BHP Real Time Forecasting System (RTFS)

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Delft-FEWS User Days Australia
24-26 August 2022

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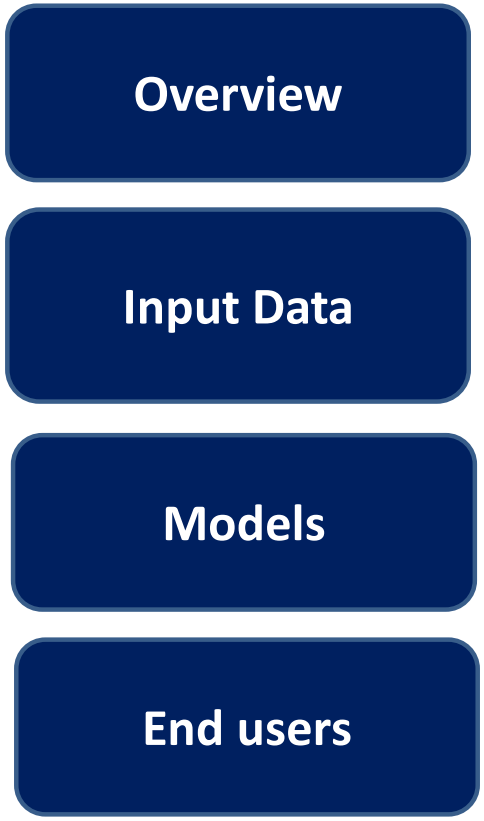
BHP RTFS



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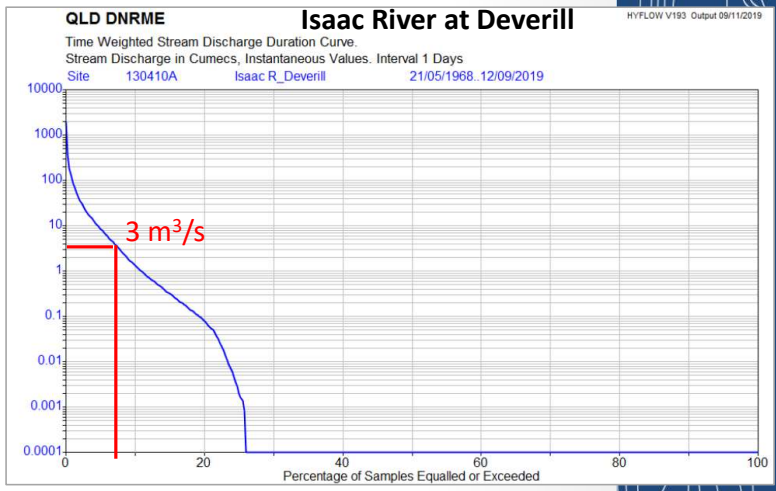
BHP RTFS:

- Decision Support System for the release of Mine Affected Water (MAW).
- **Goal**: Maximise MAW release volume while ensuring compliance with Environmental regulations.
- Under very limited release windows



BHP RTFS:

Permit
Environmental authority EPML00561913
Daunia Mine

Agency interest: Water	
Condition number	**Condition**
W1	**Contaminant release** Contaminants that will, or have the potential to cause environmental harm must not be released directly or indirectly to any waters as a result of the authorised mining activities, except as permitted under the conditions of this environmental authority.

Table W1 (Mine Affected Water Release Points, Sources and Receiving Waters)

Release point (RP)	Easting (GDA94)	Northing (GDA94)	Mine affected water source and location	Monitoring point	Receiving waters
RP 1	631319	7561566	DAM 2 and integrated water system	End of outlet pipe or spillway	Isaac River via New Chum Creek

Table W2 (Mine Affected Water Release Limits)

Quality Characteristic	Release limits	Monitoring frequency
Electrical conductivity (µS/cm)	5000	Real time telemetry for EC and pH with grab samples at commencement and weekly thereafter when safe to do so and access permits Daily grab samples if telemetry not available (the first sample must be taken as soon as practicable)
pH (pH Unit)	6.5 – 9.0	
Sulphate (SO_4^{2-}) (mg/L)	1000	Commencement of release and weekly thereafter during release when safe to do so and access permits

Table W4 (Mine Affected Water Release During Flow Events)

Receiving water description	Release point	Gauging station description	Easting (GDA94)	Northing (GDA94)	Minimum flow in receiving water for release event	Flow recording frequency
Isaac River via New Chum Creek	RP 1	Isaac River Upstream (MP3)	627886	7556459	> or = $3m^3/s^*$	Daily

Table W5 (Receiving Waters Contaminant Trigger Levels)

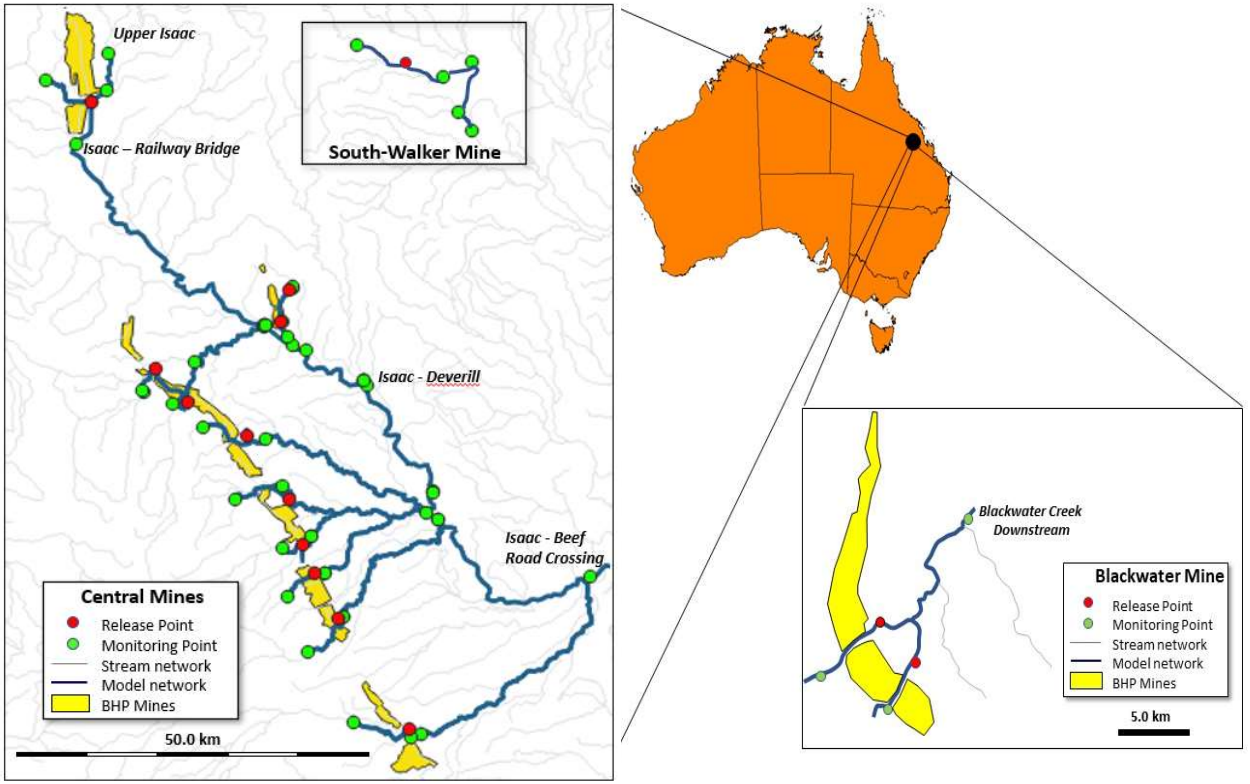
Quality characteristic	Trigger level	Monitoring frequency
pH	6.5 – 8.5	Real time telemetry for EC and pH with grab samples at commencement and weekly thereafter when safe to do so and access permits. Limits only apply at MP4
Electrical Conductivity (µS/cm)	864 – cease release	
Sulphate (SO_4^{2-}) (mg/L)	1000	

Table W6 (Receiving Water Upstream Background Sites and Downstream Monitoring Points)

Monitoring points	Receiving waters location description	Easting (GDA94)	Northing (GDA94)
Upstream background monitoring points			
Monitoring Point 1	New Chum Creek – on the lease boundary with Millennium Mine	631782	7561830
Monitoring Point 3	Isaac River – upstream of the confluence of New Chum Creek and Isaac River	627772	7556279
Downstream monitoring points			
Monitoring Point 4	Isaac River – downstream of confluence with New Chum Creek	631731	7553518

Overview | Input Data | Models | End Users

BHP RTFS:



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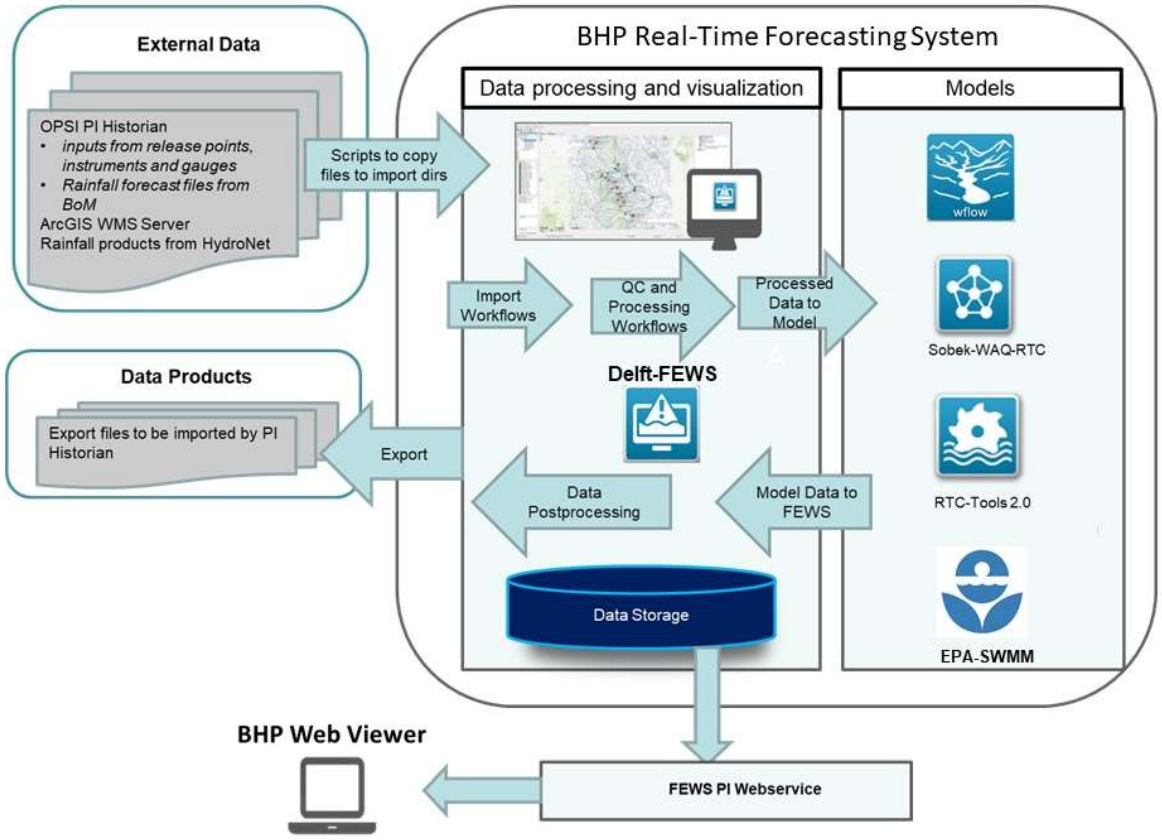

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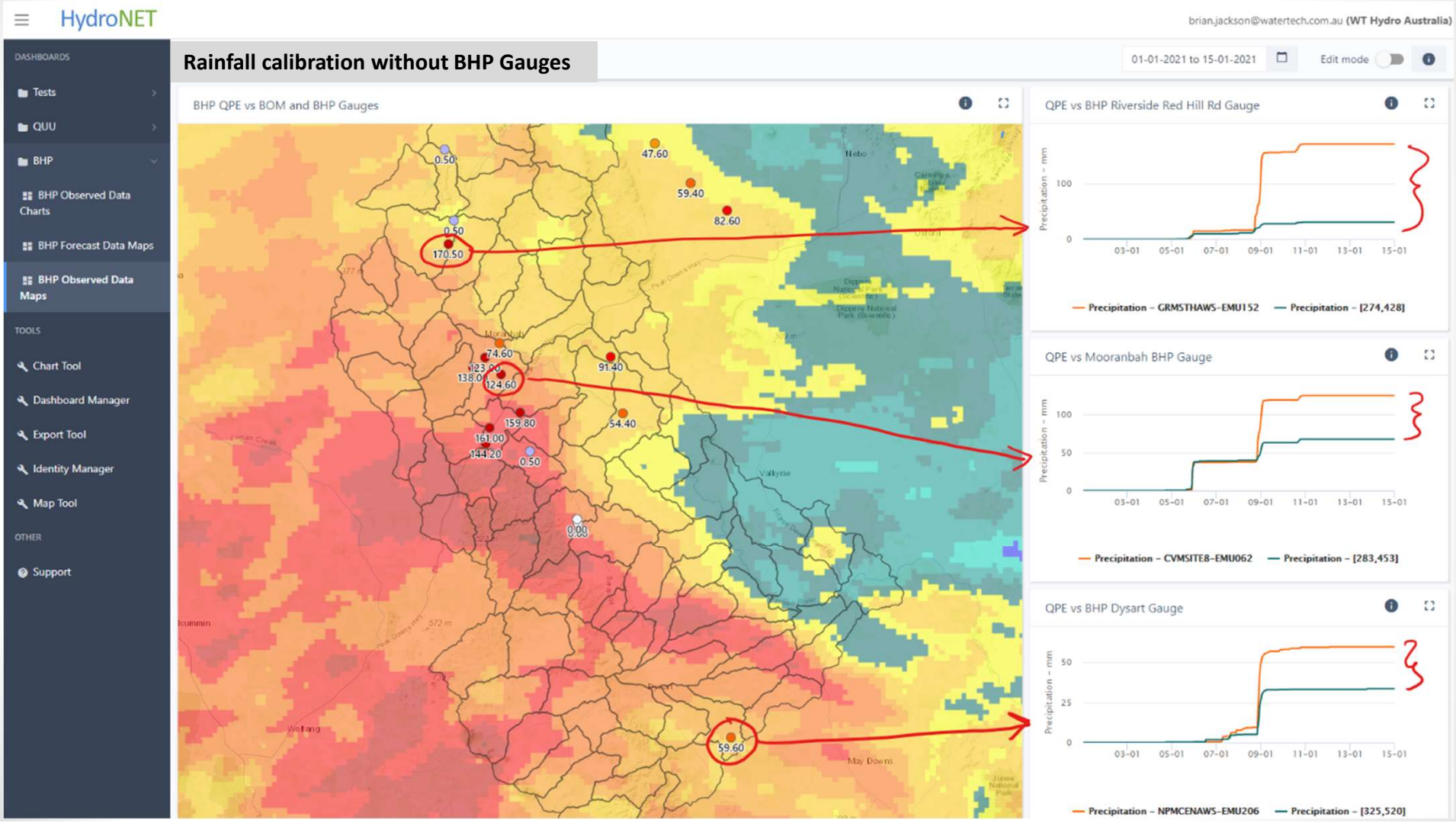
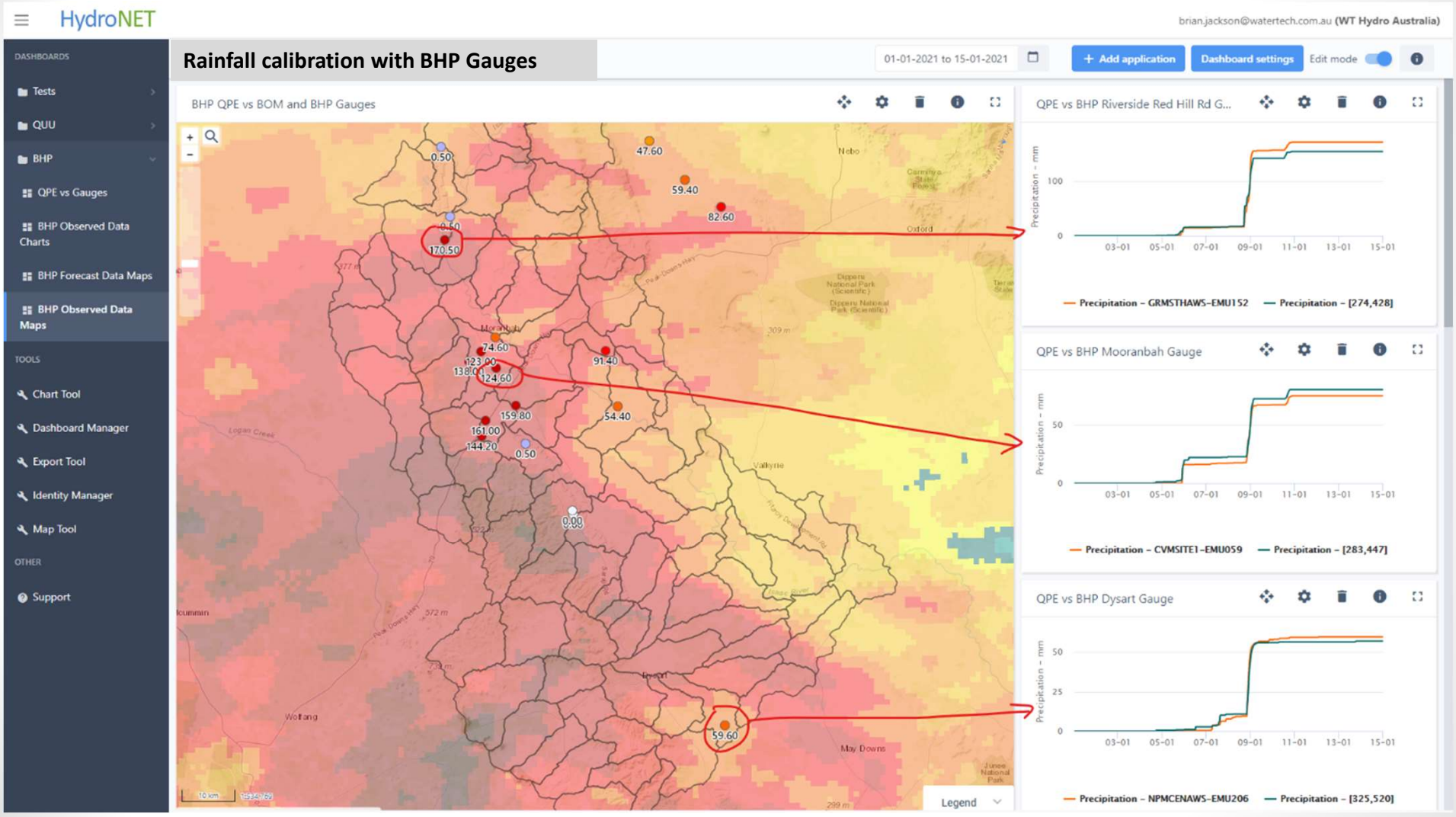
BHP RTFS: External Data

- BHP Monitoring sites
  - P, Q, WQ and weather
- Bureau of Meteorology (BoM)
  - Rain gauges, Radar
  - Australian Digital Forecast (ADFD) > 240 min ahead, 3-6 km resolution
- HydroNET (10 min intervals, 1 km resolution)
  - BHP Composite Adjusted (observed radar rainfall) QPE
  - BHP Composite Nowcast (0-120 min and 130-240 min forecast) QPF
- National Oceanic and Atmospheric Administration (NOAA)
  - Global Forecast System (GFS) 1h

Overview | **Input Data** | Models | End Users



Overview | **Input Data** | Models | End Users



BHP RTFS: Data Processing

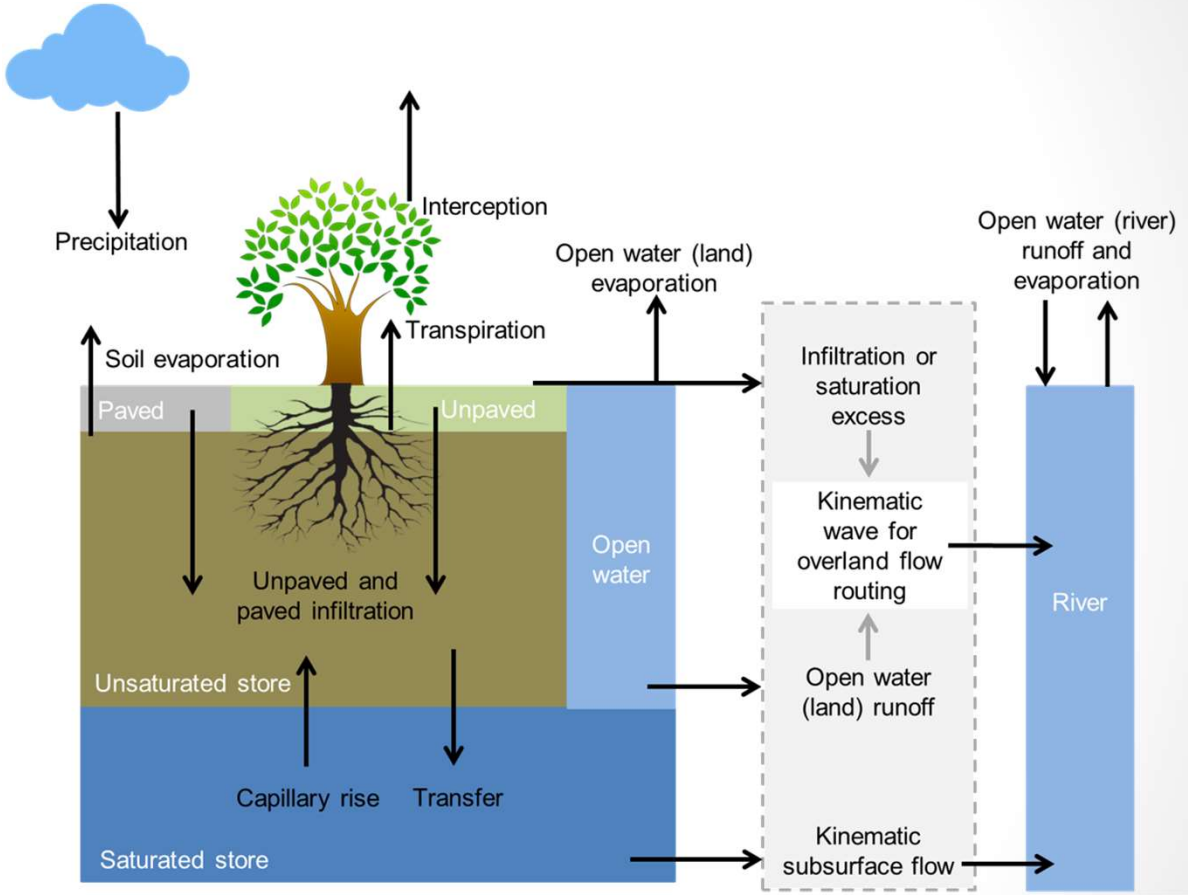
- Data validation
  - Expected range of variation for each parameter
- Missing values
  - Gap filling: Interpolation or Default values
- Hierarchy
  - Precipitation: Observed - HydroNET - BoM - GFS
- Transformations
  - e.g., temporal aggregation, look-up tables

System Operation

Alert users

Hydrological modelling:

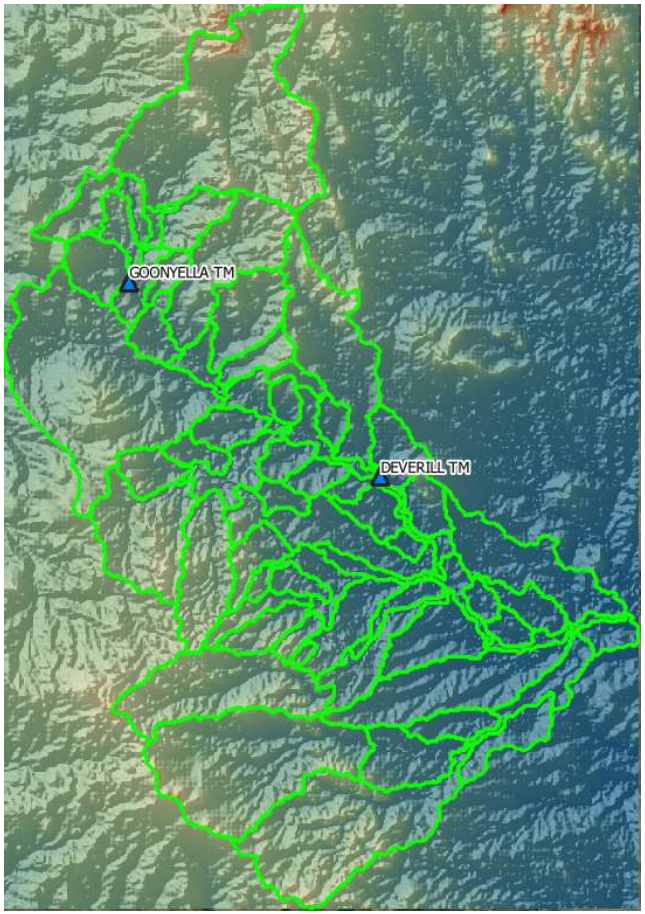
- wflow
  - Open Source
  - Physically based
  - Distributed
  - Gridded data



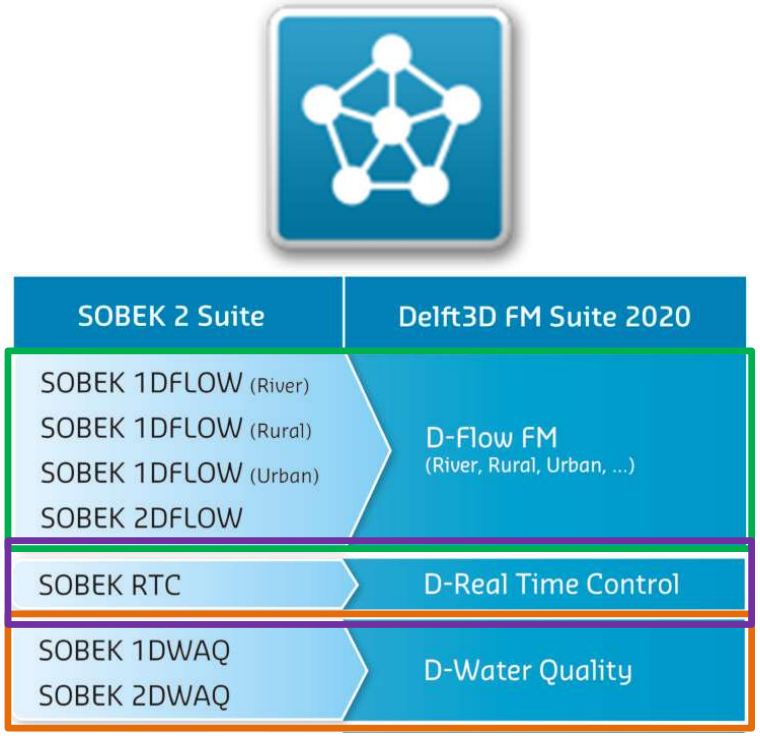
Hydrological modelling:

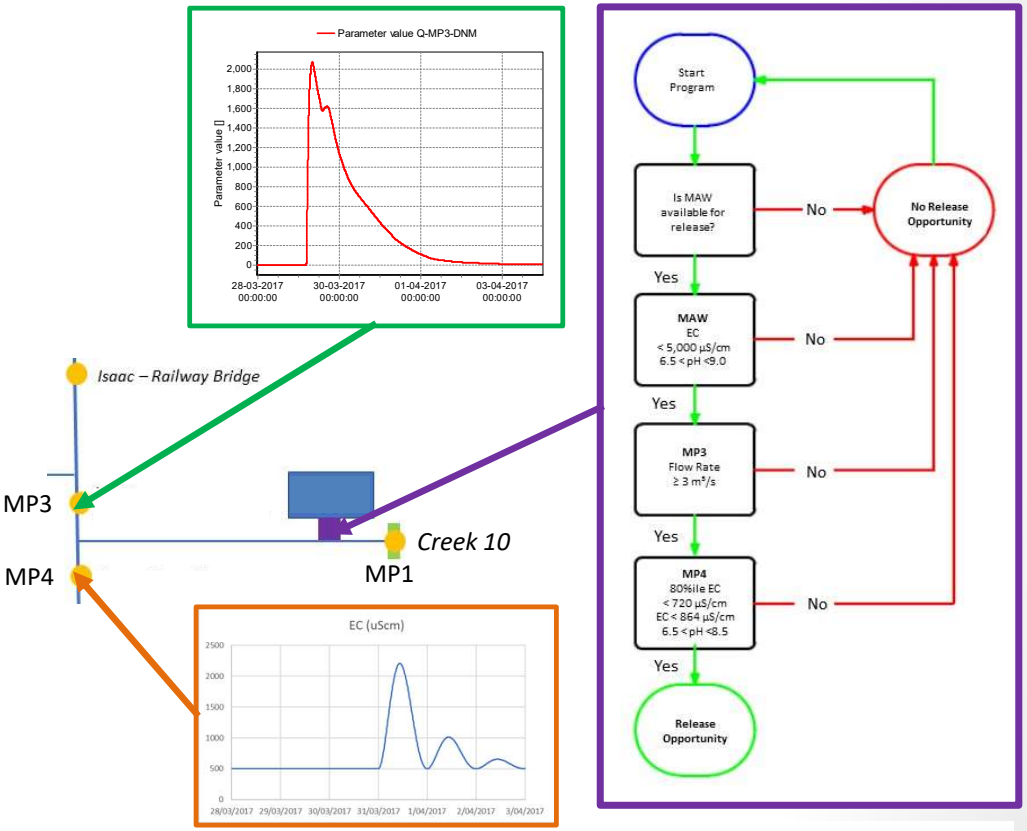
- wflow
  - Central Mines
  - 8,300 km^2
  - Grid size: 250 m
  - Events: 2019, 2016, 2017

Dry *Base* *Wet*



Hydrodynamic and Water Quality model:





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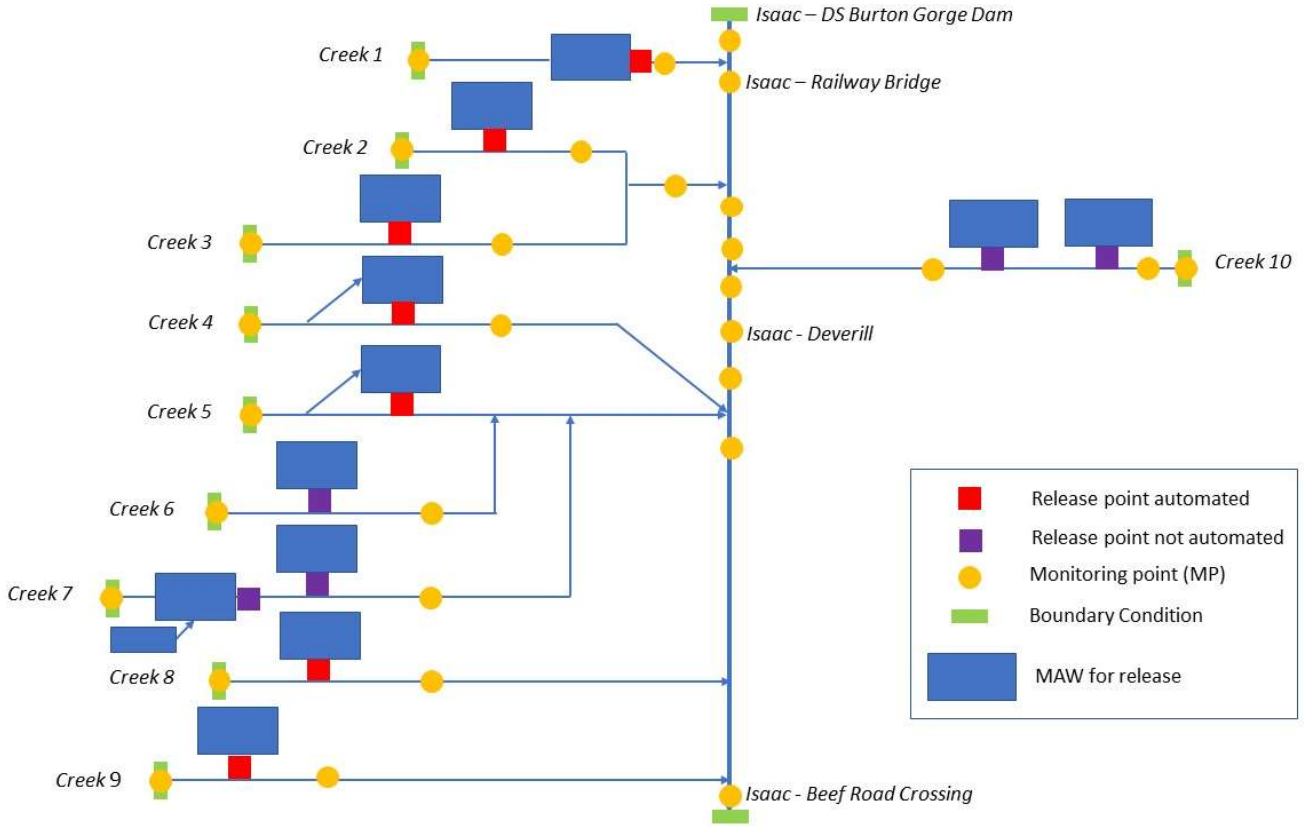
Hydrodynamic and Water Quality model:



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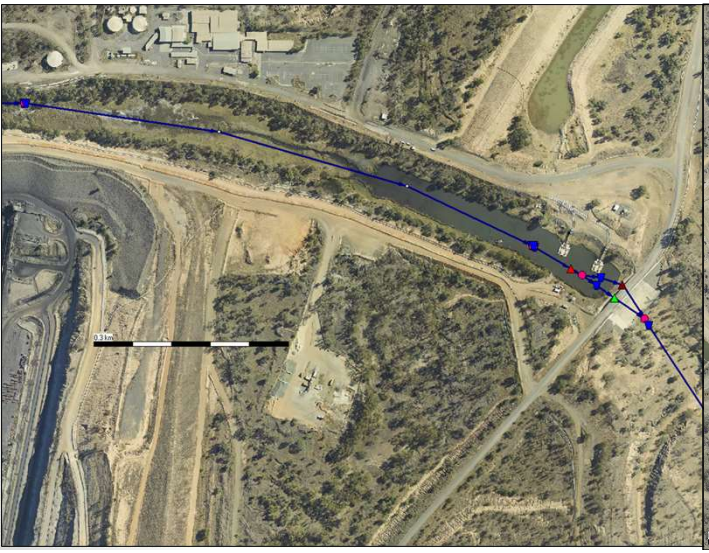
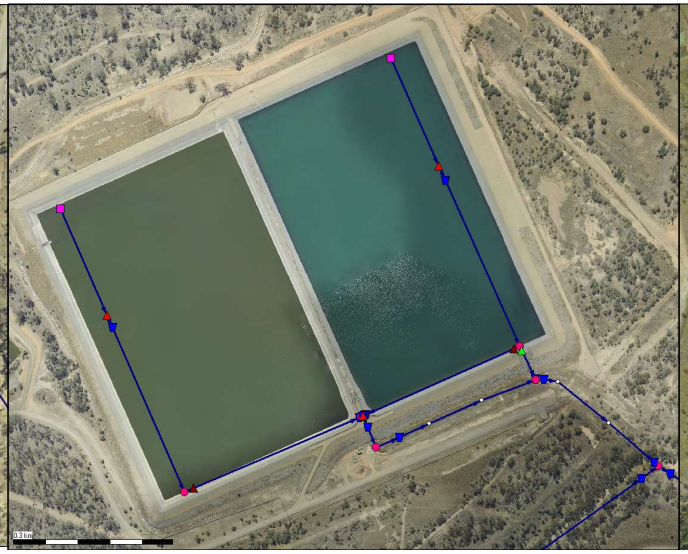
Hydrodynamic and Water Quality modelling:

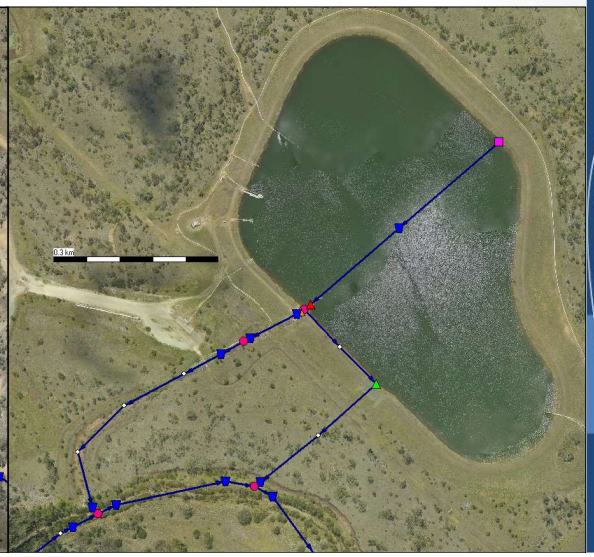
- River network:
  - 470 km Central Mines
  - Cross-sections at all MPs and other points of interest
- Release Points:
  - Reservoir
  - Controlled Release Structure
  - Spillway
  - Release Logic from EAs

All RPs are different!

- WQ parameters:
  - EC – Conservative Tracer
  - pH – Conservative Tracer
  - pH – f(T, TIC, Alka)







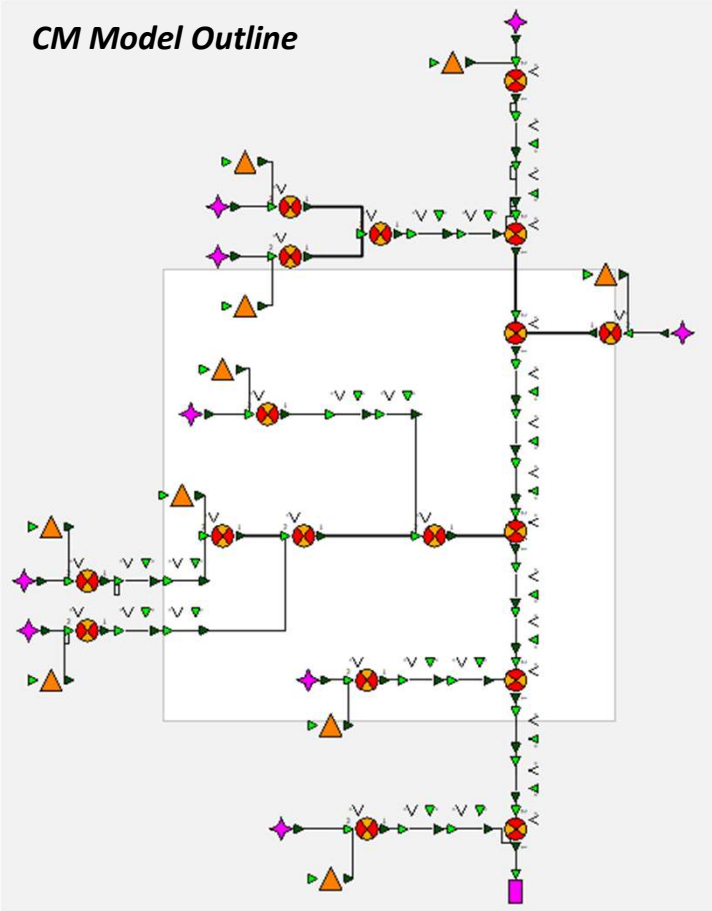
Release Optimisation:

RTC-Tools

Find the release schedule at **RP**s that:

- ❑ Satisfies:
  - EAs criteria at **MP**s
  - BHP's own prioritization
- ❑ Maximizes the total MAW release volume

Sobek ➡ RTC-Tools ➡ Sobek



MODELICA

Boundary

Confluence

Release Point

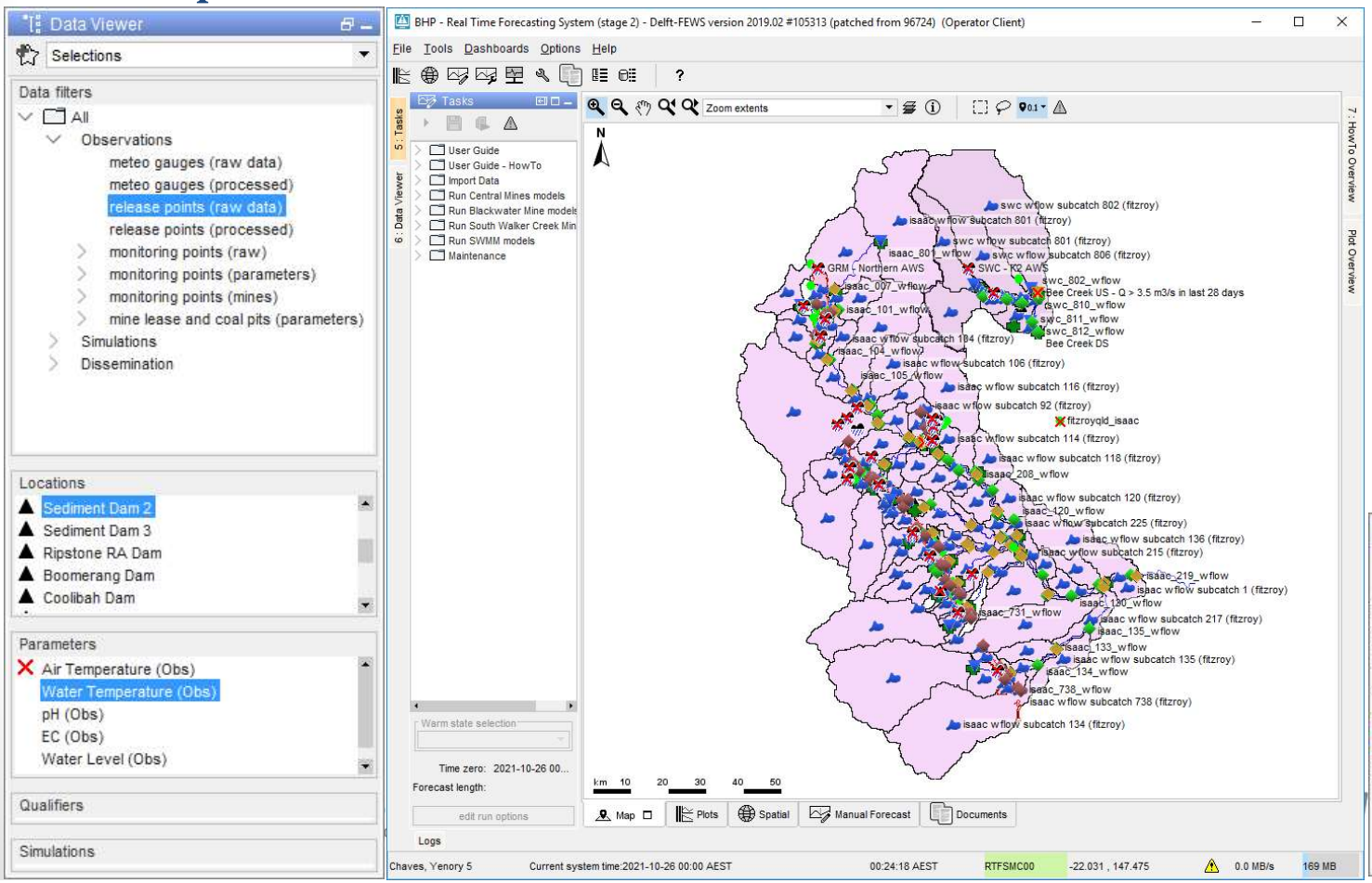
Monitoring Point

Terminal

BHP RTFS: Users

- BHP IT:
  - Support to keep system functioning
- Water Planners:
  - Super users and Operators
- People at the mines:
  - End users of data and modelling results

Water planners: Admin Front-End – Delft-FEWS GUI



People at the mines: Web Viewer

Summary

Mine: Daunia Mine (DNM)

Forecast releases from DNM

2021-10-25T15:00:00 - - (AEST)

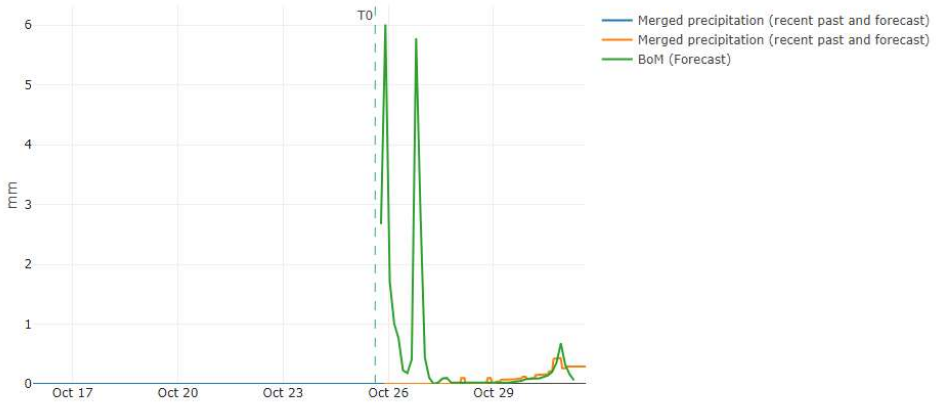
	Name	Minimum controlled release flow (m³/s)	Maximum controlled release flow (m³/s)	Minimum spillway flow (m³/s)	Maximum spillway flow (m³/s)
RP1-DNM	Sediment Dam 2	0	0	0	0

Forecast conditions at DNM monitoring points

2021-10-25T15:00:00 - - (AEST)

	Name	Flow max (m³/s)	EC max (µS/cm)	pH min	pH max
MP-DNM-01-QWQ	New Chumm Creek on lease boundary	0.01	16.00	6.33	10.25

Rainfall at 148.2568,-22.0685 (mm)



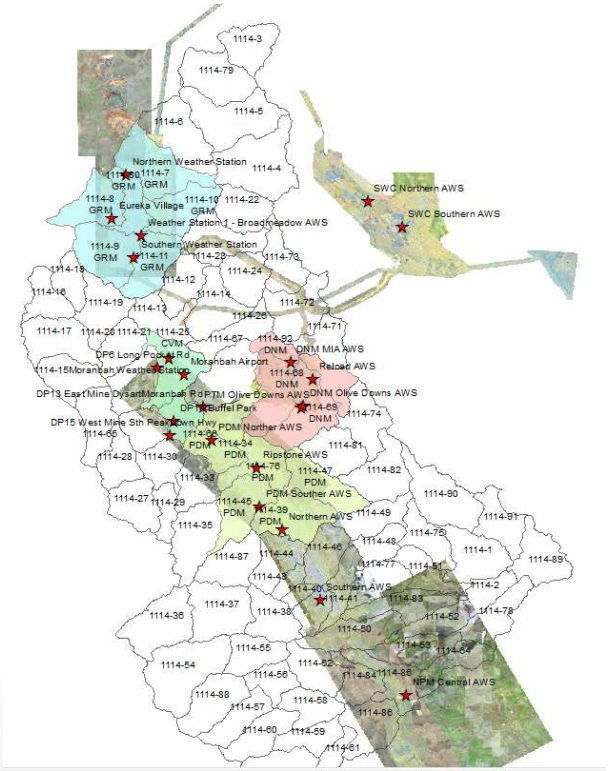
Relevant locations

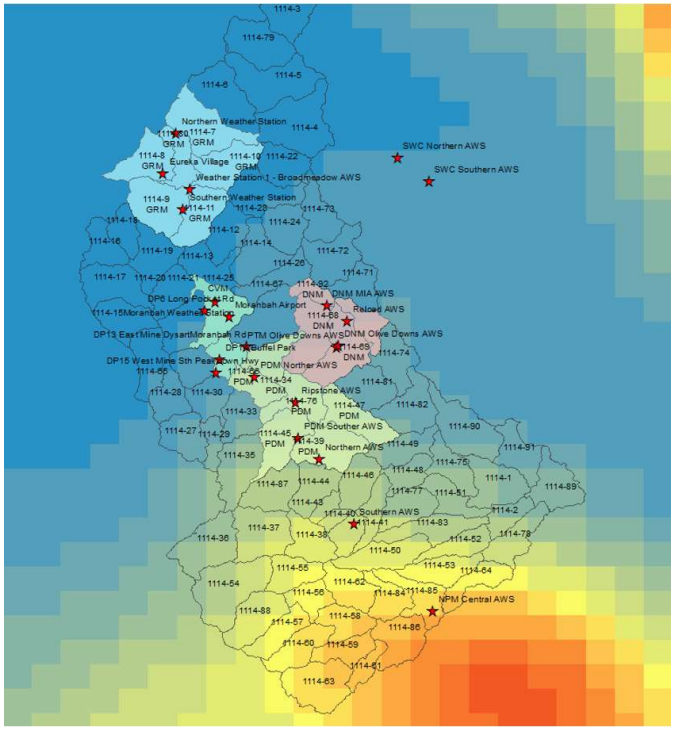
BHP RTFS: Users Experience – Water Planners

- Overall operation
  - Online since November 2021
  - Key period: December 2021 – January 2022
  - What were the observations over the past wet season?
    - Release forecasted but no real opportunity i.e. release conditions not met or estimated release volume is incorrect
    - Forecast river / creek flows but no flows in the creek or not above threshold as predicted
    - Inaccurate rainfall forecast at specific locations
    - Wrong WQ predicted in forecast (caused false release opportunity)

BHP RTFS: Users Experience – Water Planners

Feedback 1 - Rainfall data





Gridded Rainfall

Catchment averaged rainfall

Rainfall forecast feedback from BHP site rainfall gauges and public gauges

Impact on accuracy:

- Failed / malfunctioning gauges i.e. physical, telemetry, human error

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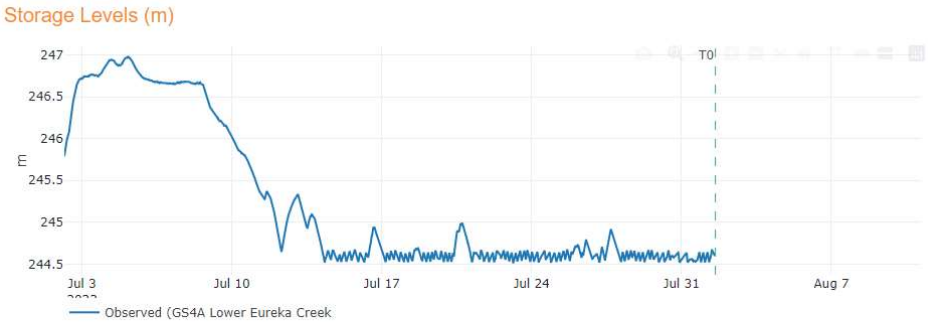
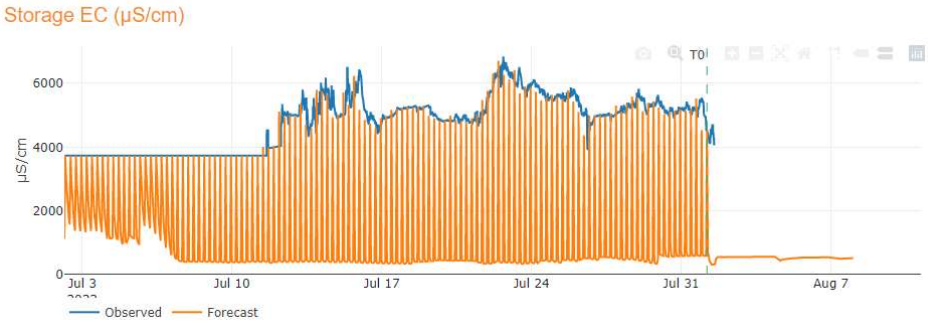
BHP RTFS: Users Experience – Water Planners

Feedback 2 – Release Dam WL and WQ





Auto sampling

Manual sampling

Telemetry control

Remote monitoring

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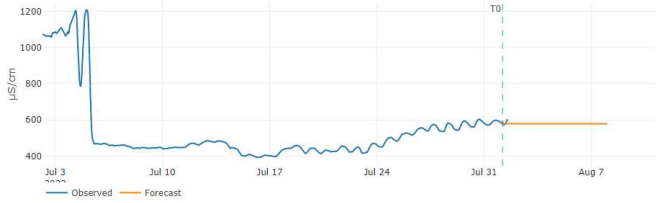
Feedback 3 – Flow monitoring

Role of monitoring points

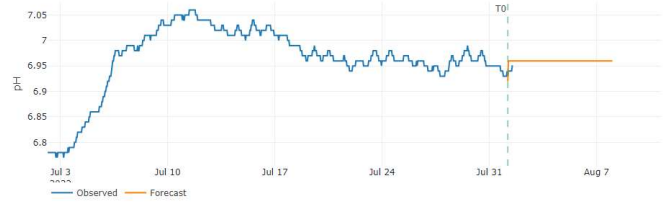
Parameter	Location	Role	Monitoring point
Flow	Creek	primary	US Eureka Creek
Water Quality	Creek	primary	US Eureka Creek
Flow	Main channel	primary	Upper Isaac River
Water Quality	Main channel	primary	Isaac River DS Railway Bridge

Q (Flow m³/s)

EC (µS/cm)



pH



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BHP RTFS: Users Experience – How can we improve the performance?

Monitor it closely and record

- The system gets updated every 4~6 hours adjusting its forecast based on observation data,
- we can monitor it closely during rainfall / creek flow events and record the discrepancy between forecast and observation.

QA/QC on gauging and monitoring stations

- Improve the system feedback loop quality is a key to accuracy (This is still in progress) – fix rainfall gauges to avoid over / inaccurate interpolation; auto-sampling and monitoring to provide timely and more accurate feedback;

System Training

- Limited calibration data was used for the system development. It needs more time (one or two more wet season) to training its data and feedback loop – more system calibration will be needed based on more observations

BHP RTFS: Users Experience – Water Planners

- Welcome advice from operators of other systems:
  - To have or not to have an Archive?
  - How to assess the system performance?
  - Where to put the priority on development of the system?

BHP RTFS: lessons learnt

- Knowledge encapsulation and communication tool
- Data intensive system
- IT infrastructure and cybersecurity
- Dynamic System – keep models and data up to date!
- Other possible uses

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BHP RTFS: Any questions?

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