‘Smarter’ water monitoring - supporting environmental assessments at a project-specific level

NSW PEP; Environment Institute of Australia & New Zealand; 23 February 2017

Dr Dan Evans

Profile

70’s-80’s

90’s

90’s / 00’s

2010 -

Beca

Why is data important?

- Data as an information business asset;

> *Q: If you managed your Financial Assets the same way you manage your Information Assets, what would your organisation look like?*
>
> *A: We'd be broke in a week.*
>
> Executive, Oil and Gas, Australia

Why is data important?

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- Understanding your (unique) environment;

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Approval of the Carmichael Mine – An Australian failure to understand and apply groundwater science

Published on December 24, 2016

Adrian Werner Follow
Professor of Hydrogeology at Flinders University

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A critical issue within the case was whether excavating one of the world's largest coal mines in close proximity to a nationally important wetland, fed by groundwater, would threaten the extinction of the associated Doongmabulla Springs and the endemic species

Why is data important?

- Data as an information business asset;
- Understanding your (unique) environment;
- Facilitate better decision making;
- Risk mitigation;
- Measurable improvements in compliance;
- It is difficult to gather when you really need it!

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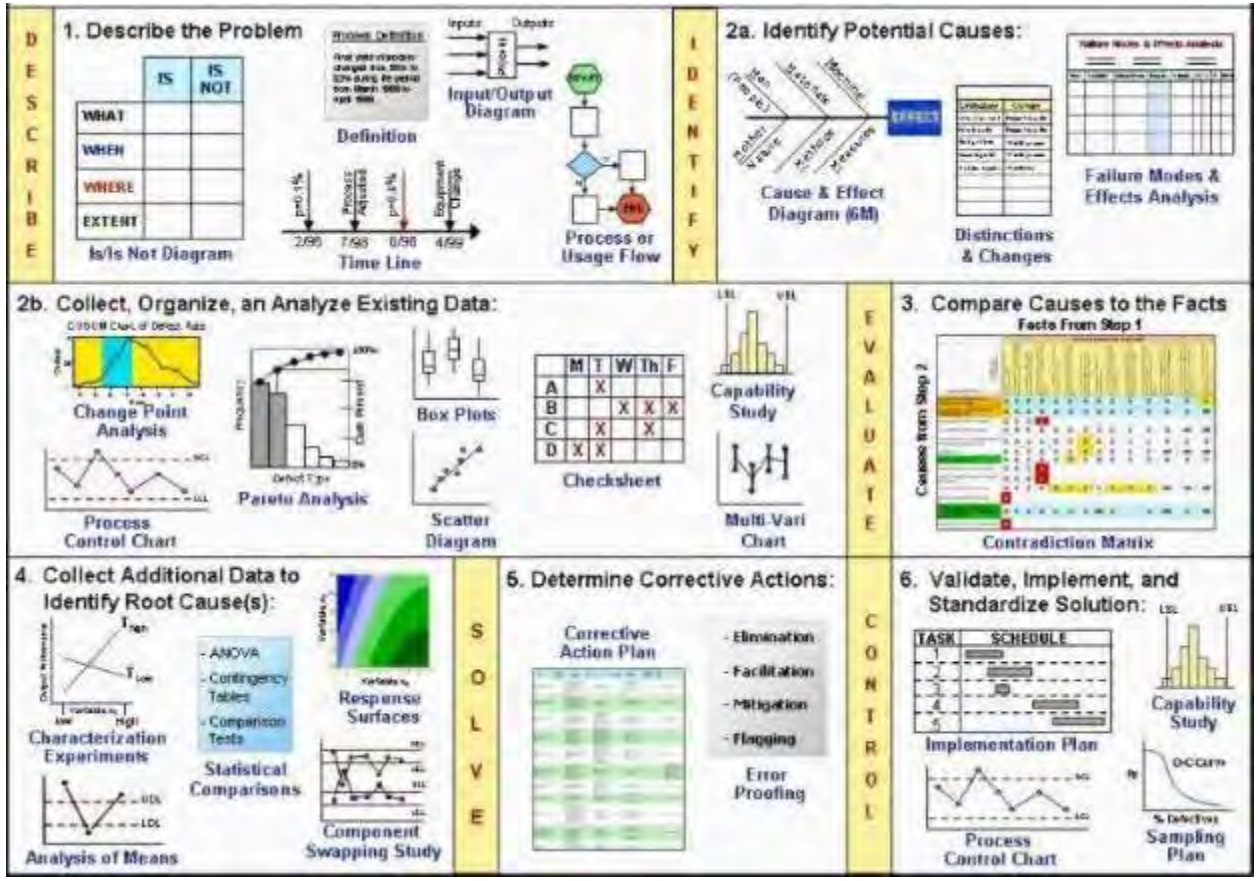
Beca

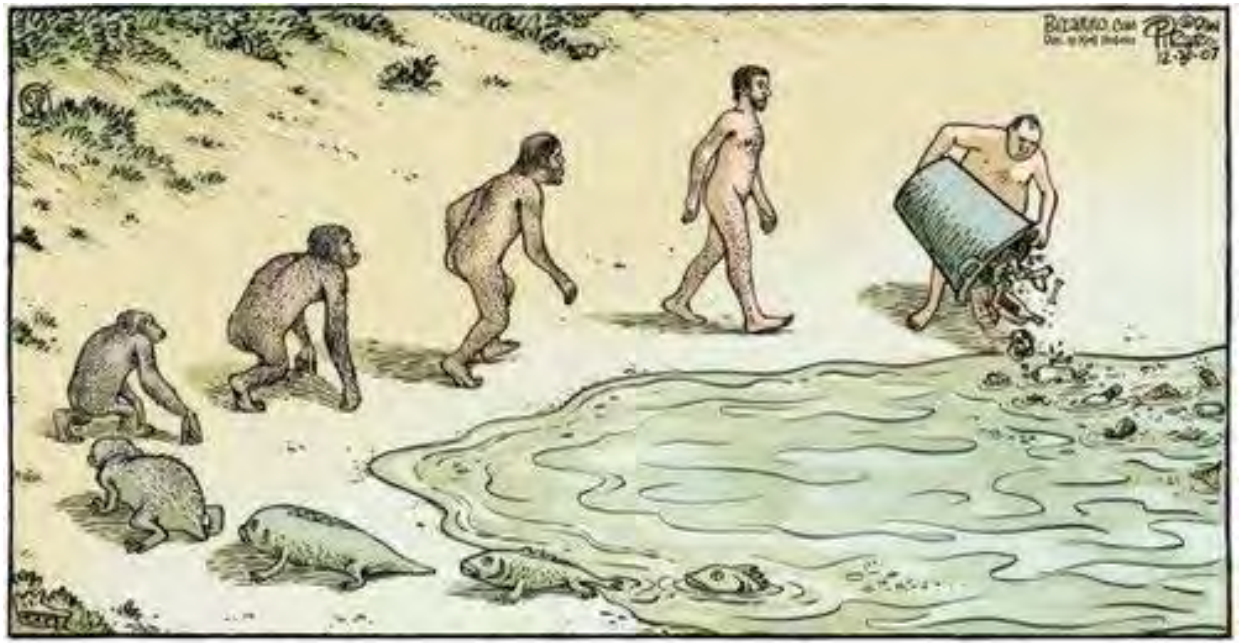
How is data used?

- Baseline condition;
- Identifying existing contamination sources impacting project sites;
- Forecasting potential impacts of development as part of the environmental impact assessment process;
- Asset management;
- Test mitigation measures / treatment efficacy;
- Ensure accountability and transparency for industry to regulatory standards;
- Drive sustainable design criteria for new developments; and
- Structured problem solving processes.



Poor approaches to designing a monitoring program

- What have we done before?
- What equipment have we already got?
- Inappropriate resourcing - junior resource / non-skilled?
- Can we out-source?
- What sites can we get easy access to?
- Tick-box exercise
- Splendid isolation!

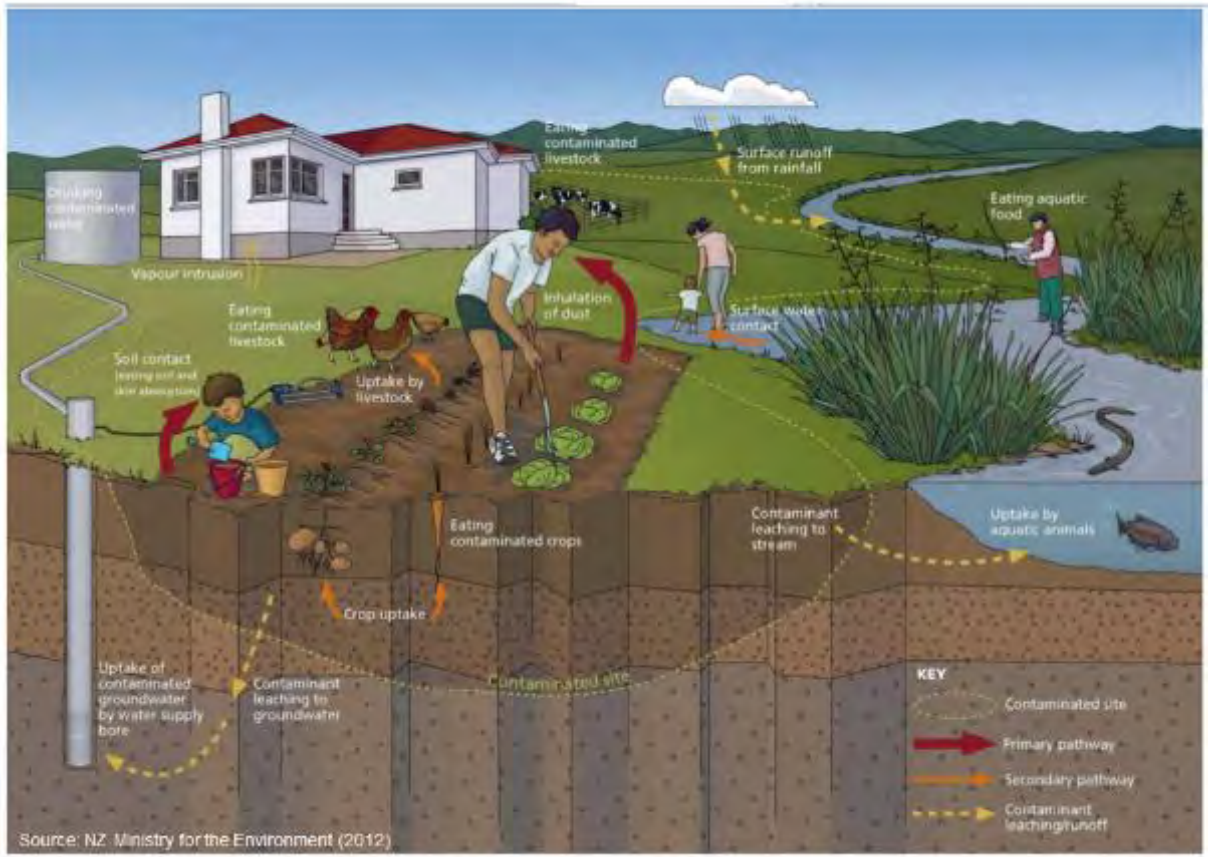


What is a monitoring program?

- Locations;
- Parameters;
- Frequency;
- Duration;
- Collection methods;
- Laboratory analysis;
- Data analysis;
- Data storage, interrogation & retrieval;
- Data reporting; and
- Re-evaluation / adaption.

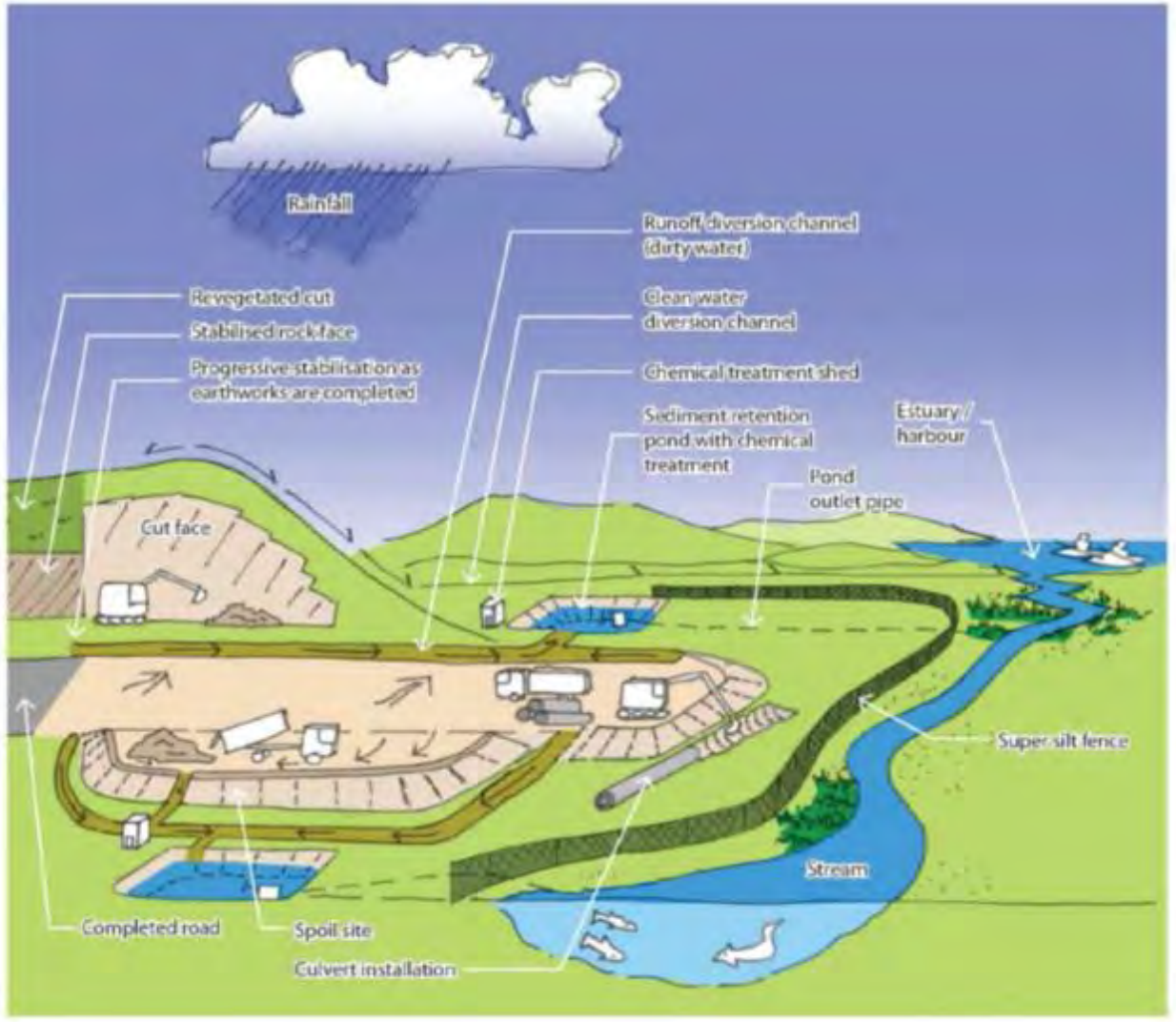
Sources, pathways & down-gradient EV's

Monitoring program component	Sources	Pathways	EV's
Locations	✓	✓	✓
Parameters	✓	✓	✓
Frequency	✓	✓	✓
Duration	✓	✓	✓
Collection methods	✓	✓	✓
Laboratory analysis	✓	✓	✓
Data analysis	✓	✓	✓
Data storage, interrogation & retrieval	✓	✓	✓
Data reporting	✓	✓	✓



How is a scheme likely to affect hydrological / WQ processes?

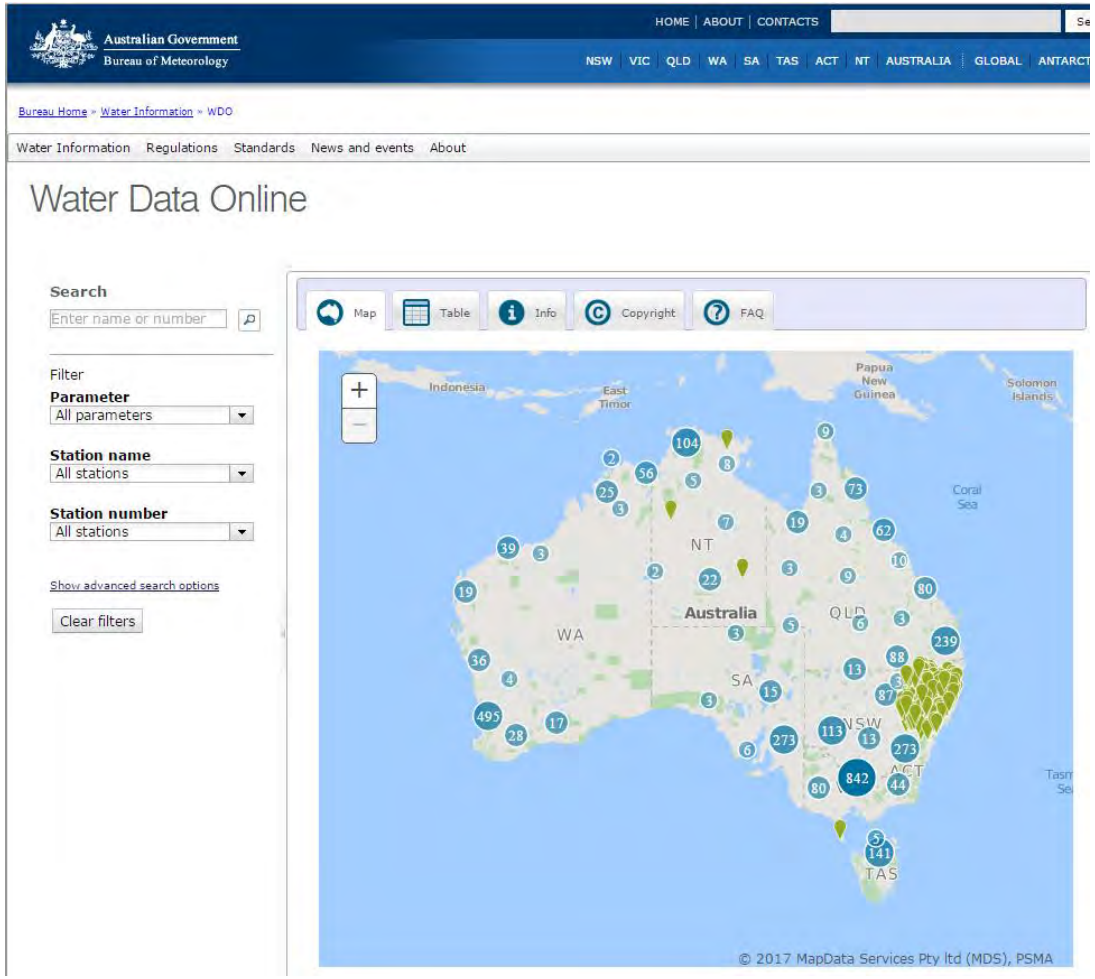
- Back-to-front
- Consider:
  - Development footprint;
  - Sources, pathways & EV's;
  - Processes (construction & operation);
  - Timeline;
  - Regulatory requirements;
  - Stakeholders expectations; and
  - Budget!!!
- Similar developments



What existing data is available?

- Aerial mapping (e.g. Google Earth, NearMap)
- DBYD
- Site reports (LotSearch)
- Government datasets
  - BoM
  - Community programs

  (e.g. Streamwatch)
  - Councils
  - State regulators
  - Water utilities



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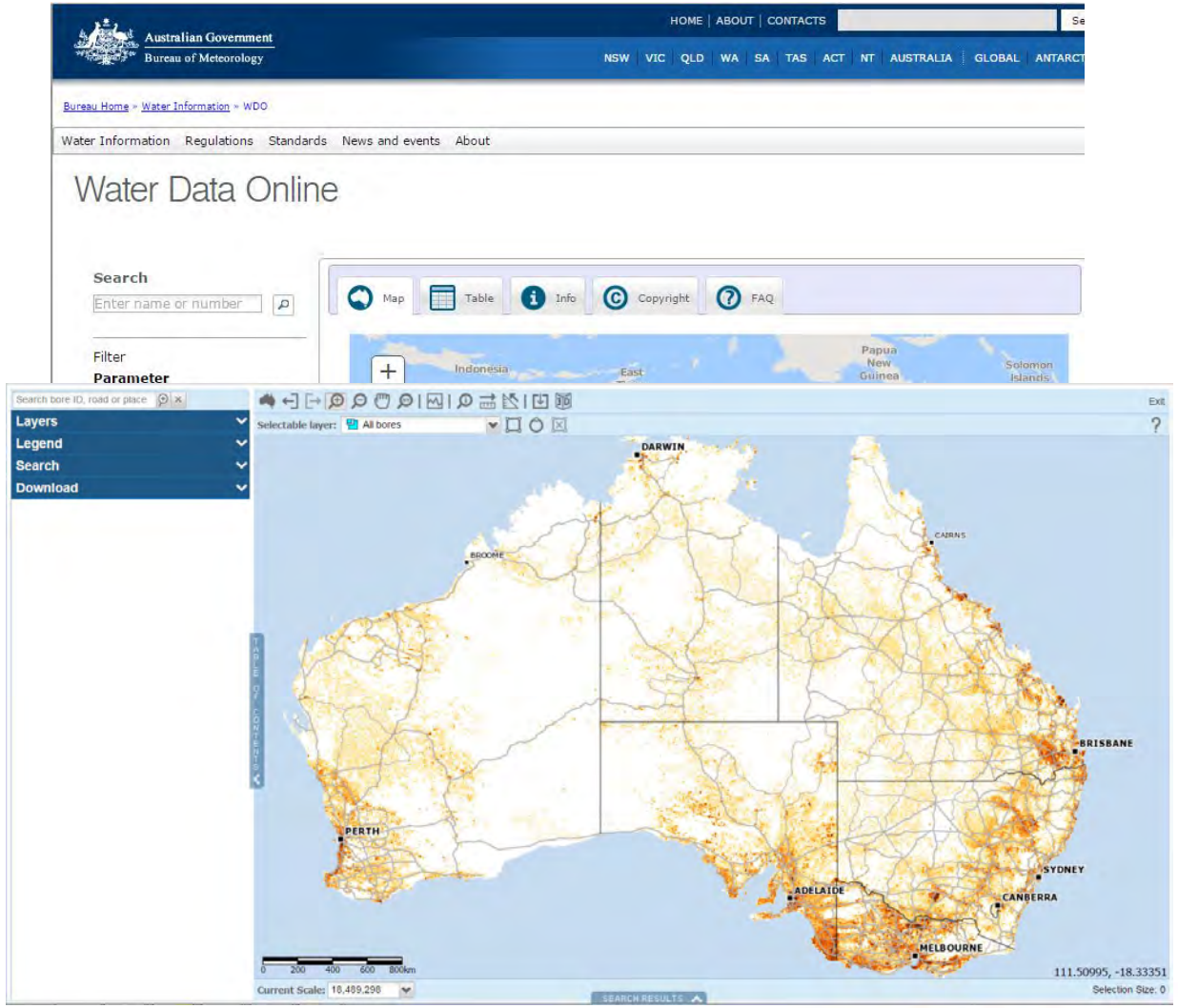

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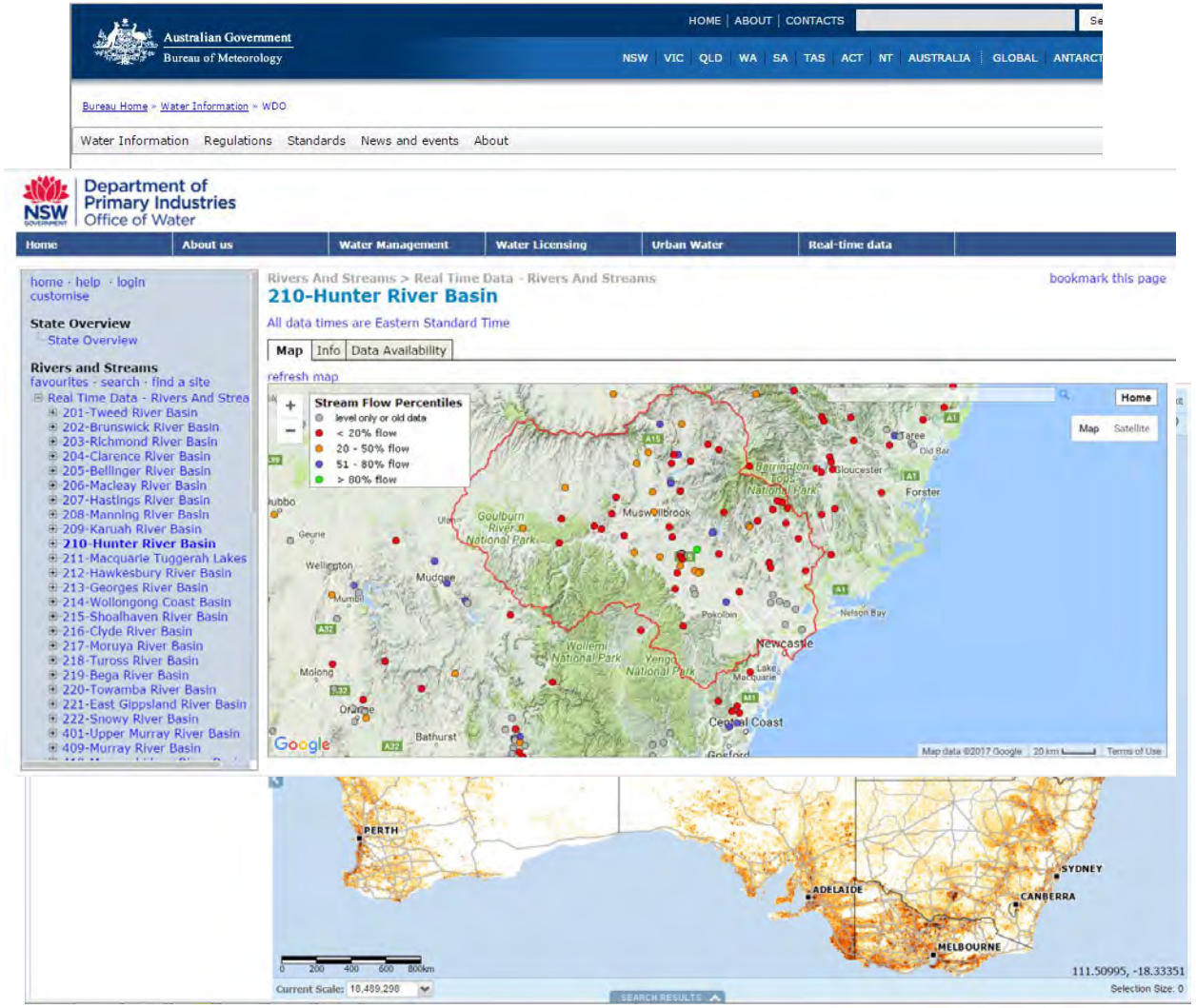

Accessing critical locations?

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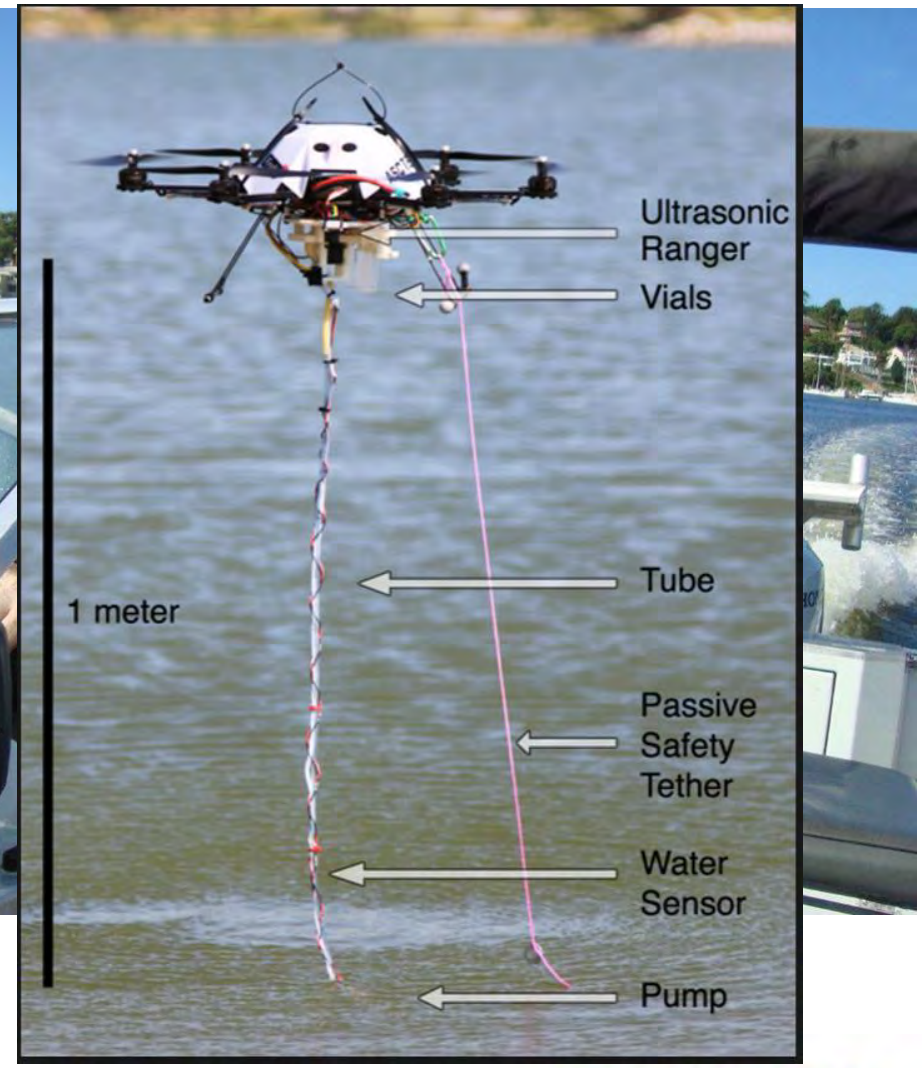
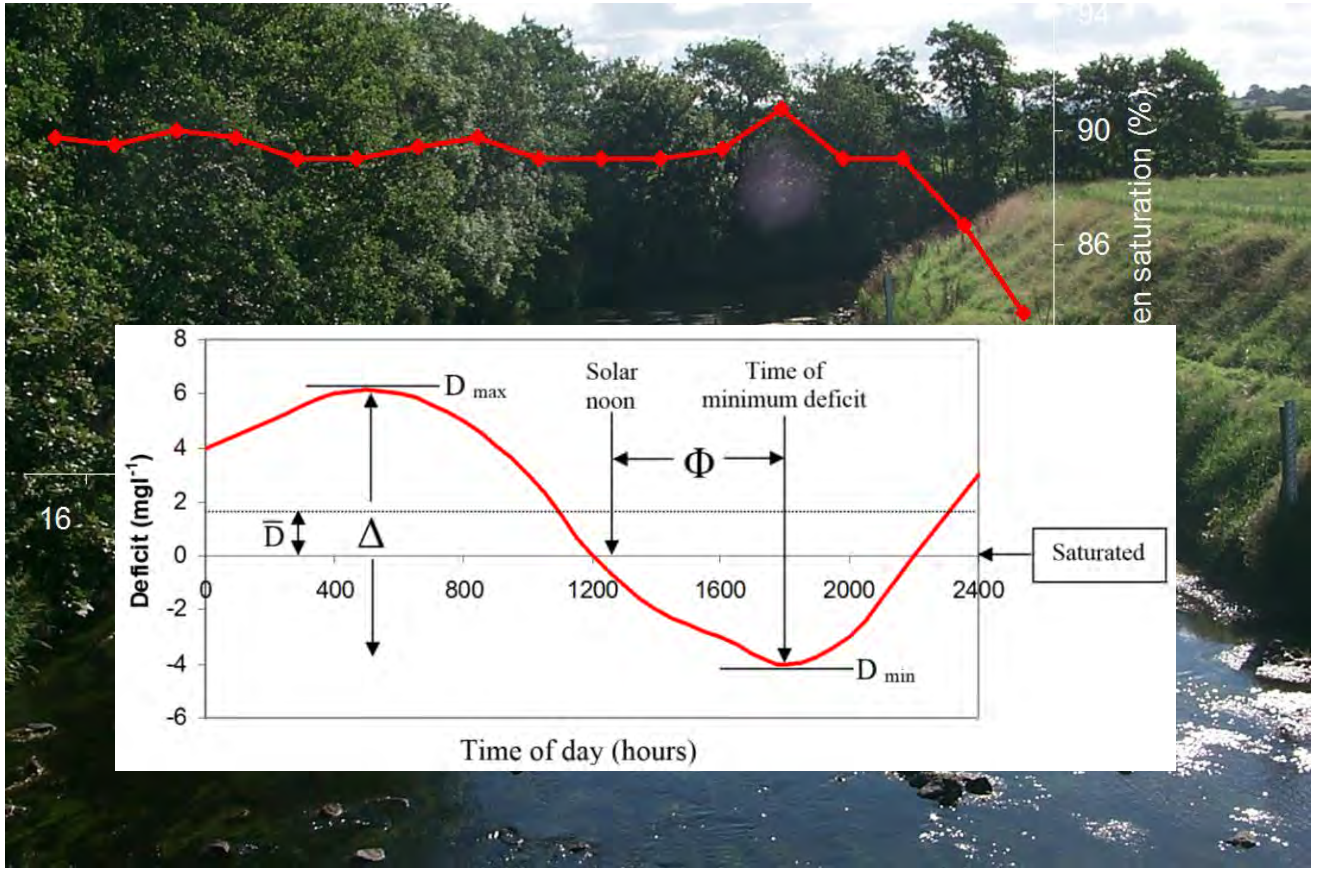


Accessing critical locations?

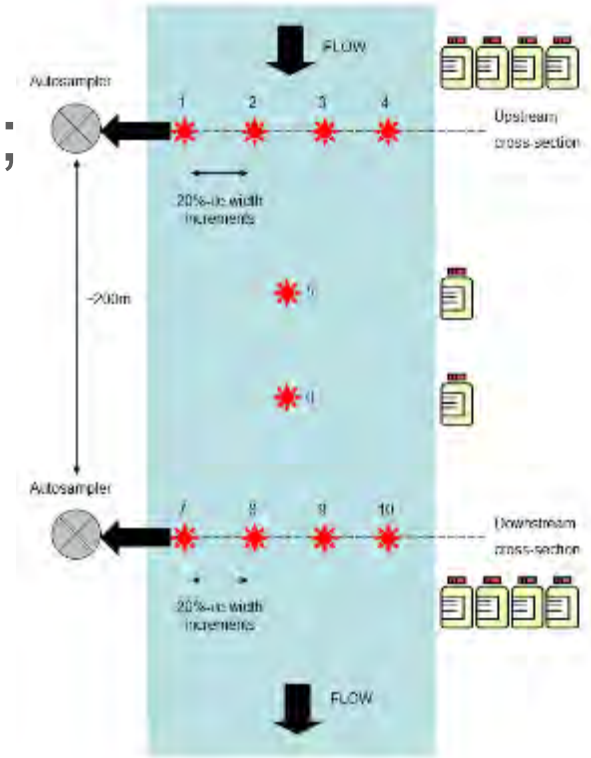
Spatial representativeness – depth & width profiles

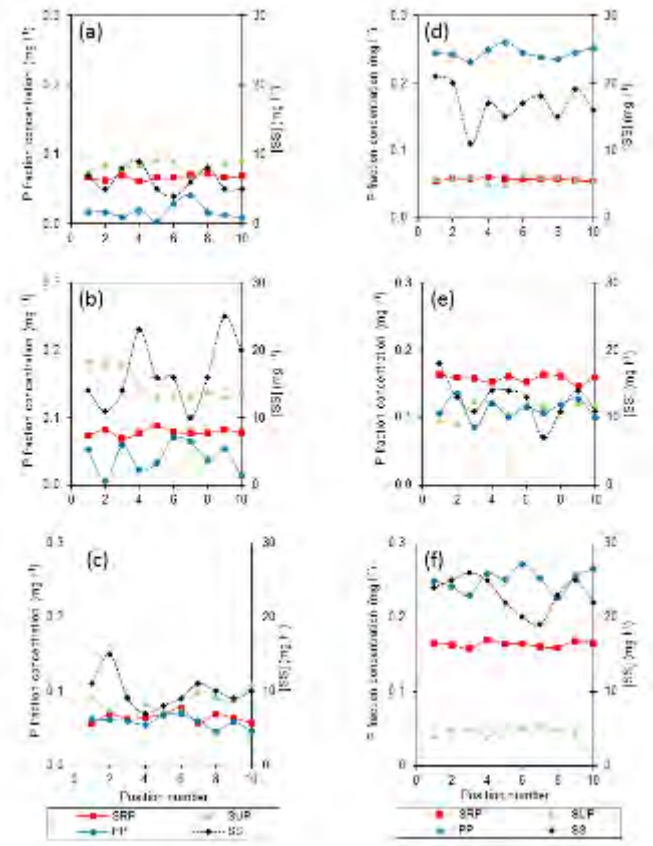
- Bush river – dissolved oxygen;



Spatial representativeness – depth & width profiles

- Bush river – dissolved oxygen;
- River cross-sections – Nutrients;





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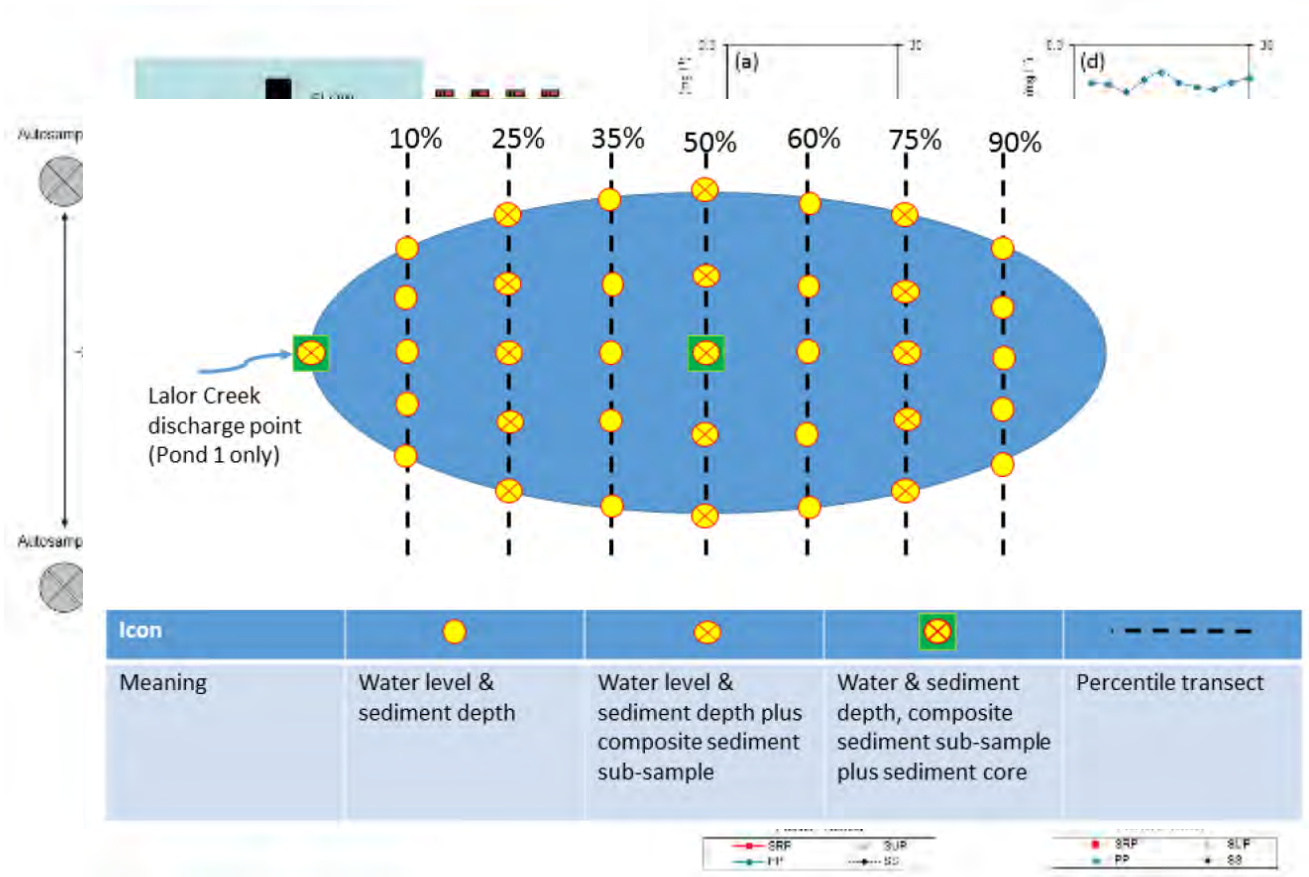
- Bush river – dissolved oxygen;
- River cross-sections - Nutrients
- Refalo Reserve transects / variation in sediment depth;



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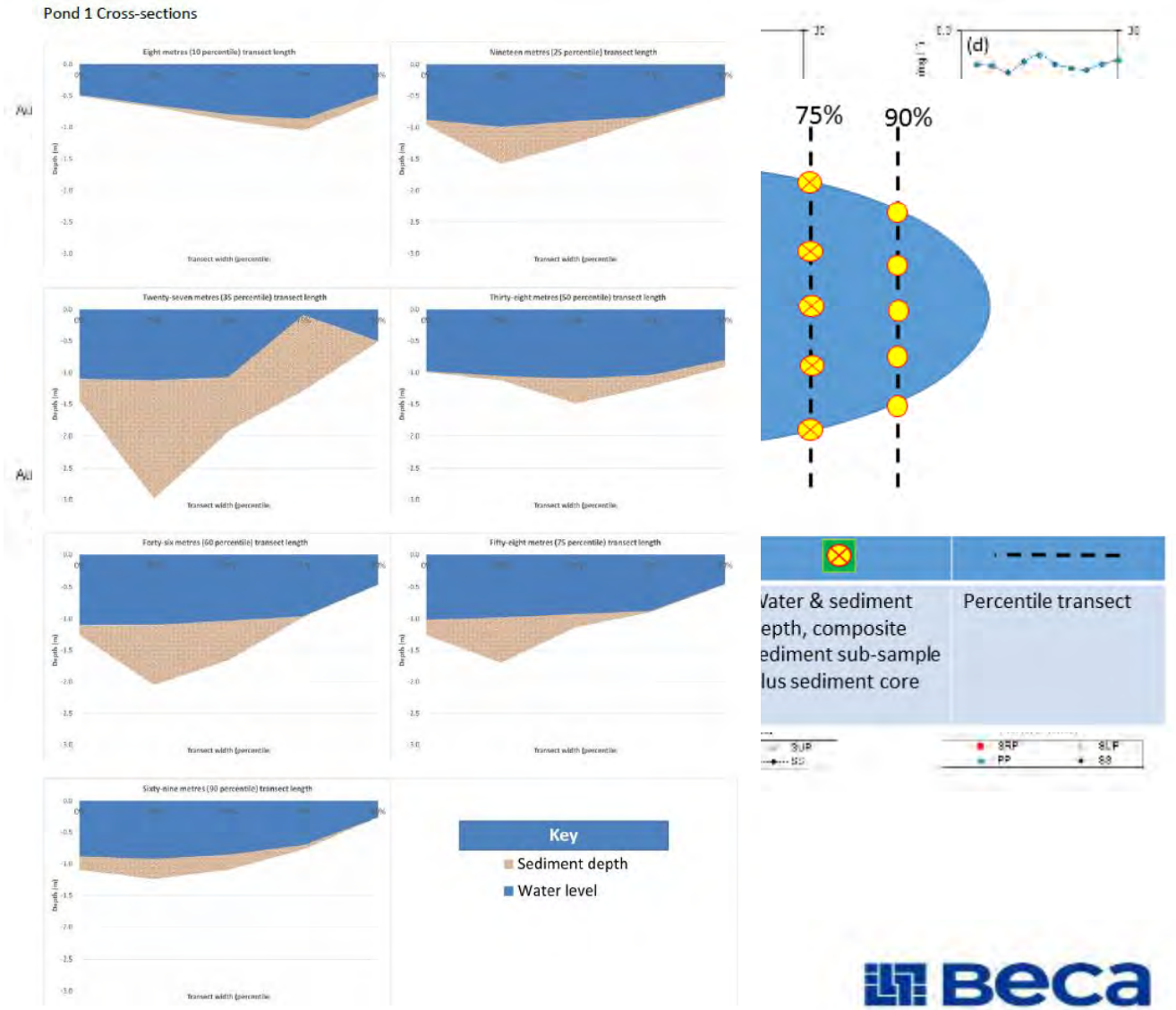
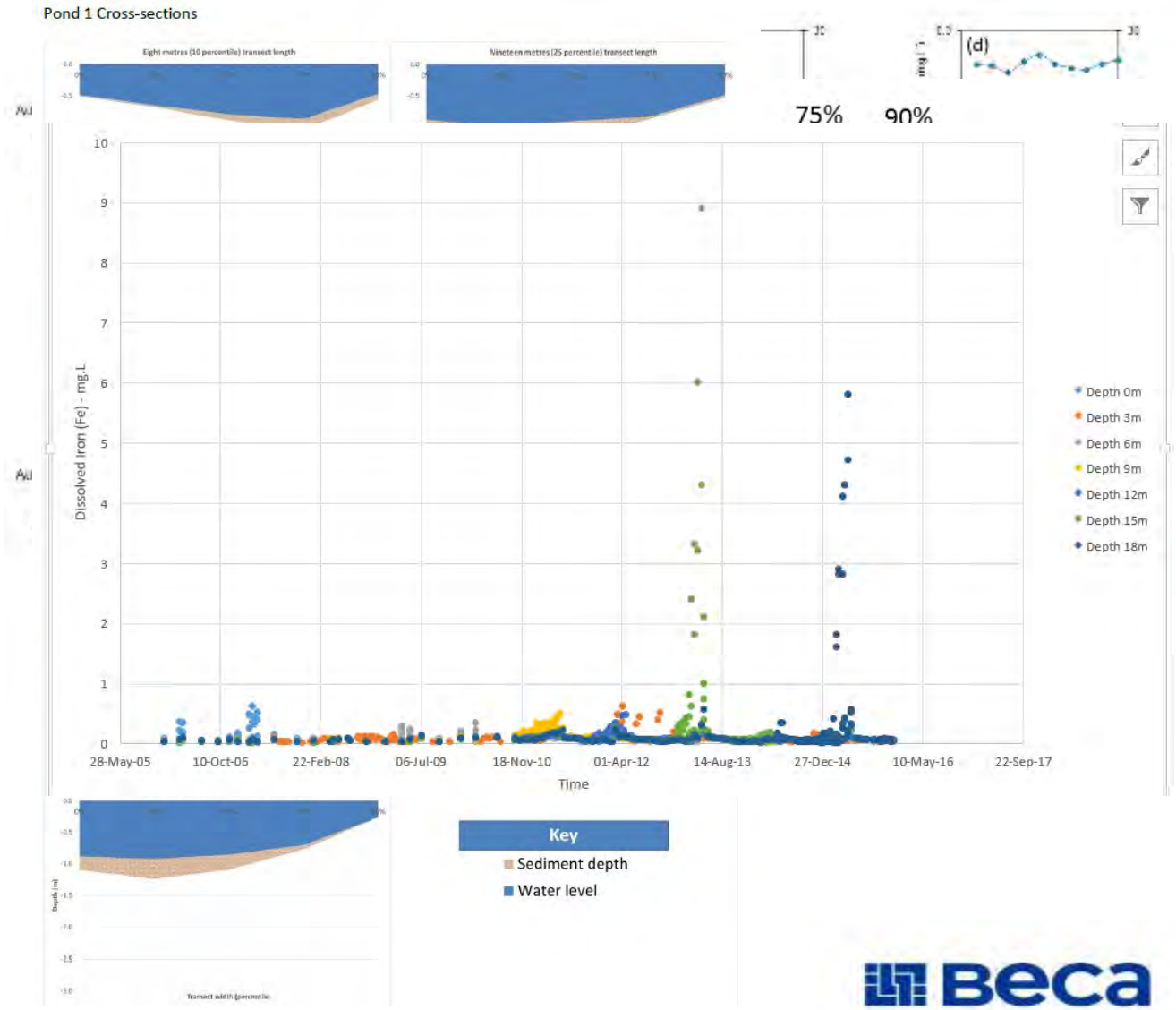


Spatial representativeness – depth & width profiles

- Bush river – dissolved oxygen;
- River cross-sections - Nutrients
- Refalo Reserve transects / variation in sediment depth;
- Reservoirs;
- Estuaries; and
- Sea.



Temporal representativeness

- Drivers behind data variation;
- Capture full range of conditions;
  - Flow;
  - Rainfall;
  - Seasonal;
  - Temperature; and
  - Tides.
- Evaluation; and
- Targeting improvements.

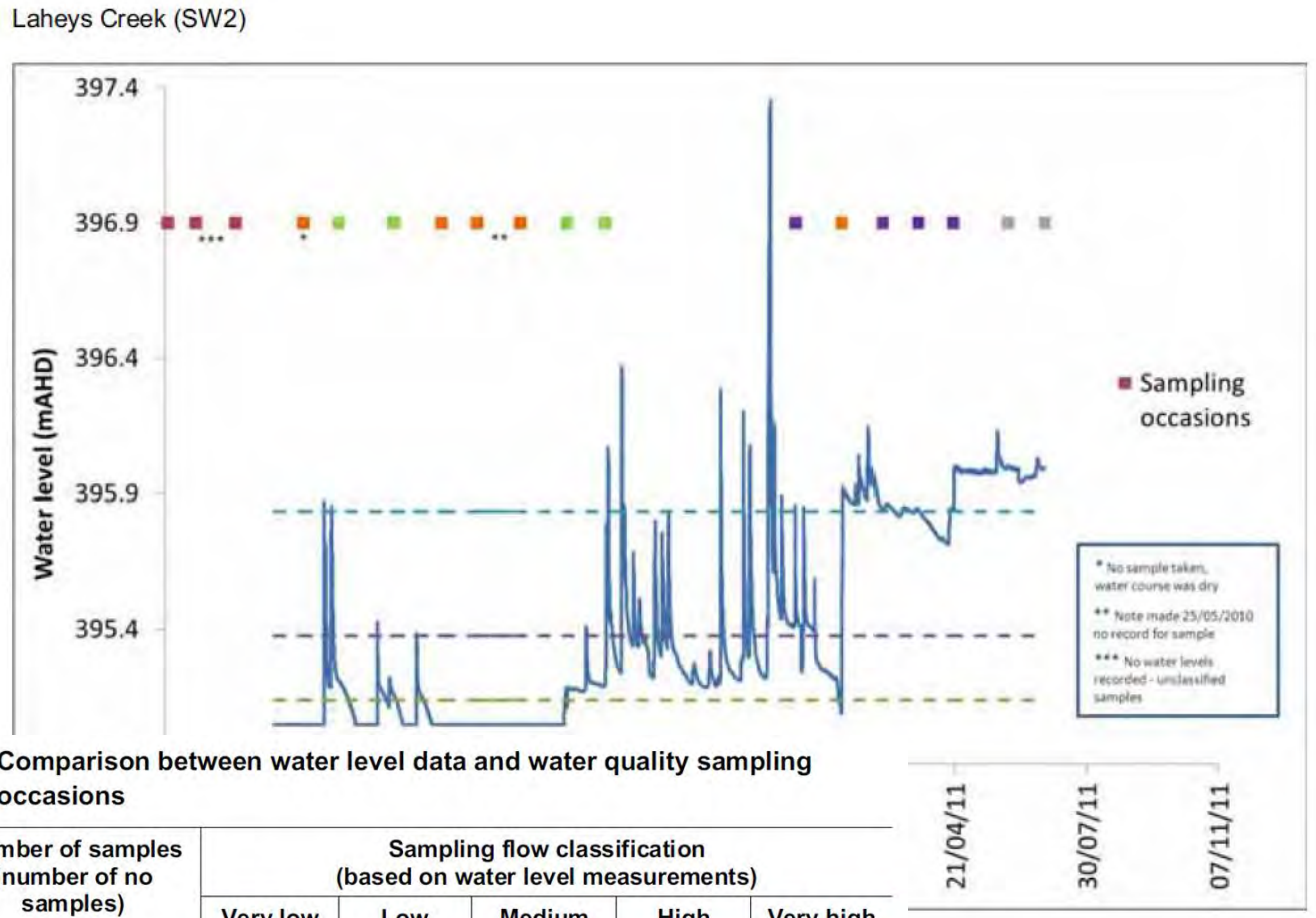


Table 7-1 Comparison between water level data and water quality sampling occasions

Sampling location	Number of samples (number of no samples)	Sampling flow classification (based on water level measurements)				
		Very low	Low	Medium	High	Very high
SW1	14	5	3	4	2	0
SW2	18 (3)	5	4	4	0	2
SW3	18 (5)	4	3	4	2	0
SW4	18	6	2	6	3	1
SW5	15	6	7	0	2	0

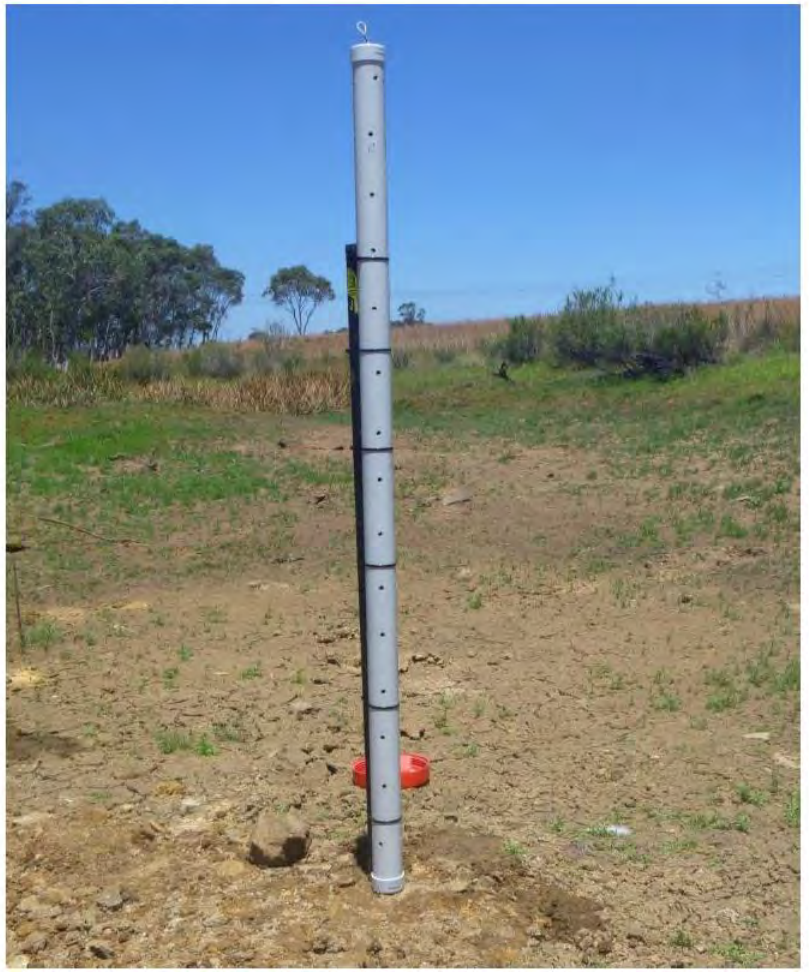
Key: ■ = sufficient samples; ■ = more samples desirable; ■ = more samples required

Data collection approaches

Water level

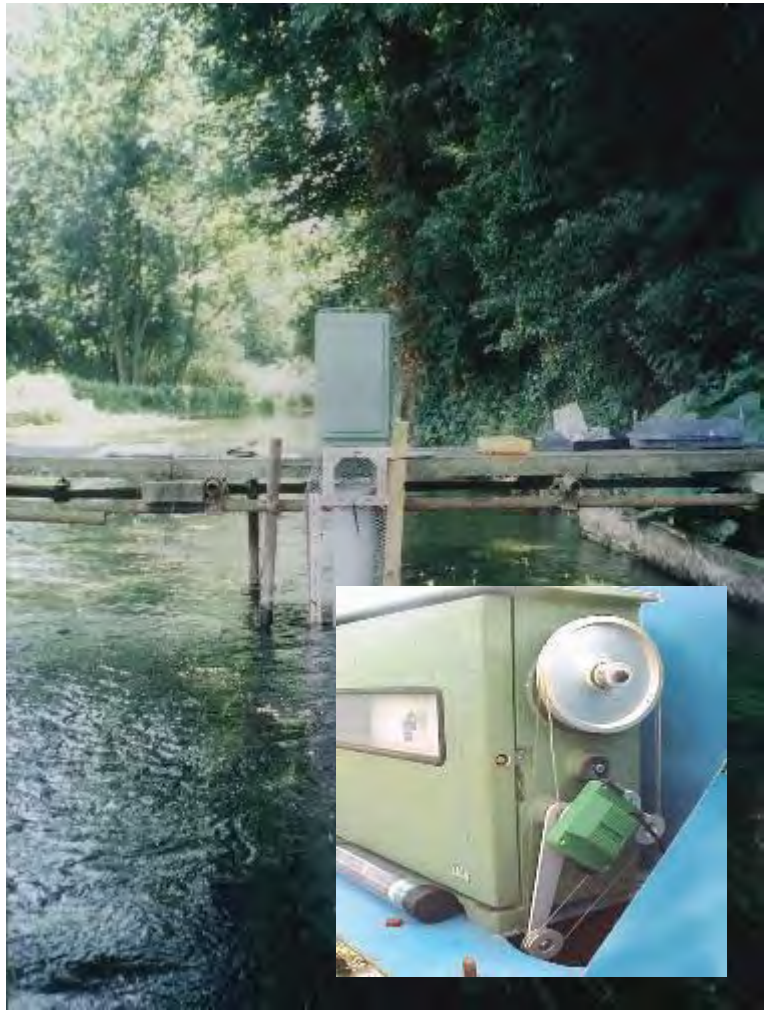
- Water level or flow;
- Spot measurements or higher resolution;
- Maximum depth or depth range;
- Calibration;
- Maintenance; and
- Other supporting data.

Pressure transducer deployment at SW05



Flow volume

- Drum-float charts;
- Current meter;
- Pressure transducer;
- Bubblers;
- ADCP; and
- Surf boards!!



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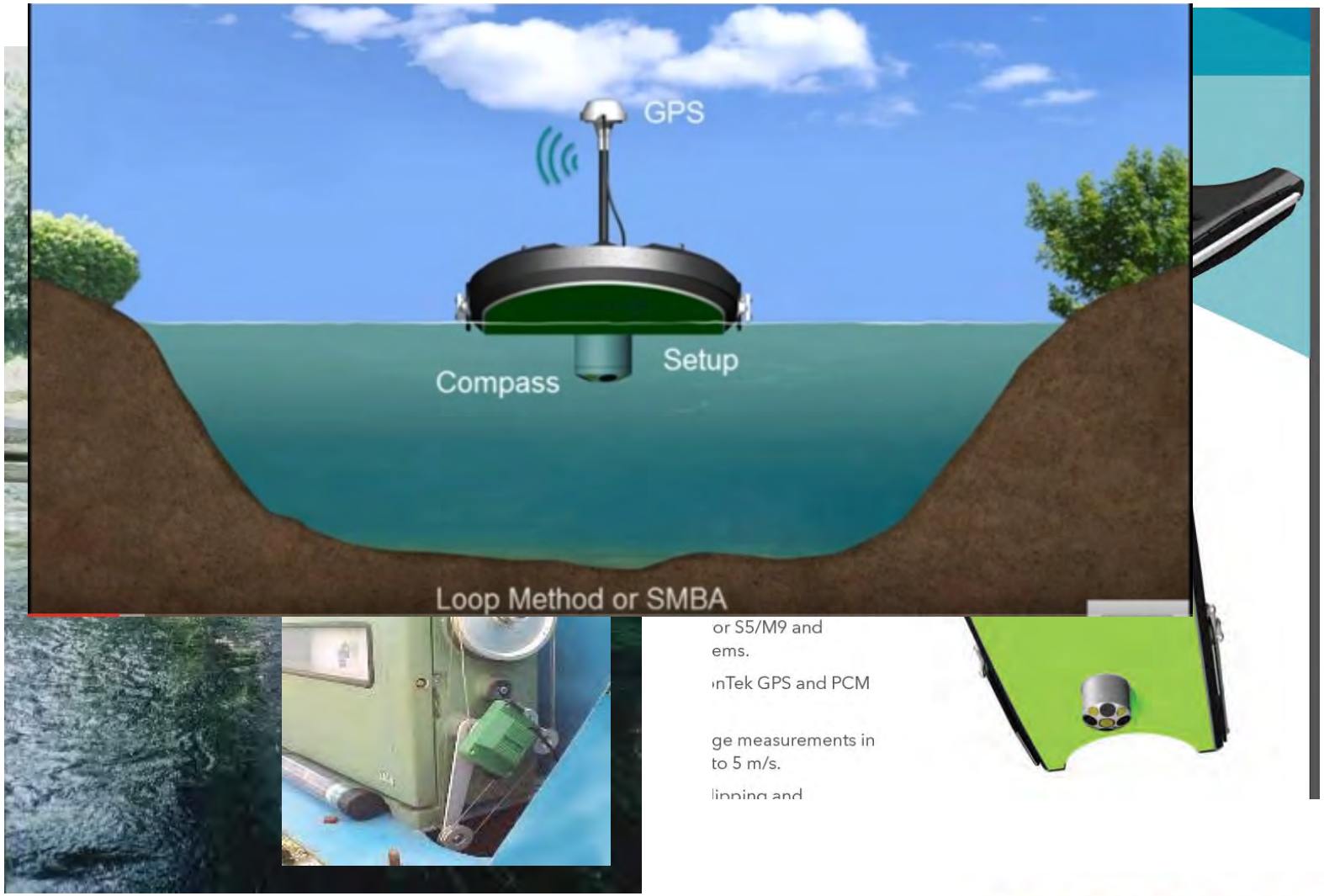

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Discharge Measurement Summary

Date Measured: Thursday, June 27, 2013

Site Information

Site Name	TSW02
Station Number	
Location	

Measurement Information

Party	
Boat/Motor	
Meas. Number	

System Information

System Type	RS-M9
Serial Number	2043
Firmware Version	3.00
Software Version	3.6.0.3384

System Setup

Transducer Depth (m)	0.08
Salinity (ppt)	0.0
Magnetic Declination (deg)	12.0

Units

Distance	m
Velocity	m/s
Area	m2
Discharge	m3/s
Temperature	degC

Discharge Calculation Settings

Track Reference	Bottom-Track	Left Method	Vertical Bank
Depth Reference	Bottom-Track	Right Method	Vertical Bank
Coordinate System	ENU	Top Fit Type	Power Fit
		Bottom Fit Type	Power Fit

Discharge Results

Width	2.495
Area	1.187
Mean Speed	0.161
Total Q	0.191
Maximum Measured Depth	0.617
Maximum Measured Speed	0.433

Measurement Results

Tr		Time			Distance				Mean Vel		Discharge							%
#		Time	Duration	Temp.	Track	DMG	Width	Area	Boat	Water	Left	Right	Top	Middle	Bottom	Total	MBTotal	Measured
2	L	12:00:20 PM	0:02:10	12.5	3.20	1.9%	2.542	1.155	0.025	0.167	0.02	0.00	0.05	0.10	0.03	0.193	--	49.9
3	R	12:07:01 PM	0:03:24	12.4	3.02	1.85	2.449	1.218	0.015	0.155	0.01	0.00	0.05	0.09	0.03	0.189	--	49.0
			Mean	12.5	3.11	1.90	2.495	1.187	0.020	0.161	0.02	0.00	0.05	0.09	0.03	0.191	0.000	49.5
			Std Dev	0.1	0.09	0.05	0.046	0.032	0.005	0.006	0.00	0.00	0.00	0.00	0.00	0.002	0.000	0.5
			COV	0.0	0.029	0.024	0.019	0.027	0.249	0.037	0.089	1.000	0.007	0.020	0.009	0.011	0.000	0.009

Exposure Time: 0:05:34

Tr2=20130627120025.riv; Tr3=20130627120700.riv;

Comments

Tr2=20130627120025.riv - ; Tr3=20130627120700.riv - ;

Compass Calibration

Passed Calibration

Calibration duration = 66 seconds
M12.00 = Magnetic influence is acceptable
Q9 = Magnetic field is uniform
H9 = Complete horizontal rotation
V9 = High pitch/roll

Recommendation(s):
Avoid any changes to the instrument setup or its orientation to the magnetic influences detected during the compass calibration.

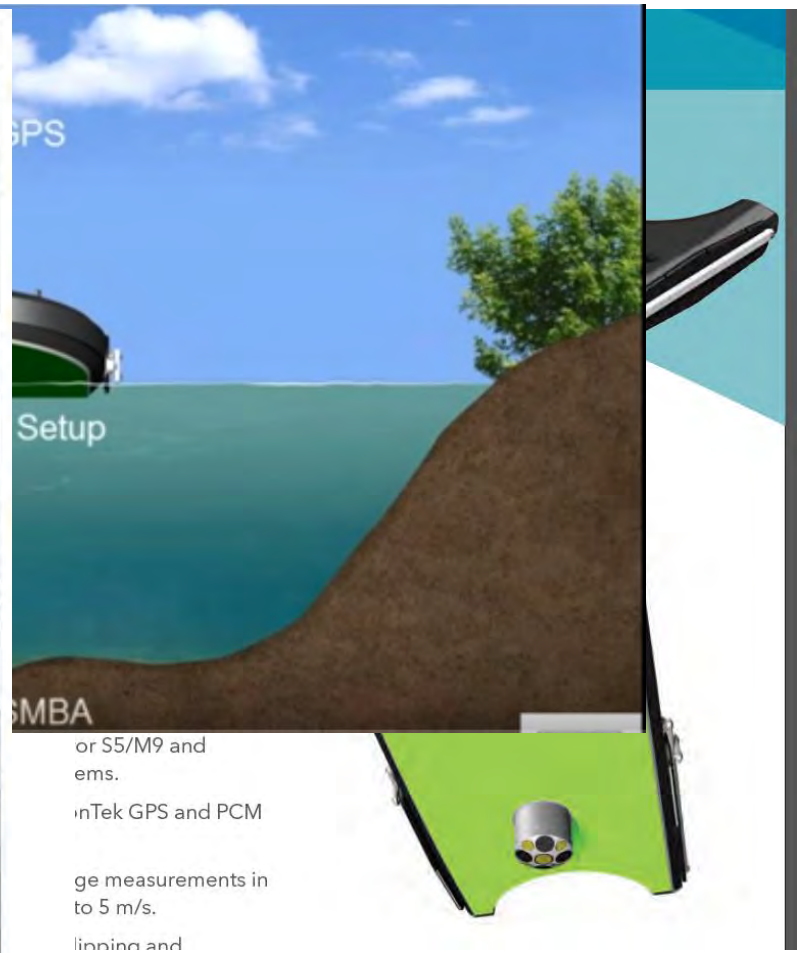
Measurements should be made in locations with similar magnetic influences as the location of the compass calibration.

System Test

System Test: PASS

Parameters and settings marked with a * are not constant for all files

Report generated using SonTek RiverSurveyor Live v3.6.0.3384



or S5/M9 and
ems.

nTek GPS and PCM

ge measurements in
to 5 m/s.

lipping and

Flow volume

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- Current meter;
- Pressure transducer;
- Bubblers;
- ADCP; and
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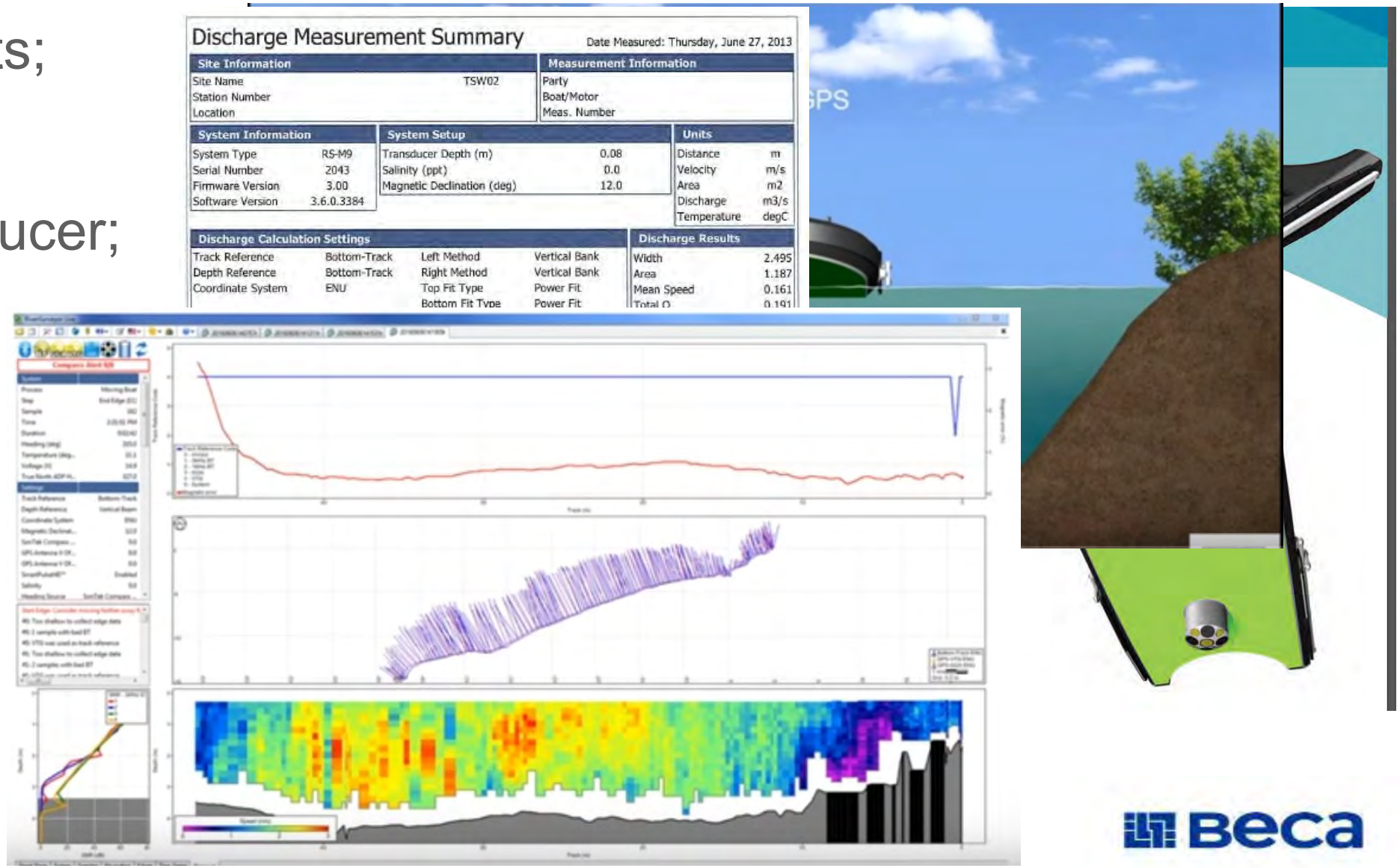
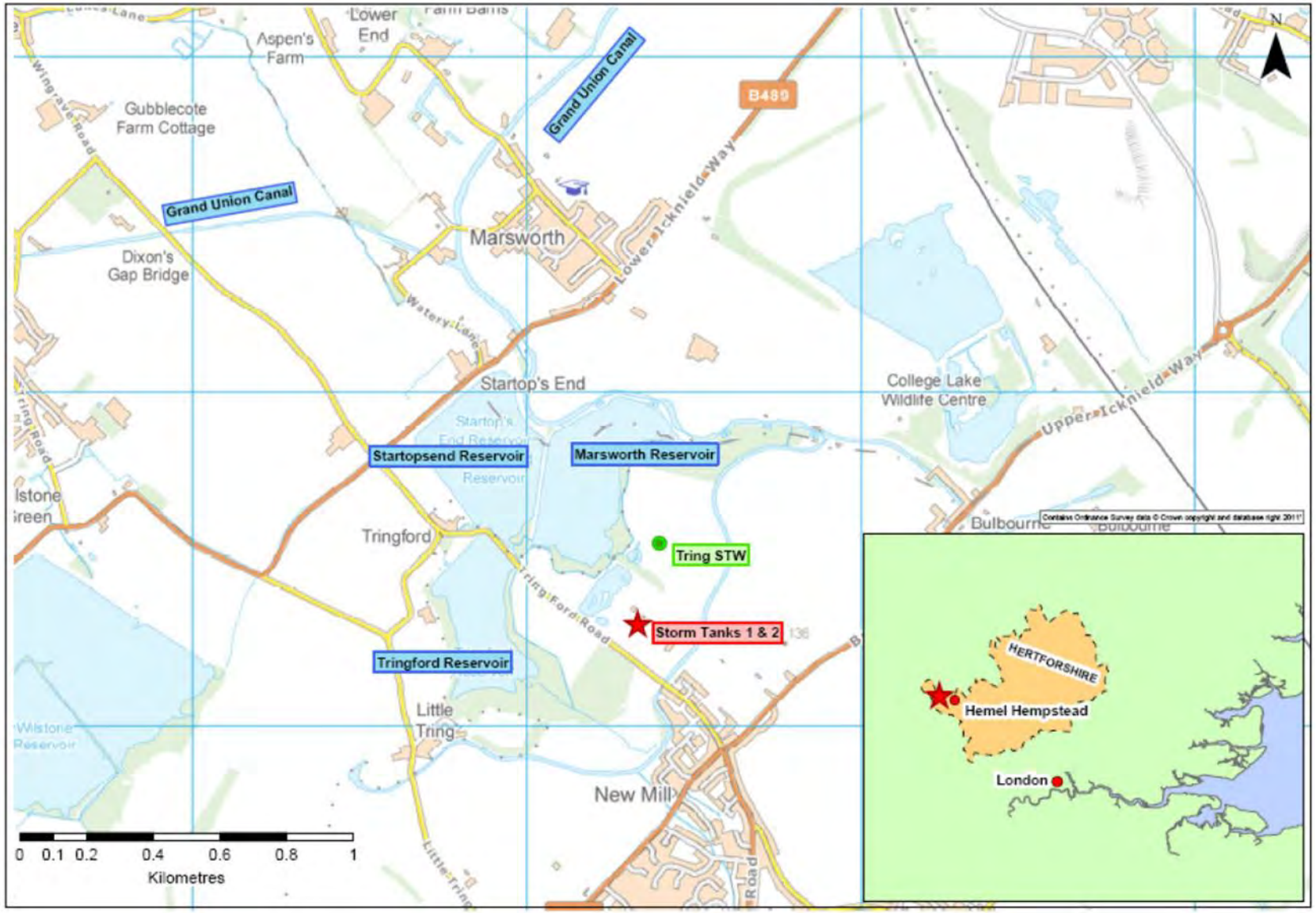


Hydrological connectivity



Hydrological connectivity

Plate 7 – Autosampler set up at sample location 8 (stream by footbridge)

Plate 8 – Autosampler sampling from water flowing into pipe on wetland adjacent to lagoon (sample location 4)

Rhodamine Dye Injection into Wetland

Plate 9 – Rhodamine dye injection into flowing water on wetland (location 3)

Plate 10 – Autosample collection at location 4 as dye approaches pipe feeding to stream running parallel to Thames Water boundary.

Plate 11 – Rhodamine dye beginning to appear in reservoir

Plate 12 – Rhodamine dye front appearing in reservoir

Plate 13 – Rhodamine dye clearly visible flowing up one of the reed bed channels

Plate 14 – Rhodamine flowing further into reservoir

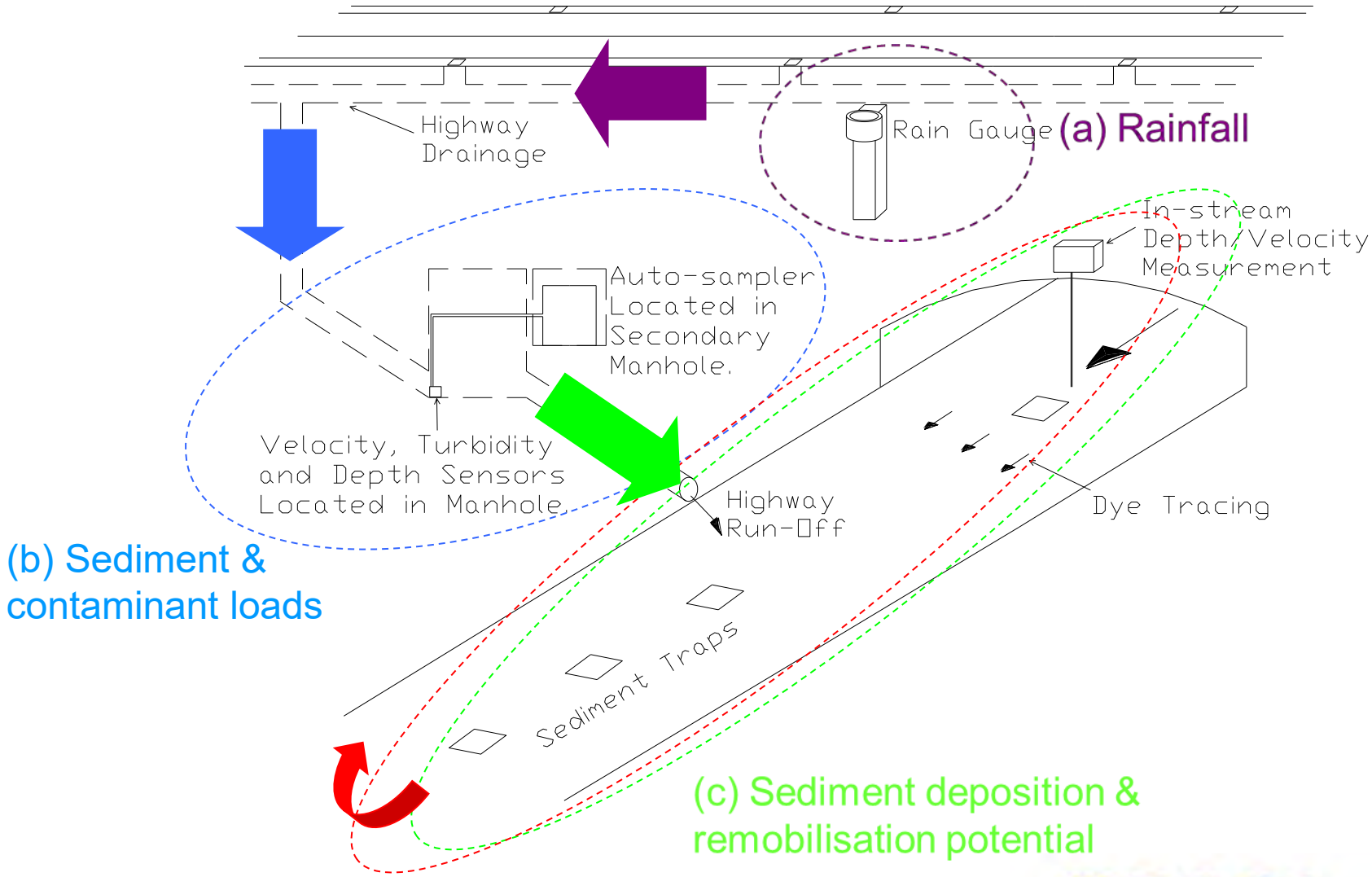
Plate 15 – Rhodamine entering open reservoir (out of the edge of the reed beds), approximately 1.5 hrs after injection

Plate 16 – Majority of rhodamine injected has entered the reservoir after two hours

Plate 17 – Visual impact of rhodamine diminishes after two hours and 10 mins as clear water from the stream flushes throughand dilution/dispersion within the reservoir occurs

Plate 18 – Rhodamine in reservoir almost two and quarter hours after injection of dye

Contaminated storm runoff – pricey!



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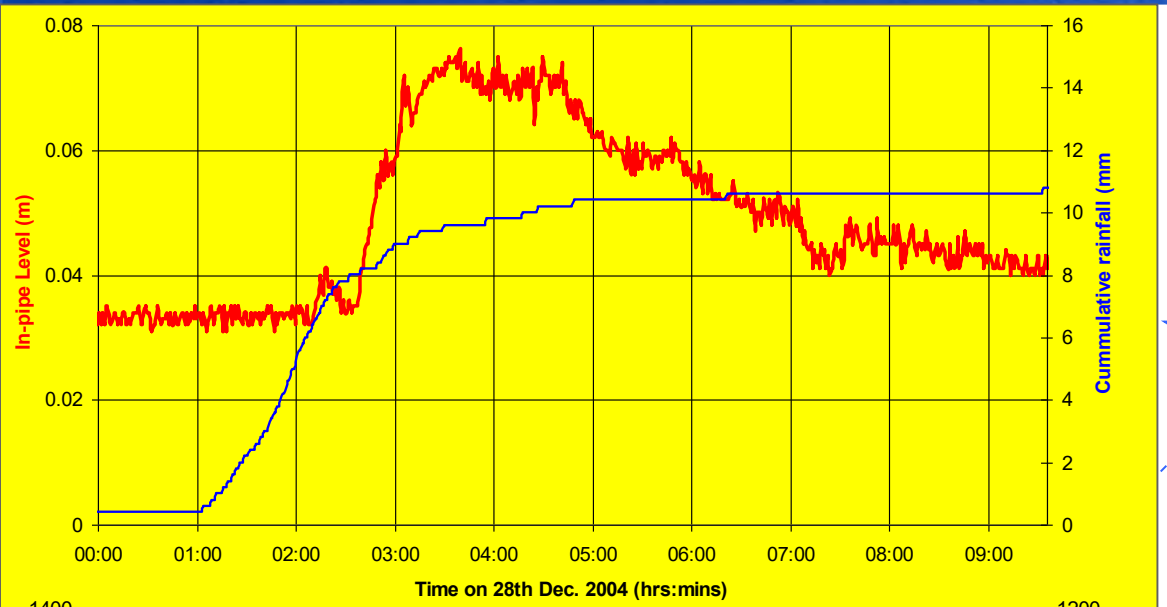
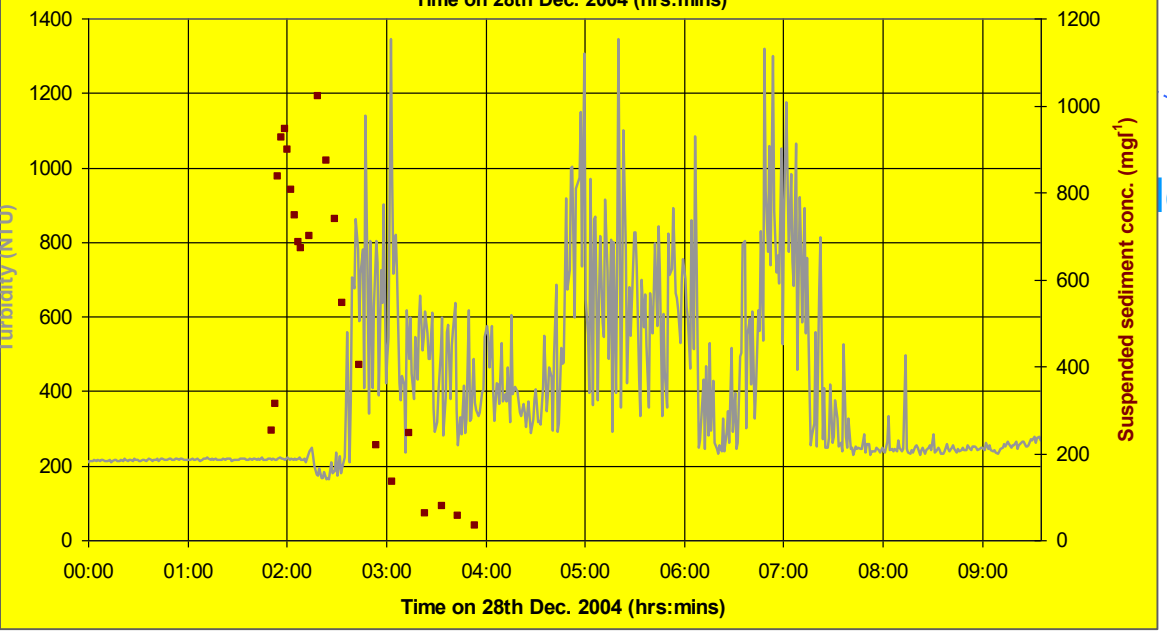
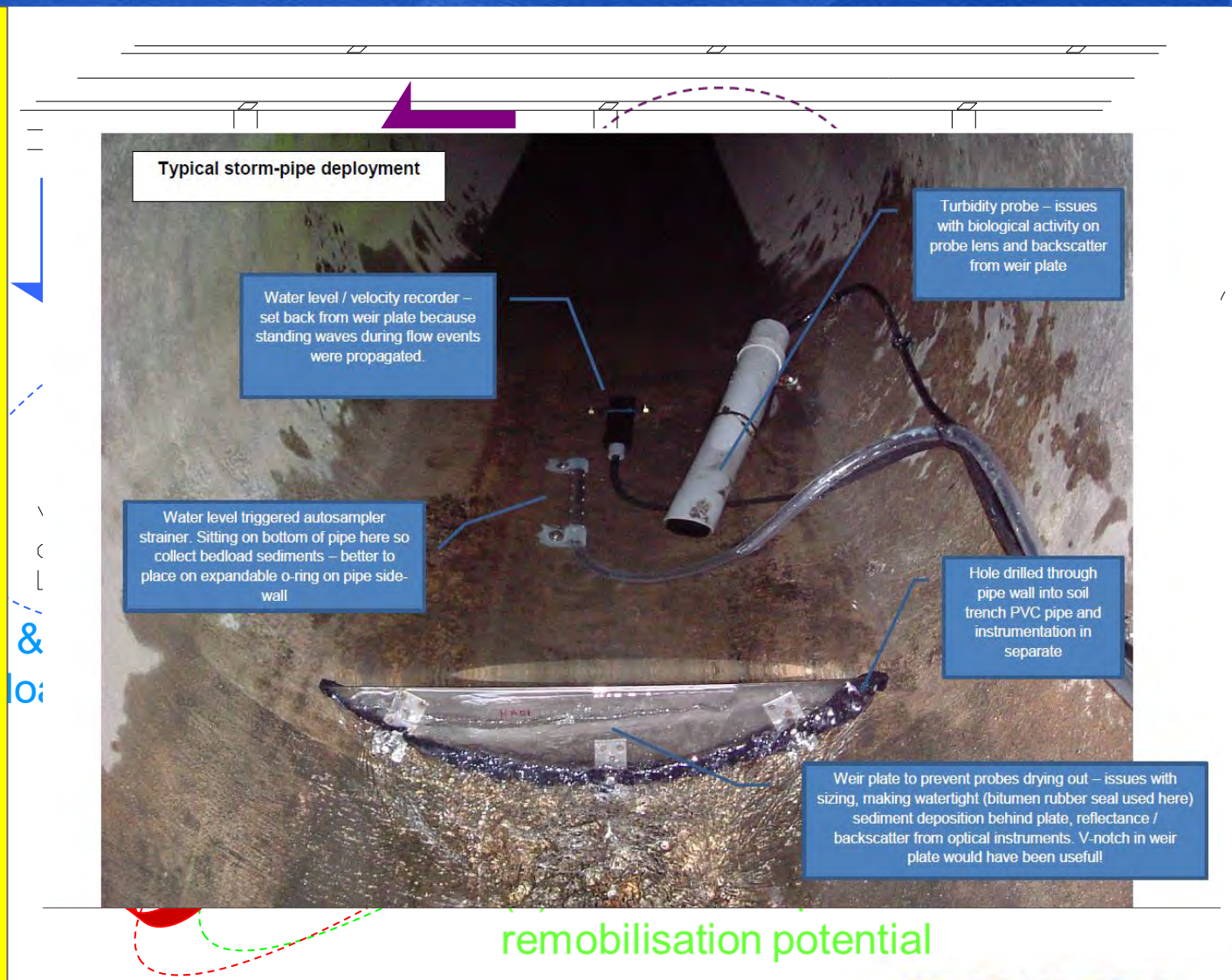






remobilisation potential

(d) Biotic impacts

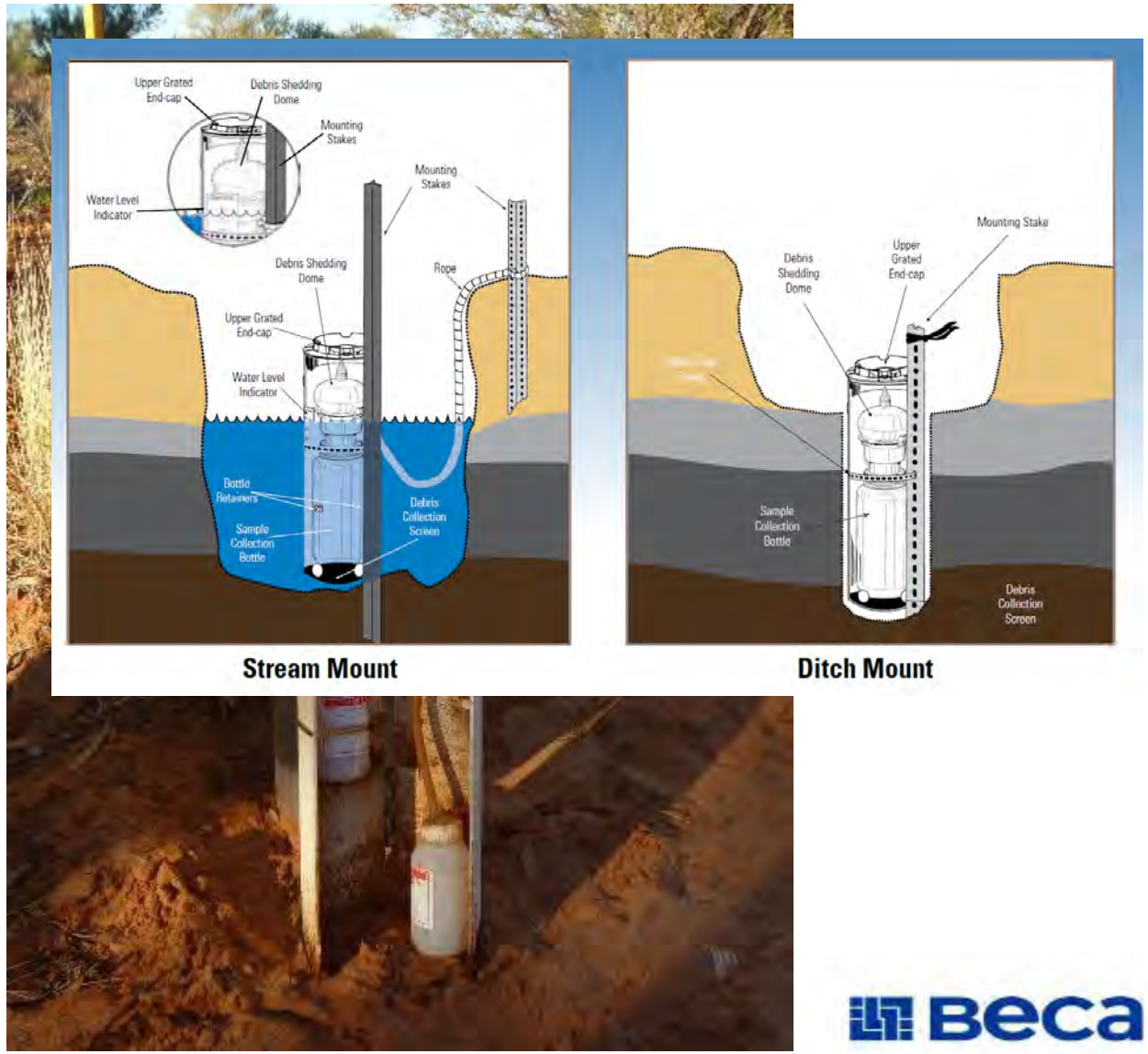
Beca

Contaminated storm runoff on the cheap!

- Remote sites;

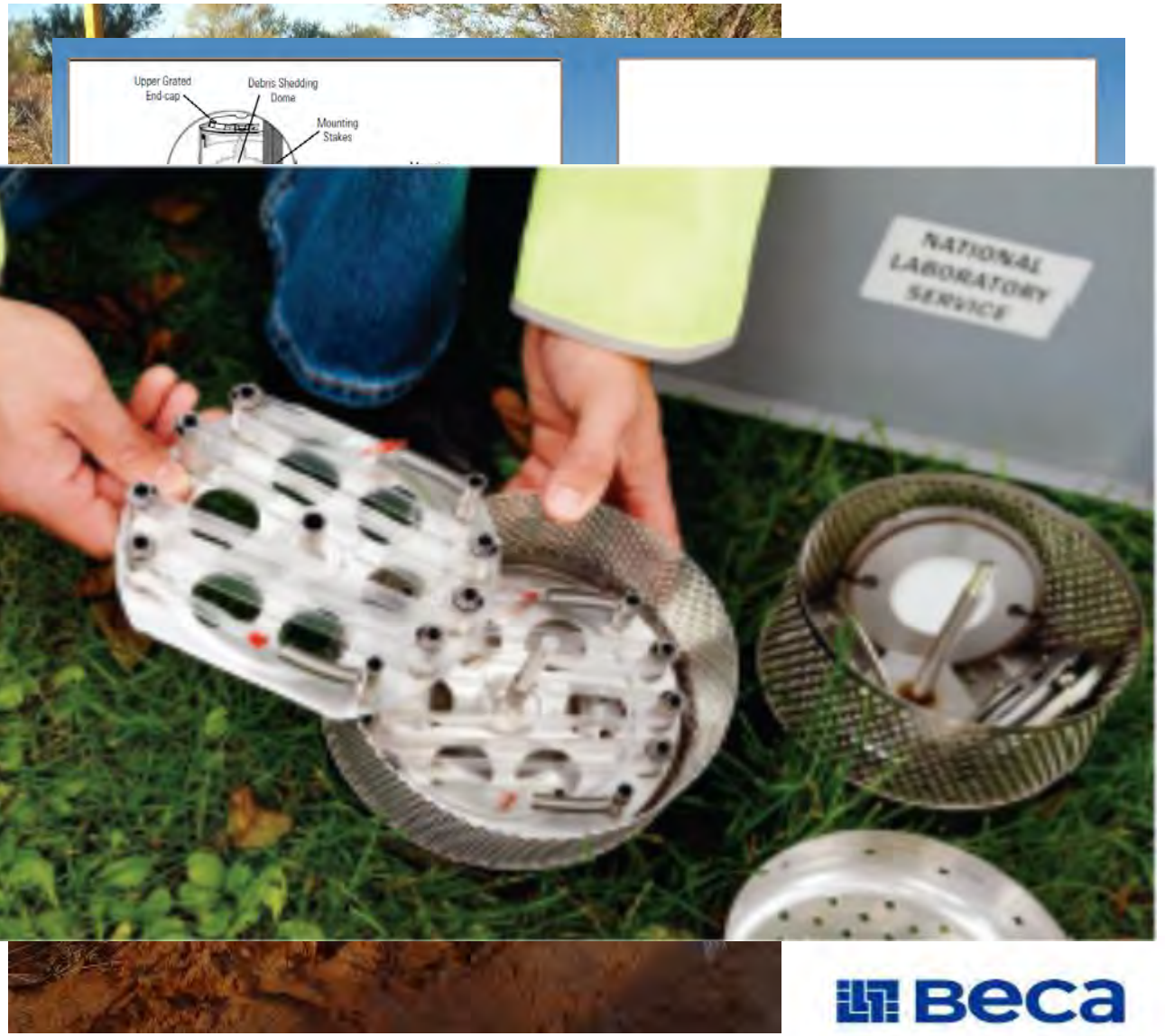
Contaminated storm runoff on the cheap!

- Remote sites;
- Flashy hydrological regime;



Contaminated storm runoff on the cheap!

- Remote sites;
- Flashy hydrological regime;
- Contaminant loading;



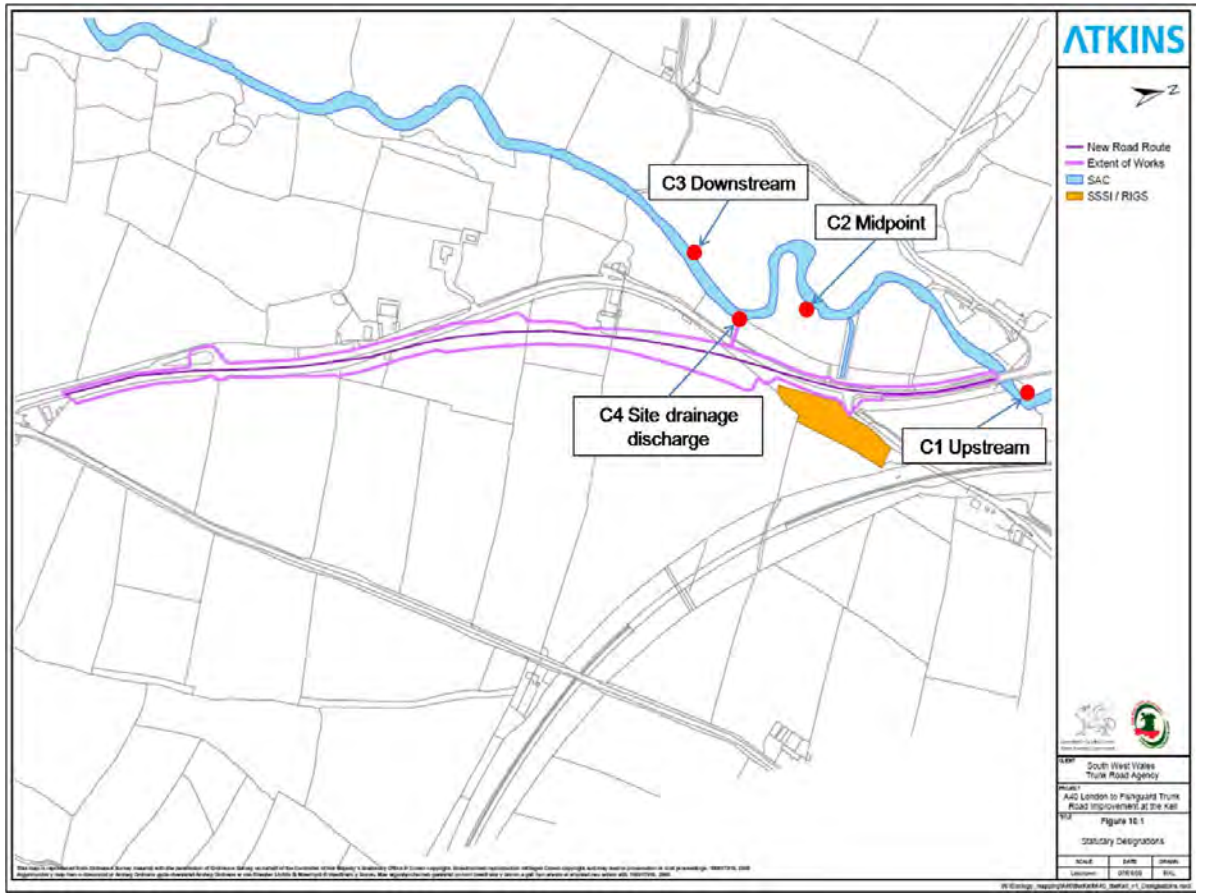
Contaminated storm runoff on the cheap!

- Remote sites;
- Flashy hydrological regime;
- Contaminant loading;
- Turbidity; and
- Inexpensive and low maintenance.

Beca

Rapid changes in water quality

- Capturing data when it counts;
- Chronic versus acute toxicity;



Source: BBC, 2014

Rapid changes in water quality

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Rapid changes in water quality

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- Practical on-site management;
- Stakeholder visibility.

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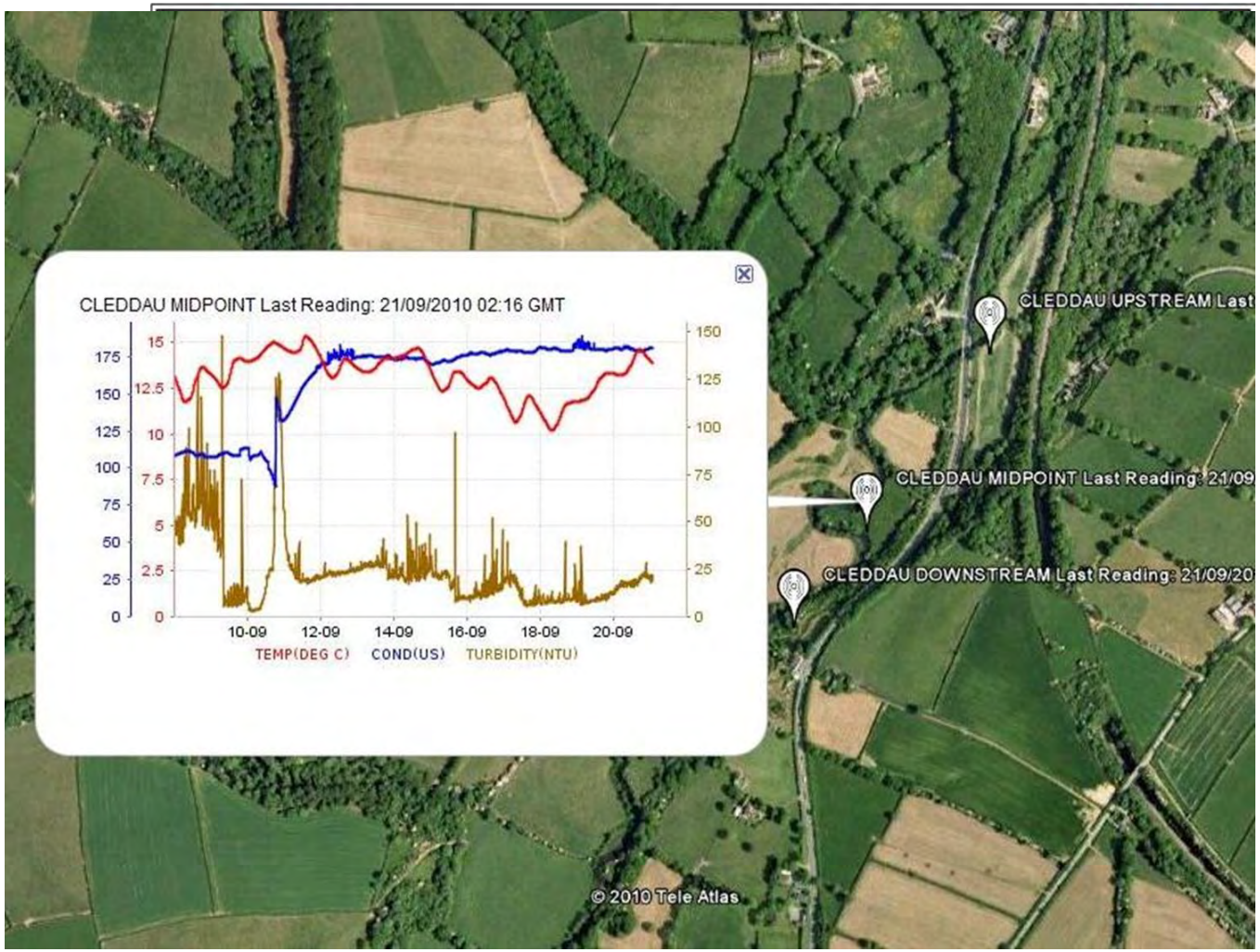

Sediment transport

- Sediment as a natural process or a contaminant;
- Affinity of contaminants to particulate matter – significant source;
- Sediment deposition;

Sediment transport

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Sediment transport

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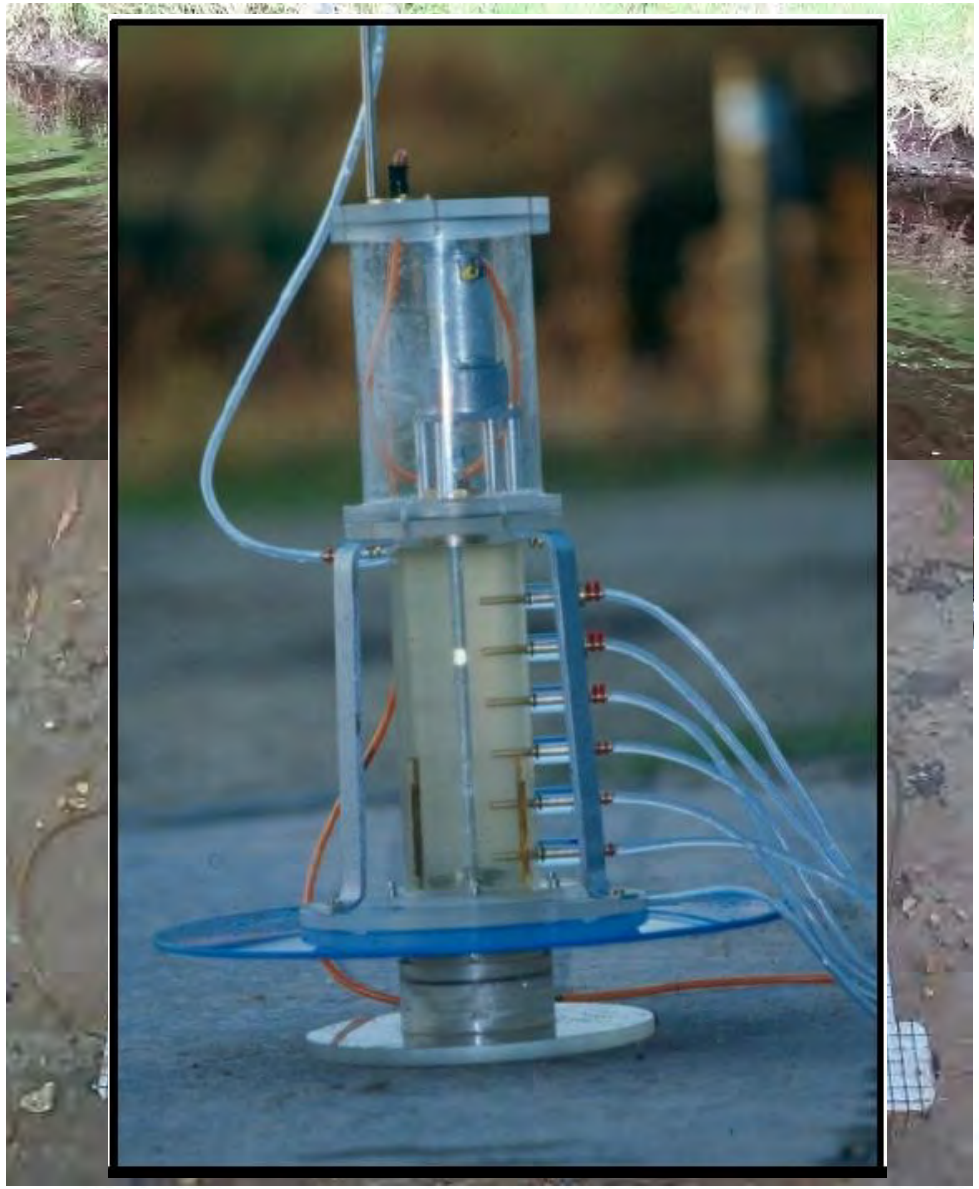
- Affinity of contaminants to particulate matter – significant source;
- Sediment deposition;
- Sediment composition;
- Suspended load or bedload;

Sediment transport

- Sediment as a natural process or a contaminant;
- Affinity of contaminants to particulate matter – significant source;
- Sediment deposition;
- Sediment composition;
- Suspended load or bedload;
- Sink / source;
- Desorption; and
- Guideline values.



Sample integrity

- Filtration (on-site verus lab);
- Storage (dark / cool);
- Appropriate material for sample bottles (LDPE, HDPE, glass, amber); and
- QA / QC procedures (trip blank, trip spike, sample blank, duplicates).

Dr. DJ Evans, Atkins

Assessing Sampling and **Analysis Techniques**

Implications for calculating nutrient and sediment loads

Do water samples collected routinely for monitoring programmes accurately reflect river phosphorus (P) and suspended solids (SS) concentrations? This paper examines several stages of standard sampling, preservation and analysis techniques (SSPAT) for water samples from two lowland UK rivers. Although universal analytical procedures are necessary for data comparison, this paper indicates that adopting a SSPAT approach alone may jeopardise sample representativeness. Therefore, preliminary surveys to assess whether SSPAT protocol is sufficient to quantify P and SS loads are highly recommended.

Introduction

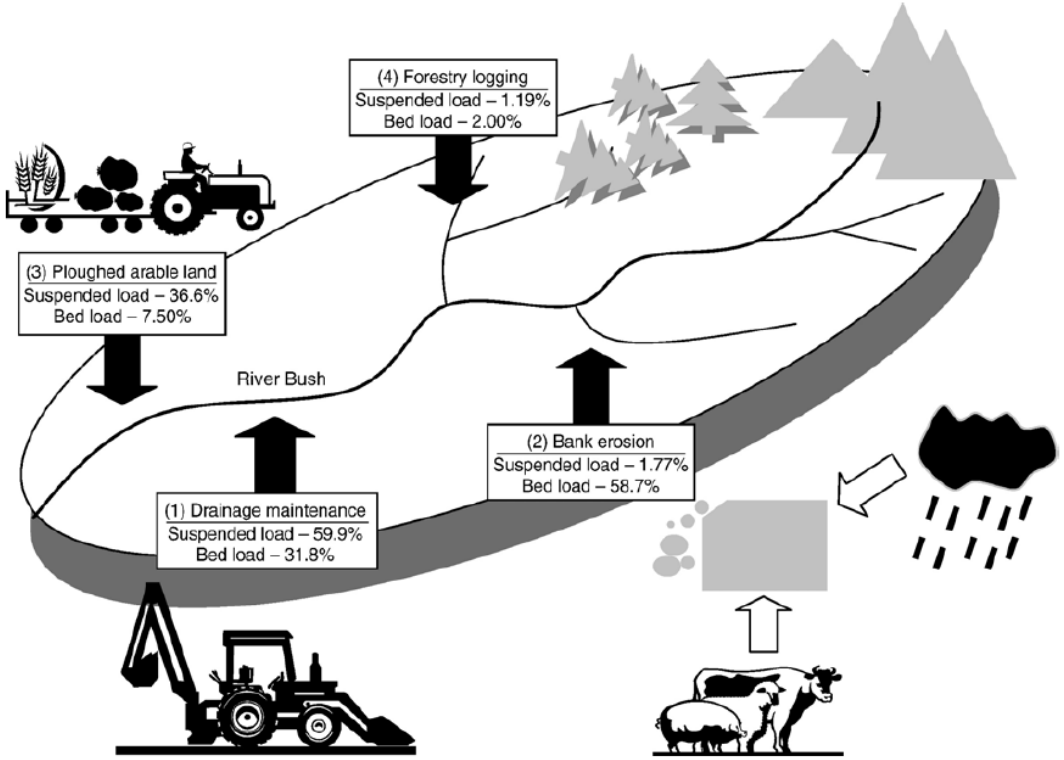
To assess nutrient and sediment mobility within rivers, P fractions and SS concentrations are normally determined on samples collected from the water column[1]. Recommendations for sampling frequency[2] and shortfalls in the laboratory analysis of P[3] are well documented in the literature. However, there are several stages of SSPAT that need more consideration before initialising a P and SS monitoring programme. Loads are derived from the product of concentration and discharge over a specified time increment. However, whilst determining discharge does not normally present any practical problems obtaining representative concentration data is more problematic. Nutrient and sediment loads in river basins are under increased scrutiny in the EU community because the deadline for meeting Water Framework Directive objectives will be implemented in 2015. A crucial question is: do water samples collected routinely in P and SS monitoring programmes accurately reflect actual concentrations in the river? If not, what degree of uncertainty does this generate in loads estimated from these programmes? This paper addresses some of the limitations involved in adopting SSPAT protocol in terms of assessing P and SS mobility within two lowland UK catchments.

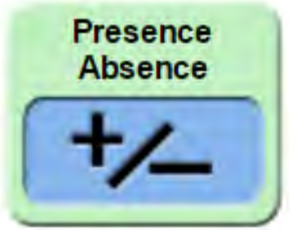
Sample sites

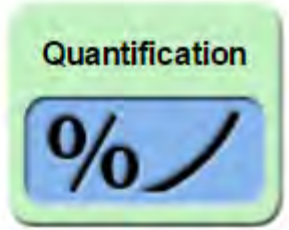
The Rivers Lambourn and Enborne are tributaries of the River Kennet, England (Figure 1). The Lambourn lies on Chalk and has a fast flowing, shallow channel with extensive water crowfoot beds (Ranunculus penicillatus var. calcareous). The regime of the Lambourn is subdued with hydrographs dominated by delayed throughflow and maximum flow in March. The Enborne drains impermeable Tertiary sand, silt and clay deposits. The river has a slow flowing, deep channel with limited submergent macrophytes. The regime of the Enborne is flashy, with maximum monthly flows in December/January, coinciding with maximum precipitation, and hydrographs are dominated by quickflow response.

Laboratory advances

- Detection limits, isomers & matrices (e.g. PFAS);
- Sediment fingerprinting;
- Microbial Source Tracking; and
- Online access through chain of custody.







Source Molecular, 2016

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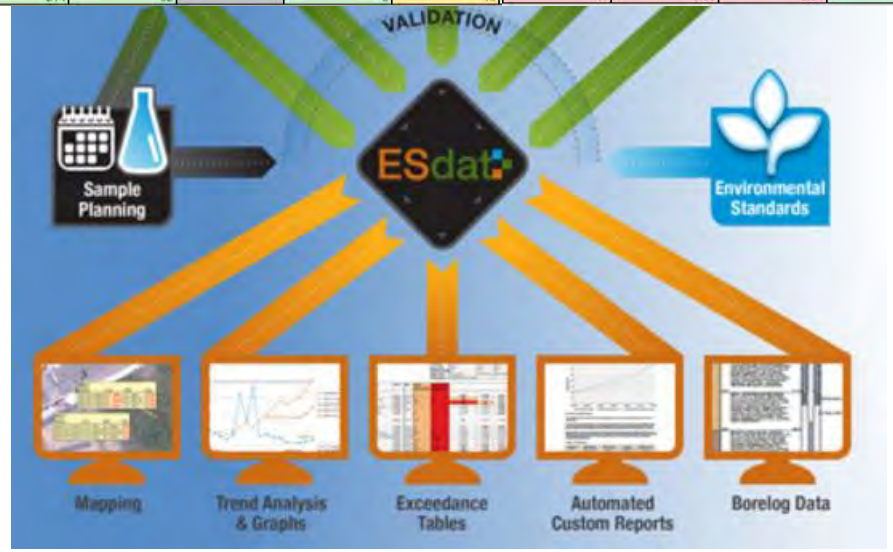
Data storage and interrogation

- Data for data's sake?
- Make data work for you;
- Asset loss;
- In-house Excel conditional formatting;
- MS Access;
- Commercial data management software;

		Total Dissolved Solids	Total Hardness as CaCO3	Turbidity	Sulfate as SO4 - Turbidimetric	Chloride	Total Nitrogen as N	Total Phosphorus as P	Reactive Phosphorus as P	pH	Electrical Conductivity
Units		mg/L	mg/L	NTU	mg/L	mg/L	mg/L	mg/L	mg/L	pH Unit	µS/cm
Aquatic ecosystems (upland River)				25		0.003	0.25	0.02	0.015	6.5-7.5	350
Livestock drinking water		2000			1000						
Irrigation STV											
Irrigation LTV											
Recreational		1000	500		400	30					
Drinking (aesthetic)			200	5	250	250				6.5-8.5	
Drinking (Health)		600		1	500					6.5-8.5	
LOR		1	1	0.1	1	1	0.1	0.01	0.01	0.1	1
SWQ01	24/04/2012	161	71		0.5	46	1	0.05	<0.01	7.3	181
	21/05/2012	138	102	3.2	0.5	65	0.5	0.01	<0.01	7.5	214
	27/06/2012	194	84		2	61	0.09	0.02	<0.01	7.7	324
	18/07/2012	201	82	6.7	2	72	0.6	0.21	<0.01	7.6	211
	14/08/2012	242	106	4.8	1	94	0.3	0.04	<0.01	7.6	374
	6/09/2012	284	132	3.5	1	95	0.4	<0.01	<0.01	7.1	436
	17/10/2012	263	110	8	2	80	0.7	0.05	<0.01	7.7	404
	7/11/2012	306	132	2.5	2	94	0.6	0.04	<0.01	7.2	472
	13/12/2012										
	7/01/2013										
SWQ02	24/04/2012	192	82		29	45	1.3	0.56	<0.01	7	200
	21/05/2012	254	139	20.9	117	55	0.4	<0.01	<0.01	6.7	302
	27/06/2012	226	111		50	56	0.7	0.12	0.01	6.9	377
	18/07/2012	242	112	8.6	49	70	0.5	0.02	<0.01	6.9	246
	14/08/2012	288	128	4.2	100	81	0.2	<0.01	<0.01	6.8	443
	6/09/2012	306	146	12.3	105	73	0.4	0.03	<0.01	6.5	478
	17/10/2012	264	110	12.7	53	69	0.5	0.01	<0.01	7.2	406
	7/11/2012	364	172	3.9	118	83	0.4	0.02	<0.01	5.6	559
	13/12/2012	341	146	0.6	104	80	0.2	<0.01	<0.01	4.7	525
	7/01/2013	331	143	1.5	90	73	0.1	<0.01	<0.01	6.6	510
	24/04/2012	214	92		5	45	1.4	0.08	0.04	7.2	207



Data storage and interrogation

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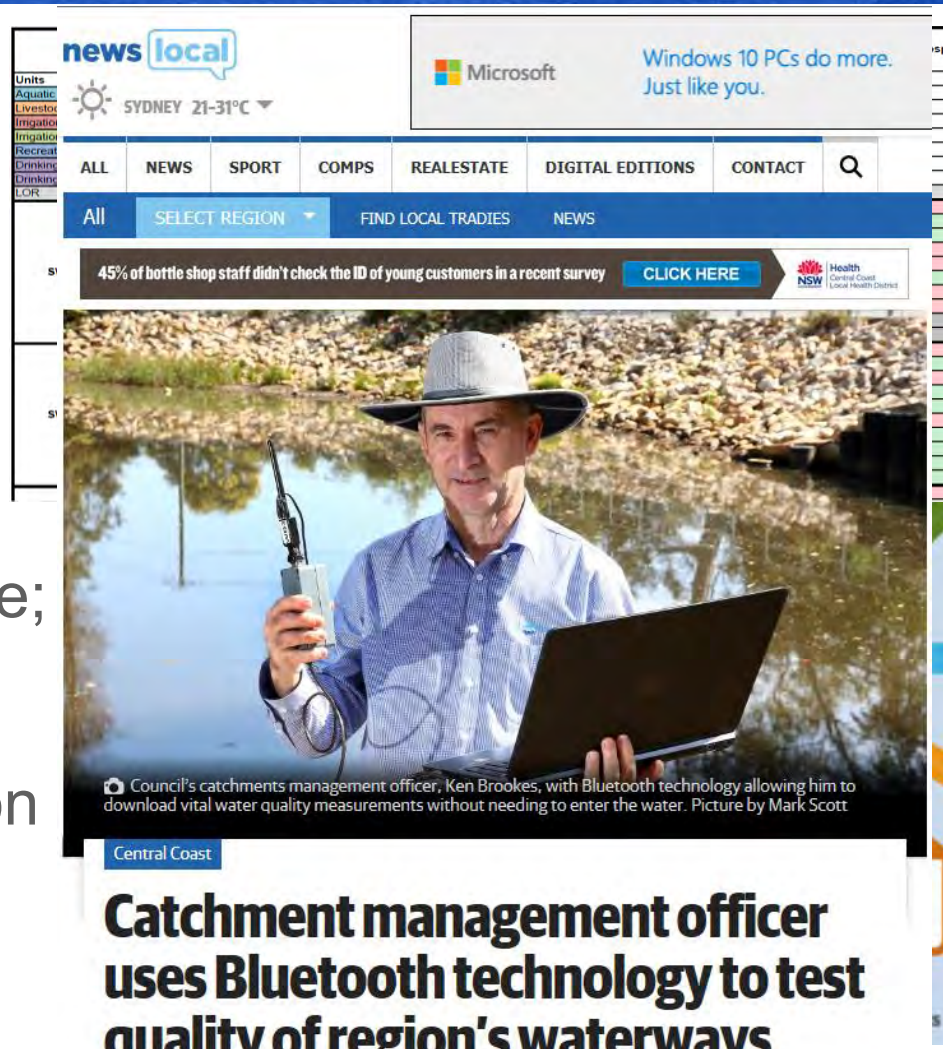
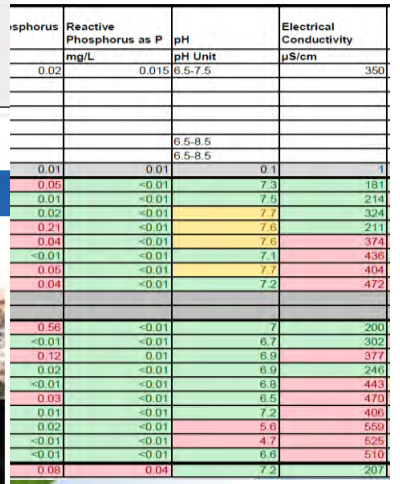
- Commercial data management software;
- GSM / Bluetooth data transfer; and
- The ‘Internet of Things’ - interconnection via the Internet of computing devices enabling data send and receive data.





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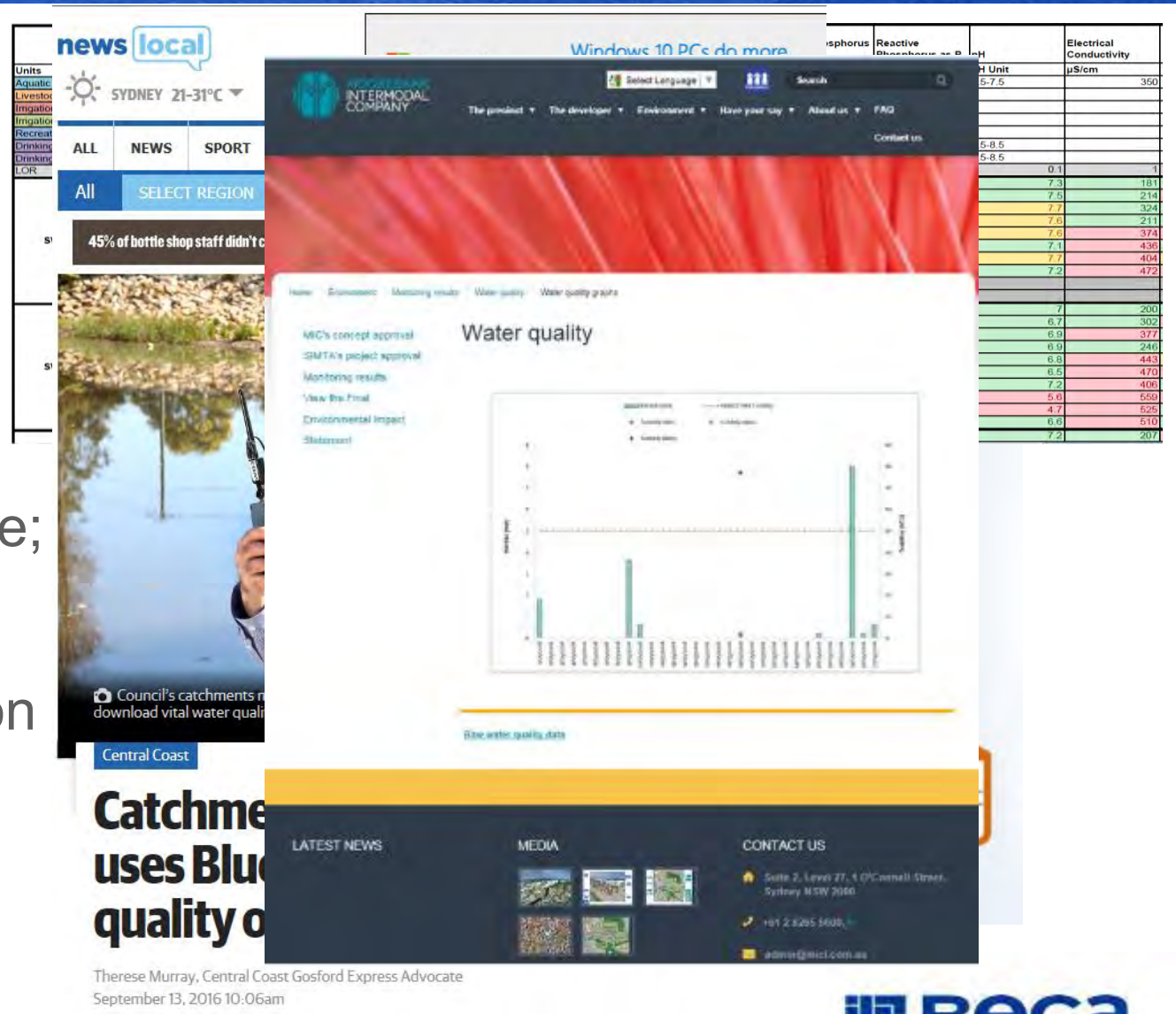

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Health & Safety

- Health & Safety representatives v practitioners v local experience;
- Working near water;
- Two people;
- Driving; and
- When things go wrong.

Acknowledgements

Environment Institute of Australia and New Zealand Inc.

ThermoFisher SCIENTIFIC

xylem Let's Solve Water

EXPERIENCE MATTERS

AHA Conference 25th October 2016 Southern Cross Club, Woden, ACT

James Price

Thank you, any questions?

dan.evans@beca.com

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