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How Beaker and Bunsen can help with Ecological Risk Assessments

2025 GEMG Environmental Management Conference

7 May 2025

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Outline

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- What are Ecological Risk Assessments (ERAs)
- Difference between Tier 1/2/3 assessments
- Case Study – Evolution from Tier 1-Tier 3 assessment
- How modelling and laboratory experiments can assist
- Conclusions/summary/take home messages

Ecological Risk Assessments

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- What is an ecological risk assessment?

  A process for determining whether a specific activity/land use change will have adverse environmental effects

- In a mining context, activities that trigger ERA requirements would include – pit dewatering discharges to rivers, salt lakes, land:
  - International Standard ISO 31000:2018: 'Risk Management — Guidelines' (ISO 2018)
  - Schedule B5a of the NEPC (2011) program.
- Potential environmental effects identified (usually from conceptual site model)
- Effects assessed on consequence & likelihood scales → identifies risk level

Ecological Risk Assessments

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Consequence Scale		Explanation
5	Catastrophic	• Severe environmental impact. • Local species destruction and likely long recovery period. • Extensive cleanup involving external resources. • Impact on a regional scale.
4	Major	• Major environmental impact. • Considerable cleanup effort required using site and external resources. • Impact may extend beyond the lease boundary.
3	Moderate	• Moderate environmental impact. • Cleanup by site staff and/or contractors. • Impact confined within lease boundary.
2	Minor	• Low environmental impact. • Rapid cleanup by site staff and/or contractors. • Impact contained to area currently impacted by operations.
1	Insignificant	• No or very low environmental impact. • Impact confined to small area.

Likelihood Scale		Explanation
A	Almost Certain	The event is expected to occur in most circumstances.
B	Likely	The event should occur and there is a higher percentage chance that it will occur.
C	Possible	The event could occur, but there is a higher percentage chance that it will not occur.
D	Unlikely	The event could occur, but it is very improbable.
E	Rare	The event is extremely unlikely, only a slight chance of occurring.

Likelihood		Consequence				
		Insignificant	Minor	Moderate	Major	Catastrophic
		1	2	3	4	5
Certain	A	11	16	20	23	25
Likely	B	7	12	17	21	24
Possible	C	4	8	13	18	22
Unlikely	D	2	5	9	14	19
Rare	E	1	3	6	10	15

Risk Assessment Score	Risk level	Risk Treatment Criteria
1-6	Very Low	No further controls required
7-11	Low	Pro-active monitoring controls required
12-16	Medium	Pro-active monitoring and engineering controls
17-22	High	Substantial engineering controls required to mitigate impacts
23-25	Very High	Unacceptable, modification of proposal required

ERA Tiers

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Tier 1 Assessment

- Default environmental criteria:
  - ANZG 95% freshwater species protection
  - ANZECC livestock drinking water
- Most common
- Starting point for all ERAs

Tier 2 Assessment

- Comparisons to site-specific or regional environmental criteria – is area naturally enriched?
- Need if exceedances of Default criteria occur
- Requires GW/SW/Sed monitoring programs
- Becoming more common
- Can be enhanced with modelling

Tier 3 Assessment

- Most complex
- Required if exceed site-specific criteria
- Direct testing in project environment
- Ecotoxicological testing of discharge water on 'representative species'
- Field trials
- Most conclusive assessment of risk

Case Study – Tier 1/2/3 ERA

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- New Gold operation in Pilbara region
- Shallow groundwater table (<5 mbgl)
- Pits covering ≈289 ha, dewatering over a 10-year period
- Significant volumes in first 3 years (10 GL/year) – surplus
- Will require discharge or re-injection
- Only viable option to discharge to adjacent river system

Potential Environmental Effects

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Potential Effects:

- **Loading of metal(loid) contaminants in river water**
- Loading of metal(loid) contaminants in river sediments

Potential Receptors:

- Aquatic organisms – benthic & water-column
- Terrestrial organisms (inc. livestock) – drinking water

Tier 1 Assessment:

- Comparison of discharge water to relevant DGVs:
  - ANZG (2018) 95% freshwater species protection.
  - ANZECC (2000) livestock drinking water

Tier 1 ERA

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Discharge Water Characteristics:

Analyte	Units	Mean	Range	LDWGV	95% FW
pH	pH units	8.2	7.9 - 8.5	6.5 – 8.5	6.5 – 8.5
EC	µS/cm	1,419	1,140 – 1,650	4,000	No DGV
Alkalinity	mg/L (as $CaCO_3$)	382	315 - 440	No DGV	No DGV
Arsenic	µg/L	13	5.5 - 40	500	13
Uranium	µg/L	37	19-48	200	0.5*
Vanadium	µg/L	32	21-39	100	6

- Alkaline pH, low salinity, high alkalinity and hardness
- Metal(loids) typically below Livestock Drinking Water DGV
- Exceedances of ANZG (2018) Freshwater Species Protection DGVs – particularly U, V & As
- **Assessment therefore focused on aquatic organisms**
- Required Tier 2 ERA to be completed
- Is area naturally enriched in As, V and U?

Tier 2 ERA

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Surface Water Characteristics (Receiving Environment):

Analyte	Units	Mean - Surface water	Range - Surface Water	Mean – Discharge Water	95% FW DGV	SSGV Trigger (80th %)	SSGV Action (95th %)
Arsenic (As)	µg/L	4.7	1.0 – 9.8	13	13	7.8	9.1
Uranium (U)	µg/L	5.3	1.4 – 16.0	37	0.5	6.8	13.0
Vanadium (V)	µg/L	4.1	0.1 – 11.2	32	6	9.1	10.6

- U, V & As concentrations much lower in receiving environment
- U & V, however, are slightly elevated compared with 95% FW DGVs – reflected in SSGVs
- **Discharge scenarios required to further assess post-discharge risks – i.e. contaminant dilution from rainfall**

Tier 2 ERA

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Discharge Scenarios:

- Scenario 1 – 10 GL discharge + no catchment rainfall
- Scenario 2 – 10 GL discharge + median annual catchment rainfall (6.3 GL/year)
- Scenario 3 – 10 GL discharge + mean catchment rainfall (28 GL/year)
- Scenario 4 – 10 GL discharge + maximum catchment rainfall (137.4 GL/year)

Analyte	Units	Scenario 1	Scenario 2	Scenario 3	Scenario 4	95% FW DGV	SSGV Trigger (80th %)	SSGV Action (95th %)
pH	pH units	8.24	8.36	8.45	8.49	6.5-8.5	N/A	N/A
Arsenic	µg/L	11.2	8.7	6.4	5.2	13	7.8	9.1
Uranium	µg/L	29.6	20.2	11.7	7.0	0.5	5.6	12.2
Vanadium	µg/L	29.0	19.4	10.7	5.8	6	8.6	10.5

Tier 2 ERA

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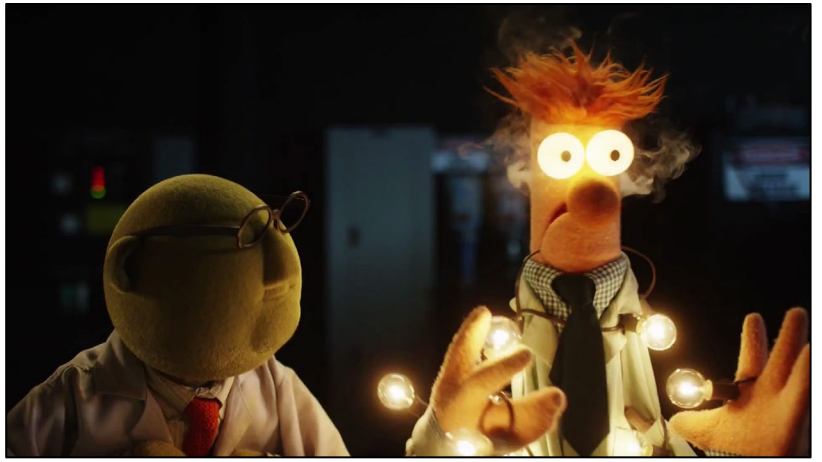
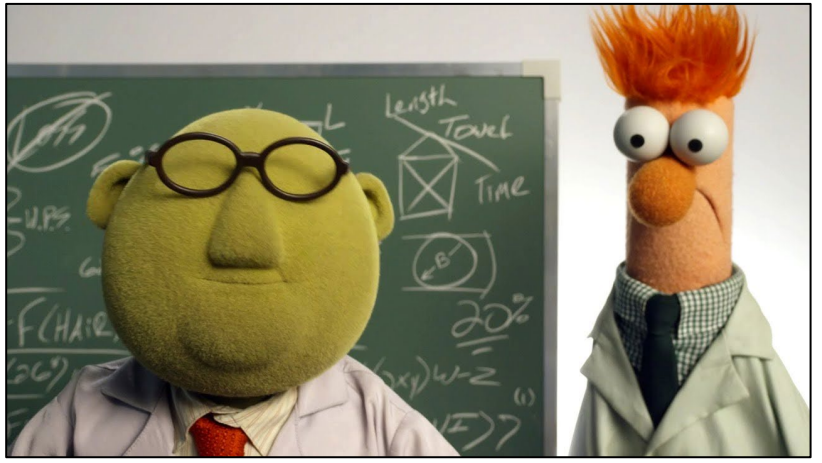
- SSGVs > DGVs –natural local enrichment with U & V
- Discharge likely to exceed SSGVs under most rainfall scenarios
- Significant uncertainties regarding the toxicity of U & V in aquatic ecosystems (especially in Australia)
- 3 options:
  - Ignore exceedances and try to get approval
  - Set up water treatment plant - expensive for only 3 years & volumes of water
  - Conduct modelling & laboratory experiments to try & understand whether exceedances are actually an environmental issue – **Tier 3 ERA**





Radiation Modelling - Uranium

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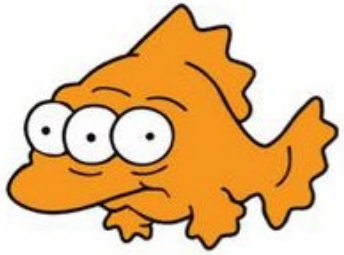
- ERICA & RESRAD - Biota
- Look to establish whether radioactive toxicity effects for U are likely to occur
- Compares calculated radiation values to critical radiation risk values
- Databases contain '*representative*' terrestrial, aquatic and marine species
- Risks to organisms living in river, or organisms drinking river water
- Under worst case scenario – no risk of toxicity from radiation



Organism	Occupancy Factor			Scenario	Scenario 1: No Flow	Background: Turner River
	Water: Surface	Water	Sediment: Surface	Screening Value (µGy/h)	Total Dose (µGy/h)	Total Dose (µGy/h)
Amphibian		0.5	0.5	40	13.3	2.18
Bird	0.5			40	31.5	5.28
Crustacean (1)			1	400	6.96	1.1
Crustacean (2)		1		400	3.45	0.53
Reptile		0.5		40	14.2	2.38
Pelagic Fish		1		400	6.49	1.08
Vascular Plant			1	400	11.7	1.83
Zooplankton		1		400	271	45.4

Geochemical Modelling

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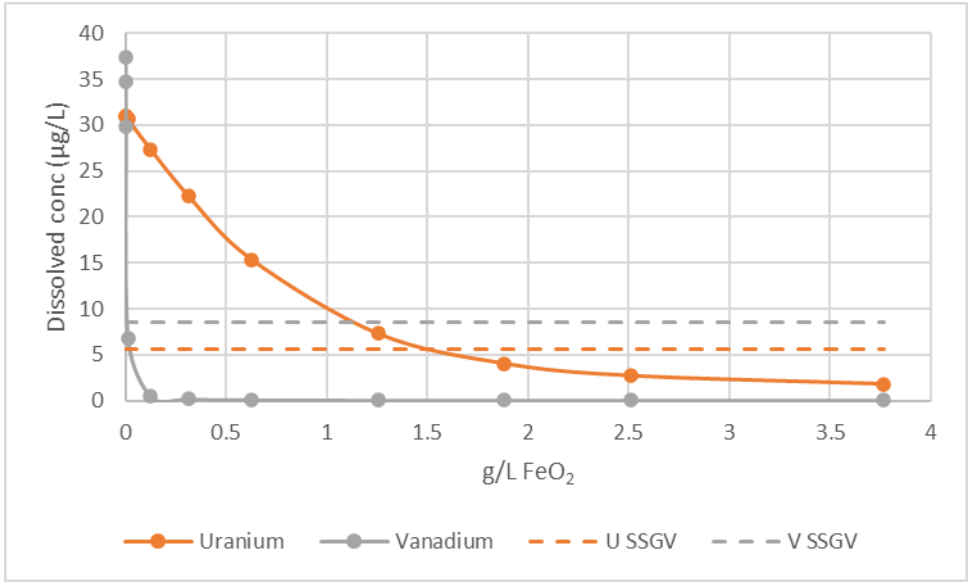
- PHREEQC package – MBS talk on this on Friday
- Model if contaminants of interest can be removed from solution
- pH, dissolved O_2 (DO), iron oxides (sorption)
- DO & pH were largely irrelevant
- Addition of iron oxides able to remove both U & V - 2 g/L for U; 0.01 g/L for V



Laboratory Bench Tests

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- Iron oxides most likely removal option (PHREEQC modelling)
- Two options for treatment prior to discharge:
  - Mixing with native soils – holding ponds
  - Dosing with iron oxide minerals
- Modelling doesn't detail timeframes for contaminant removal via adsorption (assumes equilibrium)
- On site trials – space and cost prohibitive + issues if they don't work
- Engaged with ChemCentre to lab simulate water treatment conditions

ChemCentre EXPERT SOLUTIONS

Laboratory Bench Tests

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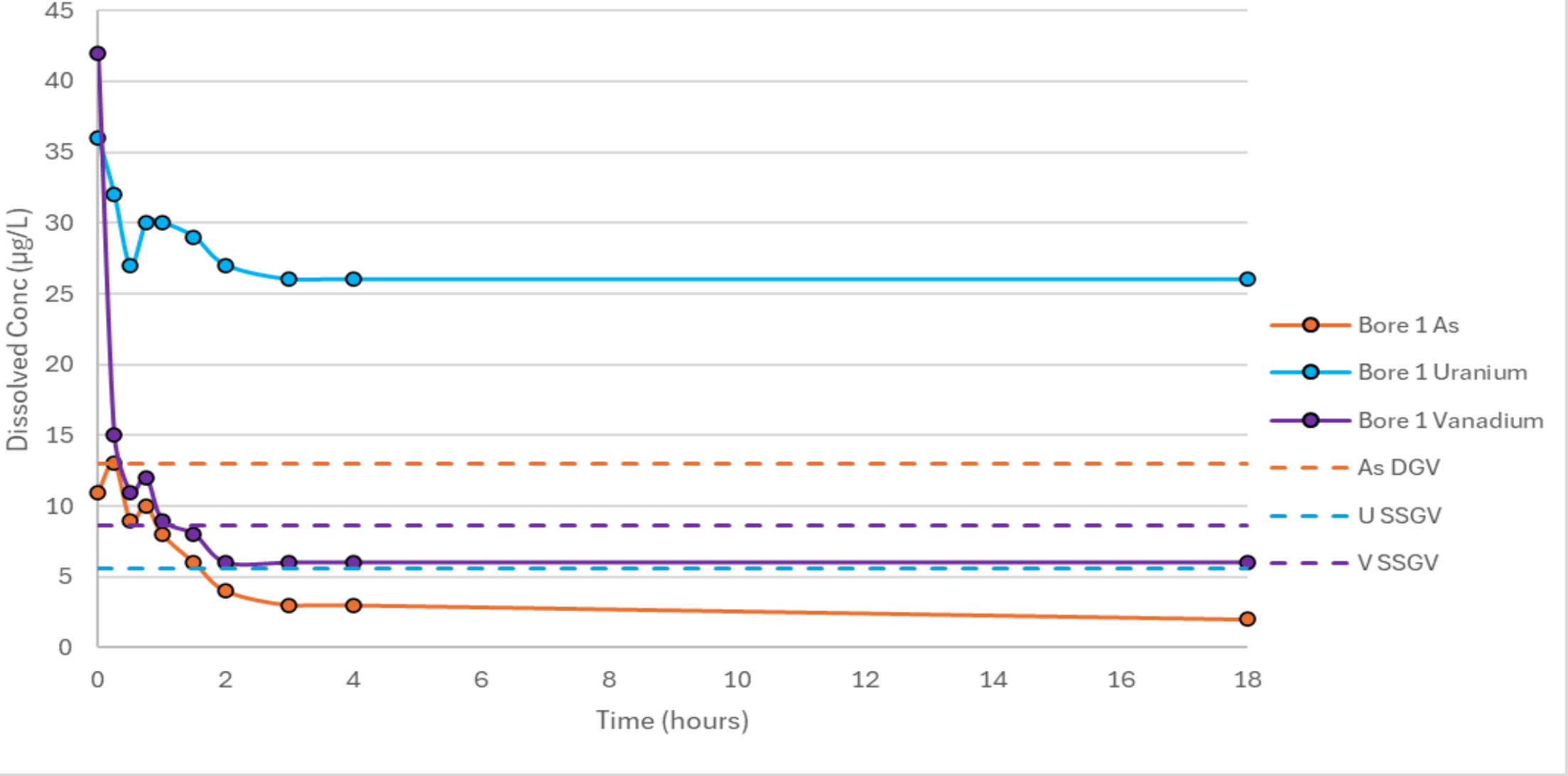

Laboratory Bench Tests

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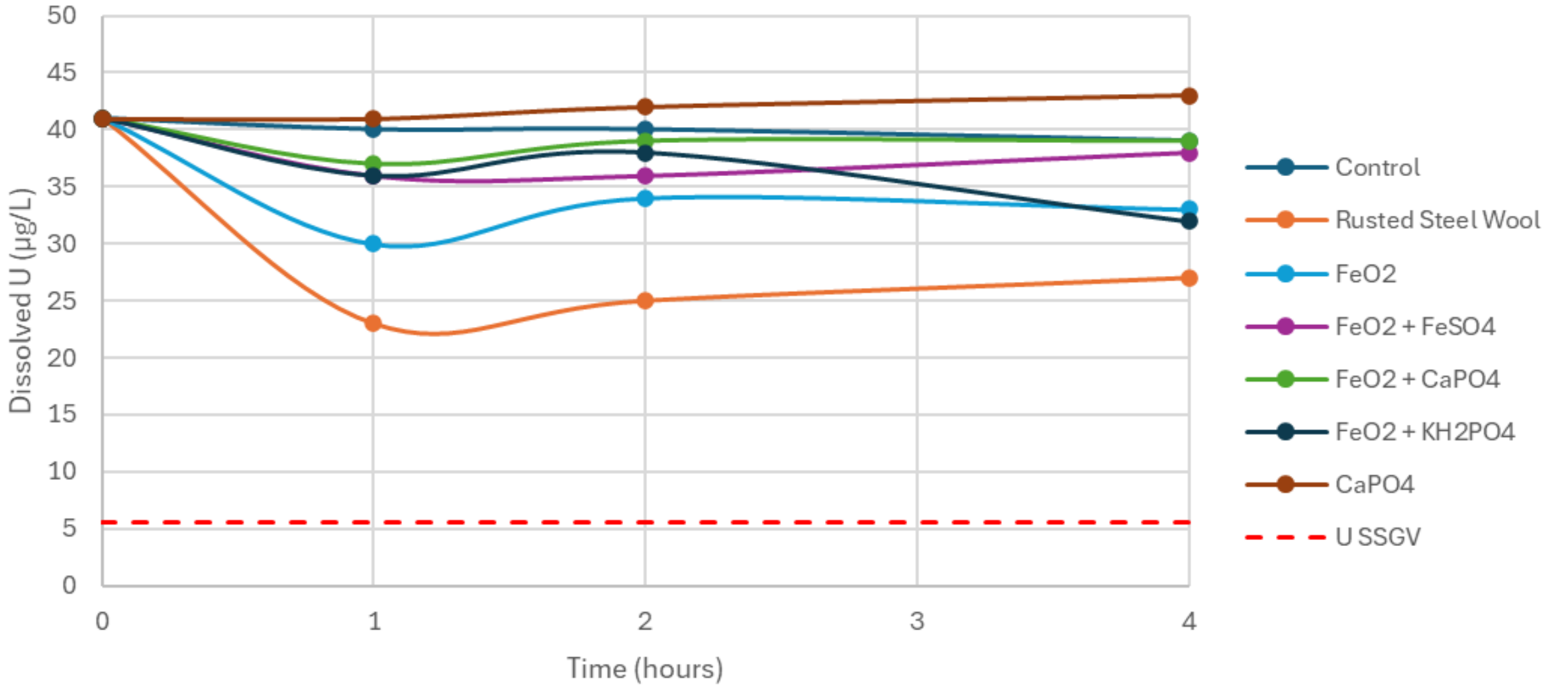

Ecotoxicology Tests – Tier 3 ERA

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- U removal – unsuccessful
- U will be elevated (temporarily) in receiving environment upon discharge
- Is this really an issue?
- Ecotoxicity tests on local species to establish risk profile
- Consisted of:
  - 5 local species – encompassing three trophic levels – algae/ plants, invertebrates, fish
  - Variable toxicology endpoints – survival, offspring viability, population growth
  - 5 dilutions – 0%, 45%, 60%, 80% and 98%
- Ecotox Services Australia (ESA)

ecotox SERVICES AUSTRALIA

Ecotoxicology Tests – Tier 3 ERA

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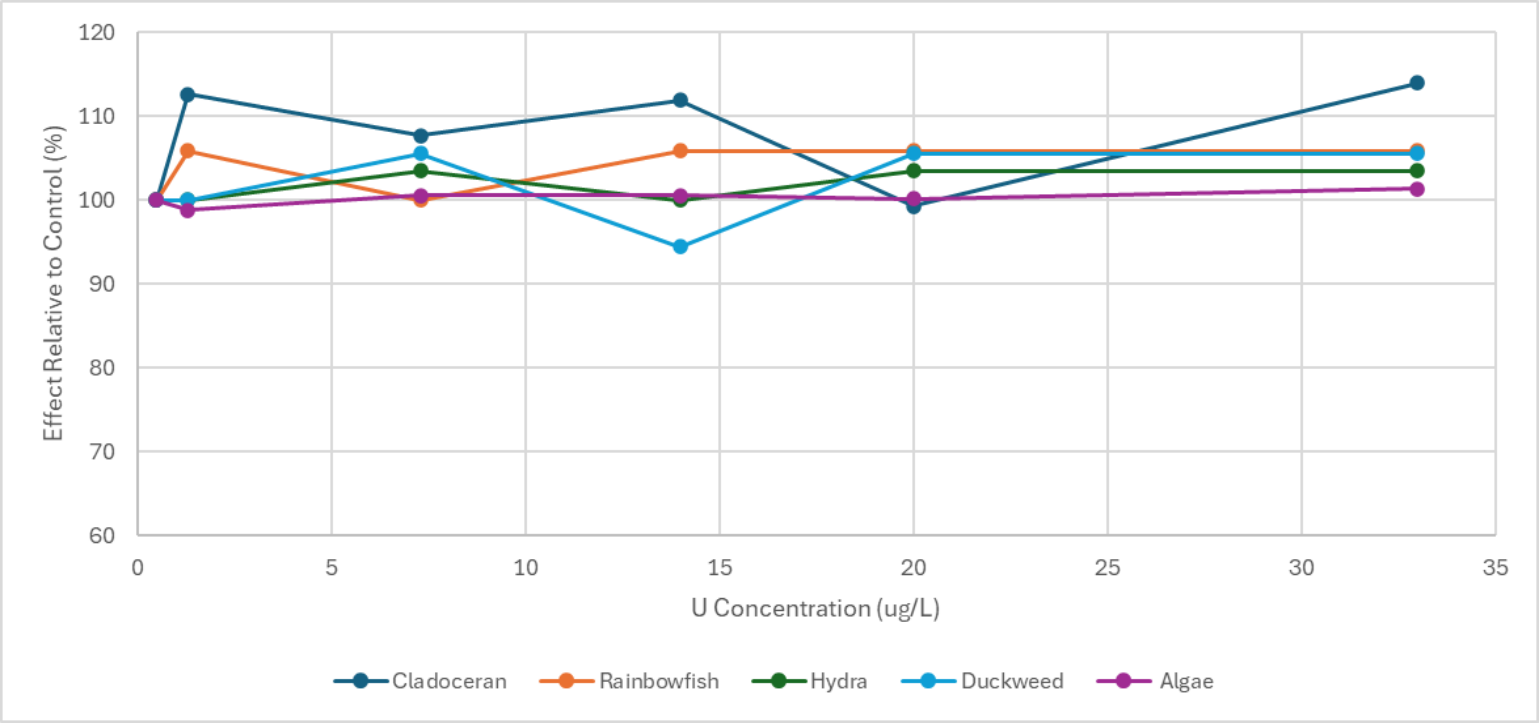

- U at approx. 33 µg/L had no effect on any test species
- Risk of discharge is therefore very low
- Likely reason is high alkalinity → formation uranyl carbonate species
- Uranyl carbonates extremely soluble, but are also of far lower environmental toxicity
- Limited information in PHREEQC on uranyl carbonates

Summary and Significance

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- Systematic approach to management of potential contaminants:
  - Modelling to confirm solubility control factors
  - Laboratory experiments to ground-truth modelling results
  - Ecotoxicology tests to determine contaminant exposure significance
- Allowed for clear presentation of risks to client
- Allowed MBS to understand the mechanisms behind limited U sorption & decreased U toxicity
- Significant cost saving:
  - Water treatment – 2 g FeO_2/L = $19 million in reagents
  - Ion exchange treatment plant - $5-6 million
  - Our approach - < $100,000

Take Home Messages

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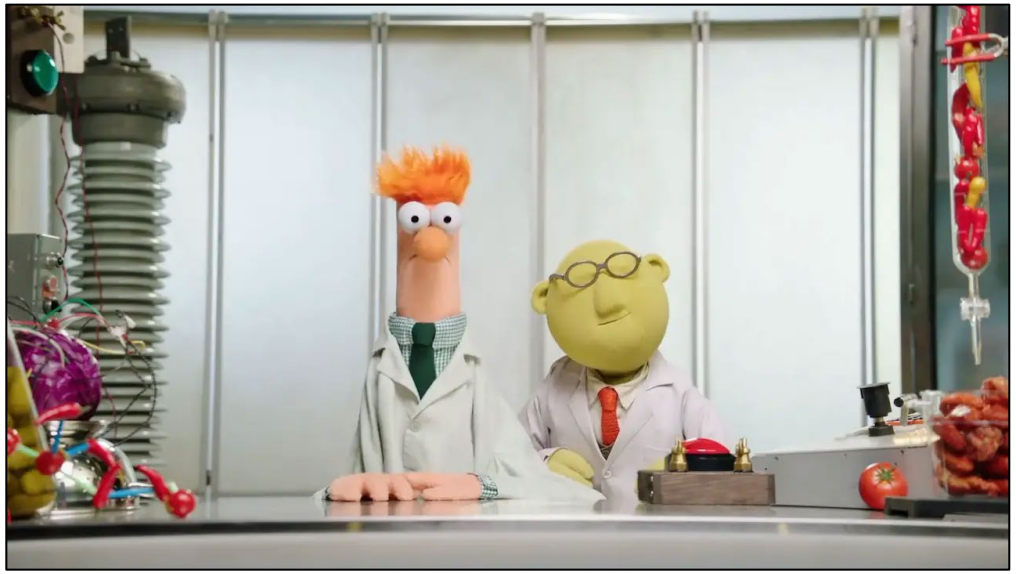
- Requirement to conduct ERAs becoming more common
- Tier 1 → Tier 2/3 assessments
- Increase in tiers → complexity
- Modelling and laboratory approach can provide cheaper solutions



Acknowledgements

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MBS Geochemistry Team

- Dr Michael North – Technical Input & Advice
- Lousie Crawley – Radiation
- Dr Greg Lekmine – PHREEQC Modelling

ChemCentre – Lab experiments

Ecotox Services Australia – Ecotoxicology Testing