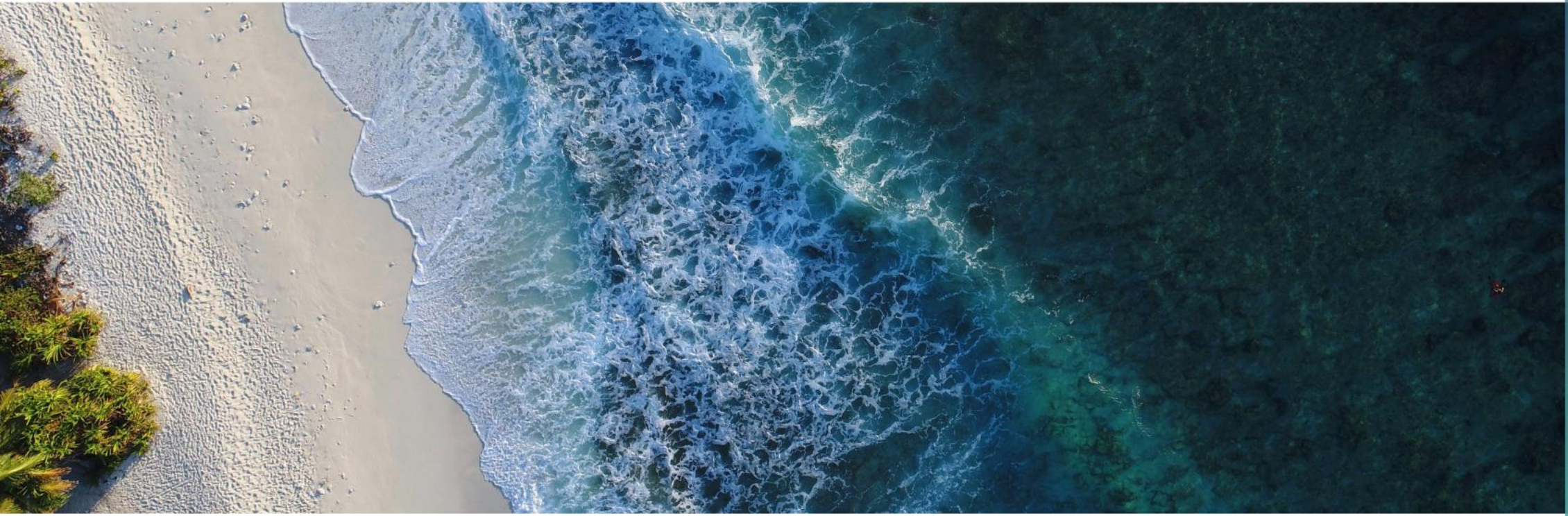
Five years of performance monitoring for a high flow biofiltration system at Western Sydney, NSW

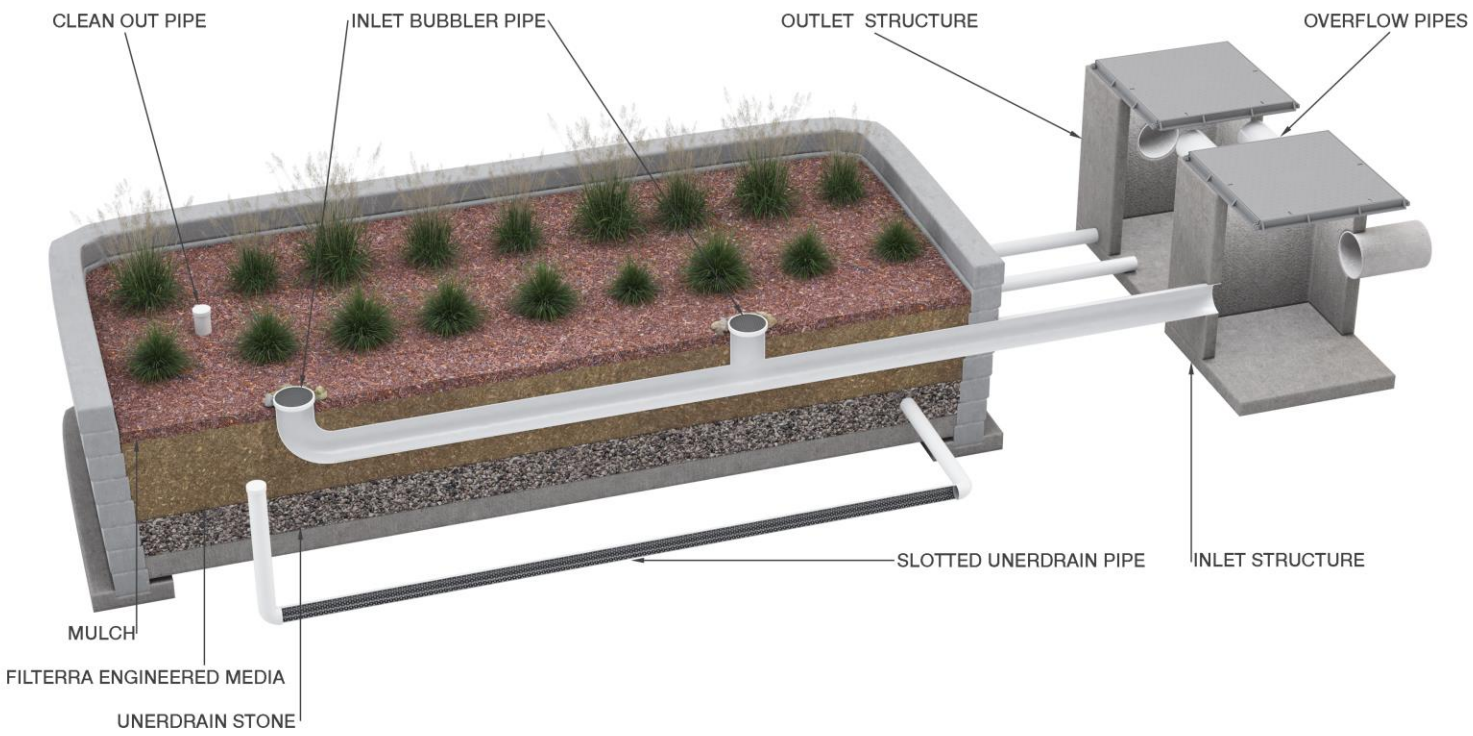
Ocean Protect webinar by Brad Dalrymple

3rd August 2023



What is Filterra ?

- Just like ‘conventional’ bio, but smaller (& better)



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Application

- Just like ‘conventional’ bio

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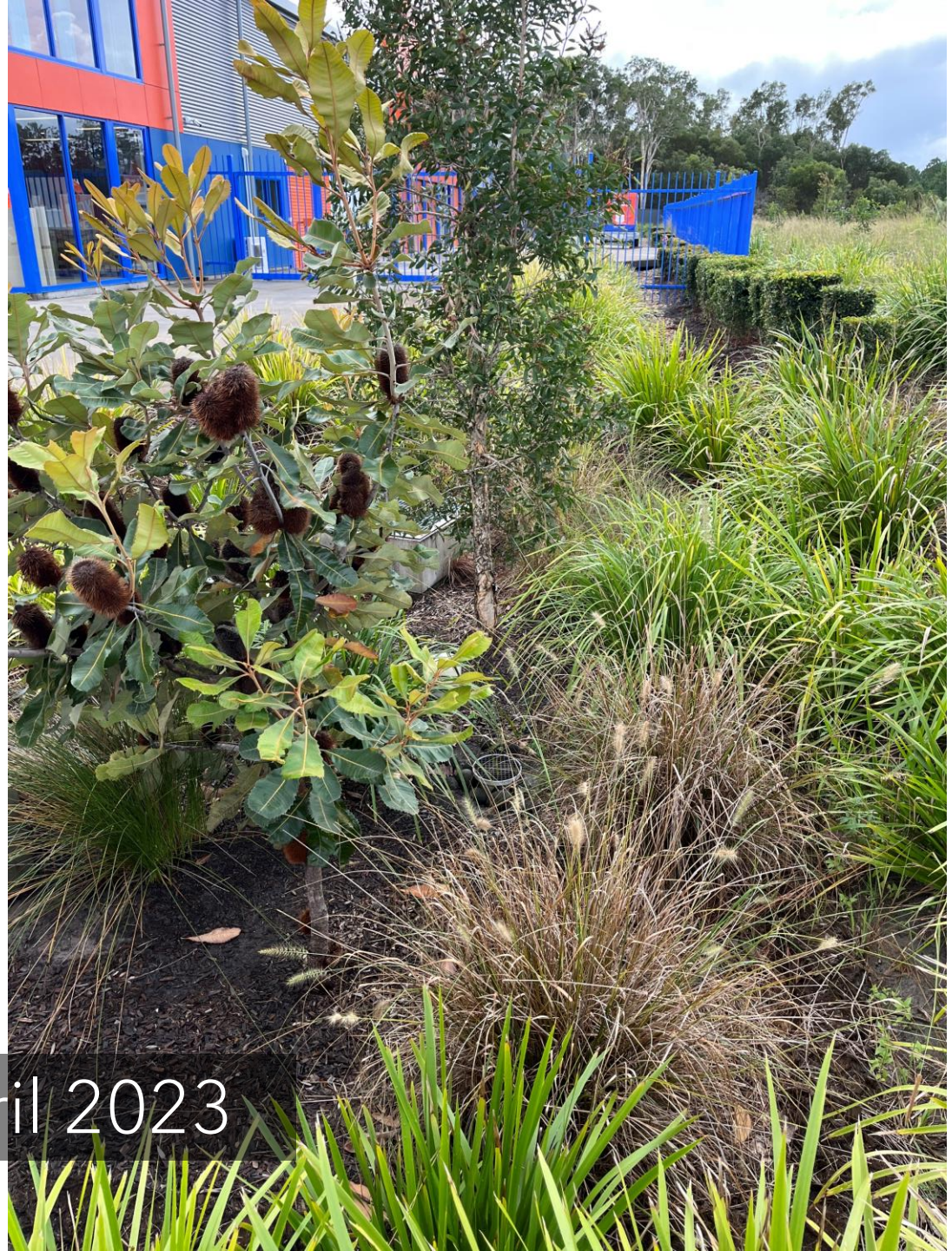
Warwick Farm, NSW – 17 May 2023

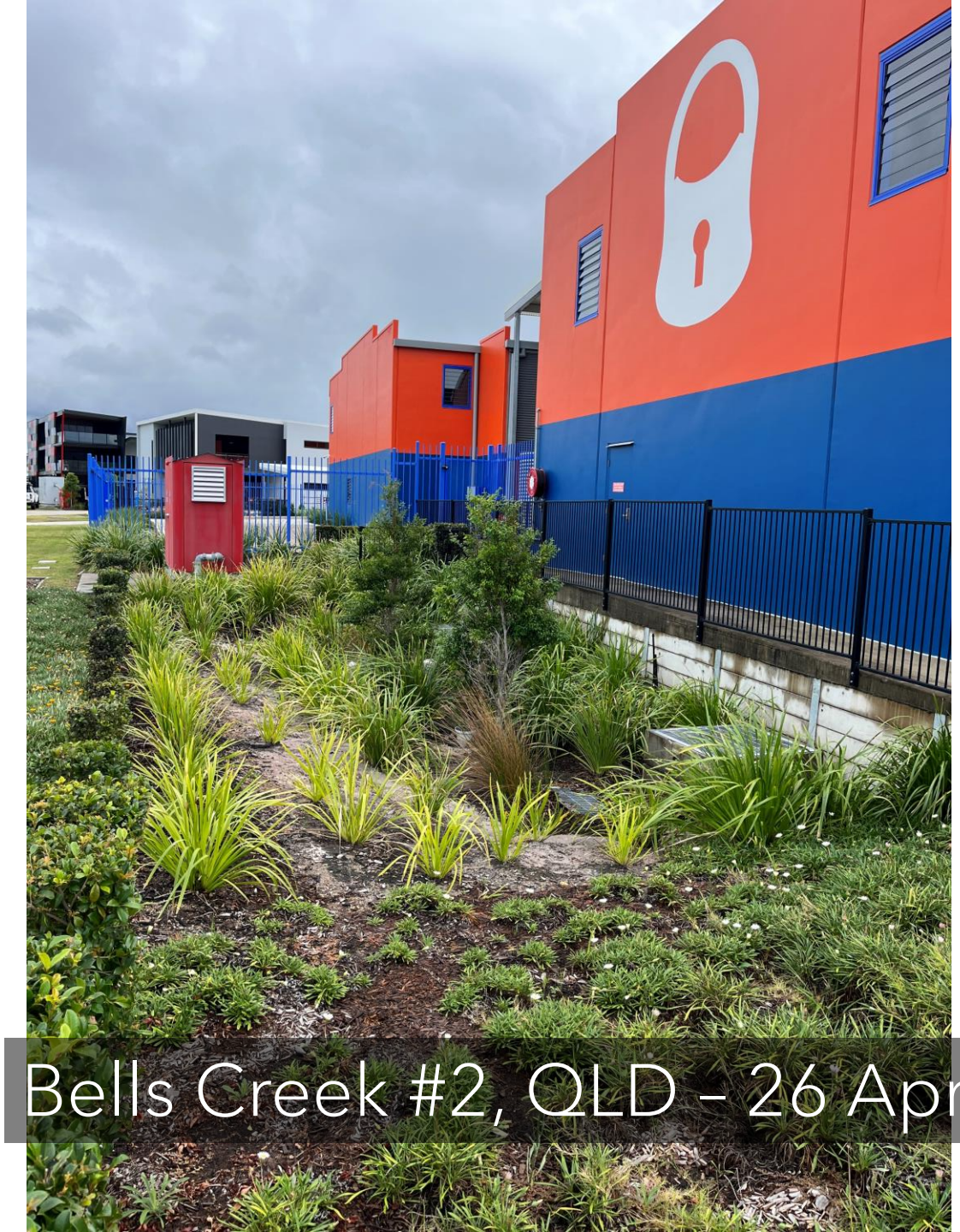

Warwick Farm, NSW – 17 May 2023


Silverdale, NSW – 17 May 2023


Silverdale, NSW – 17 May 2023



Bells Creek #1, QLD – 26 April 2023



Bells Creek #2, QLD – 26 April 2023

Conventional bioretention
Keeley Park, VIC – 10 December 2020

Filterra bioretention
Keeley Park, VIC – 3 April 2023

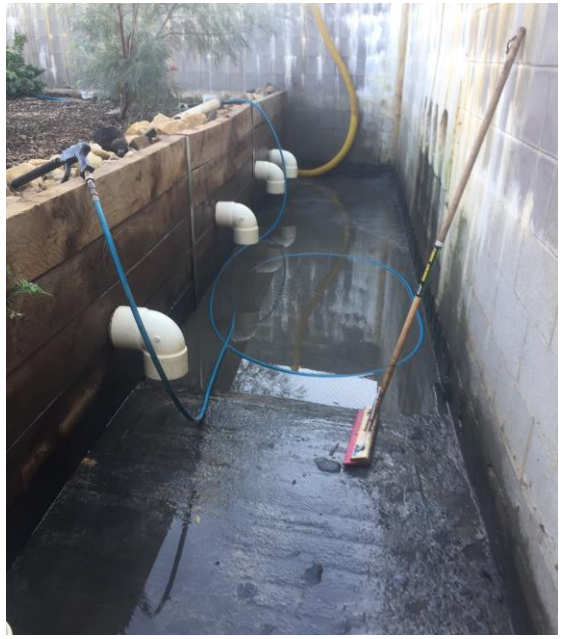

Ingleburn, NSW – 17 May 2023

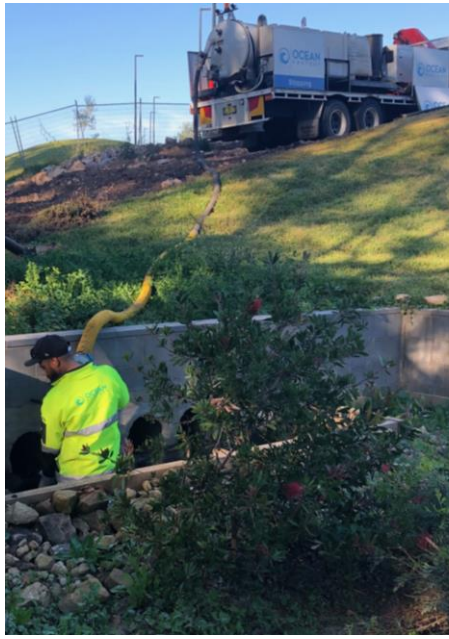

New Norfolk, TAS – 22 June 2022


New Norfolk, TAS – 22 June 2022

Maintenance

- As per conventional bio **and** replace mulch every 6-18 months
- Easy access
- No specialized equipment needed
- Sediment forebay clean-out (for bioscapes)





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Case studies

- >100 installed in Australia
- >9000 installed in USA

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The study

Methodology

Site selection

- Started with twelve (12) sites
- Each site assessed (e.g. hydraulics, equipment suitability)
- Manually sampled six (6) sites for water quality
- Two (2) sites passed for water quality parameters
- One (1) site selected for ease of location despite higher capital cost

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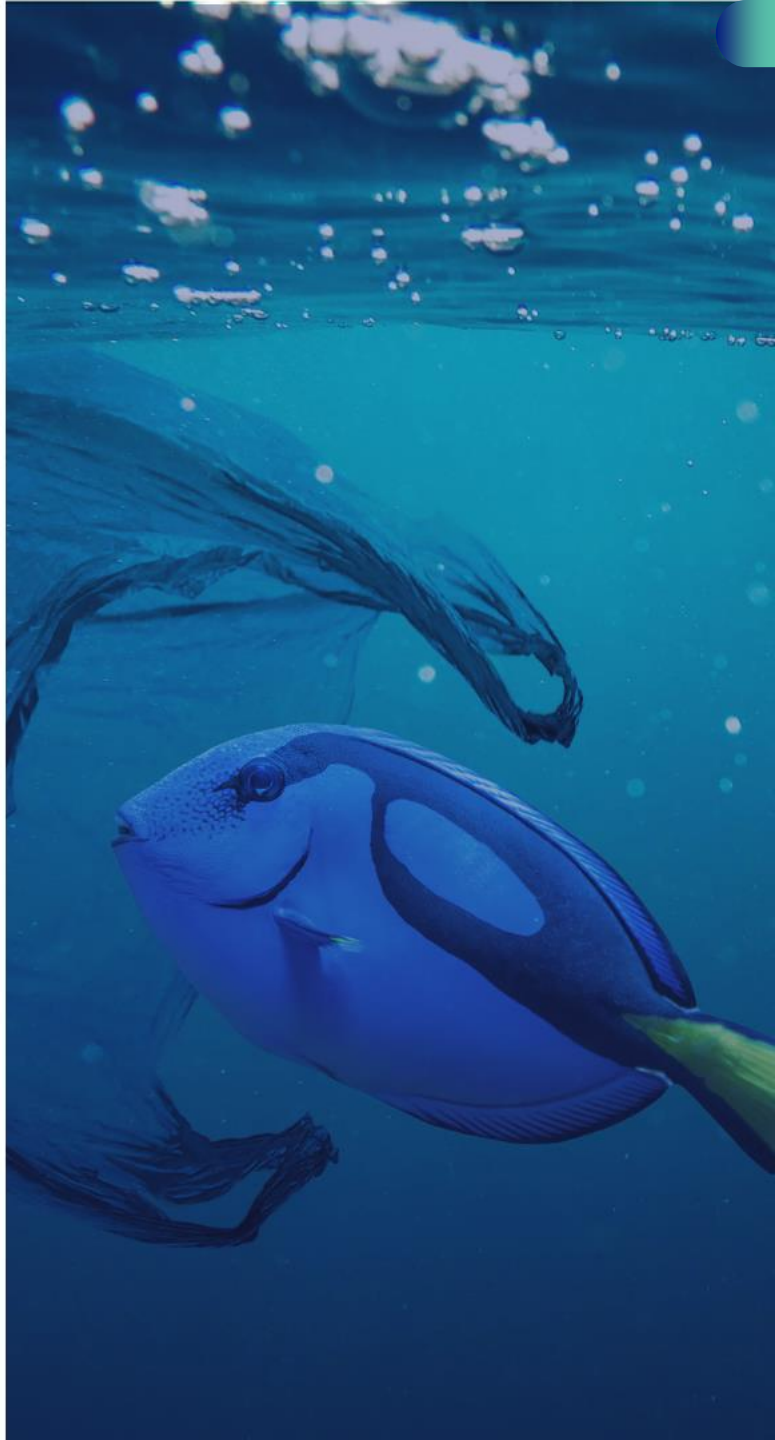
Quality Assurance Project Plan (QAPP)

- Provides an understanding of the roles for each party and methodologies adopted to suit protocols
- Outlines clear procedures when:
  - Qualifying storms
  - Non-qualifying storms
  - Chain of custody of sampling
  - Oversight
  - Reporting
  - Site abandonment
- Provides a robust framework for report generation



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Which field testing protocol ?

Parameter	WADOE - TAPE	SQIDEP (V1.3)	GCCC Protocol
Minimum # storm event:	12	15	10 – 15 (7+ from single location)
Minimum # of aliquots:	10	>?-8	6
Mean precipitation intensity (mm/hr):	> 0.76	N/A	N/A
Minimum storm coverage:	≥75%	≥?-70%	≥50%
Sampling duration:	≤36 hr	N/A	N/A
Antecedent dry period	≥6hr	≥6hr	≥6 – 72hrs
Min. dissolved Nitrogen fraction:	N/A	nil	40%

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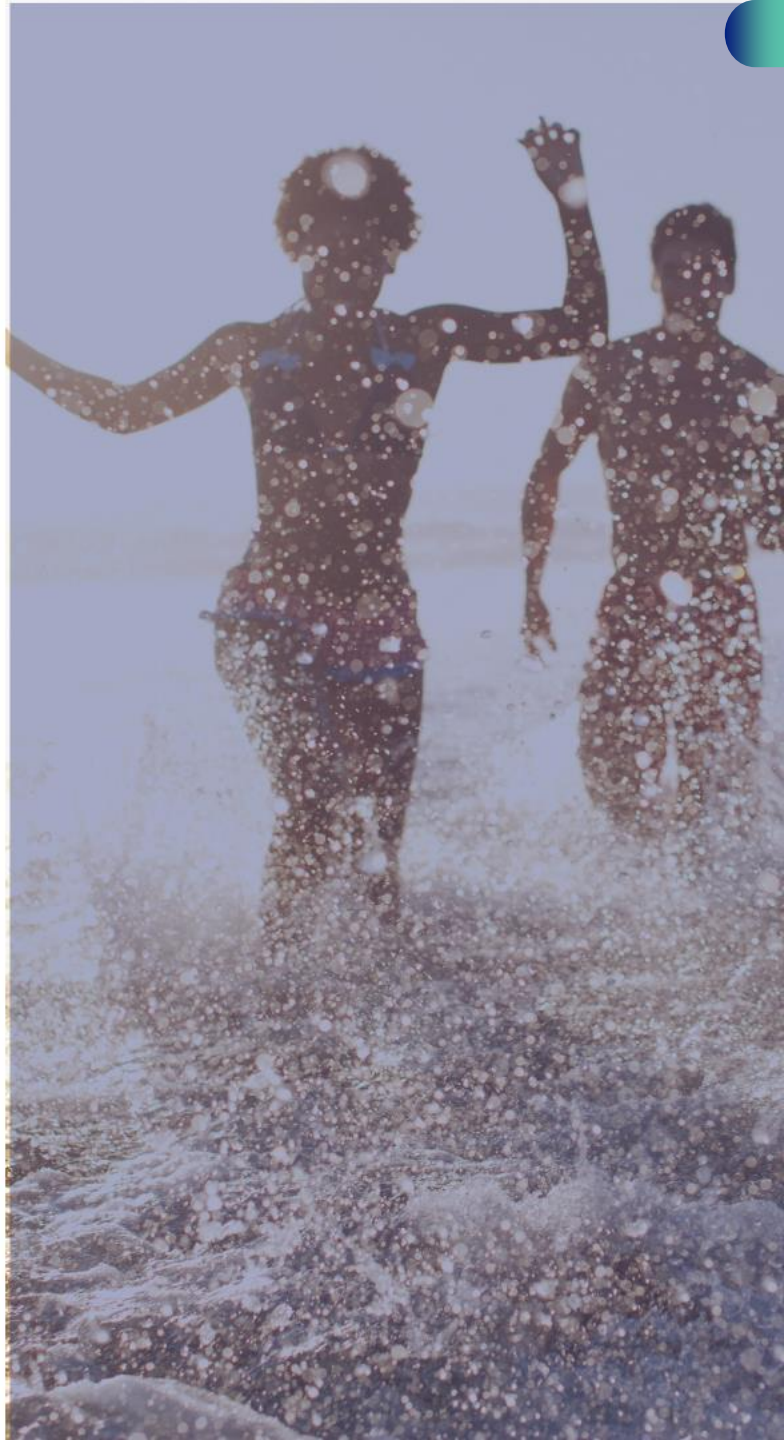
Why not just use SQIDEP ?

- Not endorsed by key stakeholders
  - Stormwater Victoria
  - Stormwater NSW
  - Stormwater Queensland
  - Melbourne Water
  - Various local Governments
- Various deficiencies



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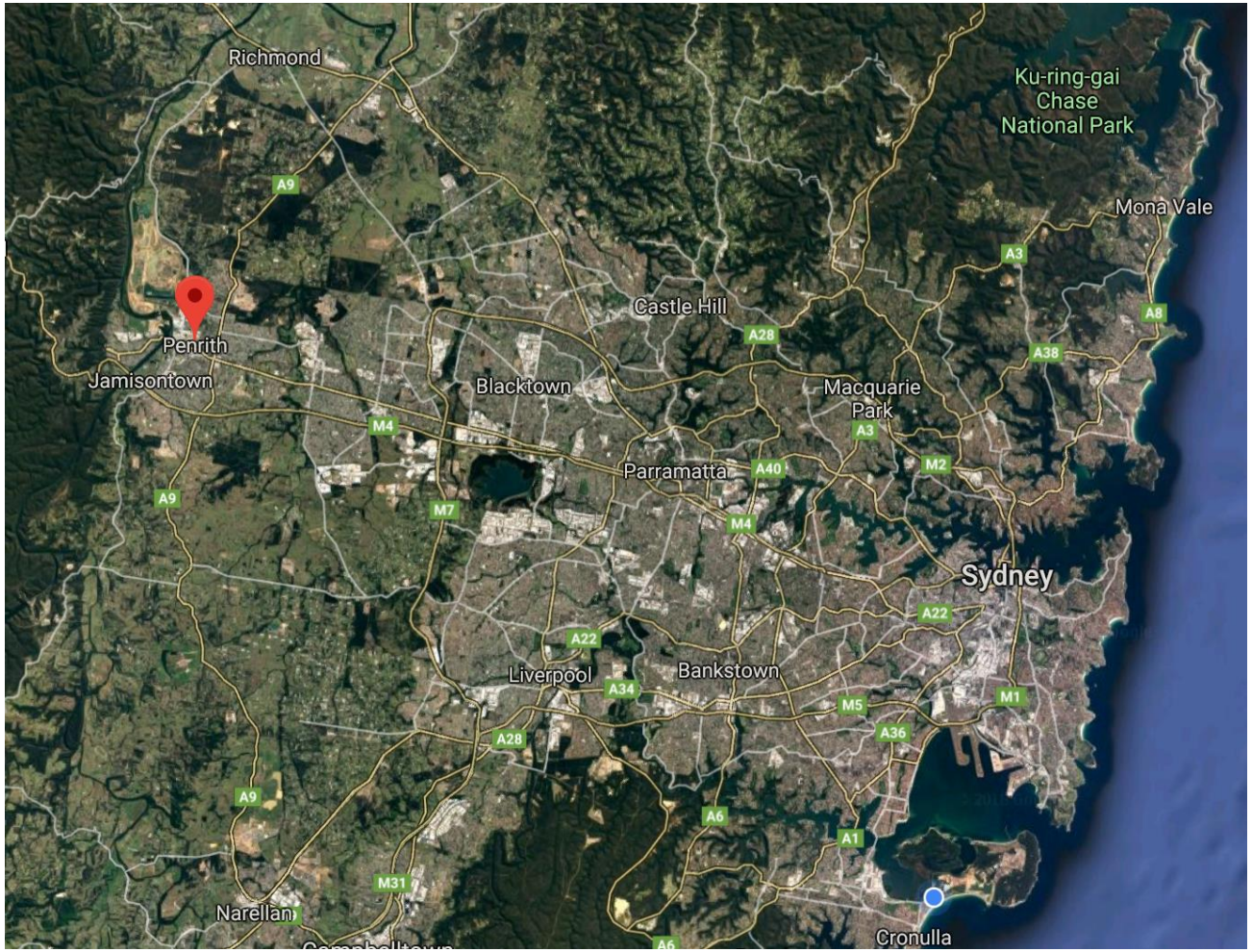
Site location

- Kingswood, Western Sydney
- Humid Subtropical climate
- 720mm mean annual rainfall
- 132 mean precipitation days/year



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Site location

- 420m^2 car-park catchment
- 1.44m^2 Filterra bioretention
  - 0.34% of catchment area
  - Typical maintenance activities

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Kingswood, NSW – 23 March 2018

Kingswood, NSW – 7 April 2018

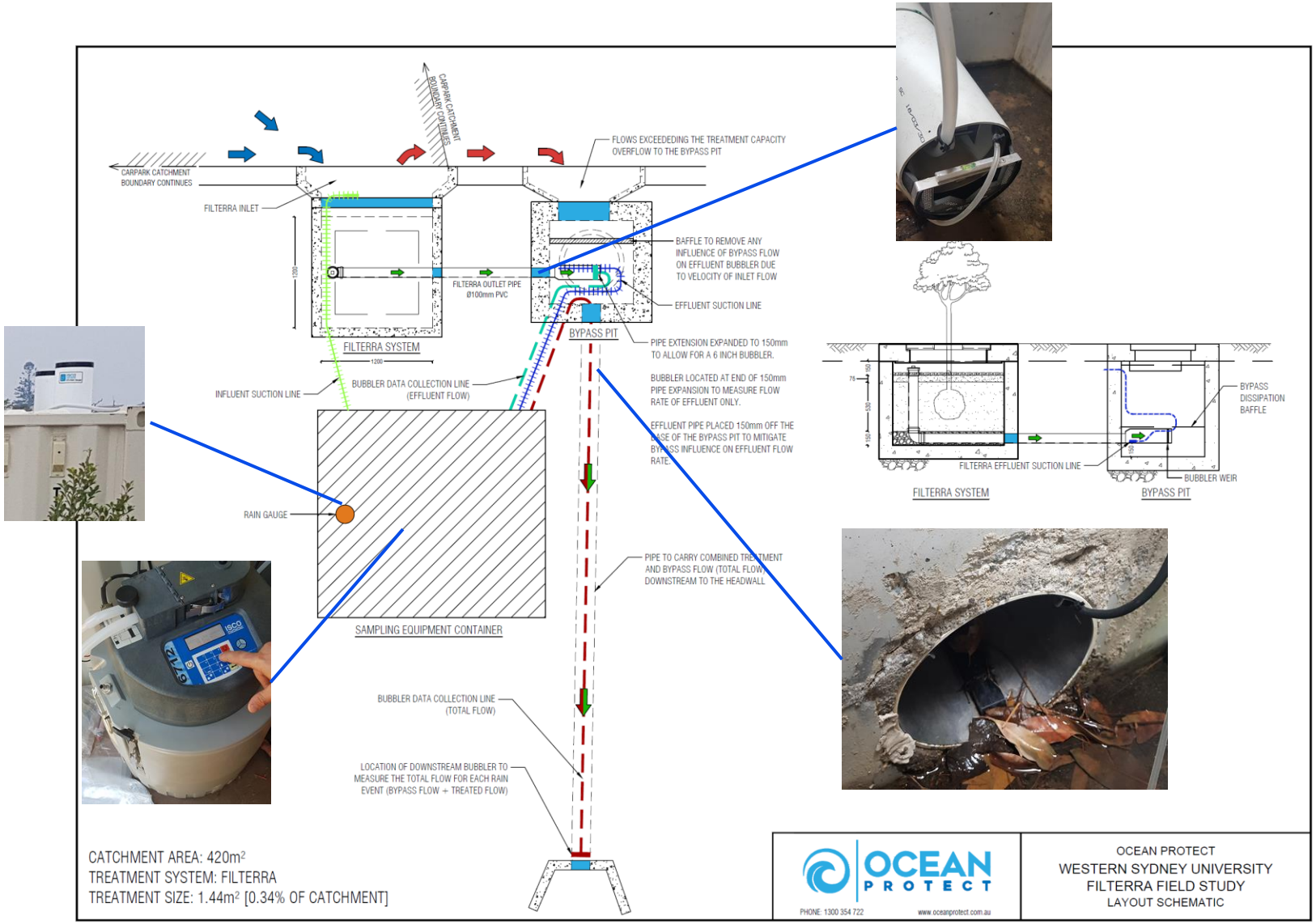
Kingswood, NSW – 4 October 2018

Kingswood, NSW – 23 April 2019


Kingswood, NSW – 15 May 2023

Site set-up

- Flow & rainfall measurement
- Automated sampling
  - Inlet & outlet
  - Flow proportional
  - Frequency programmed remotely
- Samples
  - Collected by Ocean Protect, ALS, Western Sydney University & SESL
  - Analysed by ALS



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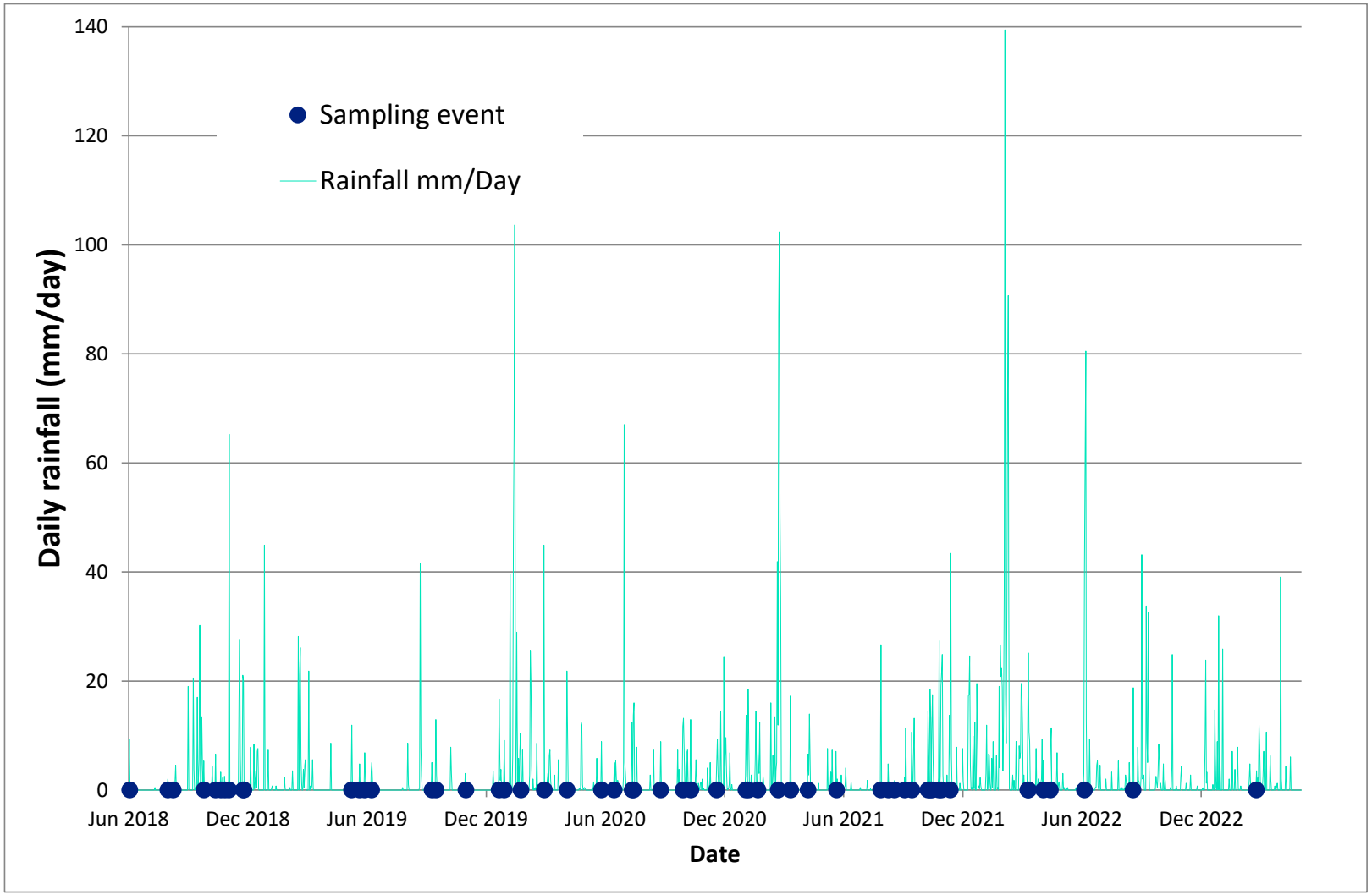
Qualifying events

- Monitoring from June 2018
- 55 qualifying events
  - 1 to 64 hours sampling durations
  - 6 to 105 aliquots (x 2)
  - 0.5 to 282mm rainfall
  - up to 107mm/hour rainfall
- 13 events with flow rate >5000mm/hr



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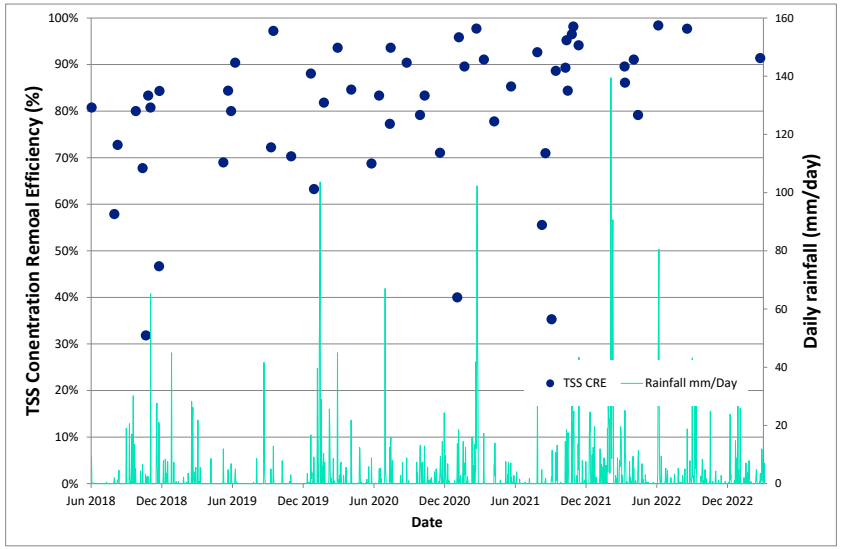
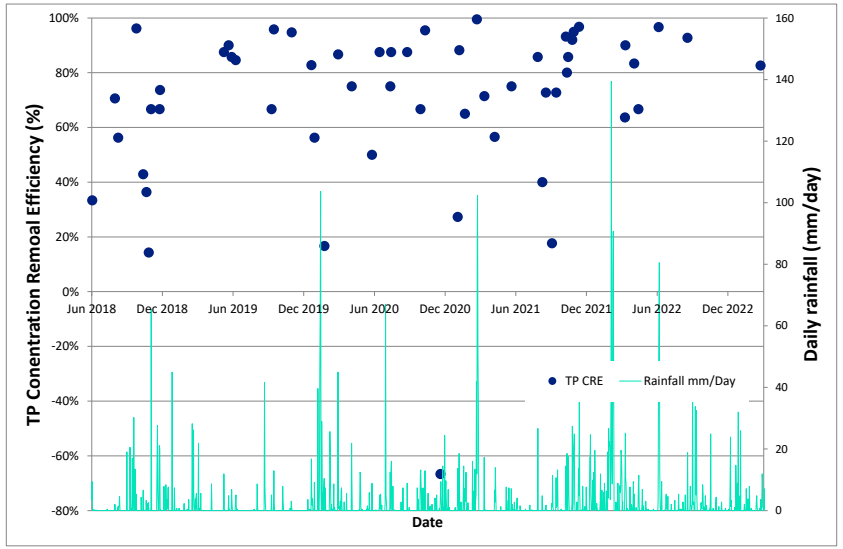
Results

Concentration reductions

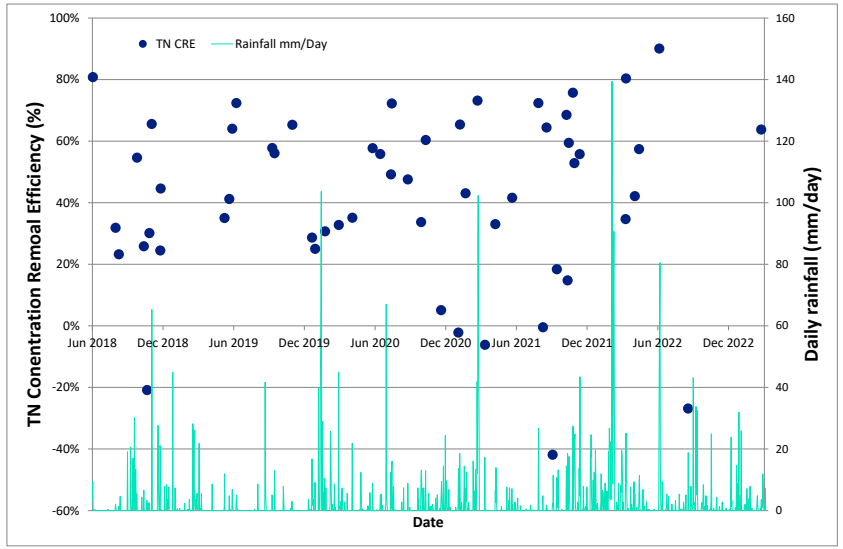
TSS



TP



TN



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All data

Analyte	no. of events	Mean Influent EMC (mg/L)	Mean Effluent EMC (mg/L)	Median Conc. Removal Efficiency (Median CRE, %)	Efficiency Ratio (ER, %)	Load removal (%)
TSS	55	50.8	6.9	84%	86%	96%
DP	55	0.02	0.01	0%	52%	25%
TP	55	0.19	0.04	75%	80%	94%
NOx	55	0.32	0.31	0%	3%	1%
NH_3-N	55	0.19	0.08	50%	59%	68%
DIN	55	0.50	0.39	57%	23%	26%
TKN	55	0.88	0.42	28%	53%	81%
TN	55	1.20	0.72	45%	40%	71%

OCEAN PROTECT

During establishment (first 12 months)

Analyte	no. of events	Mean Influent EMC (mg/L)	Mean Effluent EMC (mg/L)	Median Conc. Removal Efficiency (Median CRE, %)	Efficiency Ratio (ER, %)	Load removal (%)
TSS	10	30.0	8.2	76%	73%	78%
DP	10	0.03	0.02	0%	45%	6%
TP	10	0.11	0.04	61%	61%	66%
NOx	10	0.80	0.70	9%	13%	23%
NH_3-N	10	0.44	0.18	58%	58%	61%
DIN	10	1.25	0.88	51%	29%	36%
TKN	10	1.11	0.56	30%	50%	63%
TN	10	1.91	1.25	31%	35%	46%

OCEAN PROTECT

After establishment (after first 12 months)

Analyte	no. of events	Mean Influent EMC (mg/L)	Mean Effluent EMC (mg/L)	Median Conc. Removal Efficiency (Median CRE, %)	Efficiency Ratio (ER, %)	Load removal (%)
TSS	45	55.4	6.7	84%	88%	97%
DP	45	0.02	0.01	0%	56%	27%
TP	45	0.21	0.04	75%	83%	95%
NOx	45	0.21	0.22	0%	-7%	-6%
NH_3-N	45	0.13	0.05	50%	59%	70%
DIN	45	0.34	0.28	57%	19%	22%
TKN	45	0.83	0.38	28%	54%	82%
TN	45	1.04	0.61	45%	42%	73%

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August 2021 to July 2022

Analyte	no. of events	Mean Influent EMC (mg/L)	Mean Effluent EMC (mg/L)	Median Conc. Removal Efficiency (Median CRE, %)	Efficiency Ratio (ER, %)	Load removal (%)
TSS	16	58.6	5.7	89%	90%	96%
DP	16	0.02	0.01	0%	68%	26%
TP	16	0.26	0.04	85%	85%	95%
NOx	16	0.14	0.12	-34%	15%	-3%
NH_3-N	16	0.04	0.03	0%	24%	69%
DIN	16	0.18	0.15	60%	17%	24%
TKN	16	0.79	0.38	0%	52%	81%
TN	16	0.93	0.50	57%	47%	72%

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Comparison to other Filterra bioretention studies

Reference	Biofiltration system details	Methodology summary	TSS ER (%)	TP ER (%)	TN ER (%)
Current study	Western Sydney, NSW, Australia; installed April 2018, 1.45m^2 area (0.34% of catchment); 0.53m deep Filterra® filter media; Bush Christmas' Lilly Pilly (*Syzygium australe*)	16 real events after 'establishment'; flow & water quality monitored; 2021-22	96%	85%	47%
Shaw et al (2006)	Falls Church Virginia, USA; installed April 2018, 3.3m^2 area (0.7% of catchment); 0.53m deep Filterra® filter media; unidentified shrub/ tree	16 real events; flow and water quality monitored; 2004-2005	88%	60%	- (40% for TKN)
Stanford (2009)		7 simulated events; flow and water quality monitored; 2006-2007	-	70%	-
Herrera (2014)	Bellingham, Washington, USA; 2.2m^2 area (0.13% of catchment); installed 2007, 0.53m deep Filterra® filter media; unidentified shrub/ tree	22 real events; water quality monitored in 2013	94%	70%	-
Contech (2016)	Virginia Beach, Virginia, USA; 2.2m^2 area (unknown catchment area); installed 2007, 0.53m deep Filterra® filter media; unidentified shrub/ tree	92 real events; water quality monitored; 2008-2016	90%	66%	49%
Smolek et al (2018):	North Carolina State University, Fayetteville, North Carolina, USA; installed 2012, 2.2m^2 area (0.22% of catchment); 0.53m deep Filterra® filter media; Crepe myrtle (*Lagerstroemia* spp)	34 real events; flow & water quality monitored; 2013-14	95%	64%	27%

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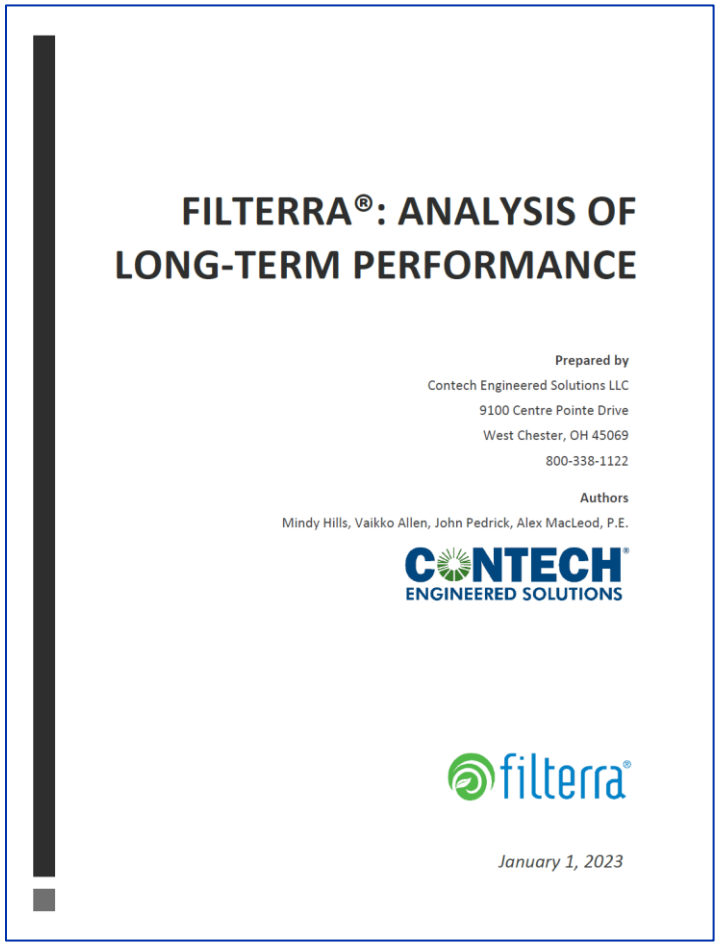
Filterra bioretention longevity study



FILTERRA®: ANALYSIS OF LONG-TERM PERFORMANCE

Prepared by
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CONTECH ENGINEERED SOLUTIONS

filterra

January 1, 2023

Study Site ID	A	B	C
Land Use	Restaurant Commercial Parking Lot	Oil Service Station Commercial Parking Lot	Gas Station Retail Area
Location	Virginia Beach, VA	Baltimore, MD	Hampton, VA
System Size (ft.)	6x4	6x6	6x8
Plant Type	Nellie Stevens Holly	Northern Bayberry	Redtwig Dogwood, Foster Holly
Activation Date	4/13/2007	6/1/2005	5/27/2005
Age at Time of Monitoring (yrs.)	1 - 11	3 - 6	0 - 13
Time Monitored (yrs.)	10	3	13

- Consistently high treatment performance
- No reduction in infiltration rate

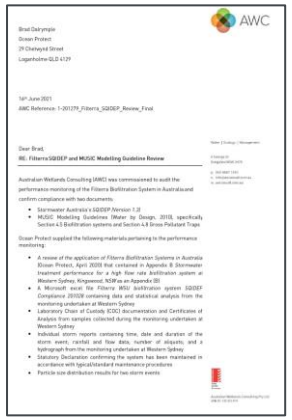
OCEAN PROTECT

Other 'conventional' bioretention studies

Reference	Biofiltration system details	Methodology summary	TSS ER (%)	TP ER (%)	TN ER (%)
Birch et al (2005)	Sydney, NSW, Australia; 420m^2 biofiltration system (approx. .4% of catchment); up to 1.1m deep filter media (1:6 mixture of zeolite and coarse, pure quartzitic sand with a mean diameter of 2 mm.); unknown planting	9 real events; water quality monitored; between October & December 1999	50%	65%	N/A
Hunt et al (2006)	Greensborough, North Carolina, USA; constructed 2000-01; two cells, 10m^2 each (5% of catchment); both with 1.2m 'organic sandy soil' filter, cell G1 included 0.45 to 0.6m internal water storage, approx. 20m^2 area; planted with river birch, common rush, yellow flag iris & sweetbay	11 real events; flow & water quality monitored; 2002-03	N/A	-409% (G1), -2900% (G2),	224% (G1), -312% (G2)
Davis (2007)	Maryland, USA; installed 2003; 2 parallel cells, 26m^2 area each (2.2% of catchment), Cell A 0.9m filter (50% sand, 30% topsoil, 20% hardwood mulch) with 80mm surface hardwood, Cell B as per Cell A but with 0.3m anaerobic sump (sand & newspaper mix); vegetated	12 real events; water quality monitored; 2003-04	22% (Cell A), 41% (Cell B)	74% (Cell A), 68% (Cell B)	N/A
McKenzie-McHarg et al (2008):	Brisbane, QLD, Australia; 20m^2 area (approx. 4% of catchment); 0.4m sandy loam filter media; vegetated	4 simulated events between 2006-2007; 3000L dose per event; flow & water quality monitored	87%	83%	28%
Hatt et al (2009)	Monash University, VIC, Australia; 3 cells, each 1.5m^2 area (1% of catchment); 0.5m deep filter media (Cell 1, sandy loam; Cell 2, 80% sandy loam, 10% vermiculite, 10% perlite, by volume; Cell 3, 80% sandy loam, 10% compost, 10% hardwood mulch, by volume; dense planting (native sedges & rushes)	Real events; water quality data for 38 events; flow data for 28 events; monitored 2006-2007	87% (Cell 1), 92% (Cell 2), 90% (Cell 3)	-2140% (C1), -1286% (C2), -1423% (C3)	18% (Cell 1), 0% (Cell 2), 18% (Cell 3)
Hatt et al (2009)	McDowall, Brisbane, QLD, Australia; constructed 2006; 20m^2 area (2% of catchment); 0.4m deep sandy loam filter media; re-planted with *Carex* spp. in 2007	4 simulated events in June & October 2007	89%	83%	19%
Roberts et al (2012)	Wakerley, QLD, Australia; constructed 2007; 3 cells (955m^2 each, 0.3% of catchment) with upstream sediment basin; sandy loam filter media; 0.9m saturated zone in Cell 3; variety of plant species	53 to 74 real events for each cell; water quality monitored 2009-10	36% (Cell 1), 53% (Cell 2), 44% (Cell 3)	25% (Cell 1), 34% (Cell 2), 38% (Cell 3)	-28% (Cell 1), -11% (Cell 2), 19% (Cell 3)
Lucke et al (2015, 2017):	Caloundra, QLD, Australia; constructed 2005; 3 systems (7m^2 each); 0.9m depth sandy loam media; *L.longifolia*	1 simulated event at each system at typical TSS/TP/TN concentrations[#]; approx. 2-year 30-min events; 2014	-25%	90%	18%
Peljo et al (2016)	Caloundra, QLD, Australia; constructed 2013; 4 systems approx.10m^2 each (approx. 1% of catchment); 0.4m deep sandy loam filter media; *Juncus & Carex spp*	2 simulated events at each of 4 systems in June 2015	91%	83%	33%
Johnson et al (2019)	Chapel Hill, North Carolina, USA; constructed 2001; 90m^2 area (14% of catchment in 2002-03; 8% of catchment 2003-present); 1.2m deep sandy filter media; perennial grasses, trees & shrubs	**1st study:** 10 real events; flow & water quality monitored; 2002-2003 **2nd study:** 18 real events; flow & water quality monitored; 2017-2018	N/A	-21% (1st), 39% (2nd)	-38 (1st), 26% (2nd)
Bonneau et al (2020)	Melbourne, VIC, Australia; 1800m^2 biofiltration system (0.5% of catchment); 0.8m average filter depth (0.35m sandy loam, 0.1m sand, 0.05m gravel, 0.3m scoria) – with bottom 0.5m being a submerged zone (of un-lined basin); densely vegetated with a mixture of swamp grasses (e.g. *Centella cordi folla*, *Amphibromus nervosus*), sedges (e.g. *Carex appressa*) and common spike rush (e.g. *Eleocharis acuta*).	13 real events analysed for water quality; 2013-2016	93%	84%	73%

Peer reviews & publications

- oceanprotect.com.au/filterra
- 7 x ‘real world’, published studies
- 3 x peer review reports
- Council approved performance values



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Key study findings

- High TSS/ TP/ TN concentration & load reductions
  - Consistent with other published studies of Filterra bioretention systems
- Performance has improved over time

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What's 'the secret' ?

- Turn-key approach
- Strict QA/ QC for the filter media
- 20+ years of R & D
- Resilience

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Where to next ?

- Additional monitoring
  - At Kingswood site
  - Large scale system(s)
- Field prove 'wicking' & exfiltration design(s)
- Investigate alternative mulches
- Explore potential of increased flow rate
- Investigate alternative biofiltration media blends

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www.oceanprotect.com.au

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THANK YOU

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