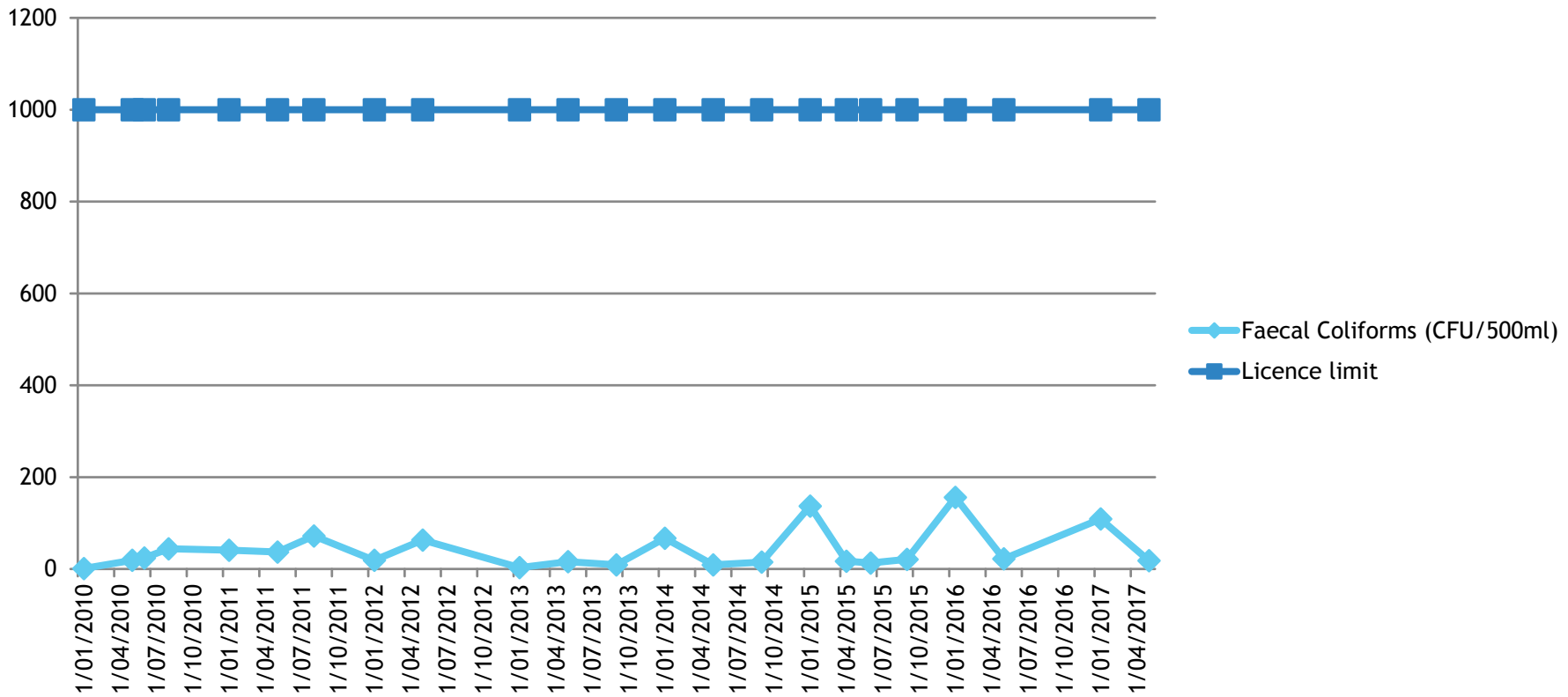


Figure: Fecal Coliform results of Woodfordia STP Treated Water

Total Nitrogen

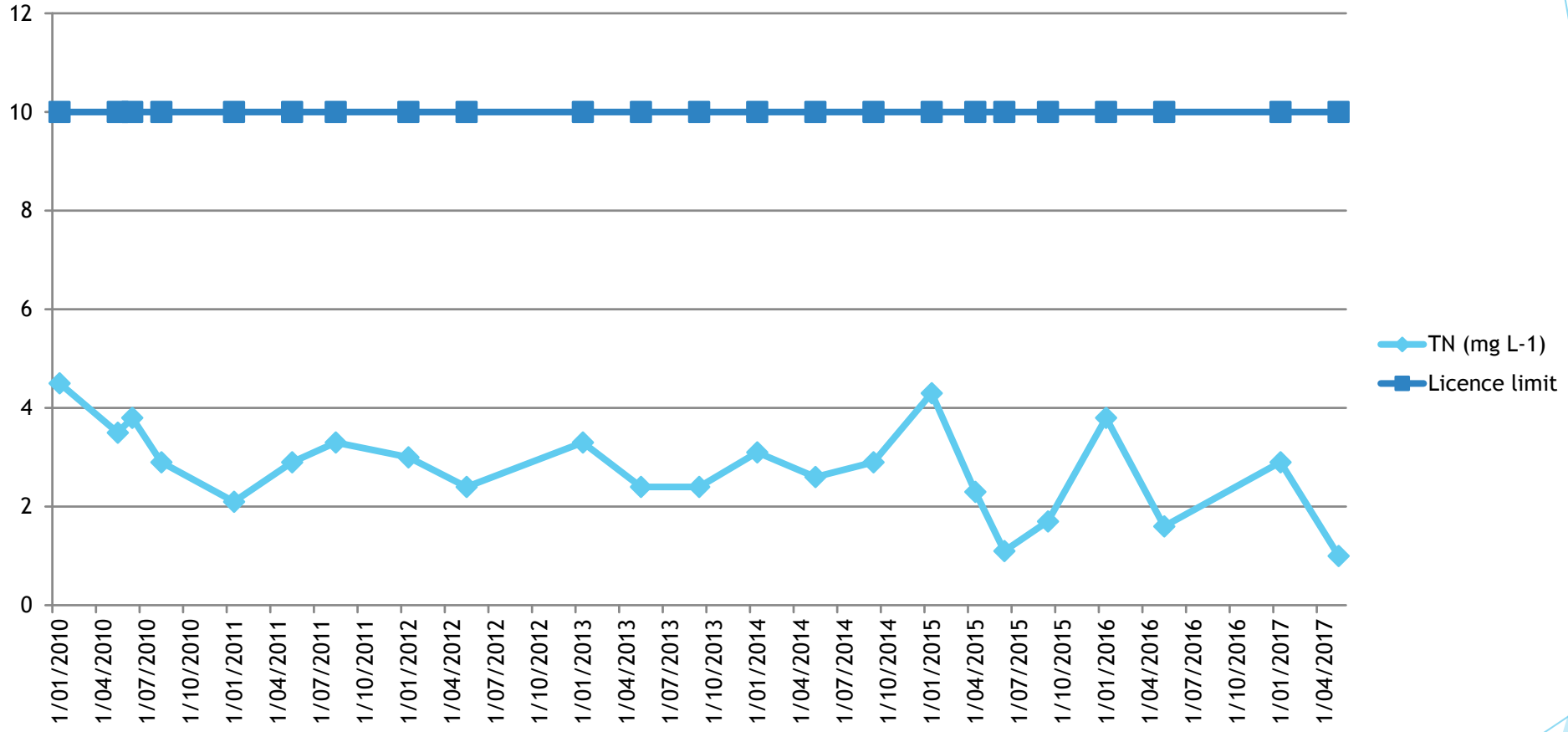


Figure: Total Nitrogen results of Woodfordia STP Treated Water

Total Phosphorus

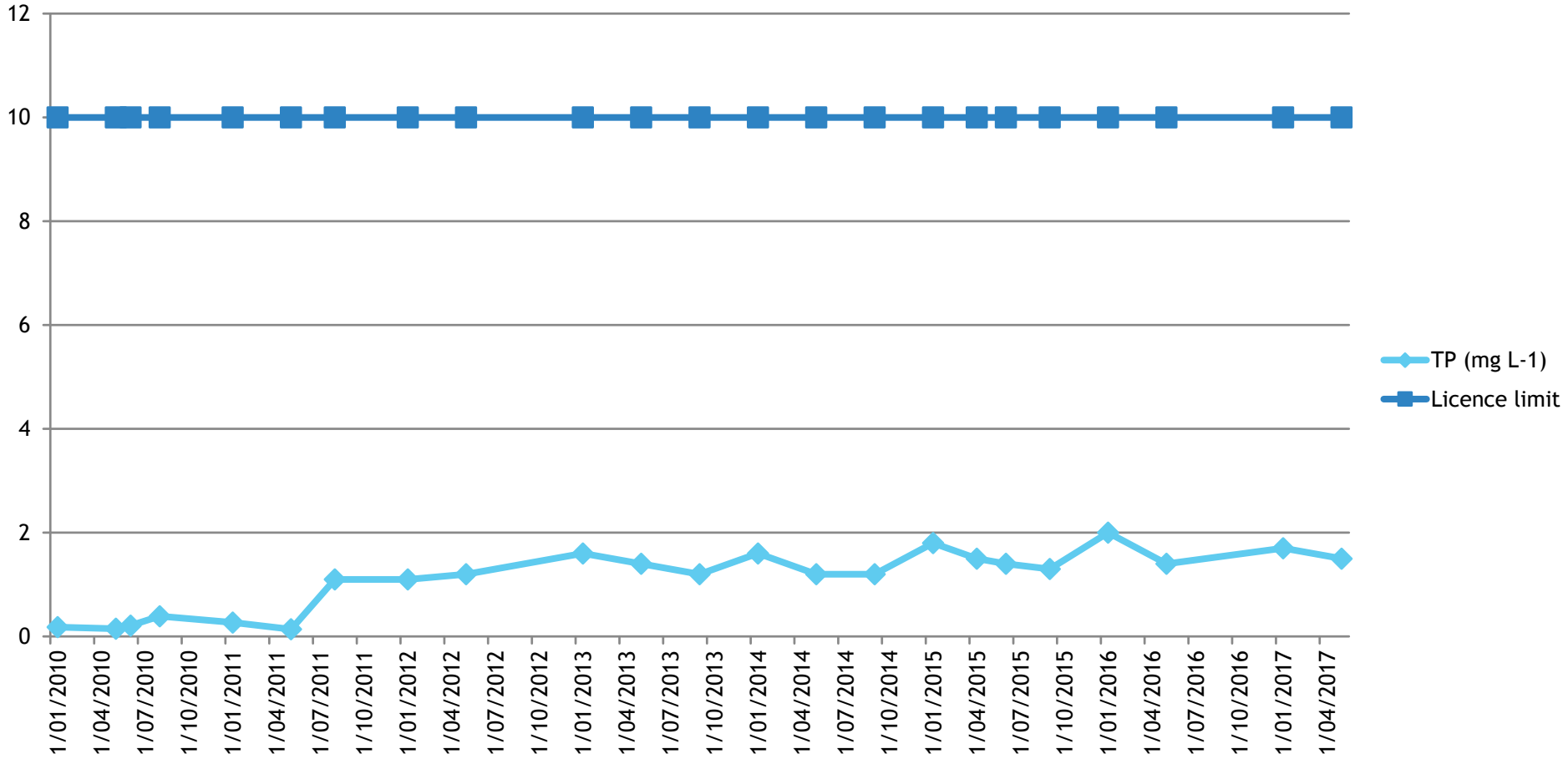


Figure: Total Phosphorus results of Woodfordia STP Treated Water

BOD^5 Results

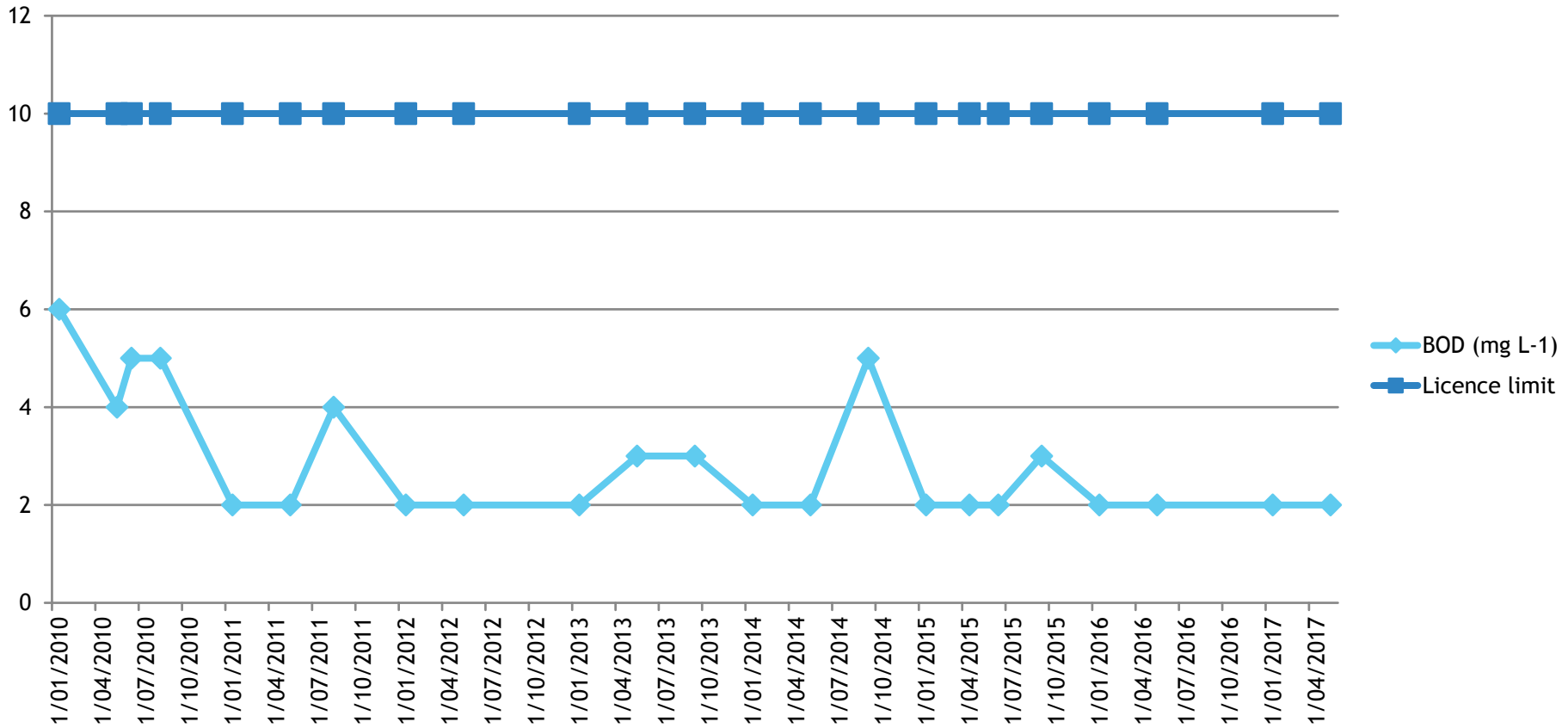


Figure: BOD^5 results of Woodfordia STP Treated Water

Turbidity

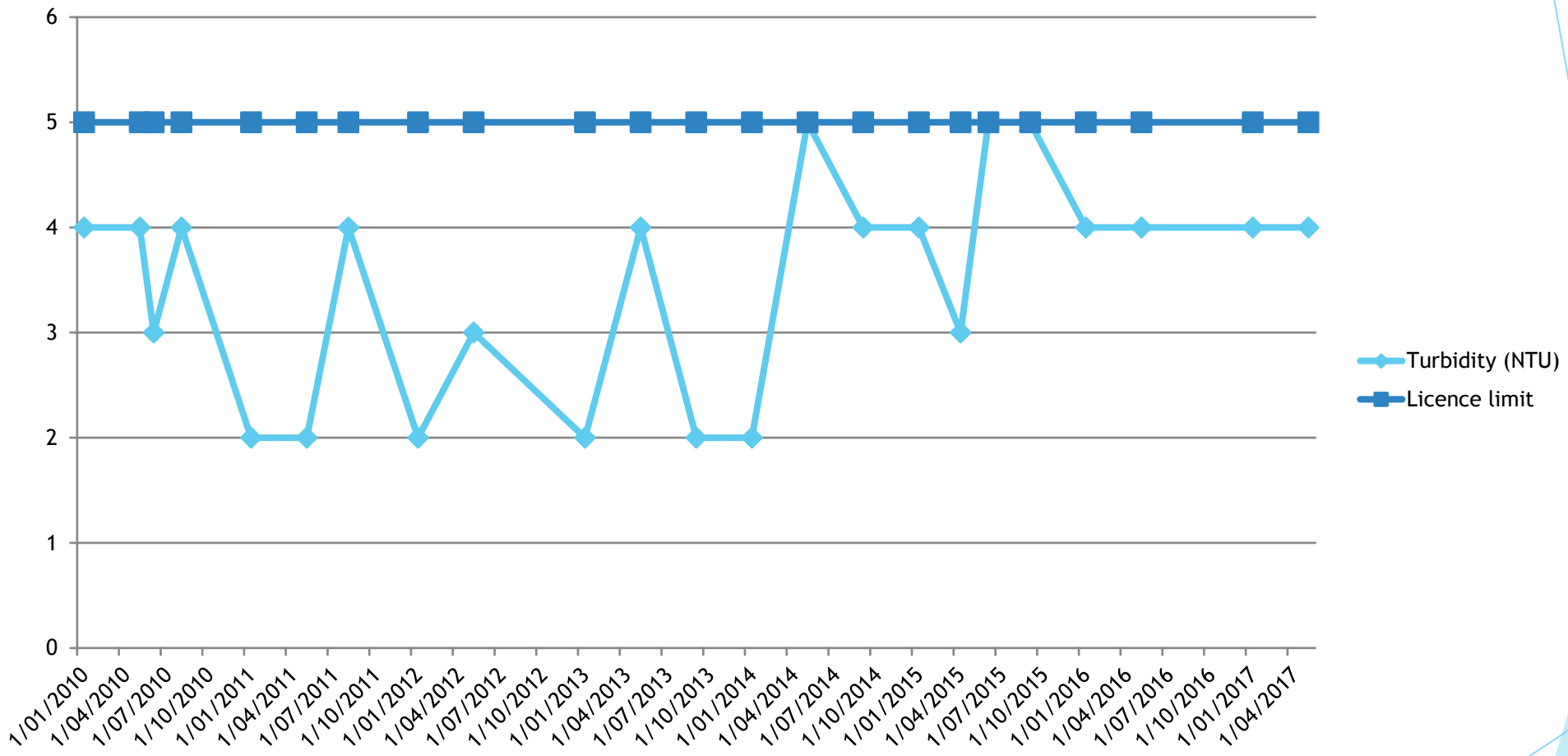


Figure: Turbidity results of Woodfordia STP Treated Water

Electrical Conductivity

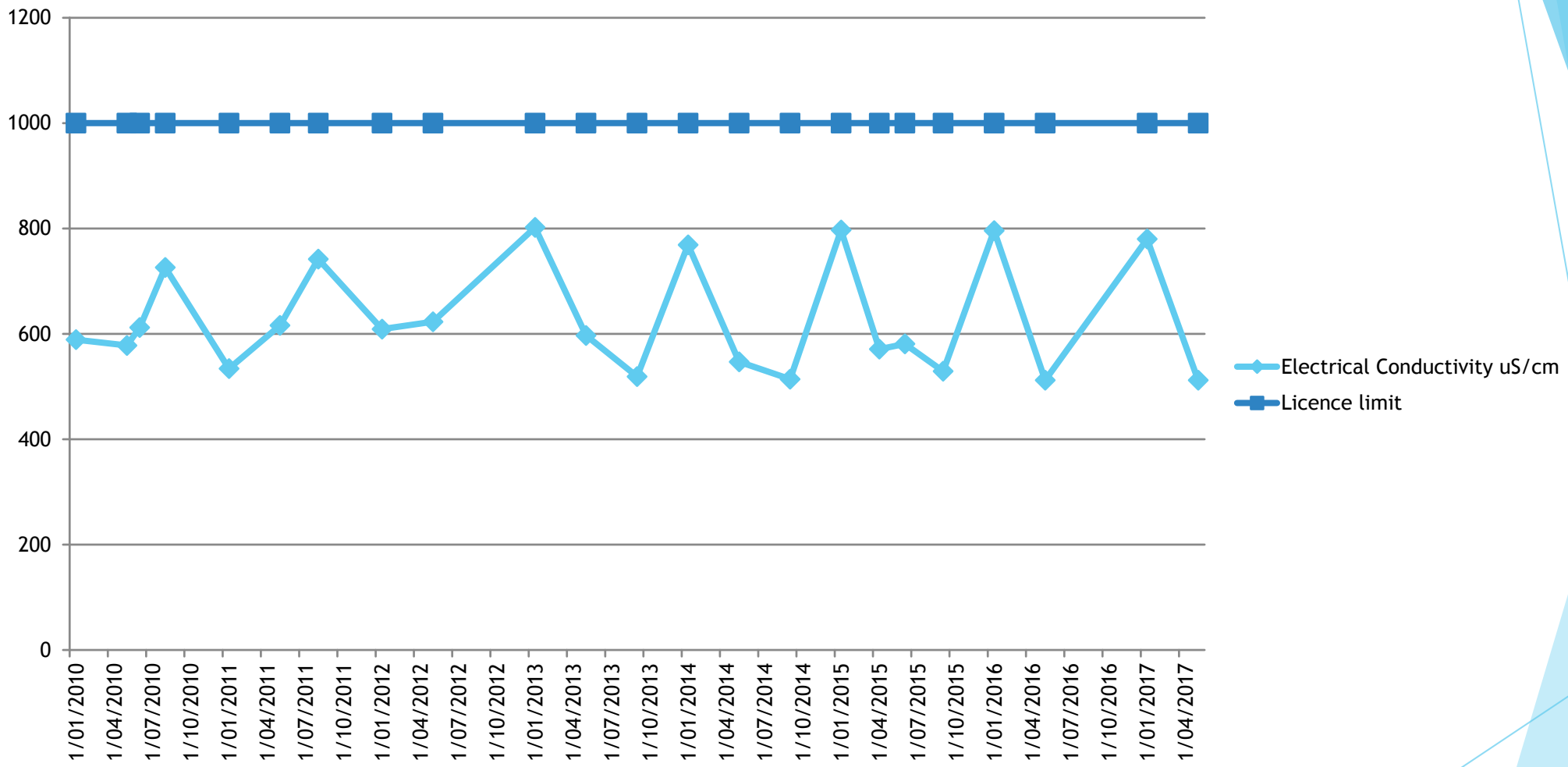


Figure: Electrical Conductivity Results of Woodfordia STP Treated Water

Sodium Adsorption Ratio (SAR)

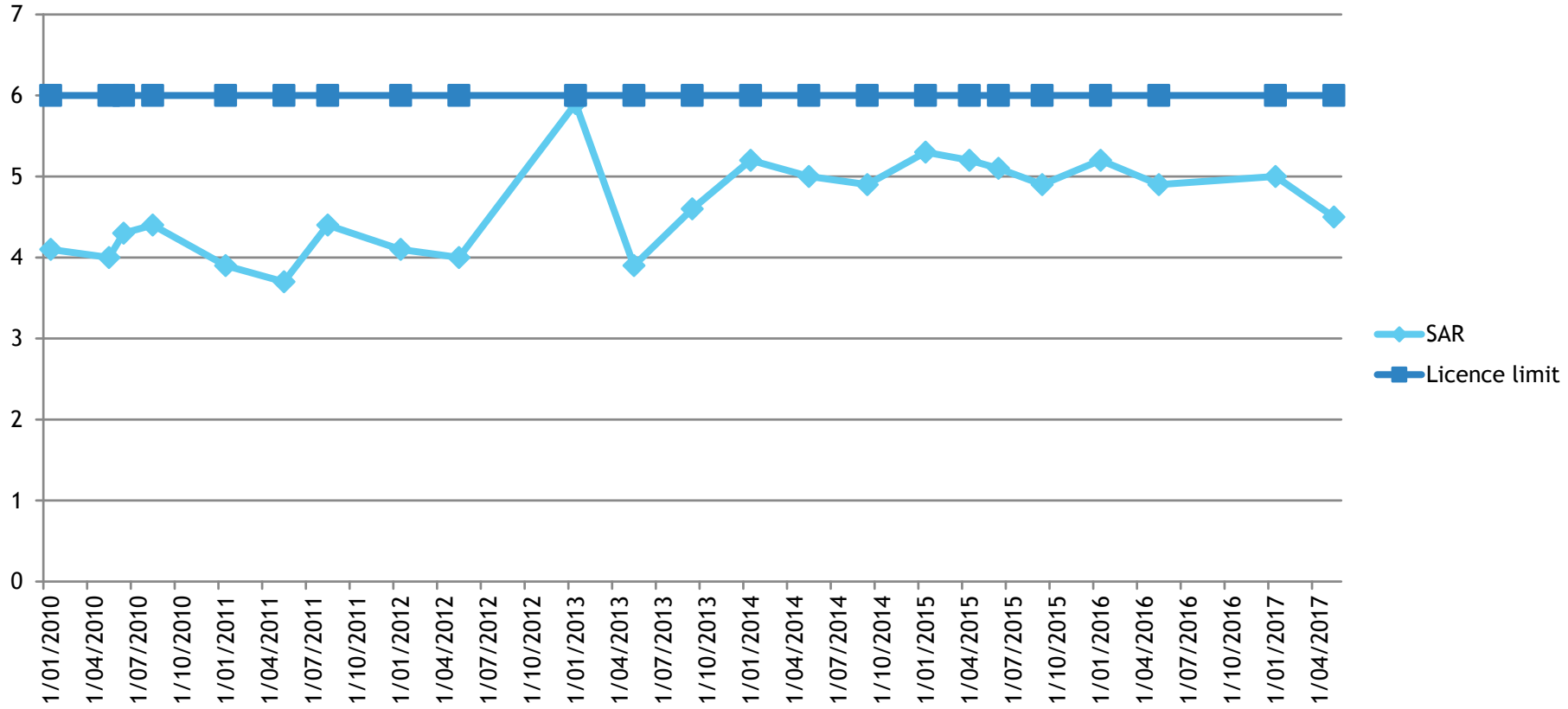
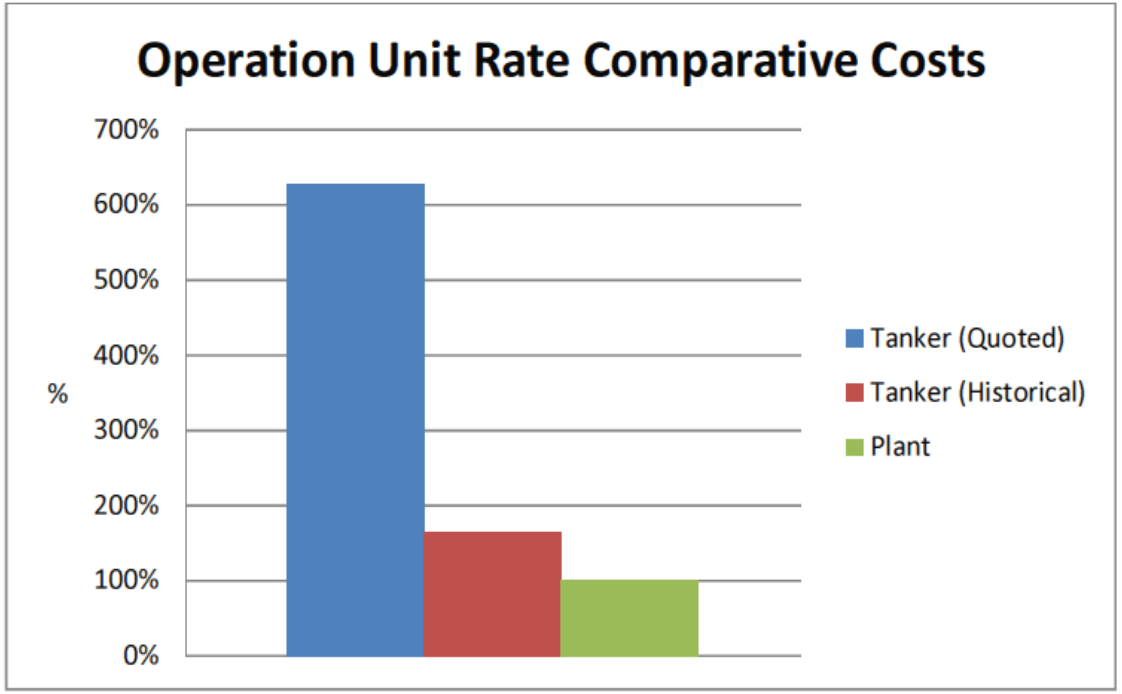


Figure: SAR results of Woodfordia STP Treated Water

Operational Cost

- STP paid its capital construction cost back within 2 years
- Pump-out costs dramatically increased:
  - Higher cost for trucking
  - Receiving facilities significantly increased their charges
- Operational costs have been kept low
- Happy Client ☺



General Maintenance

- No such things as maintenance ‘free’
- Sludge management
- Pump servicing
- Corrosion Control
- Media regeneration and replacement
- Compressor Servicing
- Wetland weeding
- Plumbing repairs
- Woodford Folk Festival occurs between Christmas and New Years
  - Most suppliers are shut
  - Spares and fabrication equipment needs to be kept on-site

Sludge Management

- All tanks and pump stations are regularly desludged
- Sludge is dewatered on-site via tube
- Wastewater on-site has a high percentage of blackwater
  - No laundry wastewater
  - Water efficient amenities
- Time between festival events also the sludge bags to dry
- Bags last approximately 3 years
- Sludge is composted and used as a soil amendment

Sludge Management

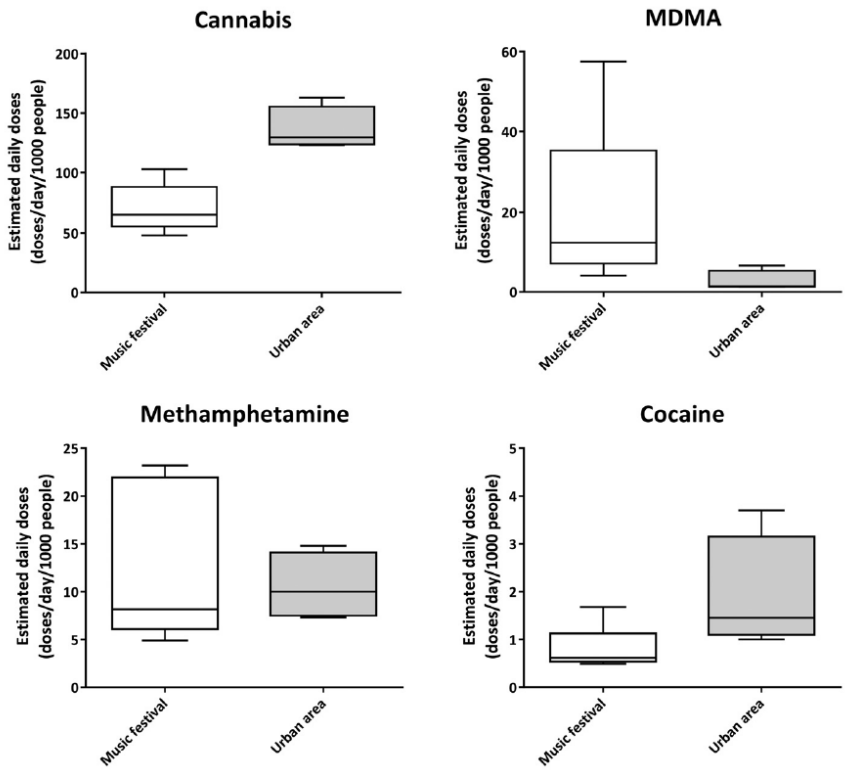
Research & Education

- Frequently run tours for interested Festival patrons
- Run training programs such as Wetland Maintenance
- Post-Graduate Student Research Programs
  - Zeolite and Scoria Ion Exchange — Central Queensland University
  - Oxidation of Recycled Irrigation Water — Central Queensland University
  - Engineering Festival Events — University of the Sunshine Coast
  - Pharmaceuticals in Wastewater — University of Queensland
- Research programs conducted by Arris
  - Ozone applications
  - Energy efficiency
- Woodfordia Inc encourages research at the site

STP Tours: Education

Pharmaceutical Research

- Conducted by Dr Jake O'Brien as part of his PhD research program
- 1st approved site for his research
- Chemical analysis of inflow water to the STP
  - Controlled site with no hospital/medical clinic/veterinary input
  - Demographics of patrons available from ticket sales data
- Looked at legal and illicit drugs
- Legal
  - Blood pressure medication, Prozac and Viagra
- Illicit
  - Lower than comparison centralised wastewater treatment facilities except for slightly elevated ecstasy consumption
- Very important research in Australia
- Census of centralized wastewater treatment plants now conducted



Comparison between the estimated doses (doses/day/1000 people) of the conventional illicit drugs consumed at the Woodford Folk Festival in 2010 and 2011 compared to a nearby urban area using wastewater analysis. The research was published by Lai et al 2013 in Drug and Alcohol Review

Bamboo Research

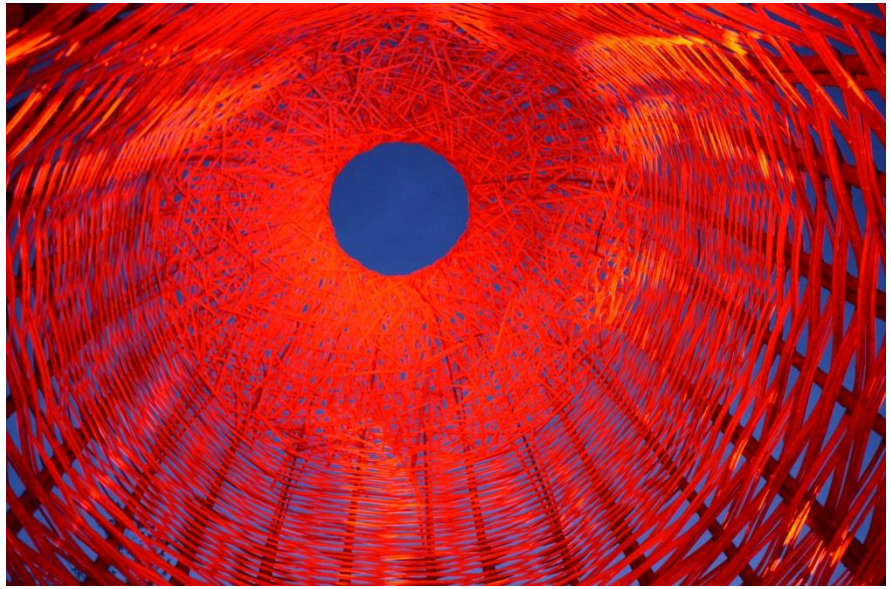
- Bamboo plantation being grown with recycled water treated by the Woodfordia STP
- Plantation aims to use 100% of the treated water
  - Excluding the water required to keep the constructed wetland alive
- Regulatory authorities approve as it minimizes the risk of off-site impacts
- Around 60 tonnes of bamboo poles are used on the site each years
  - Sculptures
  - Fencing
- Waste bamboo material used to produce biochar
- Research being conducted on the oxidation of the recycled water
  - Using Hydrogen Peroxide and Ozone
  - Prevention of biofouling in the dripper lines
  - Improved oxygen concentration in recycled water
- Aim of the project is to encourage irrigation water recycling from other larger decentralized STP's

Bamboo Irrigation Research

Bamboo Irrigation Research

Bamboo Plantation

Bamboo Sculptures



Woodfordia is a Great Site

Woodfordia is a Great Site

Woodfordia is a Great Site

Conclusion

- Woodfordia Batching Treatment Plant has been sustainable for a decade
- The required water quality has been achieved
- The STP has economic sustainability in regards to capital and operational costs
- Maintenance of the system is practical and achievable
- 100% of the Treated Water is recycled
- Research from the site has had extensive community benefit
- Decentralised Water Systems can be Successful at Festival Sites