ATTACHMENTS MINUTES

Waiāri Kaitiaki Advisory Group Meeting

Wednesday, 10 August 2022

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How we undertake Flow Monitoring

Environmental Monitoring Technicians:

Julie Proud & Eddie Bowman

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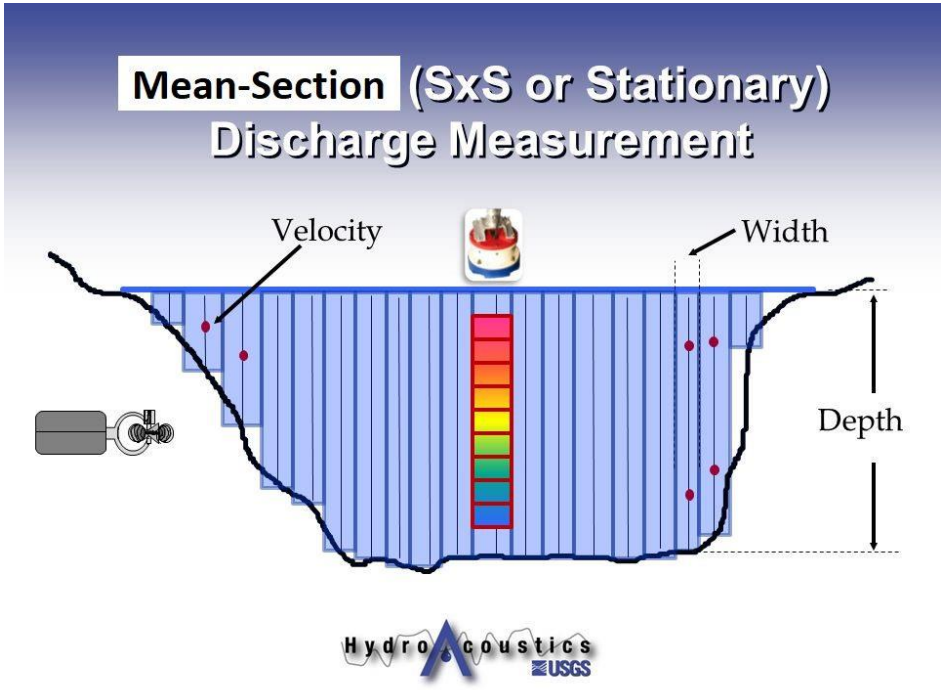
Topics we'll cover

- **The Theory behind how flow is measured**
- **Gauging Methods (ADCP and Others)**
- **Stage-Discharge Rating Curve Analysis**
- **QA Standard = ISO 9001**
- **Discuss the specifics of the Waiari Stream**
- **Q + A Session**

How Discharge (Q) is derived

- X-sectional Area x Mean Velocity
- A tagline is set up across the river at the chosen gauging section.
- River width is divided up into Verticals (around 20) and depth measured, this along with the width measurement give you the area for each section.
- Add these up for all the sections and you get the overall area of the x-section.
- Take Velocity measurements at each Vertical, average these overall to get the mean Velocity.



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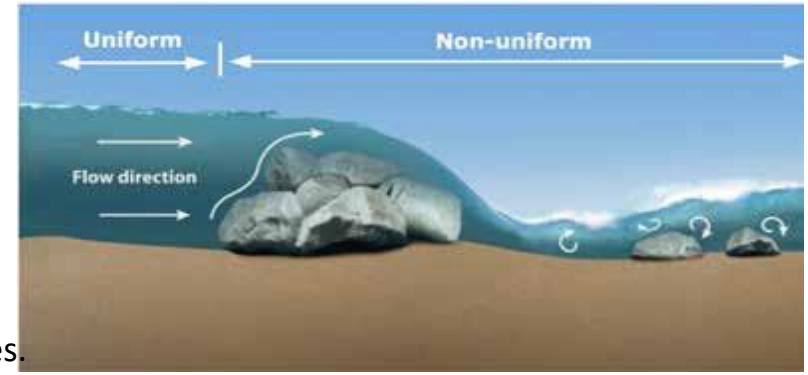
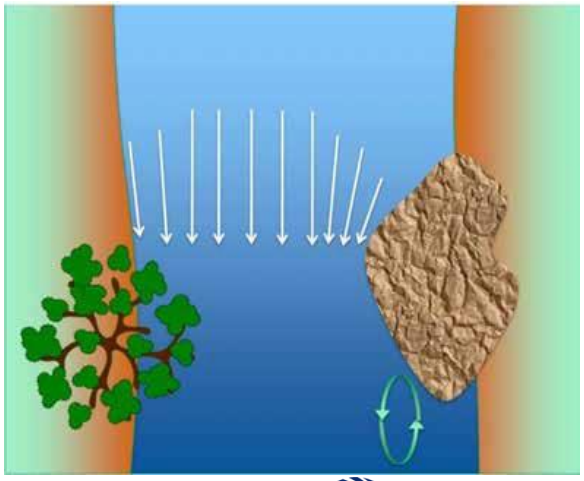
Site Selection: for gauging



- Steady uniform flow conditions.
- Straight length of channel with uniform cross-section and slope (10 times section width).
- Uniform velocity distribution over the cross-section.
- Approach velocities should be smooth and free of disturbances.
- Flow in the stream should be confined to a single well-defined channel.
- Wide flood plains and secondary channels during floods should be avoided.
- Bends upstream of monitoring site could create skew flows.
- Steep slopes upstream of monitoring site could cause turbulent and unsteady flow conditions.
- Roughness of the riverbed and banks must be investigated at the site to determine what impact it will have on the velocity distribution.
- Avoid prominent obstructions in a pool that can affect the velocity pattern.
- Aquatic plants can affect acoustic Doppler operation & Ratings.
- Access to the site during flood events is important.



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Acoustic Doppler Current Profiler (ADCP) and others

- ADCP Stream Pro/River Pro
- Current meter
- FlowTracker – used in rivers that are wadable.

- At Waiari we mostly use the ADCP StreamPro off the slackine using the SxS method described in slide 4.

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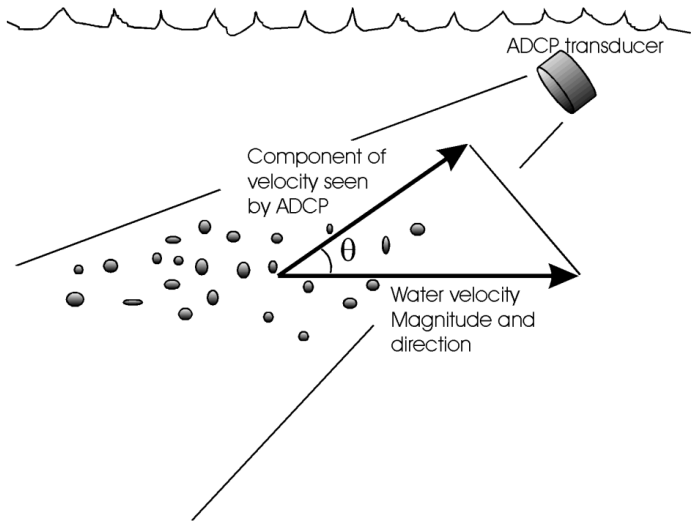
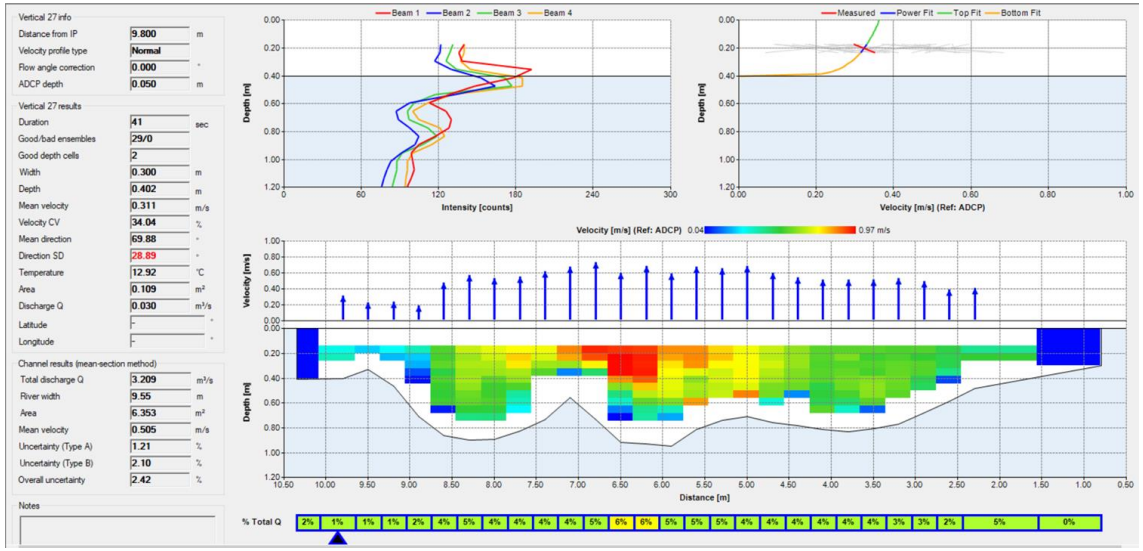
ADCP Transducers

- Ceramic element protected with a urethane coating
- The red circles denote the 4 transducer faces.
- Each produces sound waves (pulses) through the water column and then listen to returning sound waves, resulting in a velocity along that beam. It also measures the depth at the same time.

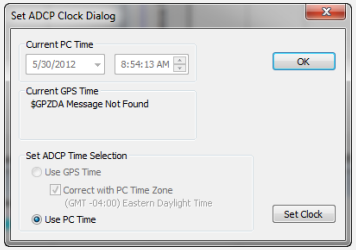


Monitors data in (near) real-time

- Data displayed as collected using Winriver SxS Pro
- Large amount of data



Pre-measurement



- Set ADCP Time
- Run diagnostic test
- Calibrate compass
  - Use internal compass calibration procedure
  - Calibration is only REQUIRED if GPS or loop correction method is used, but is recommended
- Start ADCP pinging without recording
- Measure and record independent water temperature and salinity (should verify with 2 degrees C)

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Verify Measured Q vs Rated Q (SOP)

- Measurements much be processed as completely as possible before leaving site.
- If Qm plots > 8% of rated Q, is there an obvious reason for this change (photos)?
- If no explanation, make a check measurement
- Change as much as possible during check measurement:

  Equipment (ADCP, FlowTracker, other meter), method (midsection), laptop, deployment, x-section, configuration, operator, etc)

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Carrying out an ADCP Moving boat gauging

The following video shows how an ADCP gauging is carried out from start to finish, using the moving boat method. While this isn't the exact technique we use at the Waiari site, it demonstrates how the instrument is used and the processes we go through to get a good gauging.

- https://www.youtube.com/watch?v=fcPb-gLa6eY

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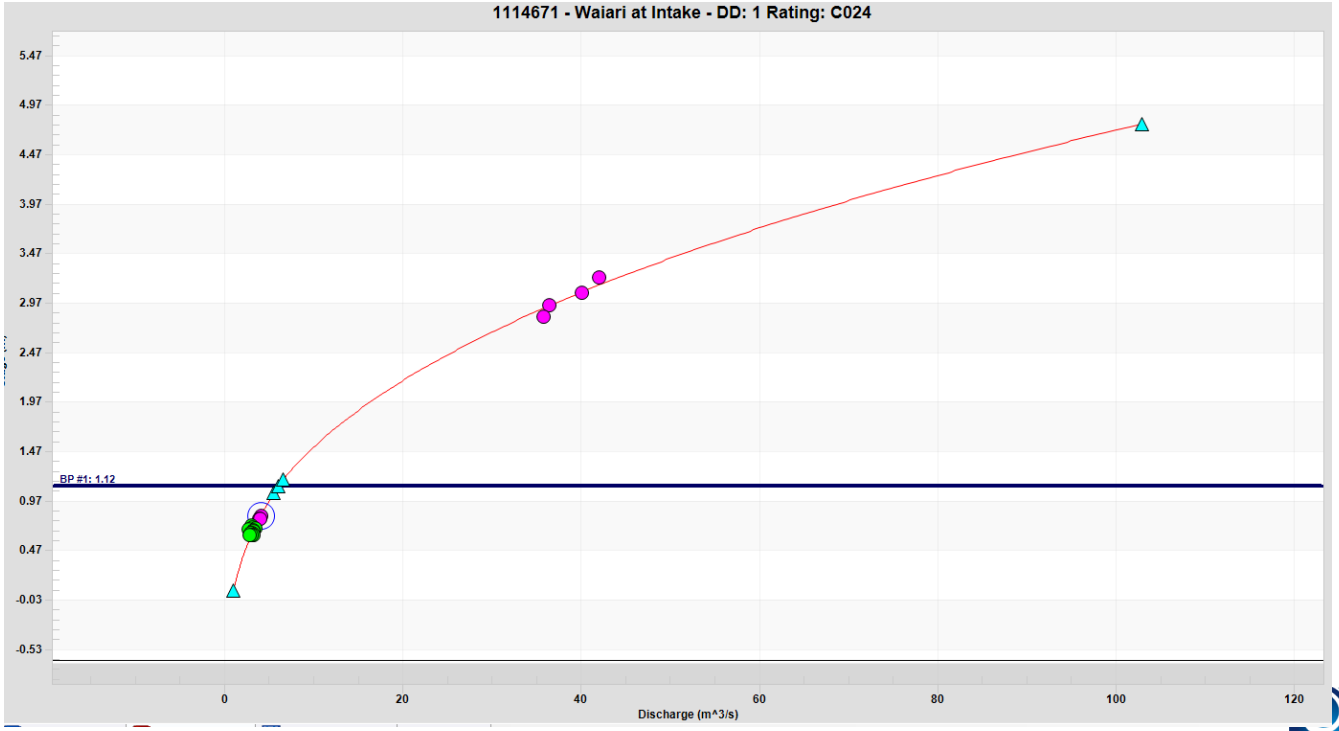
Stage-Discharge Rating Curves (Rating)



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What is a stage-discharge Rating curve?

- A model that relates the height of water (Stage or Gauge Height) at a location on a stream to the volume of water flowing past that location over some time interval (Discharge)

- This is known as a “simple stage-discharge rating” - stage is the only predictor or is the surrogate for discharge (as discharge can’t be measured directly – yet!)

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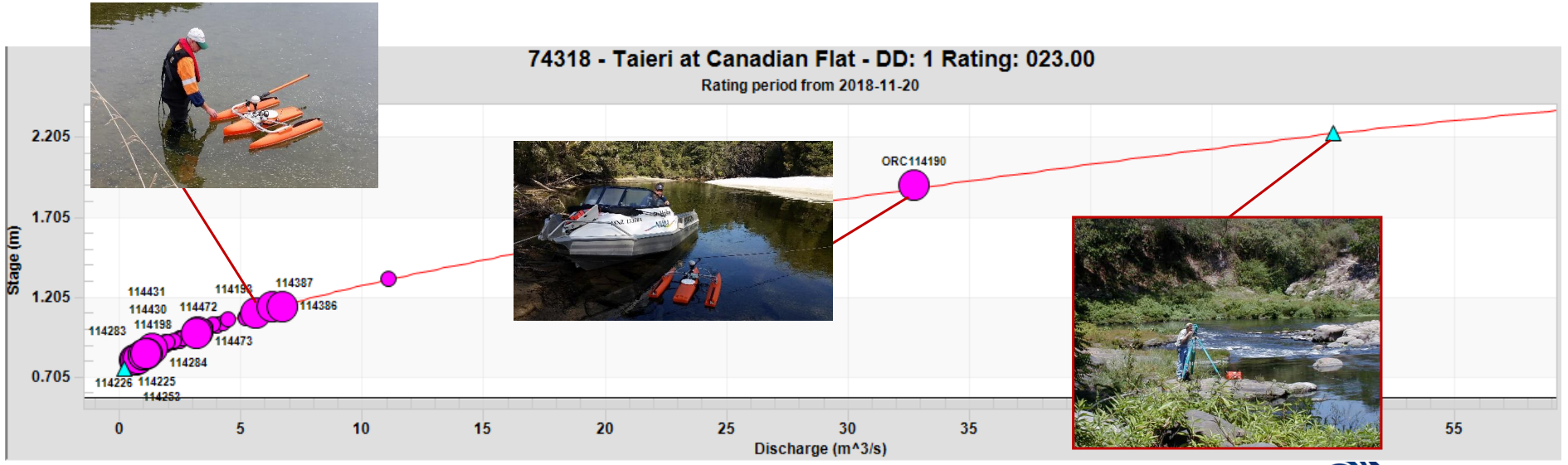
Stage-Discharge Rating curves are developed by making direct and indirect discharge measurements

- Pairs of known discharges and associated gauge heights



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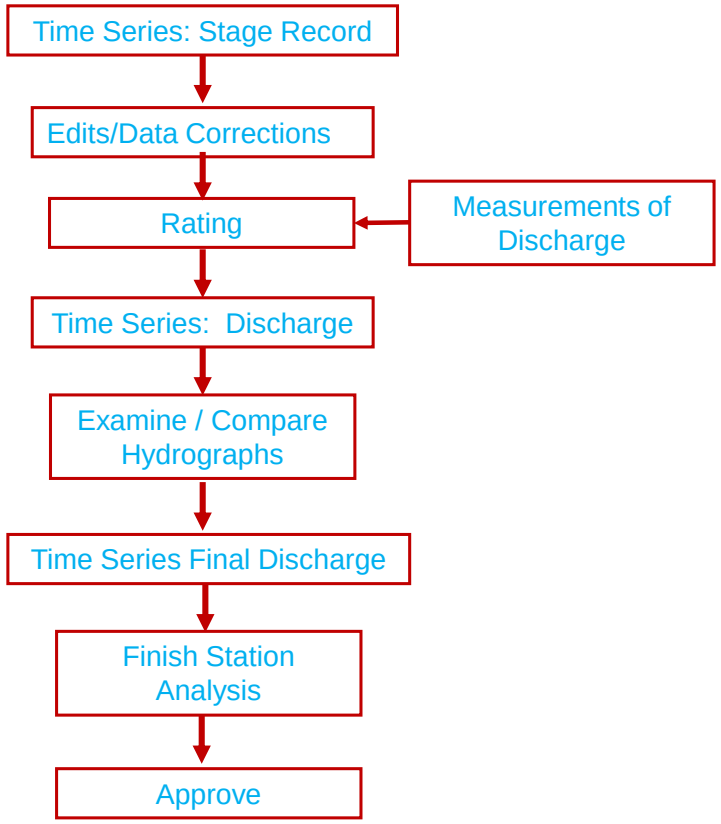
Rating curves and streamflow records computation



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Definition of a Control

- The combination of reach and channel geometry that makes water-level a function of flow (Rating).
- The downstream features that cause water-level to rise as flow increases.
- Provides sensitivity to a stage-discharge relationship.


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Rating Curve Method is “Dynamic”

- Measurements of discharge define changes to hydraulic controls
- Stage data are analysed and used to assume how the control likely changed
- Rising flows generally cause scour
- Decreasing flow generally cause fill
- Ratings are applied such that the curve changes in accordance with how the control was assumed to have changed

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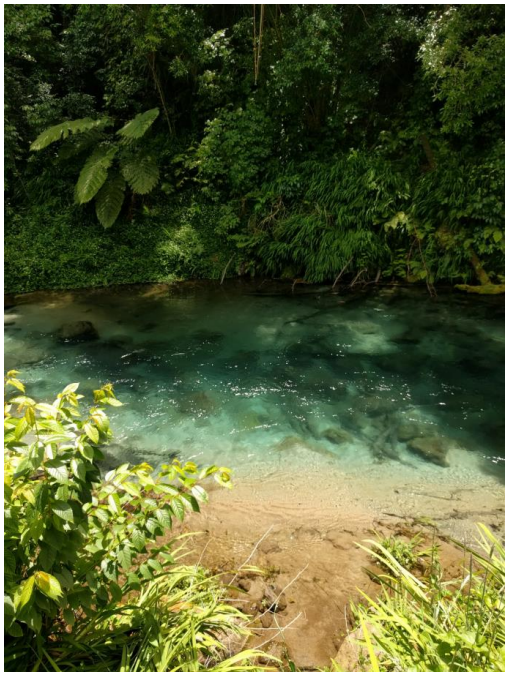
Waiari at Intake – changes over time

From a clear gauging section to one now full of logs/boulders. Not such a suitable section any more



The effect of high flows on the channel, with recent slumping of the banks. Changed the rivers hydraulic controls

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ISO 9001 Standard:

QA – “all about meeting defined standards”

What Stds? Our own:

- manuals
- procedures
- defined work flows, and
- NEMS – new national Standards.

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Timing of measurements	Instrument Resolution	1 Second
	Instrument Accuracy	± 90 seconds/month
	Time Zone	Express time as New Zealand standard time (NZST) Do not use New Zealand daylight time (NZDT)
	Discharge Results	Assign date and time of mean gauge height 1 minute resolution
Supplementary Instrument Measurements	Temperature	± 0.5 ˚C *Required for acoustic methods*
	Salinity	± 5 ppt (parts per thousand) *Required for acoustic methods*
	Bearing	Compass calibrated on site *Required for acoustic methods*
	Water level	Required if result is to be used for discharge rating Read at regular intervals over duration of discharge measurement
Calibration check	Frequency	Current Meter: 2 years, or 300 hours of use ADV: 5 years ADCP: 3 Years POEM: 2 Years or 100 Hours of Use
	Method	Where relevant follow manufacturers' specifications, AS3778.6.3, ISO3455 and ISO748:2007. Further details in Standard.
Validation Methods	Instrument Tests	Required pre-deployment, and post-deployment for rotating element current meters.
	Moving Bed	Test required Pre-measurement for Velocity-Area Moving Boat method

Open Channel Flow

As a means of achieving the standard (QC 600), the following requirements apply:

Deployment	Site Selection	Use criteria within Standard, method dependent
	Sampling *Velocity-Area Stationary Method*	≥ 40s velocity measurement at ≥20 verticals, and each partial segments with <10 % of the total discharge
	Sampling *Velocity-Area Moving Boat Method*	≥ 720s total sampling time, and reciprocal transect pairs
	Width Measurement *Velocity-Area Stationary Method*	± 0.5% of total cross-section width (Velocity-Area stationary method)
	Depth Measurement *Velocity-Area Stationary Method*	≥ 22 verticals to +/- 5 mm for depths < 0.3 m, or +/- 10 mm for depths > 0.3 m

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Other Quality Assurances we have in place

- Rolling annual external audits undertaken by Telarc NZ
- Internal audits every 2 years
- Annual Data Reviews
- Regatta's

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Comparison Regattas

- Requires consideration for quality measurement cross sections
- Opportunity for employee communication and training
- Identify issues with equipment and field technique

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Summary

- We measure flow using ADCP's SxS method off the slackline, unless we can wade it!
- These measurements are checks against our Ratings. If >8% off the curve we investigate why, and more gauging's are carried out to confirm or deny a rating change.
- There are lots of uncertainties around carrying out measurements; site selection, instruments chosen, changes in the control, user abilities, which all add to the overall uncertainty.
- Pre + Post measurement QA checks carried out according to NEMS standards ensure a quality of control. As do several other internal and external audits.
- River flows are normally measured indirectly – relying on the conversion of water level (stage) to flow using a stage-discharge relationship (Rating).
- Ratings are Dynamic – the stage-discharge relationship may be disturbed by changes to the river bed following a flood or the seasonal impact of aquatic growth. Such circumstances are relatively common and necessitate an ongoing review, and updating, of the rating.

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WAIĀRI STREAM MONITORING 2022
Keren Bennett
Freshwater Ecologist
LAND. PEOPLE. WATER.

Overview

- Biological monitoring of the Waiāri Stream is required as a condition of resource consent
- Monitoring of macroinvertebrate communities, fish, macrophytes (aquatic plants) and basic water quality
- Four survey sites:
  - Upstream and downstream of the WTP intake location
  - Upstream and downstream of the Te Puke WWTP discharge
- Monitoring began in 2010, with repeat baseline surveys in 2011, 2012, 2017, 2019, 2020, 2021 and 2022
- Construction of the WTP intake and infrastructure began in 2018

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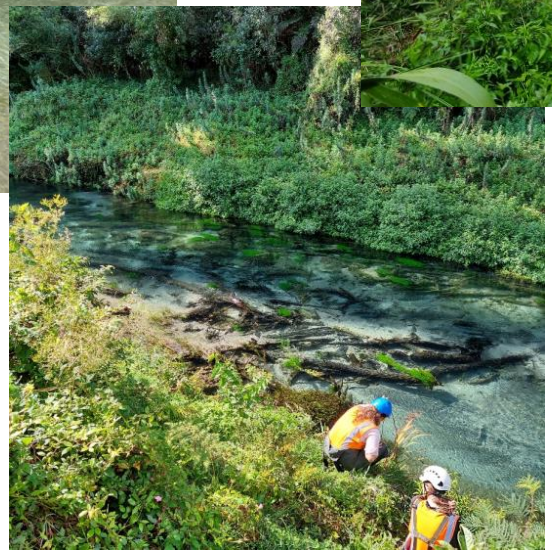
Waiāri Stream habitats



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Waiāri Stream habitats

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Macroinvertebrate communities - 2022

- Samples are taken from wood near the WTP and aquatic plants near the WWTP
- A range of indices are calculated that each tell part of the community story
- There are differences between results from the upper stream and lower stream
- Communities on oxygen weed in the lower stream are dominated by snails
- Communities on wood in the upper stream are dominated by non-biting midge larvae (Chironomids)

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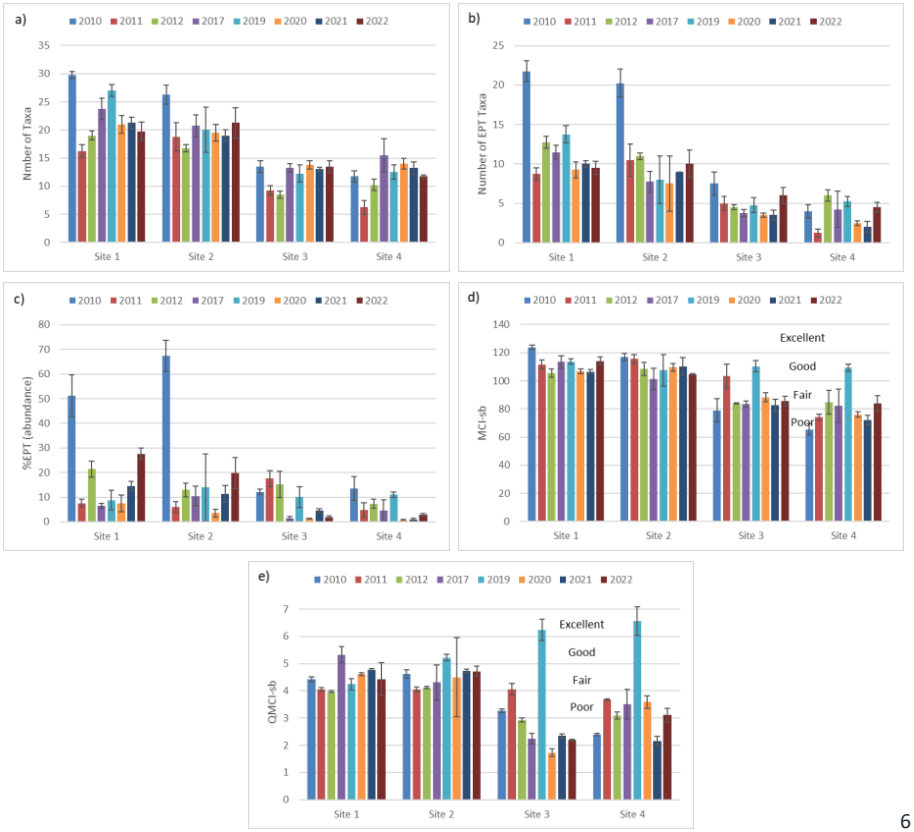
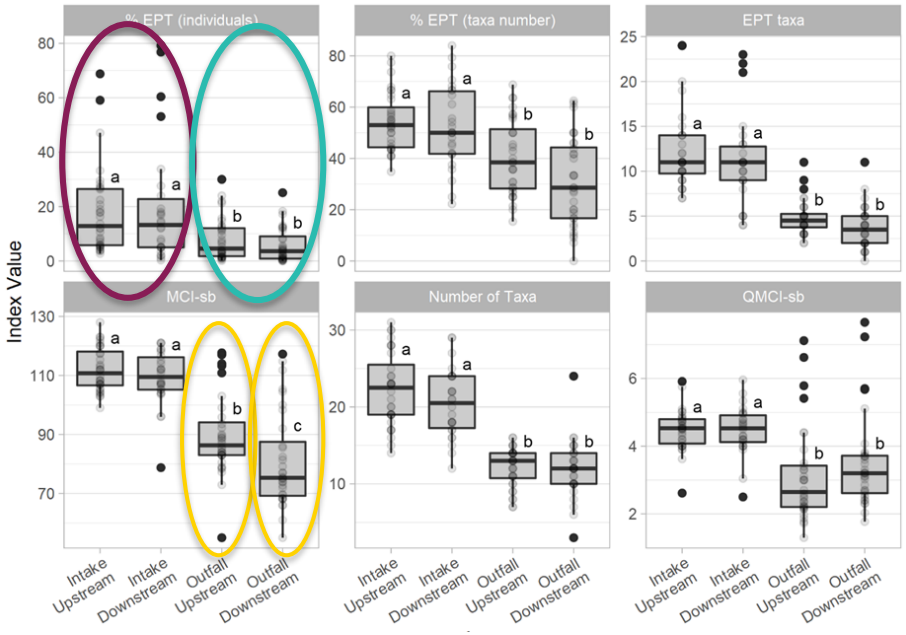
Macroinvertebrate communities – baseline results

- Eight years of baseline sampling results have been collected
- Observable differences in community indices in the upper vs lower Waiāri
- Variation in results between years
- Communities can be influenced by:
  - High flow / storm events
  - Low flow / drought conditions
  - Regularity of events and time since last event
  - Sediment (substrate) types
  - Water quality



Statistical comparisons and trend analysis

- Mean index values in the upper Waiāri were typically statistically higher than those of the lower Waiāri
- Index values upstream and downstream of the WTP intake were statistically similar
- Index values upstream and downstream of the WWTP outfall were statistically similar, except for MCI-sb



Statistical comparisons and trend analysis

- Preliminary trends analysis carried out on eight years of data
- Less than the recommended 10 years of data
- Small, but statistically significant trends observed in some indices

Site	No. Taxa	EPT taxa	% EPT (individuals)	% EPT (taxa number)	MCI-sb	QMCI-sb
Site 1: upstream of WTP intake		-ve		-ve		+ve
Site 2: downstream of WTP intake		-ve		-ve	-ve	
Site 3: upstream of WWTP outfall			-ve	-ve		-ve
Site 4: downstream of WWTP outfall	+ve		-ve			

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Fish communities - 2022

- Diversity of native fish within the stream
- Fish IBI indicates ‘excellent’ diversity at all sites
- Longfin eel, inanga and redfin bully were the most common recorded species
- Giant bullies recorded in the lower stream (site 4)

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Fish communities – upper Waiāri

Genus	Species	Common Name	Site 1 – upstream of WTP								Site 2 – downstream of WTP							
			2010	2011	2012	2017	2019	2020	2021	2022	2010	2011	2012	2017	2019	2020	2021	2022
Anguilla	sp.	unidentified eel																
	australis	Shortfin eel																
	dieffenbachii	Longfin eel																
Galaxias	*fasciatus*	Banded kōkopu																
	maculatus	Īnanga																
	argenteus	Giant kōkopu																
Gobiomorphus	sp.	juvenile bully																
	cotidianus	Common bully																
	gobioides	Giant bully																
	huttoni	Redfin bully																
Retropinna	*retropinna*	Smelt																
Mugil	*cephalus*	Mullet																
Oncorhynchus	*mykiss*	Rainbow trout																
Salmo	*trutta*	Brown trout																
Gambusia	*affinis*	Gambusia																
Fish QIBI			**52**	**44**	**48**	**50**	**46**	**40**	**52**	**54**	**52**	**50**	**48**	**46**	**52**	**52**	**54**	**52**

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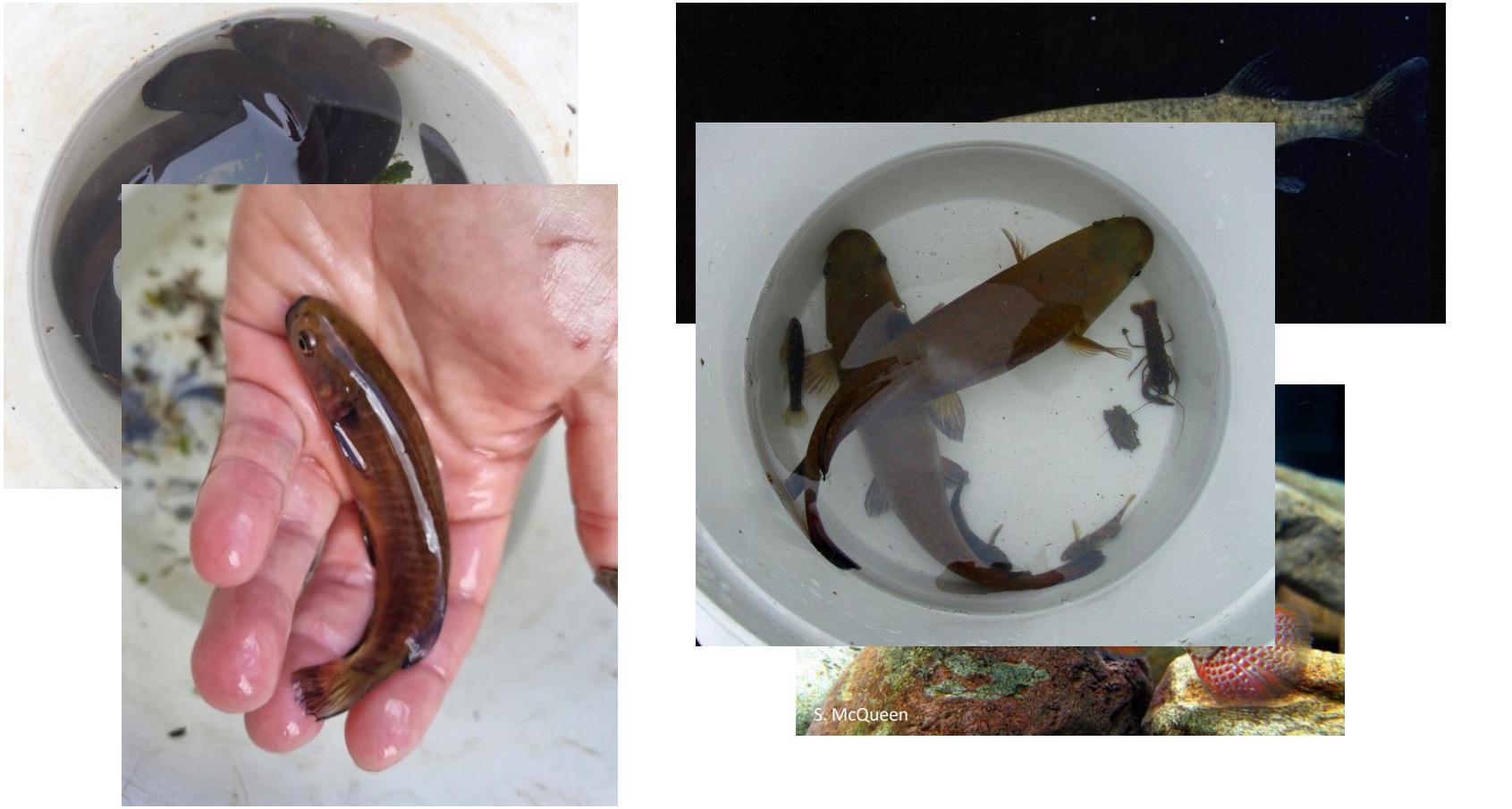

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Fish communities – lower Waiāri

Genus	Species	Common Name	Site 3								Site 4							
			2010	2011	2012	2017	2019	2020	2021	2022	2010	2011	2012	2017	2019	2020	2021	2022
Anguilla	sp.	unidentified eel																
	australis	Shortfin eel																
	dieffenbachii	Longfin eel																
Galaxias	*fasciatus*	Banded kōkopu																
	maculatus	Īnanga																
	argenteus	Giant kōkopu																
Gobiomorphus	sp.	juvenile bully																
	cotidianus	Common bully																
	gobioides	Giant bully																
	huttoni	Redfin bully																
Retropinna	*retropinna*	Smelt																
Mugil	*cephalus*	Mullet																
Oncorhynchus	*mykiss*	Rainbow trout																
Salmo	*trutta*	Brown trout																
Gambusia	*affinis*	Gambusia																
Fish QIBI			52	58	58	52	52	52	38	56	54	58	52	52	52	28	48	50

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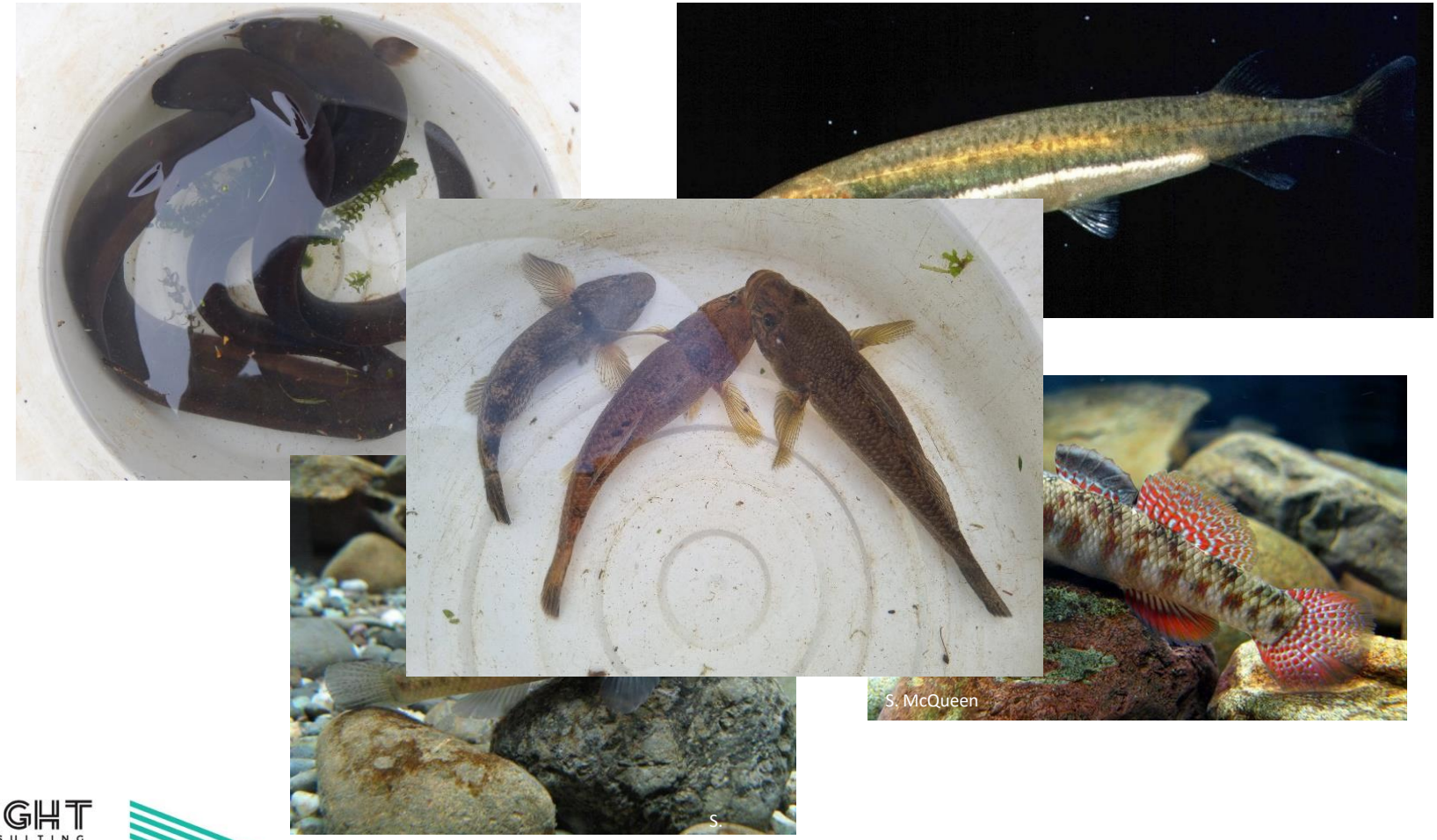

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Summary

- Diverse range of aquatic biota are present in the Waiāri Stream
- Very diverse range of fish species
- Macroinvertebrate communities are diverse however there are differences in community structure and index values between the upper and lower stream
- Basic water quality monitoring indicates consistently cool, clear, well oxygenated water
- Extensive baseline data set collected over eight surveys, in advance of the water take commencing

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land
people
water.
thrive
together
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8/2/22

1

Te Mauri O Te Wai

- Understanding freshwater quality in Te Ao Māori
  - Rangatiratanga = authority to manage water
  - Kaitiakitanga = obligation to enhance mauri
- mauri is the life supporting capacity of a thing
- mauriOmeter – informs the action necessary
- mauriOmeter allows accurate measurement of what matters / communicates what matters
- mauriOmeter facilitates a holistic understanding

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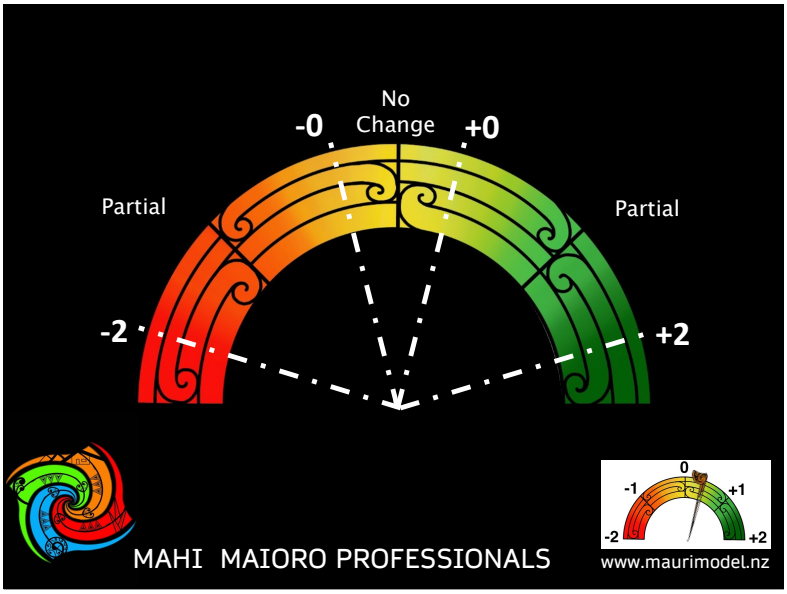
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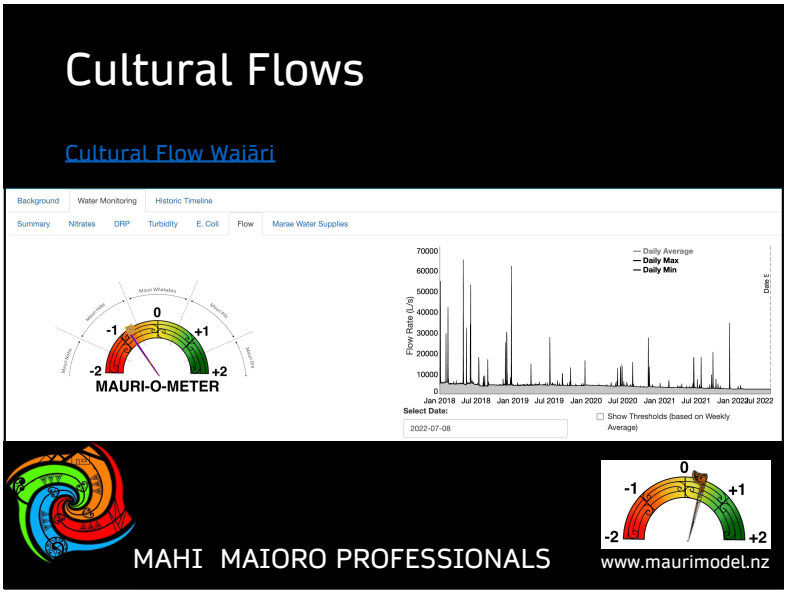
Cultural Flows
Cultural Flow Waiāri
Background
Water Monitoring
Historic Timeline
Summary
Nitrates
DRP
Turbidity
E. Coli
Flow
Marae Water Supplies
MAURI-O-METER
Daily Average
Daily Max
Daily Min
Select Date:
2022-07-08
Show Thresholds (based on Weekly Average)
MAHI MAIORO PROFESSIONALS
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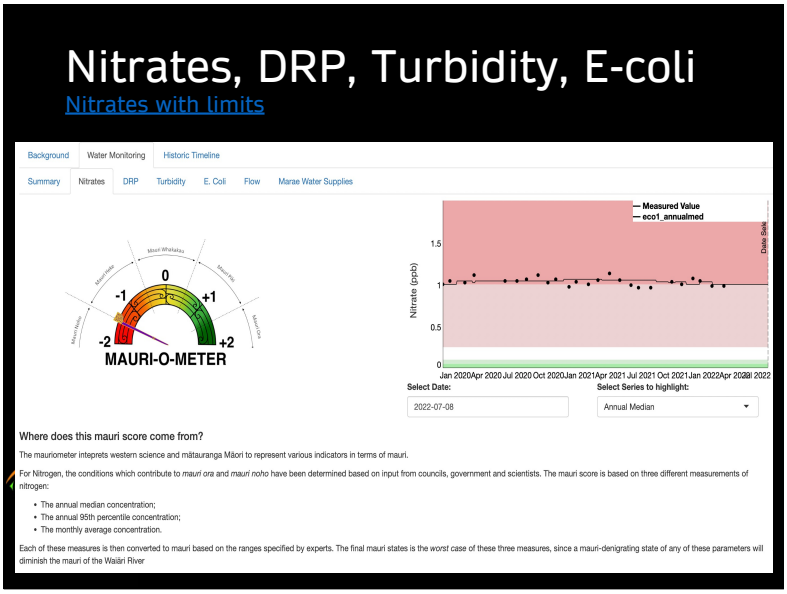
8/2/22


Nitrates, DRP, Turbidity, E-coli
Nitrates with limits
Background
Water Monitoring
Historic Timeline
Summary
Nitrates
DRP
Turbidity
E. Coli
Flow
Marae Water Supplies
0
-1
+1
-2
+2
MAURI-O-METER
Measured Value
eco1_annualmed
Nitrate (ppb)
Select Date:
2022-07-08
Select Series to highlight:
Annual Median
Where does this mauri score come from?
The mauriometer inteprets western science and mātauranga Māori to represent various indicators in terms of mauri.
For Nitrogen, the conditions which contribute to mauri ora and mauri noho have been determined based on input from councils, government and scientists. The mauri score is based on three different measurements of nitrogen:
The annual median concentration;
The annual 95th percentile concentration;
The monthly average concentration.
Each of these measures is then converted to mauri based on the ranges specified by experts. The final mauri states is the worst case of these three measures, since a mauri-denigrating state of any of these parameters will diminish the mauri of the Waiāri River

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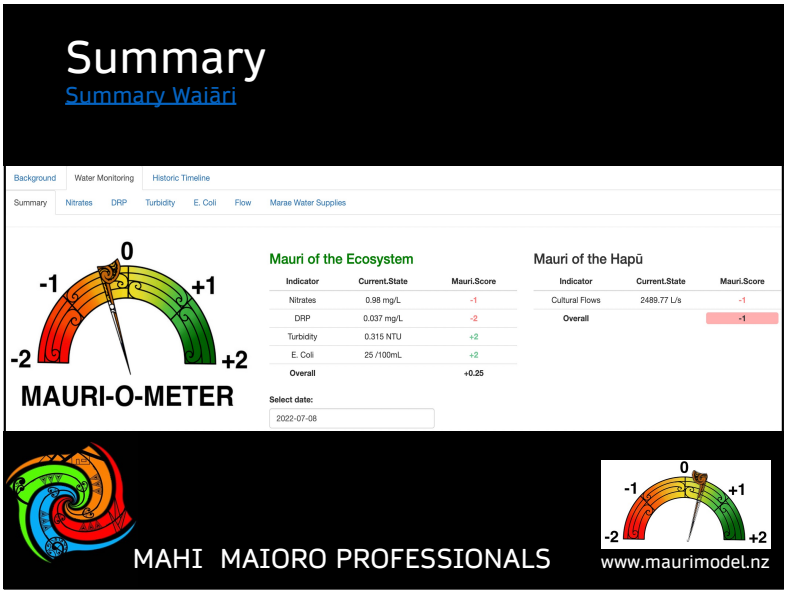
Summary
Summary Waiāri
Background
Water Monitoring
Historic Timeline
Summary
Nitrates
DRP
Turbidity
E. Coli
Flow
Marae Water Supplies
0
-1
+1
-2
+2
MAURI-O-METER
Mauri of the Ecosystem
Indicator
Current.State
Mauri.Score
Nitrates
0.98 mg/L
-1
DRP
0.037 mg/L
-2
Turbidity
0.315 NTU
+2
E. Coli
25 /100mL
+2
Overall
+0.25
Mauri of the Hapū
Indicator
Current.State
Mauri.Score
Cultural Flows
2489.77 L/s
-1
Overall
-1
Select date:
2022-07-08
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