Roots for Resilience Fellowship

Research Topic: Techno-Economic and Life Cycle Assessment of Membrane Distillation

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Department of Chemical and Environmental Engineering

Varinia Felix
November 17th, 2023

OUTLINE

- R4R Introduction
- Program
- Useful tools
- Examples
- Future work

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R4R INTRODUCTION

- Program is led by the Arizona Institute for Resilience (AIR), CyVerse, and the Data Science Institute (DSI)
- Multidisciplinary graduate student cohort, fosters collaboration and building network
- Open Science and data science tools are at the core of the program
- Integration of studied tools and increasing colleges data science capacity is the main takeaway

How to get involved?

- The program targets departments that support environment/resilience-focused research.

- Departments must be invited to nominate a student for participation by AIR.

- Candidates should be of collaborative-mind, PhD candidates who have completed qualifying exams, preferably not on their graduating semester.

CyVerse Foundational Open Science Skills FOSS 2023

PROGRAM

- Intro to Open Science
- Data management
  - FAIR data
  - Data management plans
- Project Management
- Intro to Cyverse
- Documentation/Communication
  - Internal/External
  - GitHub for Website
- Version Control
  - General
  - GitHub
- Reproducibility
  - Containers

Extra:
AI For research

Taken from: https://foss.cyverse.org/schedule/

OPEN SCIENCE

- Aims to make scientific research, data, and dissemination accessible to all members of society, regardless of their level of expertise.
- It seeks to make the process of science transparent and inclusive, from professionals to amateurs, by fostering collaborative networks that share and develop knowledge

Current Research

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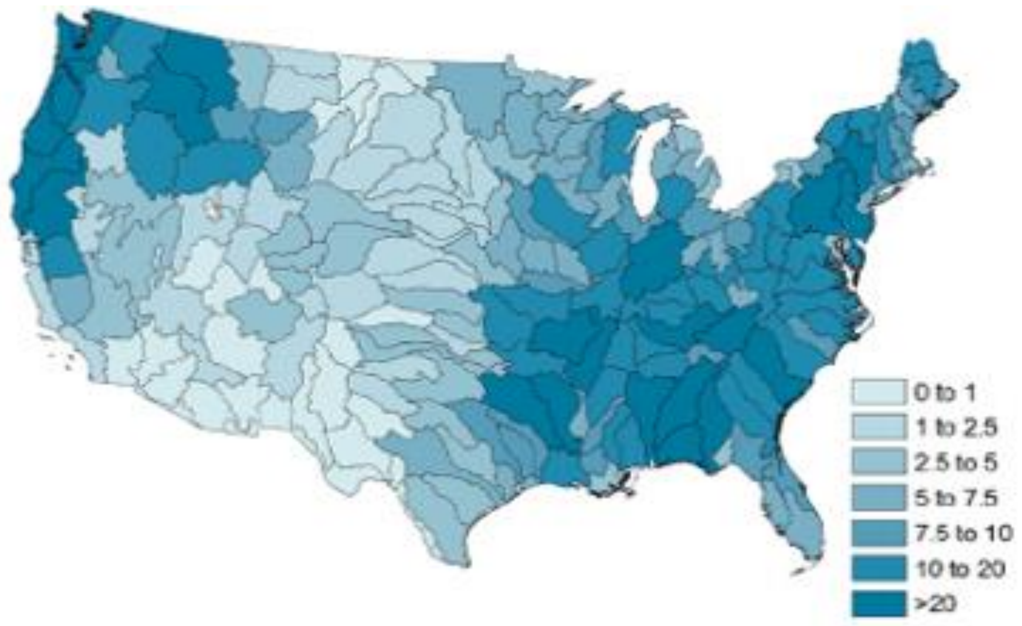
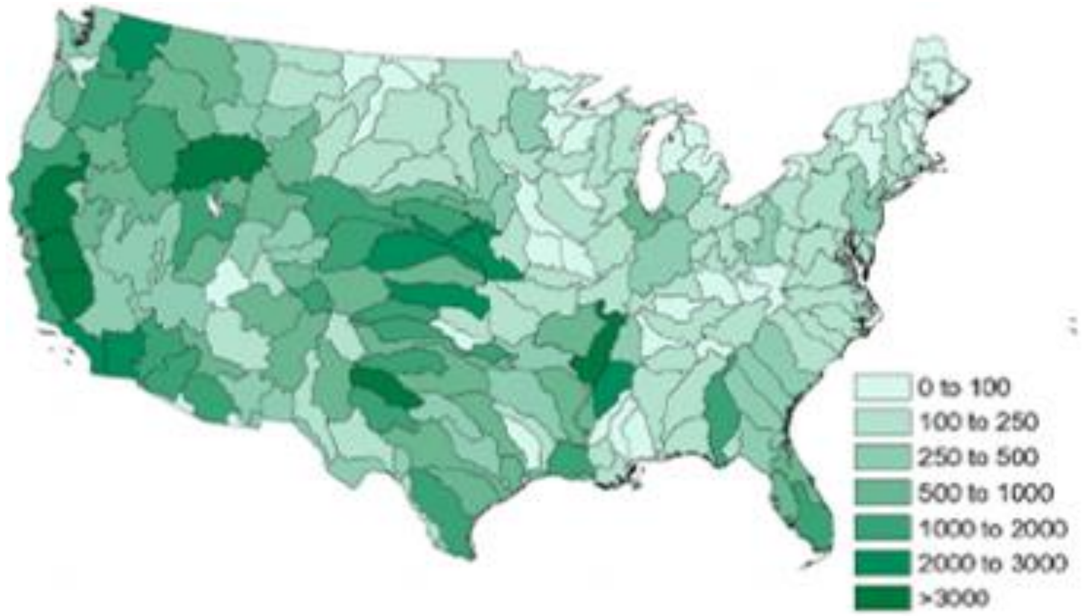
MOTIVATION

Water crisis

Water Yield 1985–2010 Bm^3

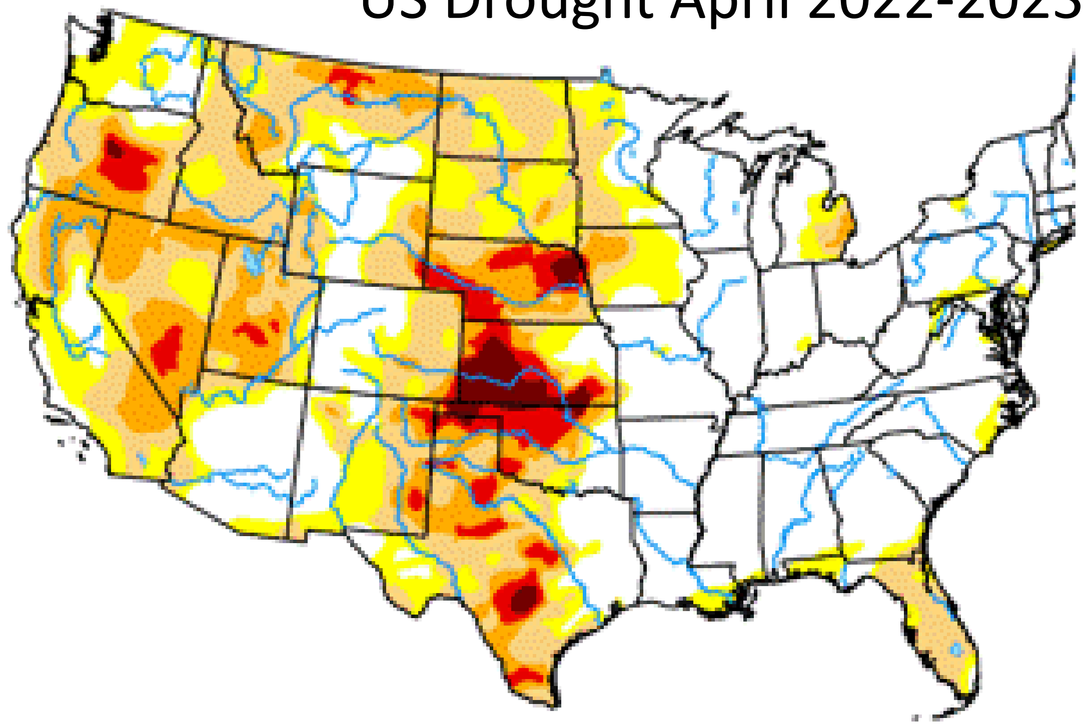


Water Demand 1985–2010 Mm^3



Climate change affects water security

US Drought April 2022-2023



Tucson wildfire 2021

Lake Mead Dec 2022

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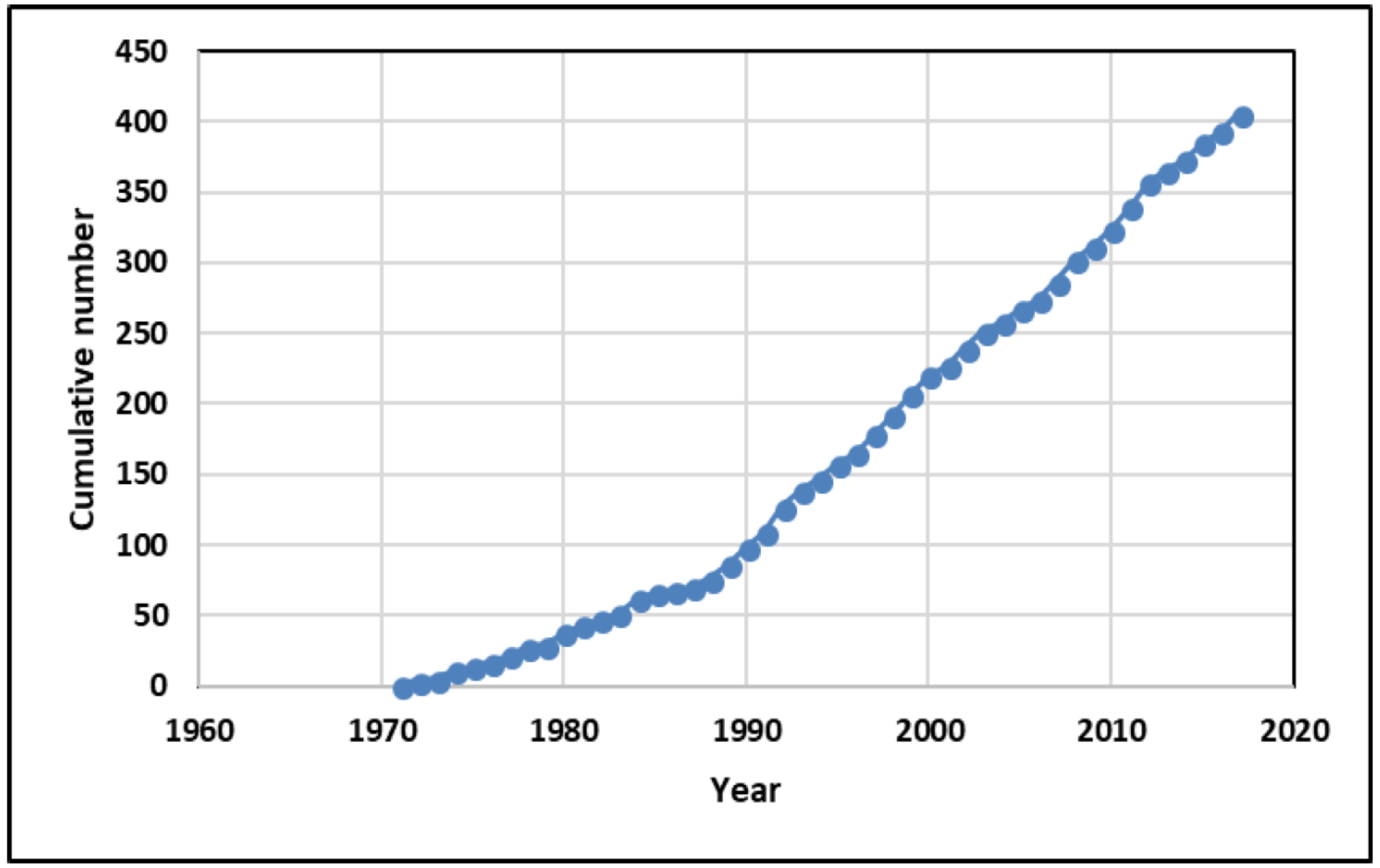
Inland regions can augment their supply by brackish water desalination and treatment of reclaimed water for potable reuse.

US Desalination plants



Mickley M., Report 207: Updated Survey of U.S. Municipal Desalination Plants U.S. Department of the Interior. Bureau of Reclamation, 2017.

- **379** Water treatment plants (WTP) producing potable water
- **24** Wastewater treatment plants (WWTP) producing water for disposal or recycle

80% of these plants have RO as part of their treatment train

MOTIVATION

Problem: The industry standard for Desalination and Reuse has as a byproduct, large volumes of high salinity and organic matter streams known as Concentrate/Brine that need to be managed

Concentrate

- High salinity
- Rich in organic matter
- High disposal cost
- Negative environmental effects:

MOTIVATION

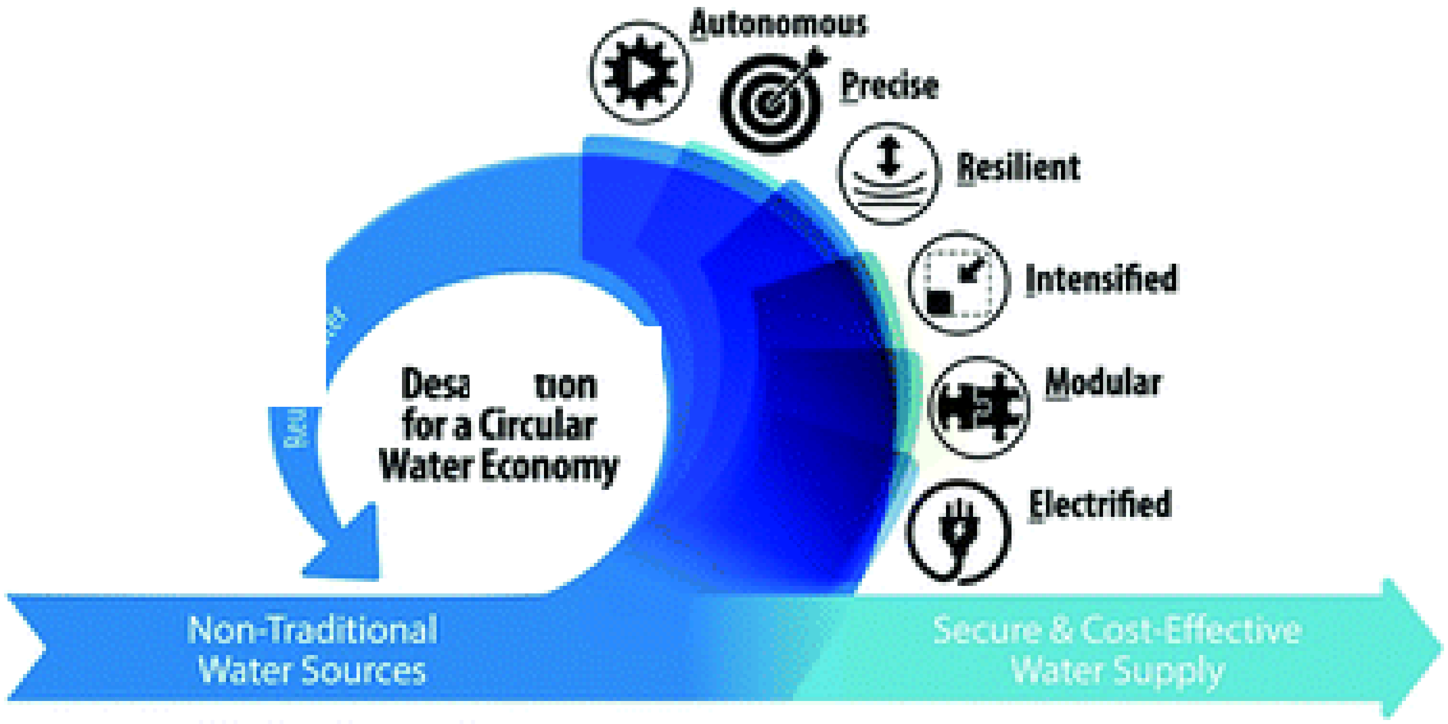
Conventional concentrate management

CAN LIMIT POTABLE REUSE AND DESALINATION IMPLEMENTATION

- Challenging for inland regions due to policy/regulation, land requirements and hydrogeologic conditions
- Lack of waste to resource approach
- Not modular
- High cost
- Unsustainable long term

Membrane Distillation for concentrate management

- High rejection of non-volatile solutes
- Treat to high feed concentration
- Low grade heat can be utilized
- Lower energy requirements than RO at high salinity
- Can achieve Near Zero Liquid Discharge
- Modular

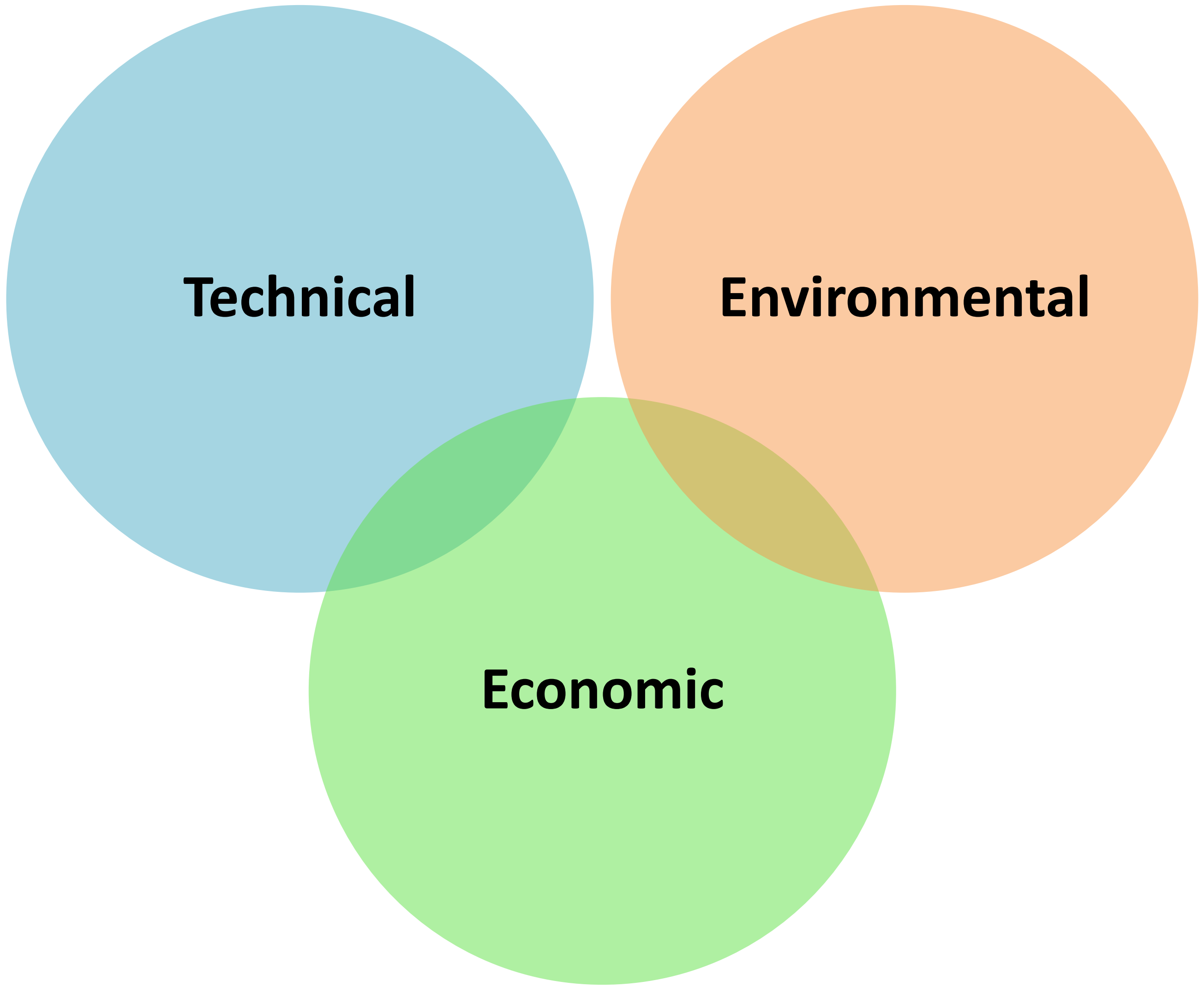


Membrane Distillation

- Past studies focus on performance and technical feasibility and challenges

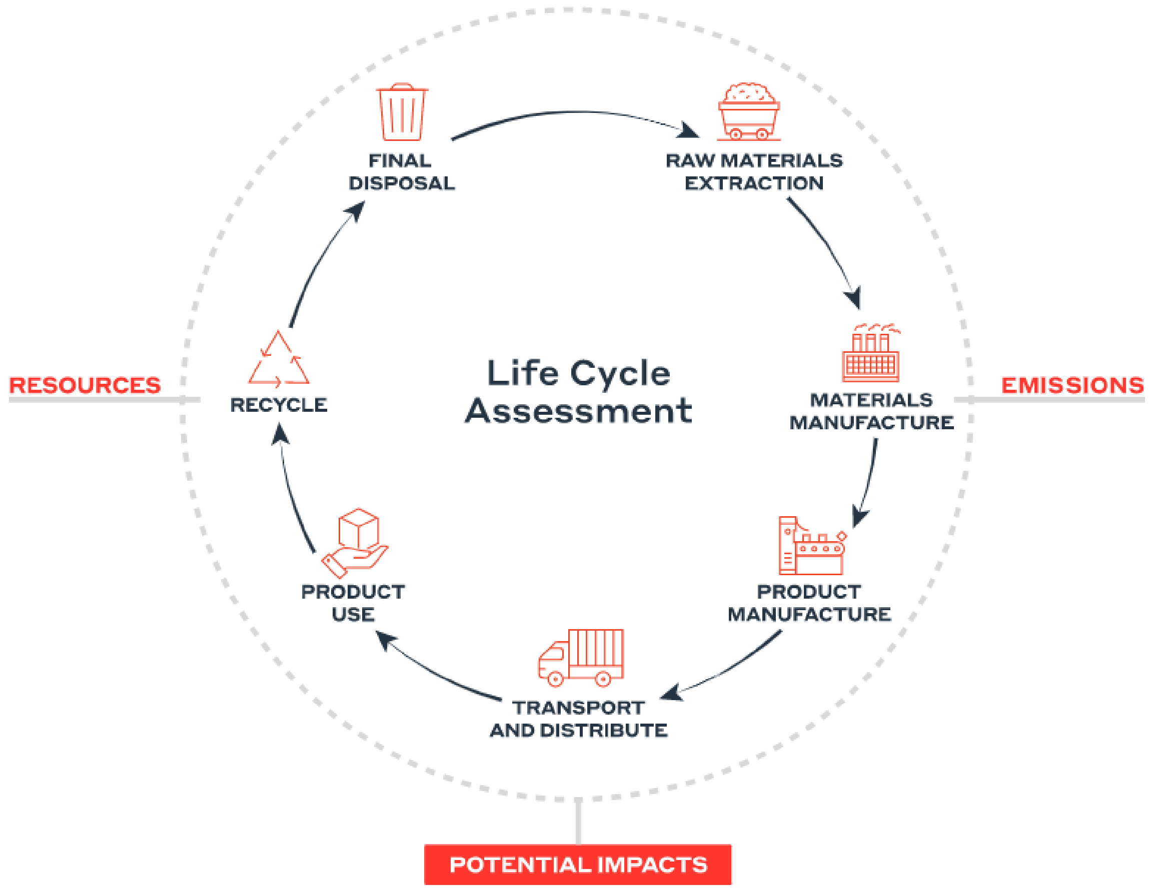
- **Minimal attention** in techno-economic and life cycle environmental impact assessments, especially when comparing its scale-up feasibility to conventional technologies for managing concentrated streams

Holistic assessment is crucial for successful implementation

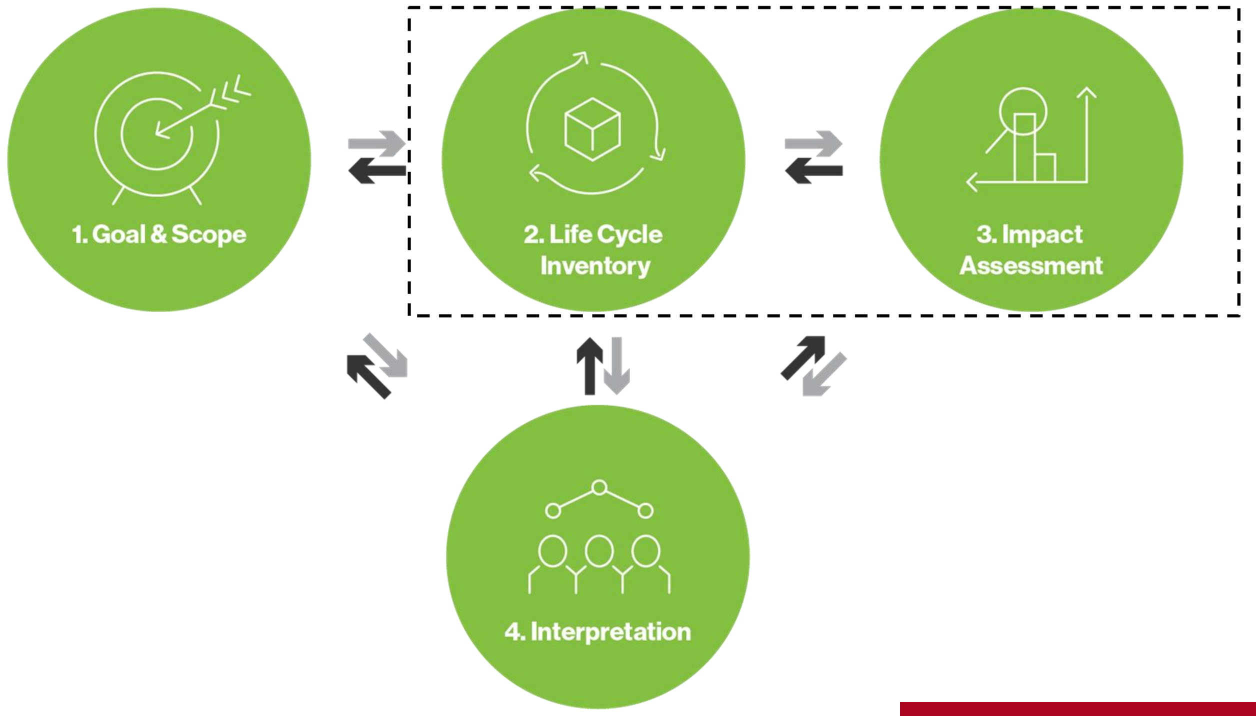


Where I am at

Life Cycle Assessment (LCA)



Iterative process



Quantify and understand the environmental impacts of a product or system throughout its lifespan.

Identify impact drivers and areas where the biggest opportunities to reduce the environmental footprint are.

Communicate results to the user/decision maker/stakeholders/developers, developer

SimaPro

R4R Outcomes

For my project:

- Data visualization
- Version control
- Reproducibility

For general lab practice improvement

- Communication / Documentation
- Transfer of knowledge, data and skills
- Project Management
- Lab governance documents

Lots of parameters, not great to visualize if you are not familiar with the process and/or software!

Human health (Years)	Ecosystems (Species)	Resources ($)
• Global warming, Human health • Stratospheric ozone depletion • Ionizing radiation • Ozone formation, Human health • Fine particulate matter formation • Human carcinogenic toxicity • Human non-carcinogenic toxicity • Water consumption, Human health	• Global warming, Terrestrial ecosystems • Global warming, Freshwater ecosystems • Ozone formation, Terrestrial ecosystems • Terrestrial acidification • Freshwater eutrophication • Marine eutrophication • Terrestrial ecotoxicity • Freshwater ecotoxicity • Marine ecotoxicity • Land use • Water consumption, Terrestrial ecosystem • Water consumption, Aquatic ecosystems	• Mineral resource scarcity • Fossil resource scarcity

System Comparison

LCA **Single score point system**

ReCiPe Endpoint Hierarchic global impact method

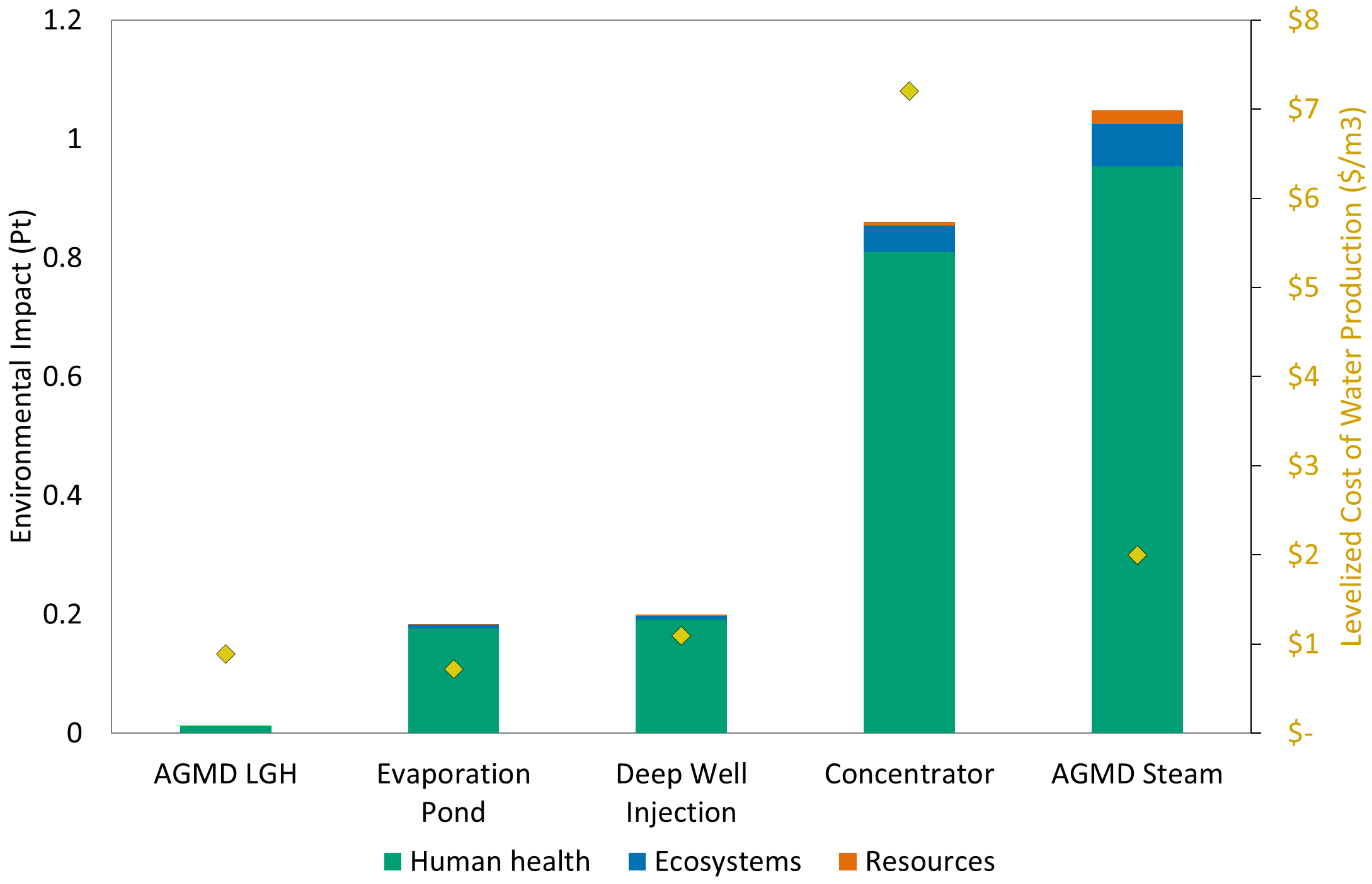
-Endpoint indicators

*Human Health (40% of total Impact)

*Ecosystems (40% of total Impact)

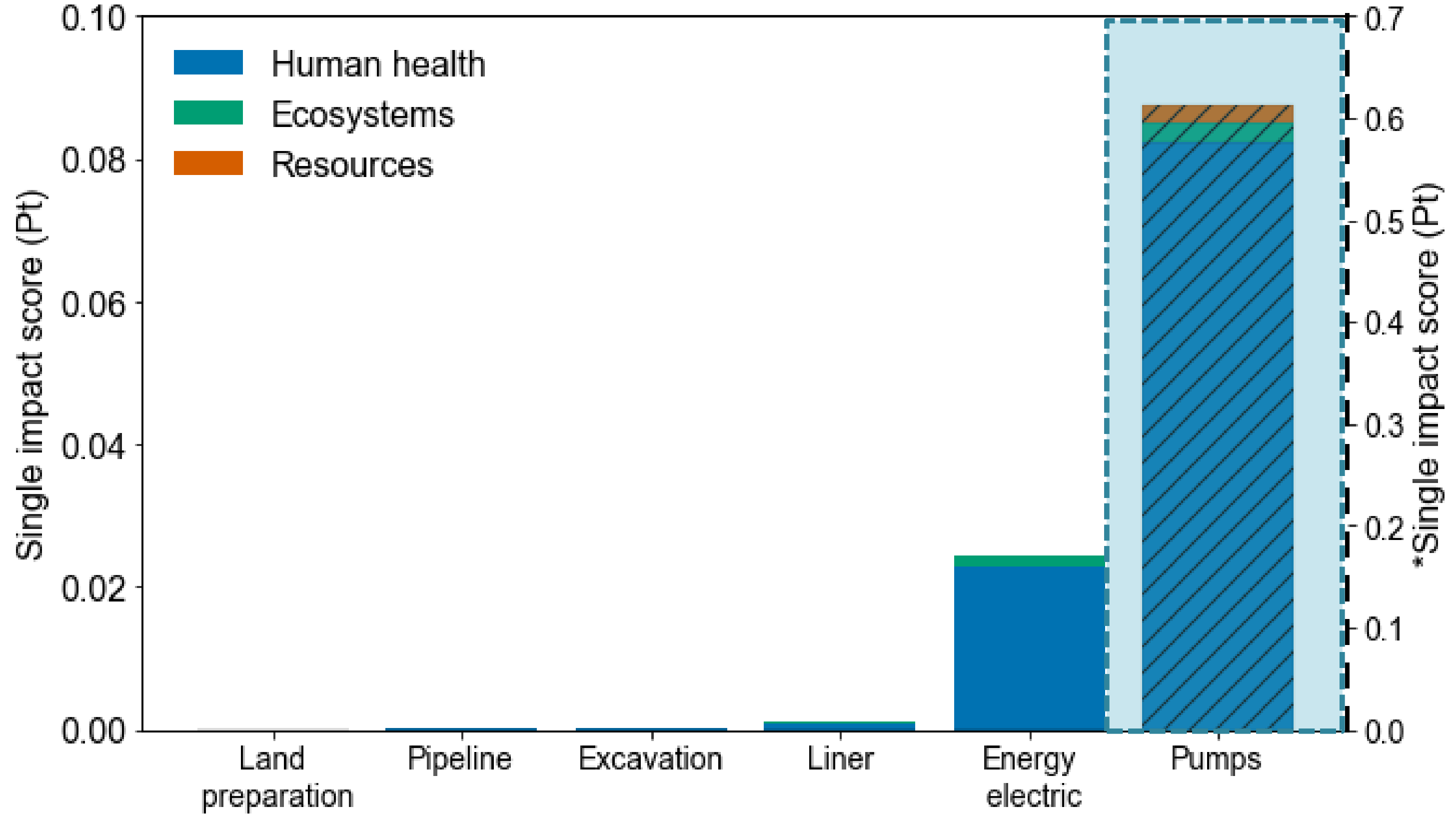
*Resources (20 % of total Impact)

Functional unit 1m^3 concentrate treated or disposed



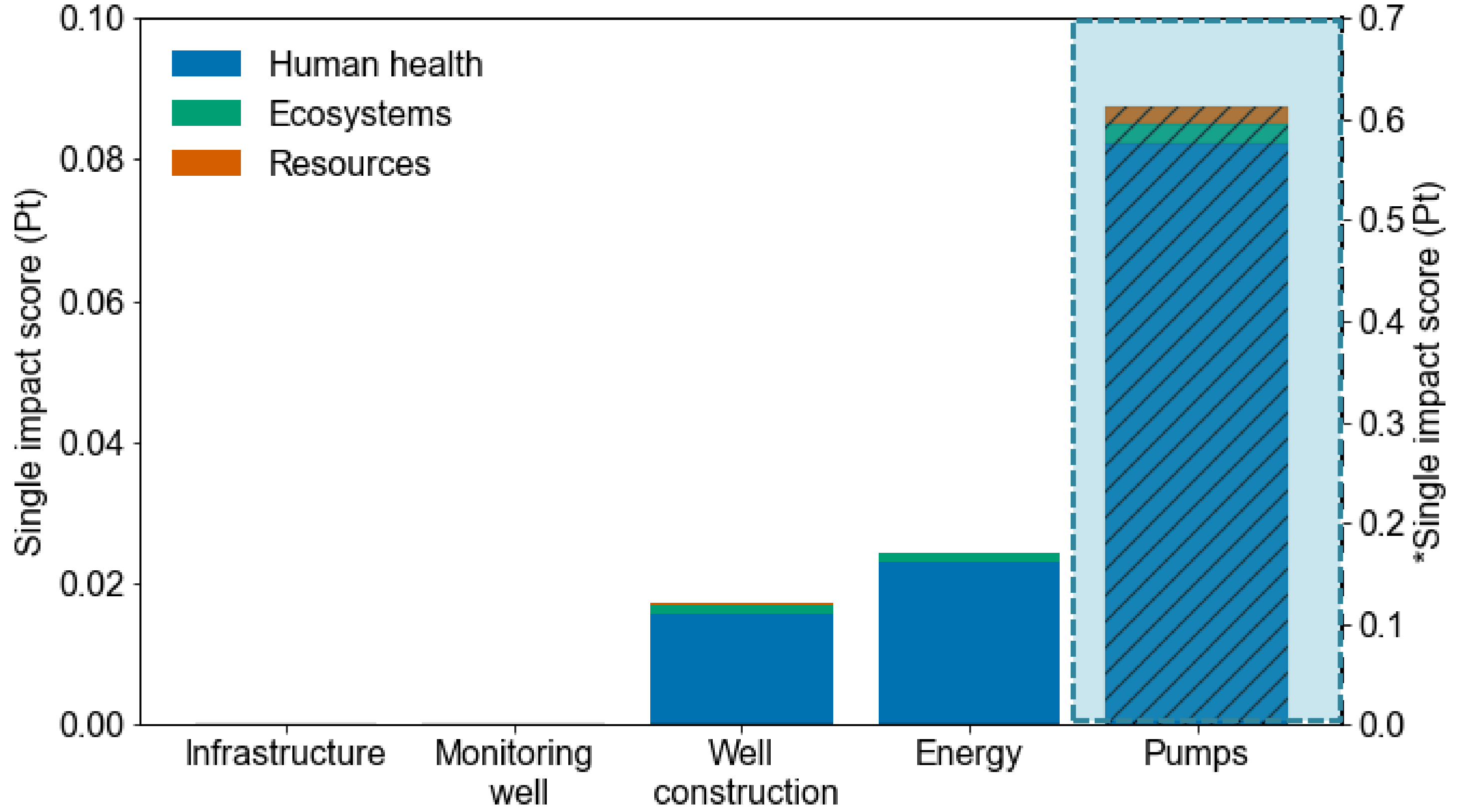
LIFE CYCLE ASSESSMENT

Evaporation pond



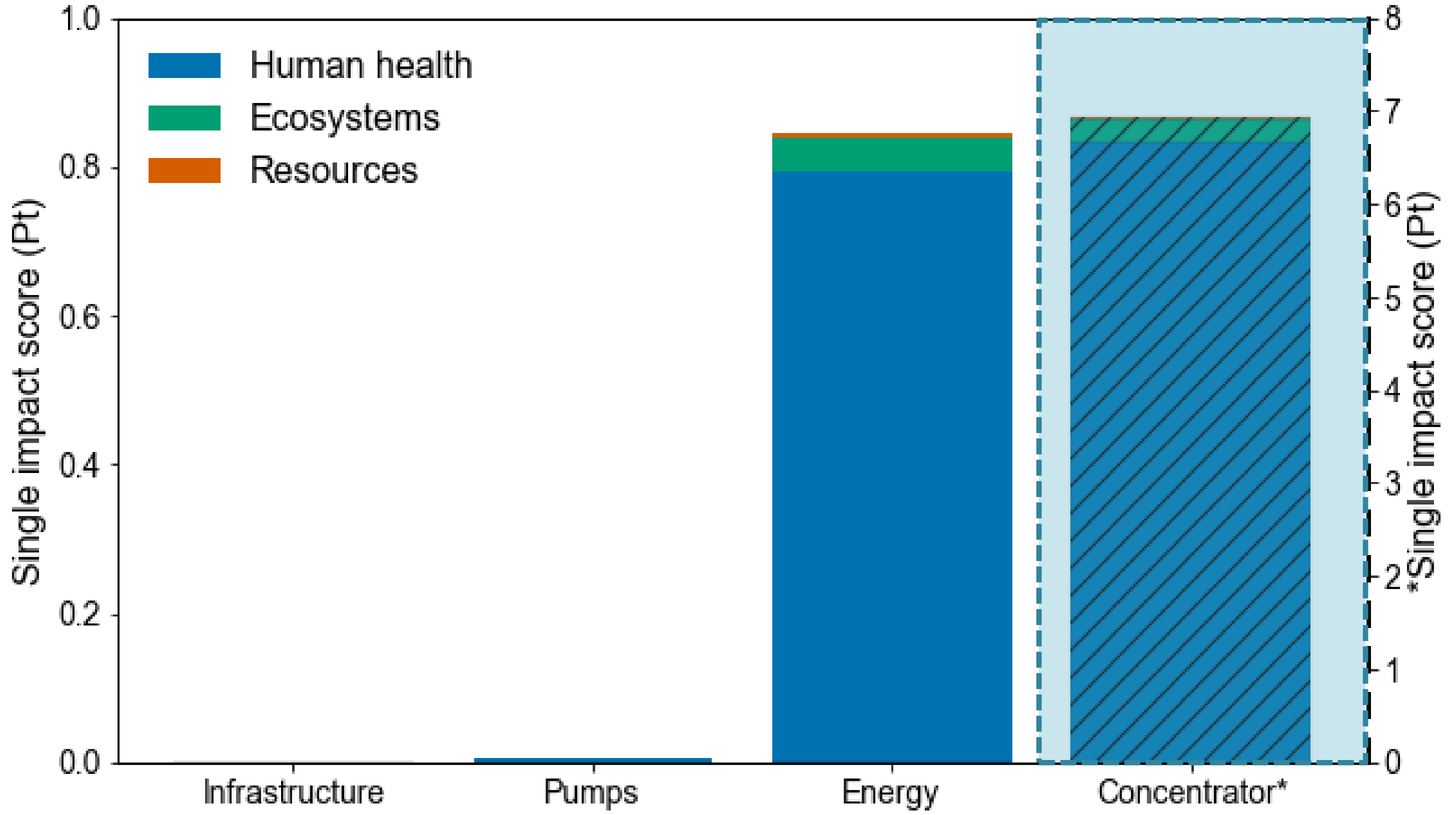
Concentrate transport to injection site is the major influence on environmental effects

Deep well injection



Concentrate transport to injection site is the major influence on environmental effects

Concentrator



Concentrator equipment has the highest impact in the system

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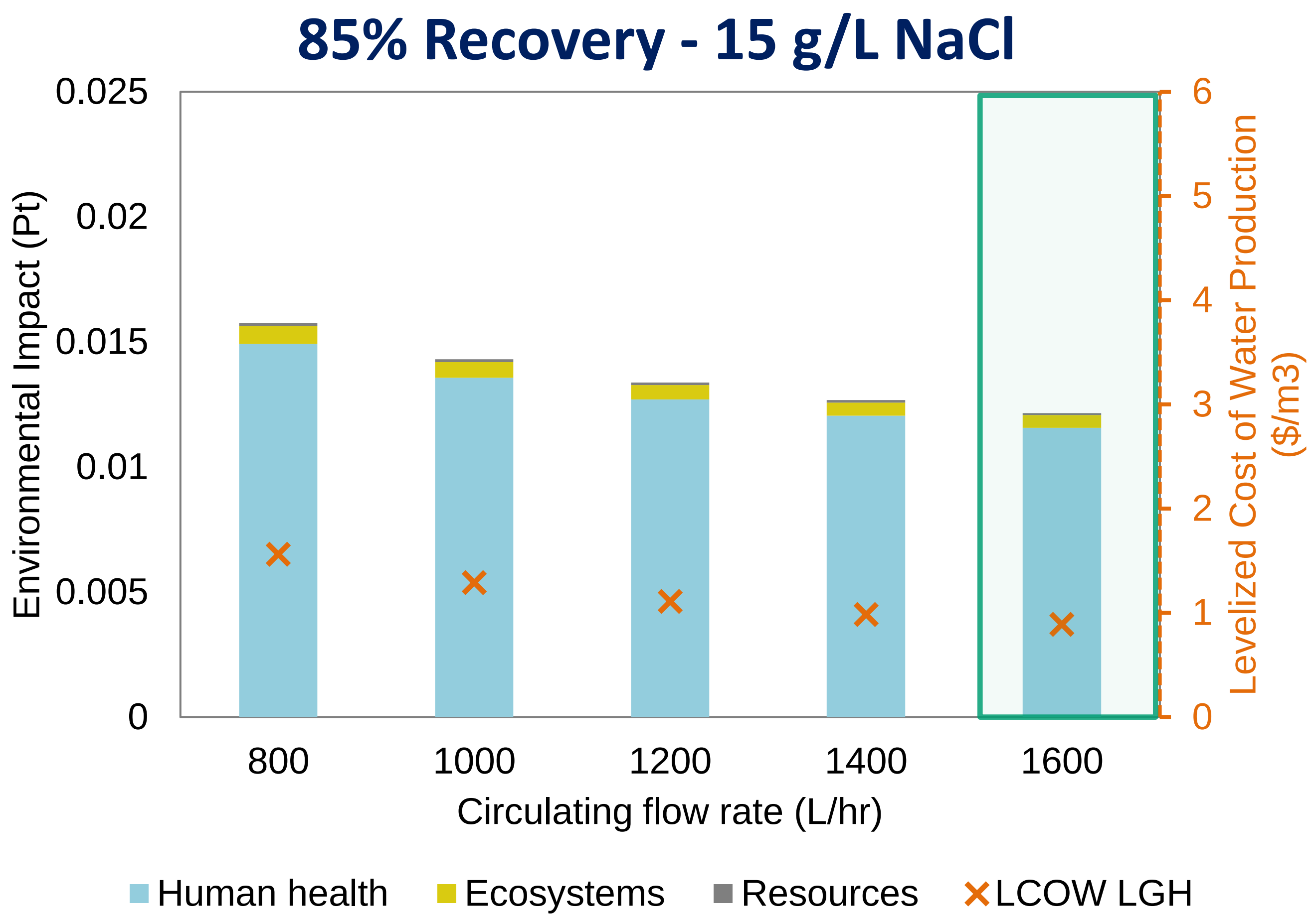
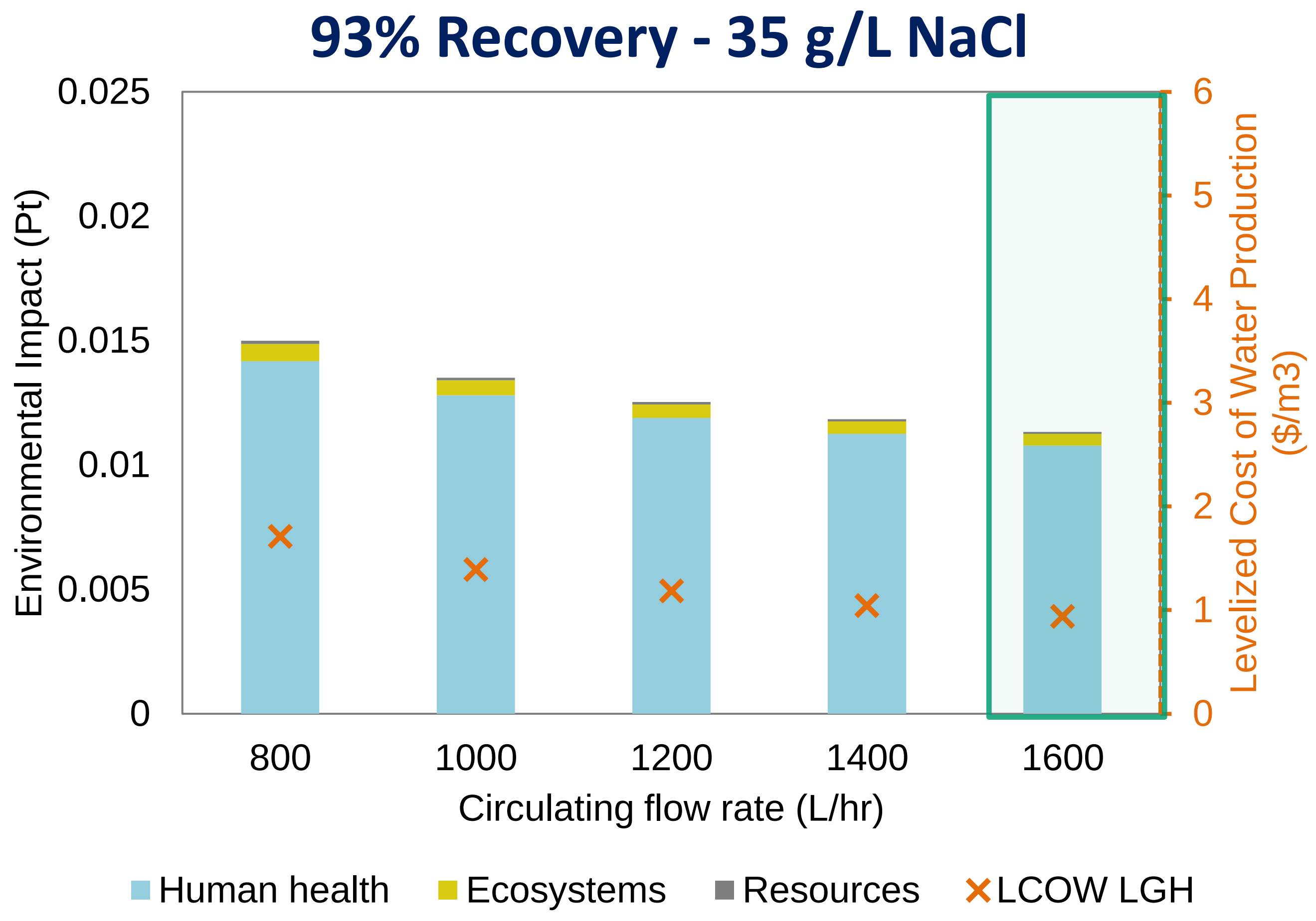
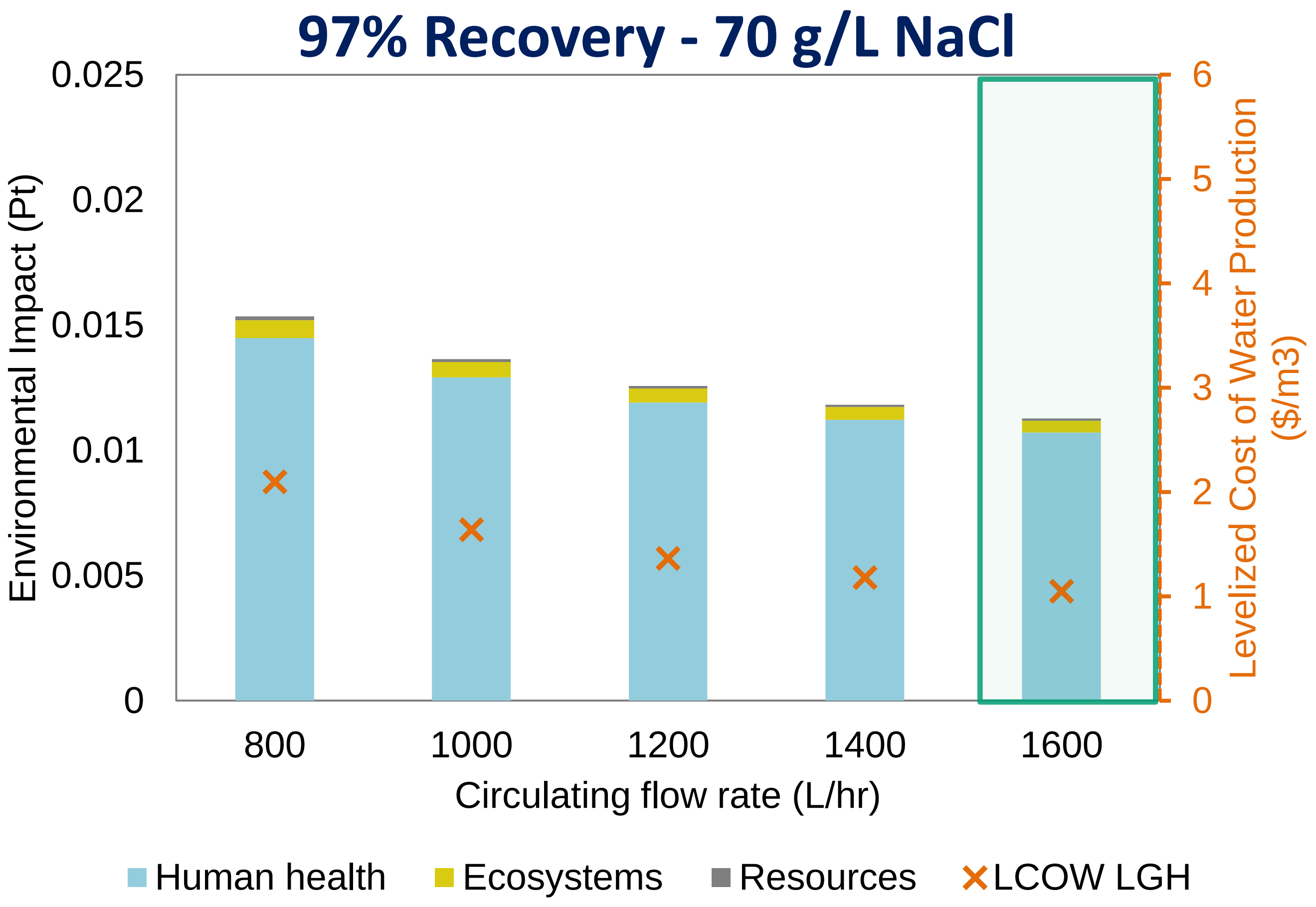
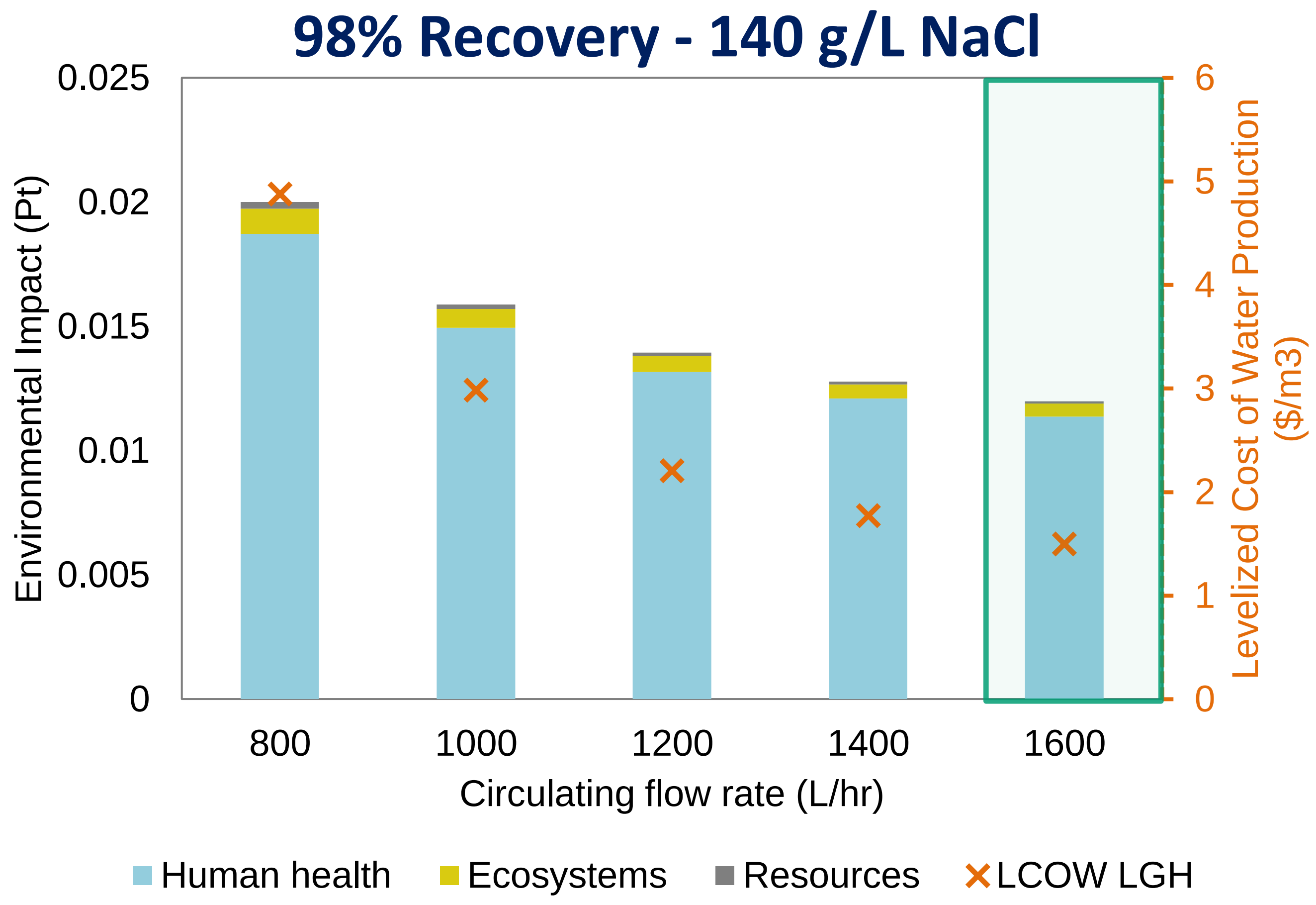
LIFE CYCLE ASSESSMENT

Sensitivities AGMD-LGH









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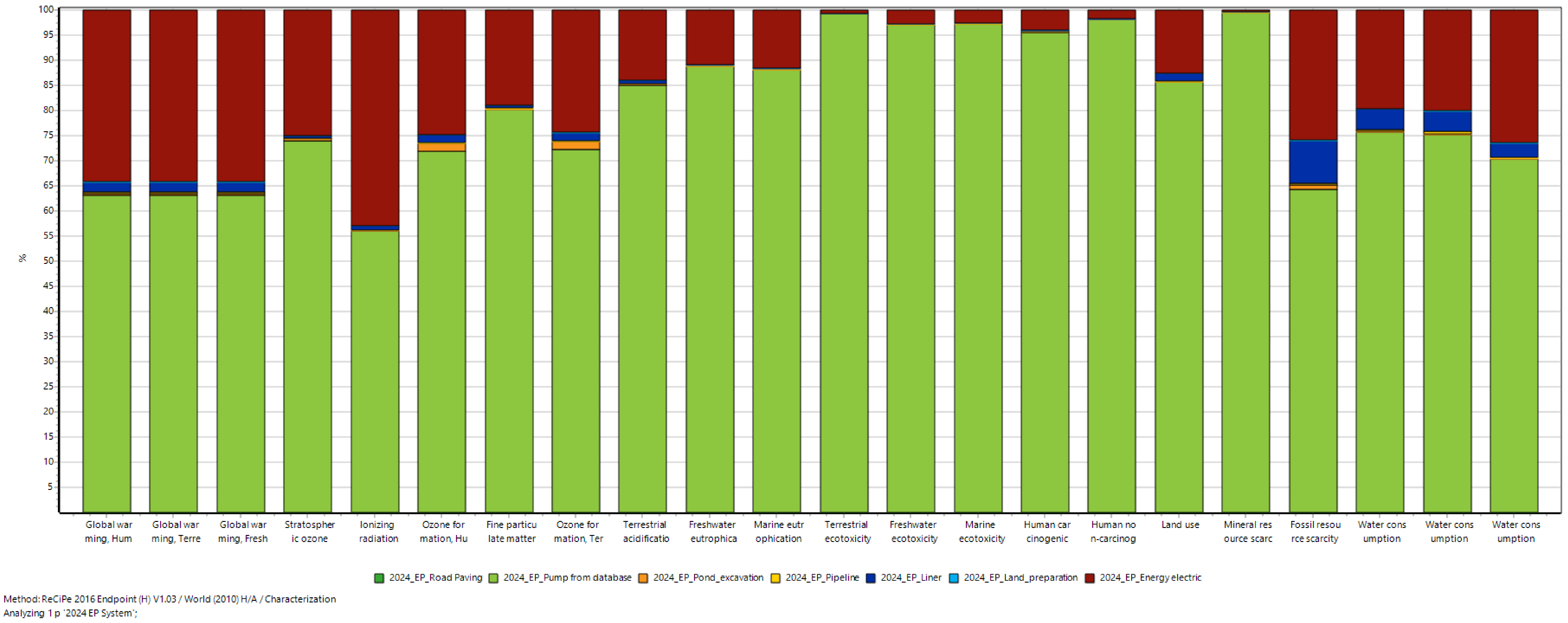
Results Evaporation Pond | Life Cycle Assessment

EXAMPLES Data Viz



Initial and quick data visualization with AI

Experimental evidence on the productivity effects of generative artificial intelligence

Shakked Noy, Whitney Zhang

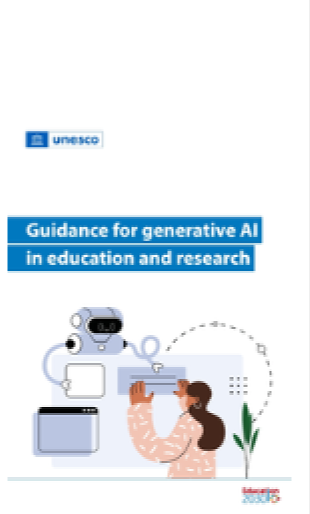
Science

2023 37 citations Semantic Scholar ↗ DOI

Abstract summary

The assistive chatbot ChatGPT raises productivity in professional writing tasks and reduces productivity inequality.

book



Online

Open Access

Guidance for generative AI in education and research

Corporate author : UNESCO [6720]

Person as author : Miao, Fengchun [author] [49], Holmes, Wayne [author] [17]

ISBN : 978-92-3-100612-8

Collation : 44 pages

Language : English

Year of publication : 2023

Licence type : CC BY-SA 3.0 IGO [12373]

Type of document : book

Favourites Add Print Share

Software makes data visualization accessible

Microsoft Excel (still good for exploratory data analysis!)

Programming languages

- Mathematica
- MATLAB
- Python: matplotlib, seaborn, plot.ly
- R: ggplot2
- Javascript: (lots)

Taken from DSFellows DataViz Roadshow Presentation

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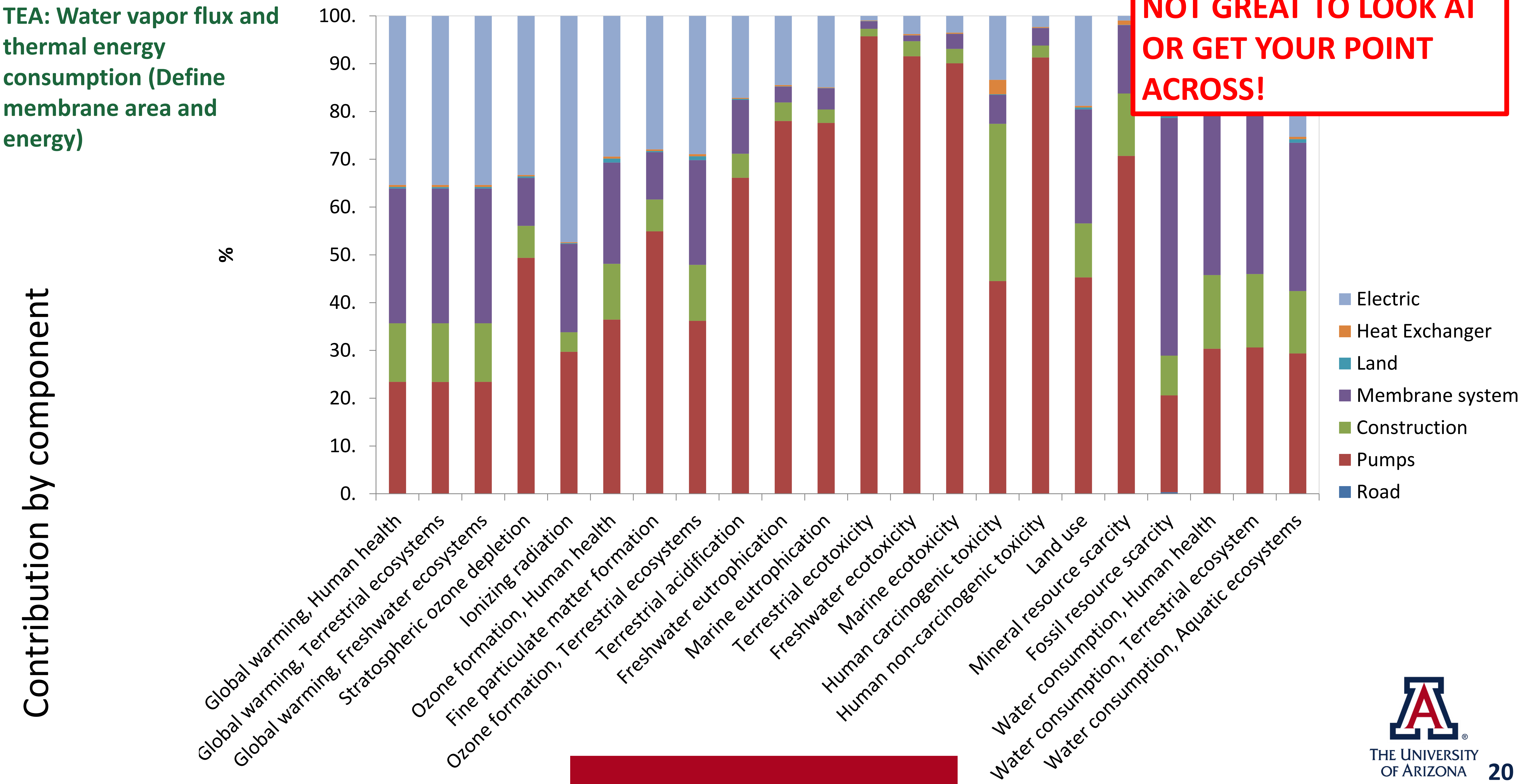
AGMD-LGH

TEA: Water vapor flux and thermal energy consumption (Define membrane area and energy)

NOT GREAT TO LOOK AT OR GET YOUR POINT ACROSS!



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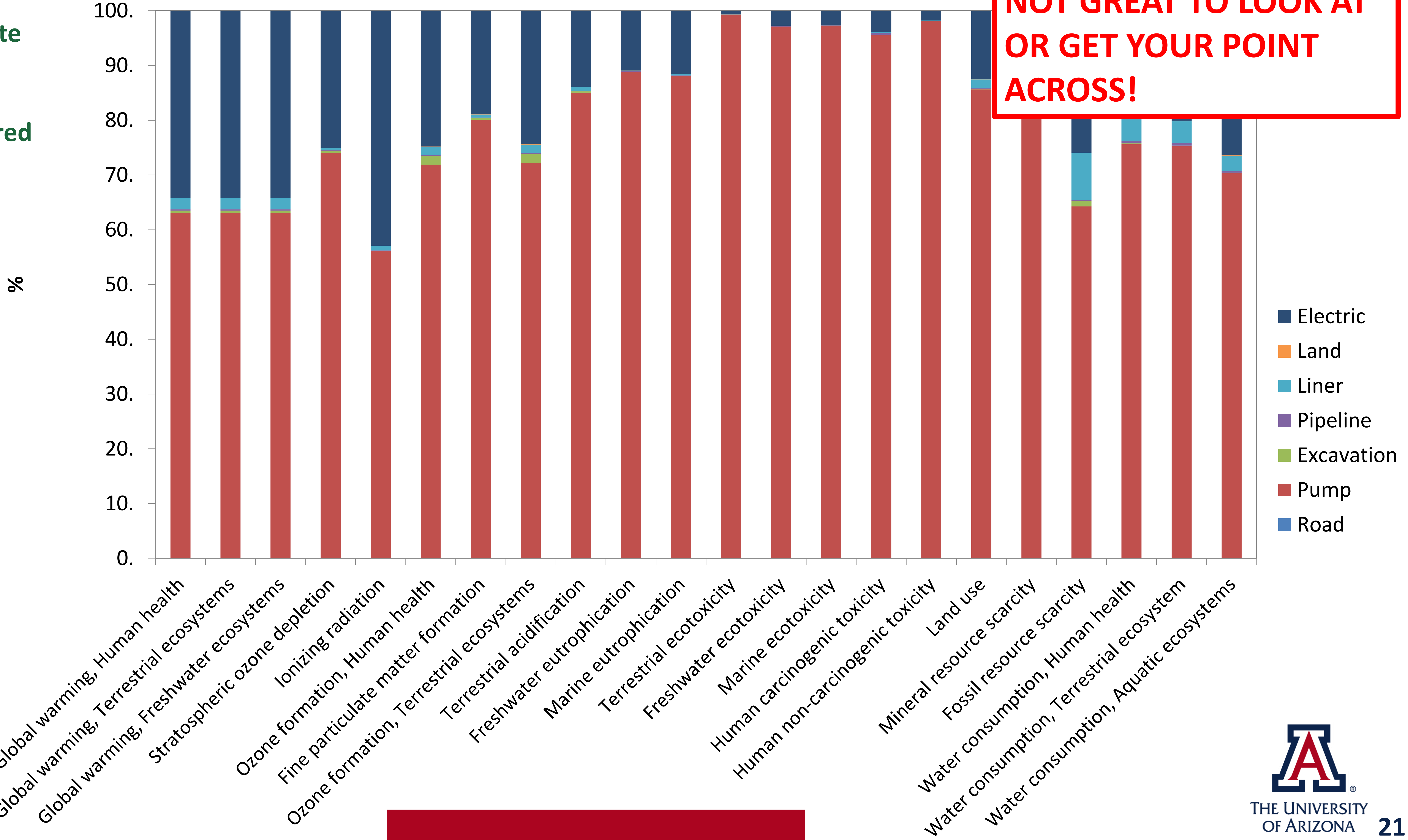
EVAPORATION POND

TEA: Evaporation rate and concentrate transport distance (Defines liner required and energy)

NOT GREAT TO LOOK AT OR GET YOUR POINT ACROSS!

Contribution by component



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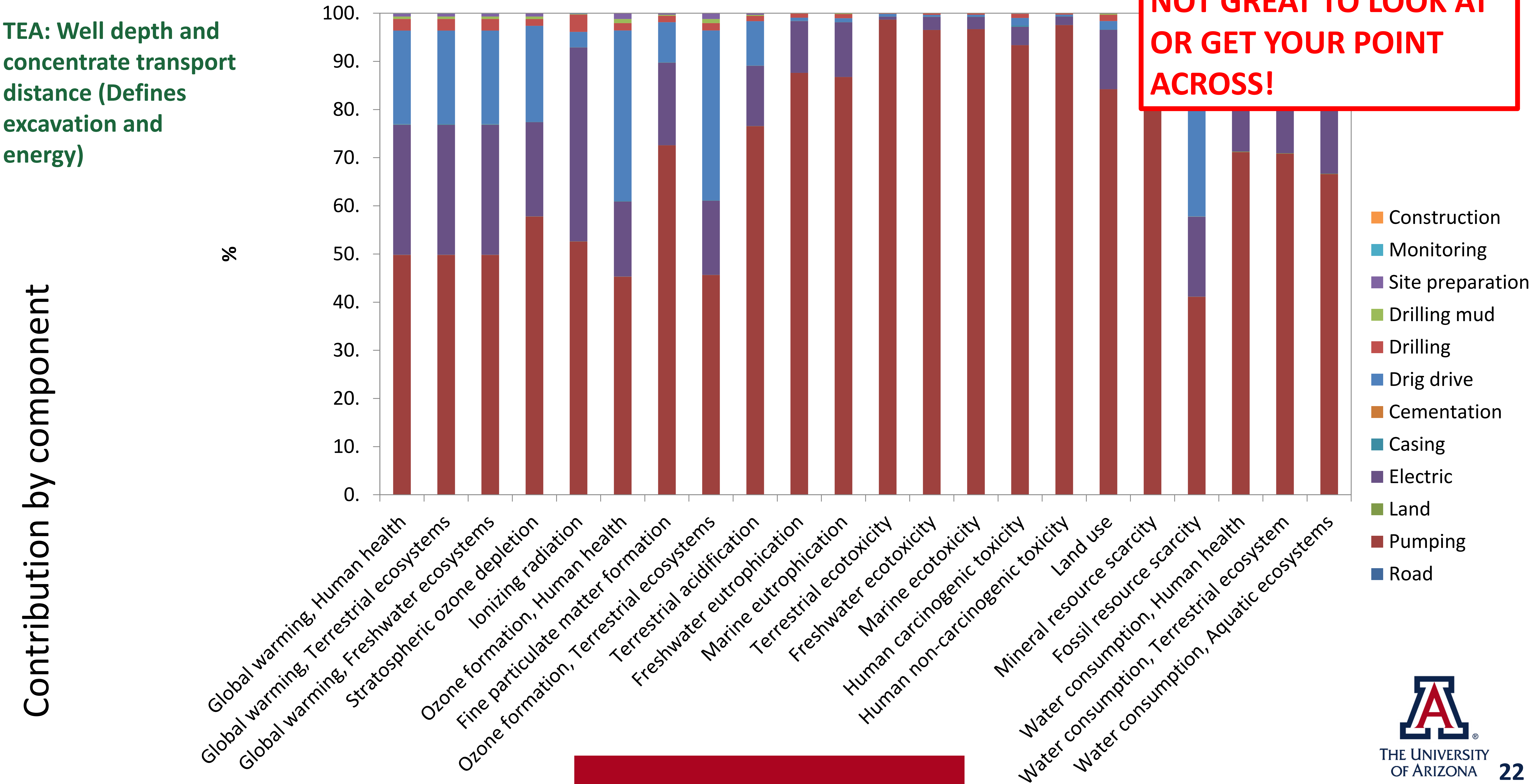
DEEP WELL INJECTION

TEA: Well depth and concentrate transport distance (Defines excavation and energy)

NOT GREAT TO LOOK AT OR GET YOUR POINT ACROSS!



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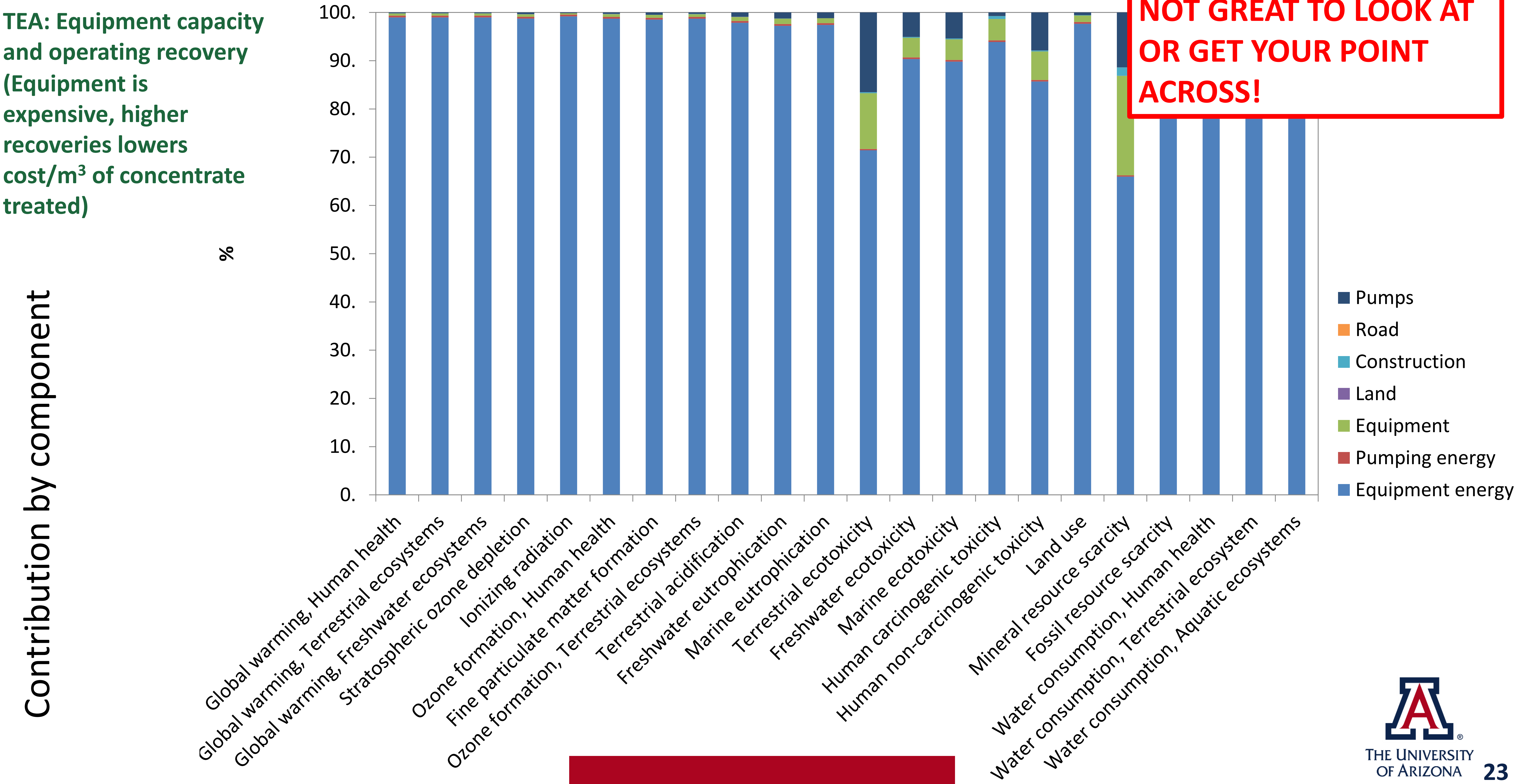
CONCENTRATOR

TEA: Equipment capacity and operating recovery (Equipment is expensive, higher recoveries lowers cost/m³ of concentrate treated)



NOT GREAT TO LOOK AT OR GET YOUR POINT ACROSS!

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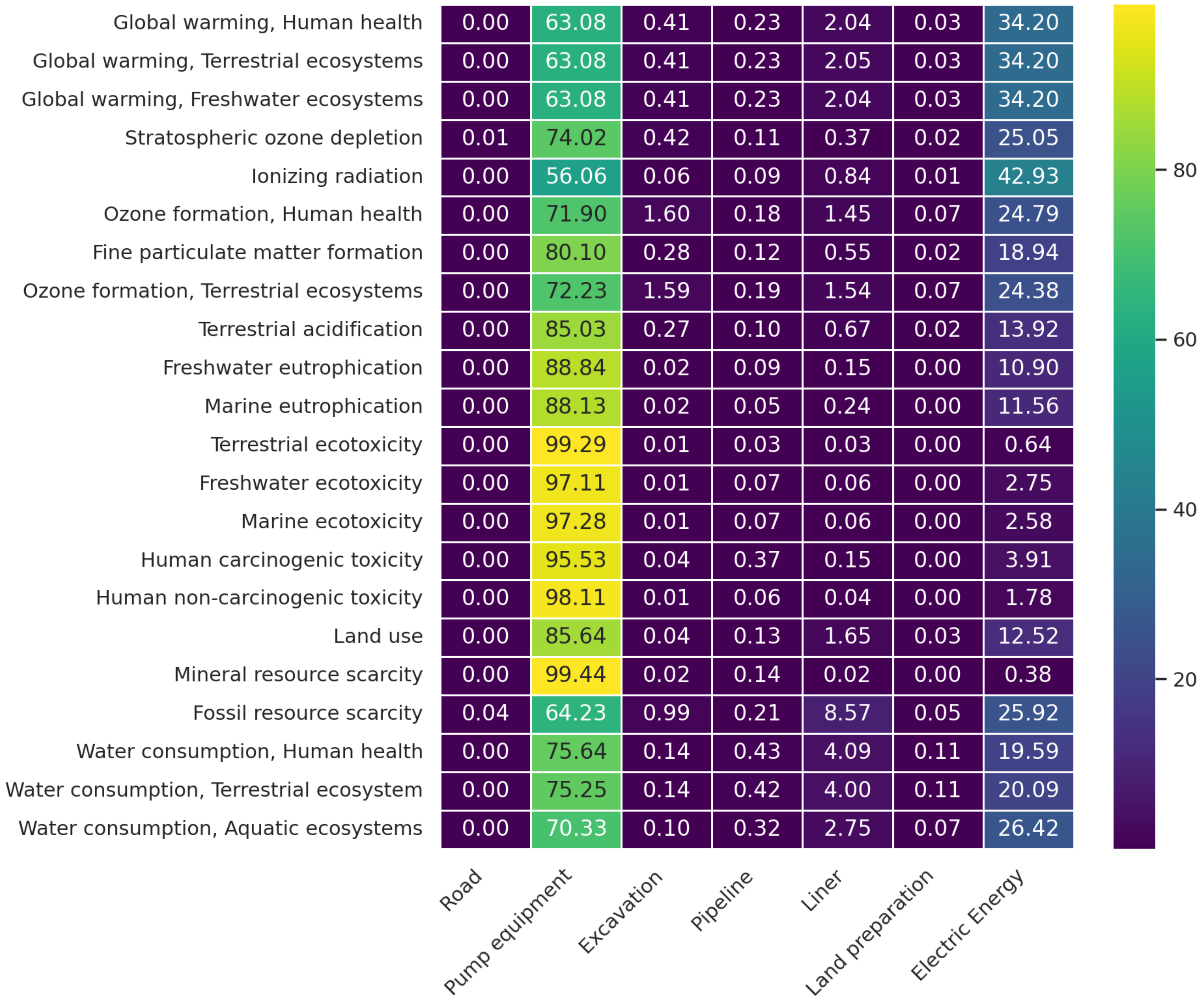
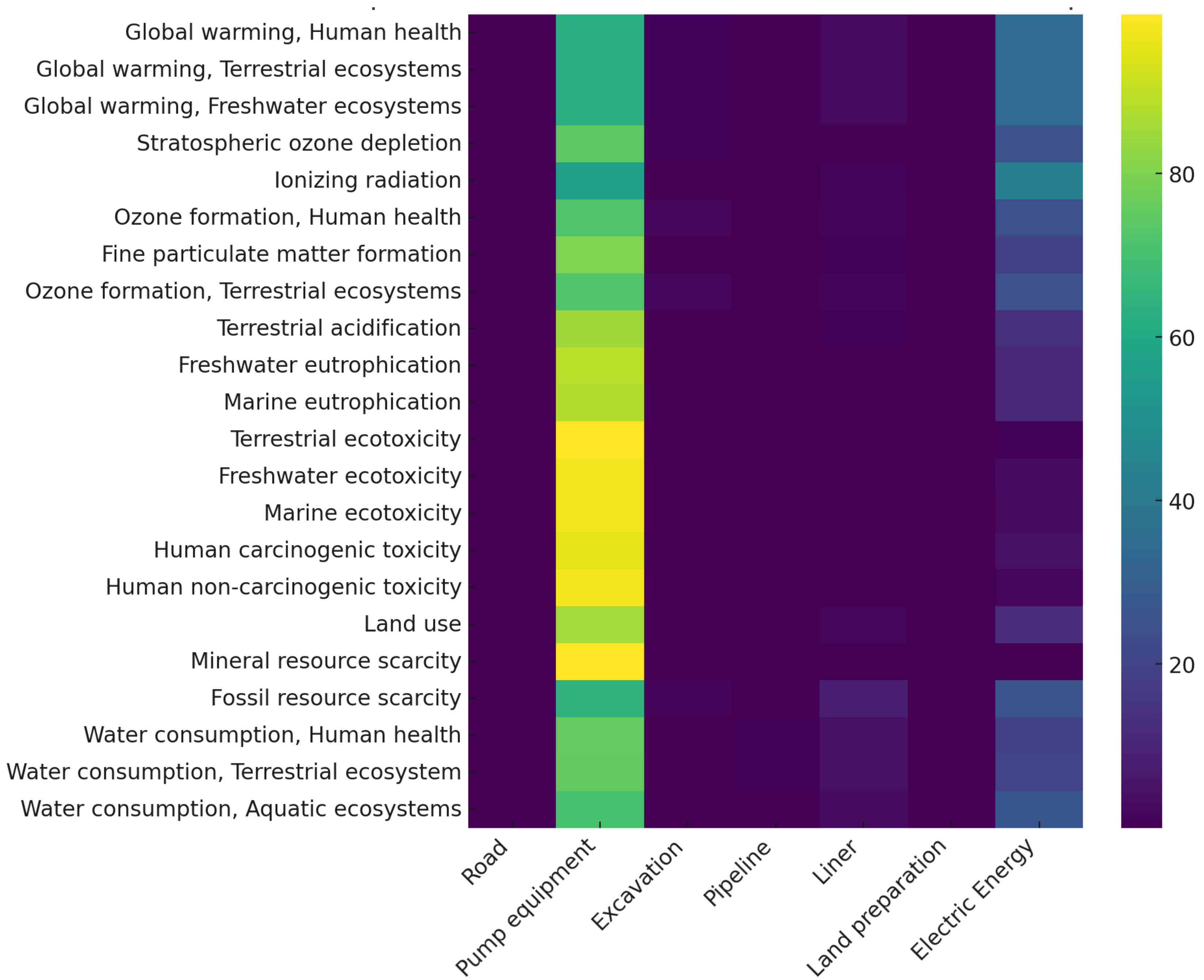
EXAMPLES

Results Evaporation Pond | Life Cycle Assessment
Fractional contribution to cost



	Road	Pump equipment	Excavation	Pipeline	Liner	Land preparation	Electric Energy
Global warming, Human health	0.00	63.08	0.41	0.23	2.04	0.03	34.20
Global warming, Terrestrial ecosystems	0.00	63.08	0.41	0.23	2.05	0.03	34.20
Global warming, Freshwater ecosystems	0.00	63.08	0.41	0.23	2.04	0.03	34.20
Stratospheric ozone depletion	0.01	74.02	0.42	0.11	0.37	0.02	25.05
Ionizing radiation	0.00	56.06	0.06	0.09	0.84	0.01	42.93
Ozone formation, Human health	0.00	71.90	1.60	0.18	1.45	0.07	24.79
Fine particulate matter formation	0.00	80.10	0.28	0.12	0.55	0.02	18.94
Ozone formation, Terrestrial ecosystems	0.00	72.23	1.59	0.19	1.54	0.07	24.38
Terrestrial acidification	0.00	85.03	0.27	0.10	0.67	0.02	13.92
Freshwater eutrophication	0.00	88.84	0.02	0.09	0.15	0.00	10.90
Marine eutrophication	0.00	88.13	0.02	0.05	0.24	0.00	11.56
Terrestrial ecotoxicity	0.00	99.29	0.01	0.03	0.03	0.00	0.64
Freshwater ecotoxicity	0.00	97.11	0.01	0.07	0.06	0.00	2.75
Marine ecotoxicity	0.00	97.28	0.01	0.07	0.06	0.00	2.58
Human carcinogenic toxicity	0.00	95.53	0.04	0.37	0.15	0.00	3.91
Human non-carcinogenic toxicity	0.00	98.11	0.01	0.06	0.04	0.00	1.78
Land use	0.00	85.64	0.04	0.13	1.65	0.03	12.52
Mineral resource scarcity	0.00	99.44	0.02	0.14	0.02	0.00	0.38
Fossil resource scarcity	0.04	64.23	0.99	0.21	8.57	0.05	25.92
Water consumption, Human health	0.00	75.64	0.14	0.43	4.09	0.11	19.59
Water consumption, Terrestrial ecosystem	0.00	75.25	0.14	0.42	4.00	0.11	20.09
Water consumption, Aquatic ecosystems	0.00	70.33	0.10	0.32	2.75	0.07	26.42



Plots done using AI, quick visualization allows a first look into different plots for decision making on how to present your data without using many hours to code for a plot that might now be great, like in this case!

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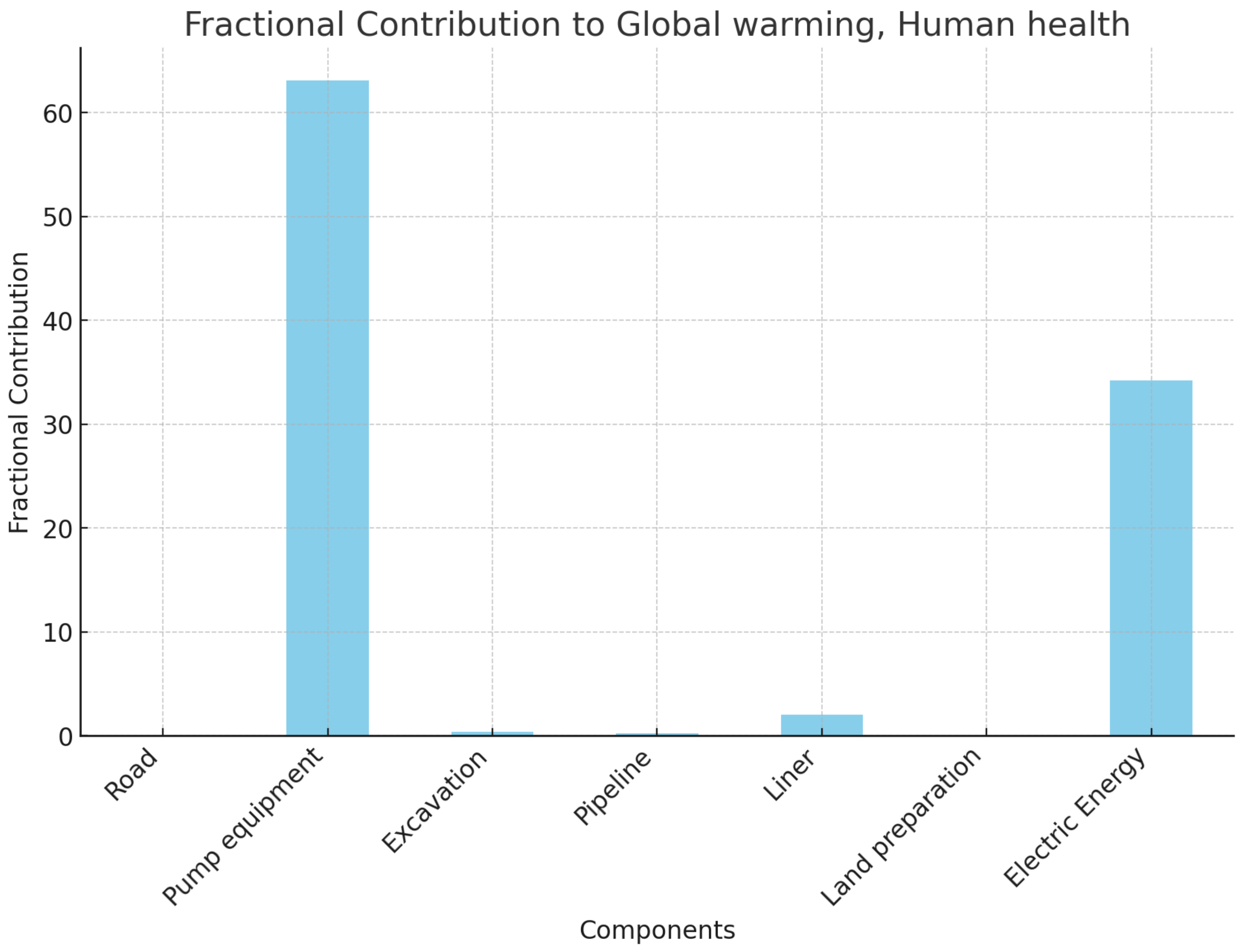
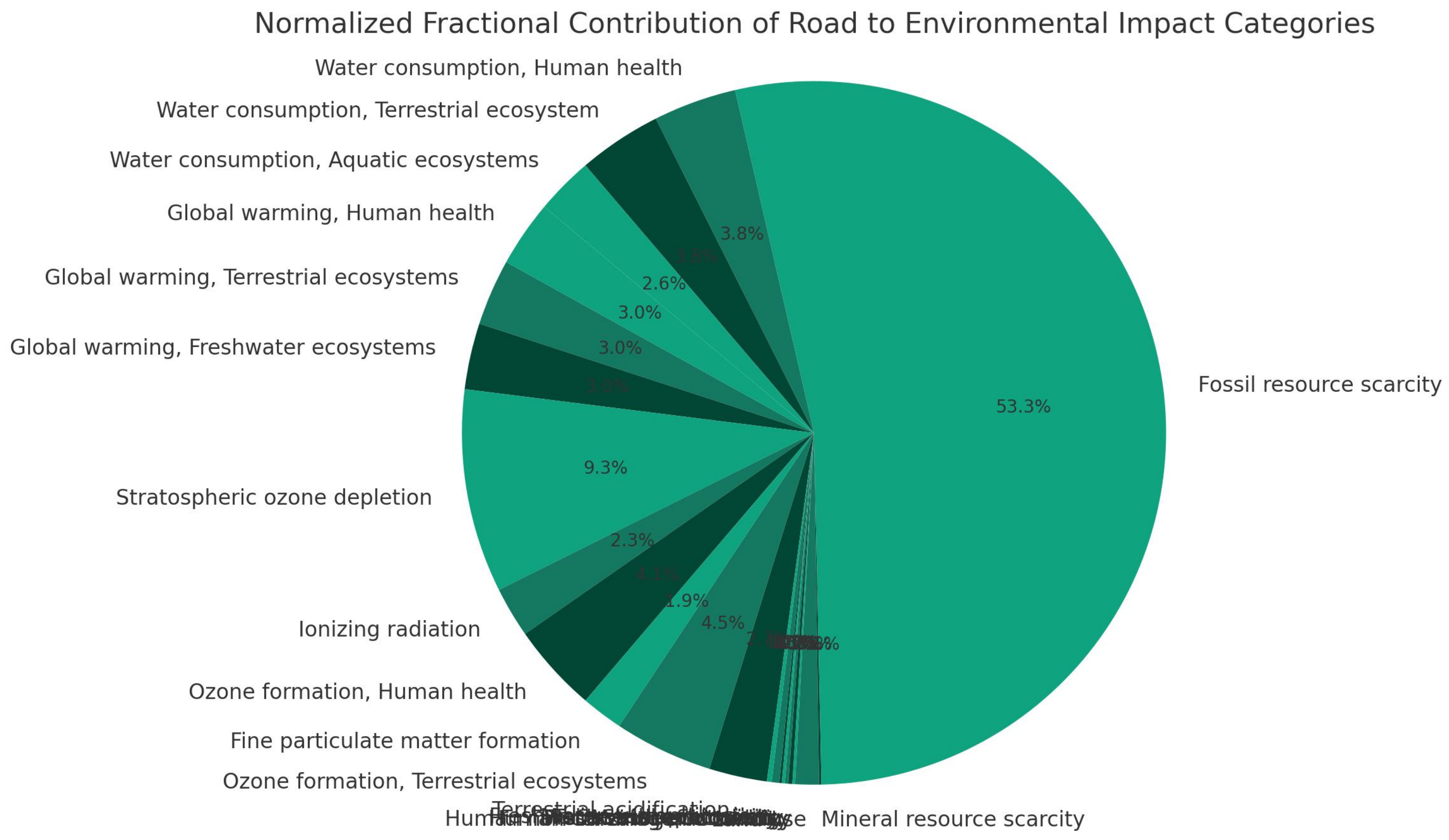
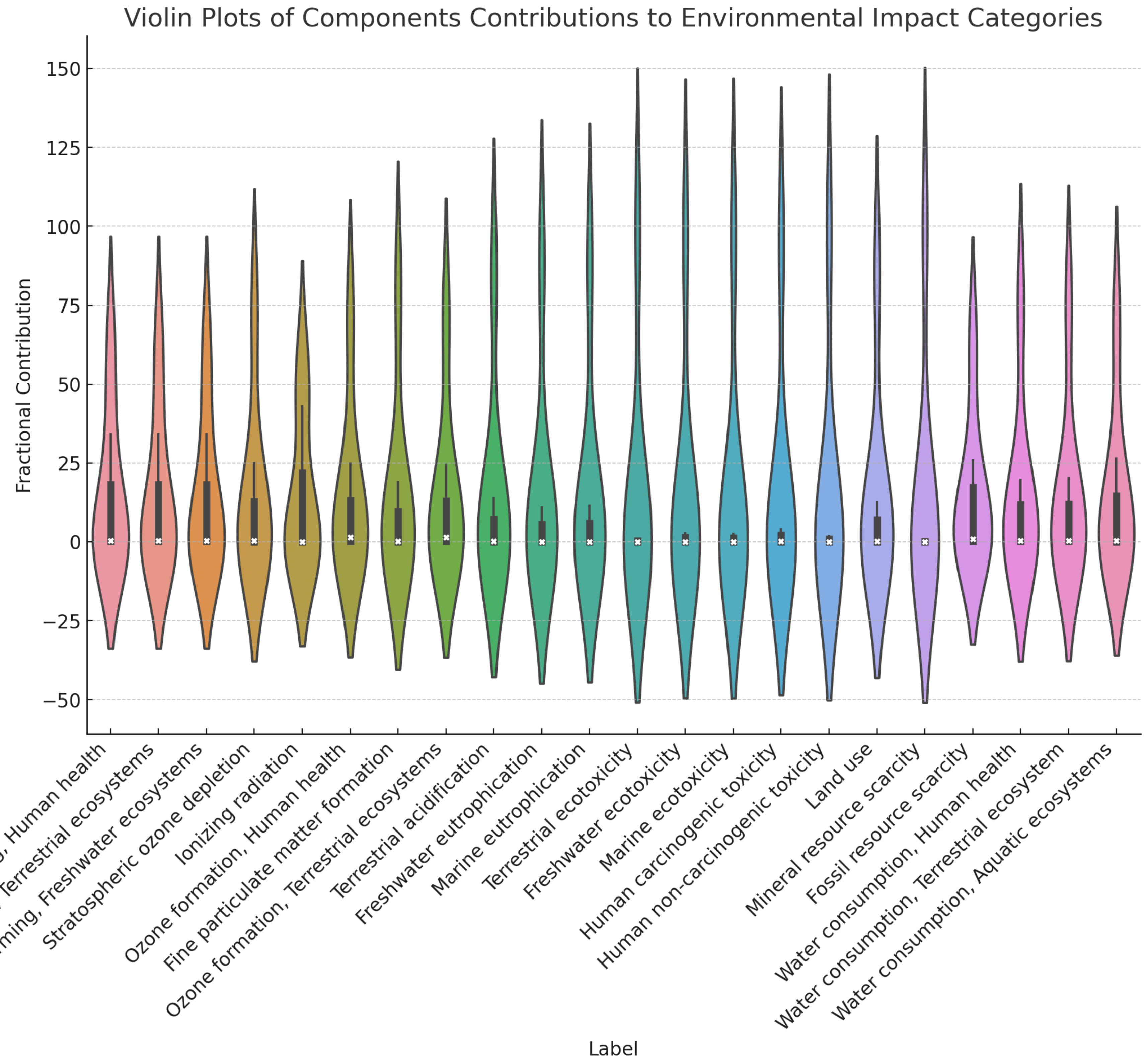
EXAMPLES

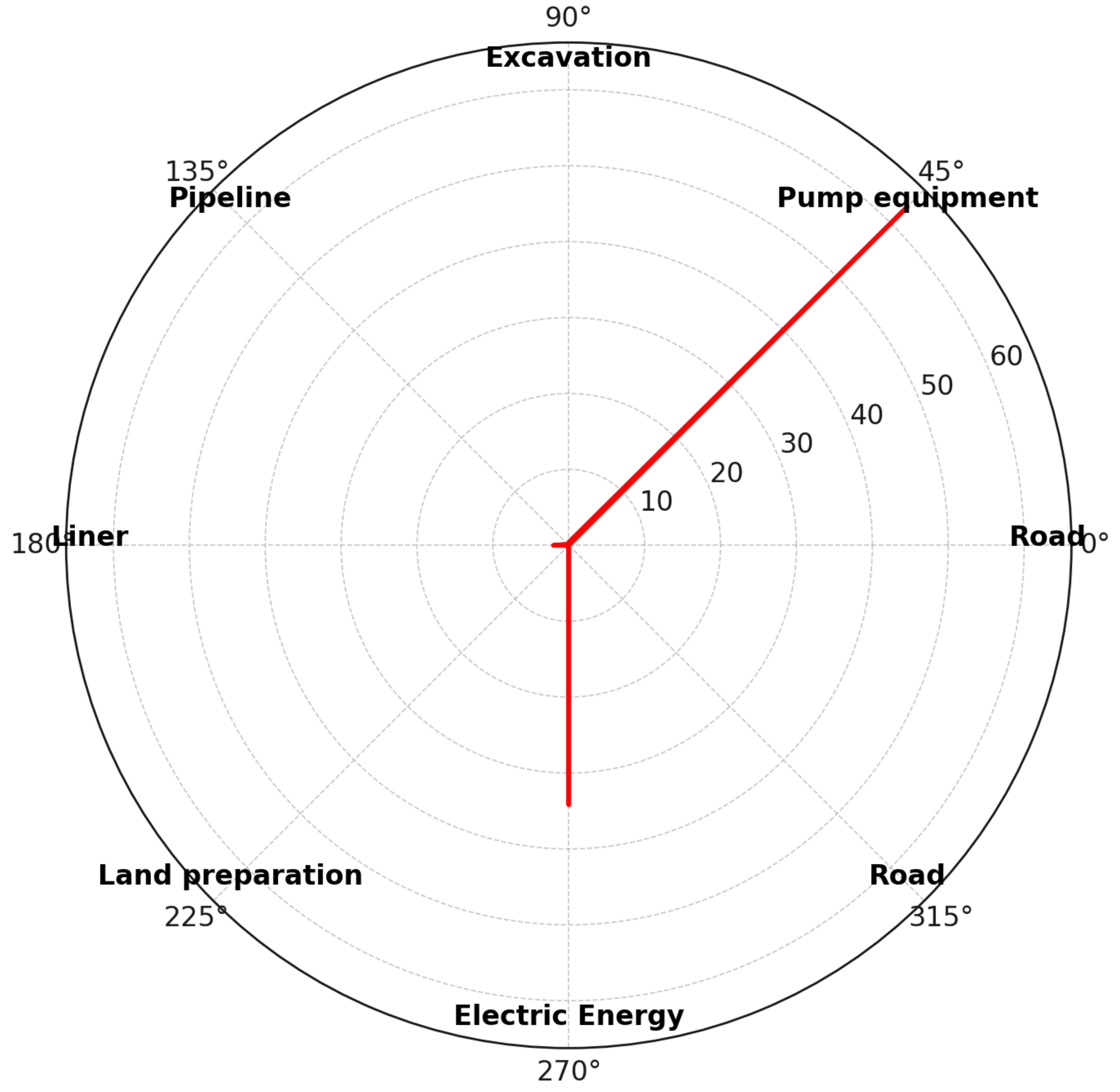

Fractional Contribution to Global warming, Human health
Fractional Contribution
0
10
20
30
40
50
60
Road
Pump equipment
Excavation
Pipeline
Liner
Land preparation
Electric Energy
Components


Normalized Fractional Contribution of Road to Environmental Impact Categories
Water consumption, Human health
Water consumption, Terrestrial ecosystem
Water consumption, Aquatic ecosystems
Global warming, Human health
Global warming, Terrestrial ecosystems
Global warming, Freshwater ecosystems
Stratospheric ozone depletion
Ionizing radiation
Ozone formation, Human health
Fine particulate matter formation
Ozone formation, Terrestrial ecosystems
Terrestrial acidification
Mineral resource scarcity
Fossil resource scarcity
53.3%
9.3%
3.8%
2.6%
3.0%
3.0%
2.3%
1.9%
4.5%

EXAMPLES



Global warming, Human health



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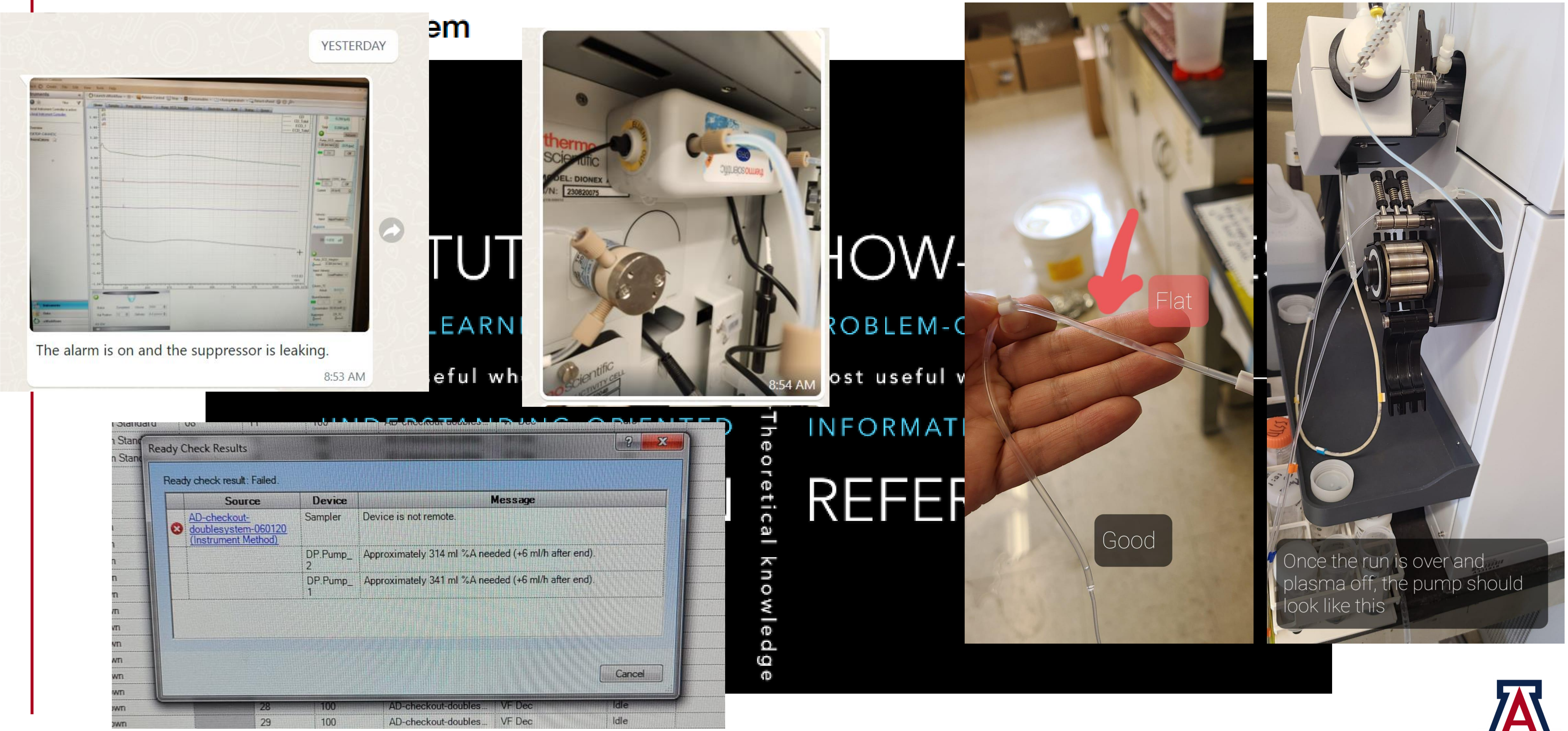
Highly iterative process! I am still looking for the perfect plot.

Documentation Transfer of knowledge/skills/data

The Grand Unified Theory of Documentation
- David Laing

Wet lab SOP and troubleshooting videos



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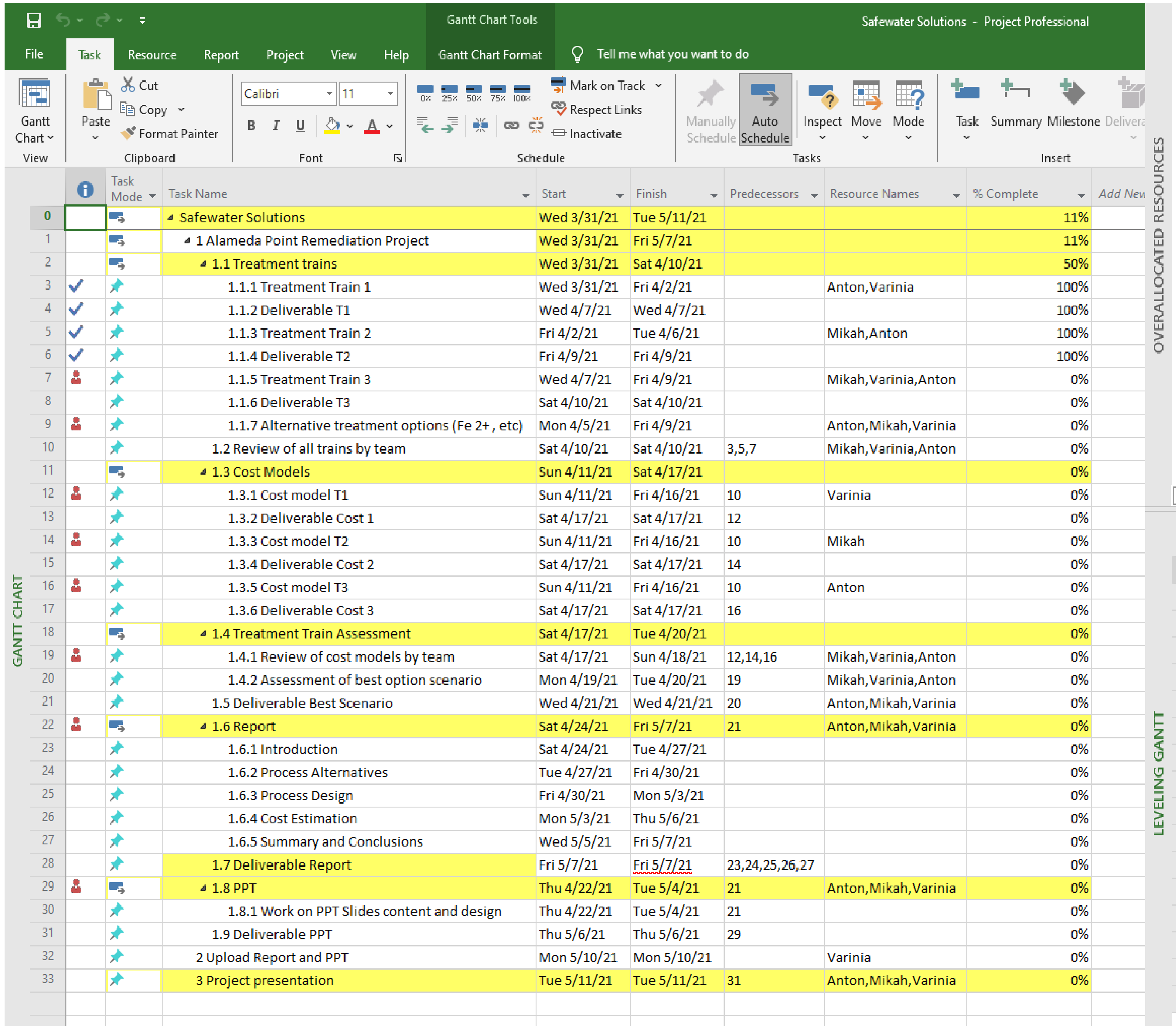
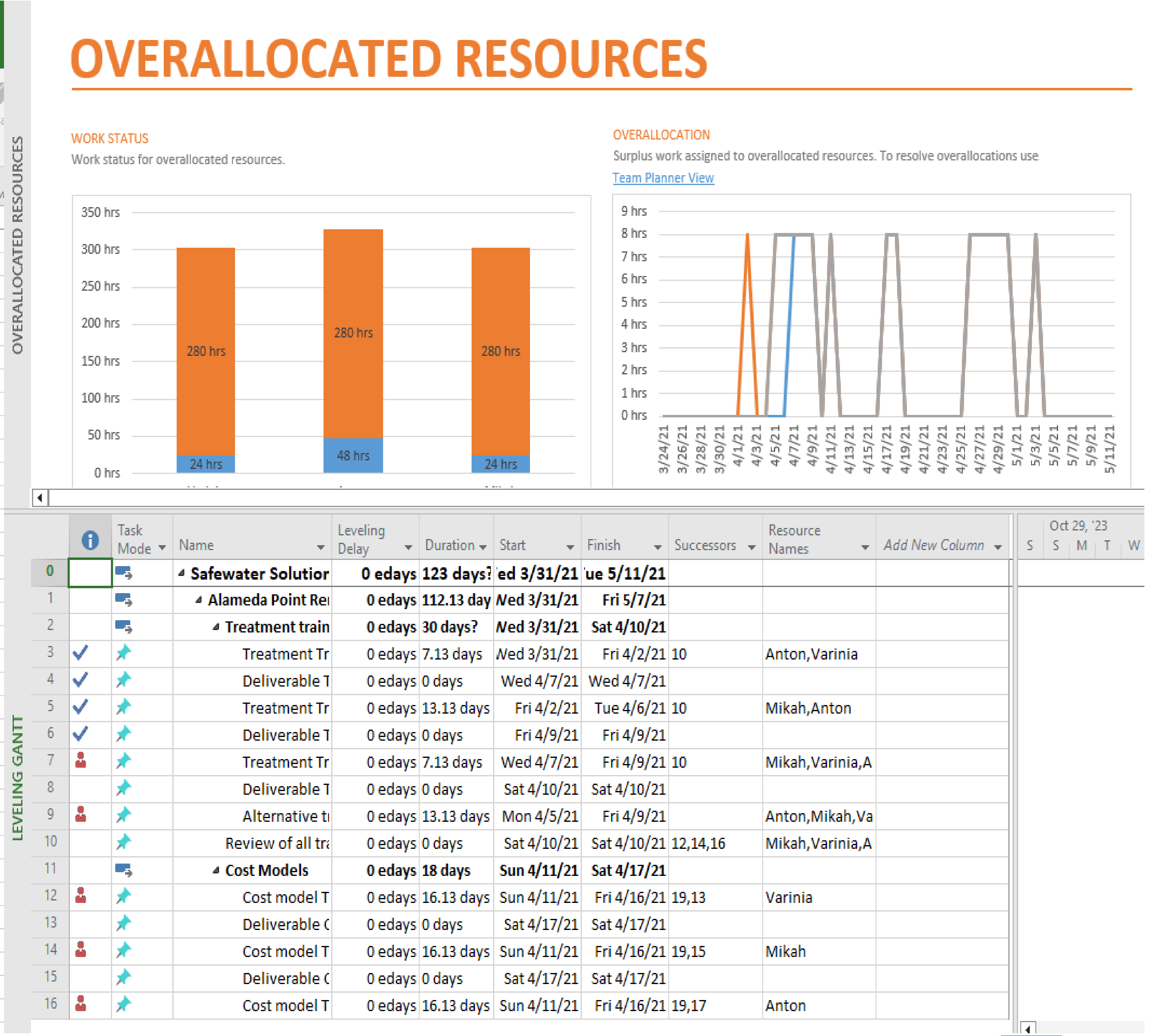
Project Management



	Task Mode	Task Name	Start	Finish	Predecessors	Resource Names	% Complete
0		Safewater Solutions	Wed 3/31/21	Tue 5/11/21			11%
1		1 Alameda Point Remediation Project	Wed 3/31/21	Fri 5/7/21			11%
2		1.1 Treatment trains	Wed 3/31/21	Sat 4/10/21			50%
3		1.1.1 Treatment Train 1	Wed 3/31/21	Fri 4/2/21		Anton,Varinia	100%
4		1.1.2 Deliverable T1	Wed 4/7/21	Wed 4/7/21			100%
5		1.1.3 Treatment Train 2	Fri 4/2/21	Tue 4/6/21		Mikah,Anton	100%
6		1.1.4 Deliverable T2	Fri 4/9/21	Fri 4/9/21			100%
7		1.1.5 Treatment Train 3	Wed 4/7/21	Fri 4/9/21		Mikah,Varinia,Anton	0%
8		1.1.6 Deliverable T3	Sat 4/10/21	Sat 4/10/21			0%
9		1.1.7 Alternative treatment options (Fe 2+ , etc)	Mon 4/5/21	Fri 4/9/21		Anton,Mikah,Varinia	0%
10		1.2 Review of all trains by team	Sat 4/10/21	Sat 4/10/21	3,5,7	Mikah,Varinia,Anton	0%
11		1.3 Cost Models	Sun 4/11/21	Sat 4/17/21			0%
12		1.3.1 Cost model T1	Sun 4/11/21	Fri 4/16/21	10	Varinia	0%
13		1.3.2 Deliverable Cost 1	Sat 4/17/21	Sat 4/17/21	12		0%
14		1.3.3 Cost model T2	Sun 4/11/21	Fri 4/16/21	10	Mikah	0%
15		1.3.4 Deliverable Cost 2	Sat 4/17/21	Sat 4/17/21	14		0%
16		1.3.5 Cost model T3	Sun 4/11/21	Fri 4/16/21	10	Anton	0%
17		1.3.6 Deliverable Cost 3	Sat 4/17/21	Sat 4/17/21	16		0%
18		1.4 Treatment Train Assessment	Sat 4/17/21	Tue 4/20/21			0%
19		1.4.1 Review of cost models by team	Sat 4/17/21	Sun 4/18/21	12,14,16	Mikah,Varinia,Anton	0%
20		1.4.2 Assessment of best option scenario	Mon 4/19/21	Tue 4/20/21	19	Mikah,Varinia,Anton	0%
21		1.5 Deliverable Best Scenario	Wed 4/21/21	Wed 4/21/21	20	Anton,Mikah,Varinia	0%
22		1.6 Report	Sat 4/24/21	Fri 5/7/21	21	Anton,Mikah,Varinia	0%
23		1.6.1 Introduction	Sat 4/24/21	Tue 4/27/21			0%
24		1.6.2 Process Alternatives	Tue 4/27/21	Fri 4/30/21			0%
25		1.6.3 Process Design	Fri 4/30/21	Mon 5/3/21			0%
26		1.6.4 Cost Estimation	Mon 5/3/21	Thu 5/6/21			0%
27		1.6.5 Summary and Conclusions	Wed 5/5/21	Fri 5/7/21			0%
28		1.7 Deliverable Report	Fri 5/7/21	Fri 5/7/21	23,24,25,26,27		0%
29		1.8 PPT	Thu 4/22/21	Tue 5/4/21	21	Anton,Mikah,Varinia	0%
30		1.8.1 Work on PPT Slides content and design	Thu 4/22/21	Tue 5/4/21	21		0%
31		1.9 Deliverable PPT	Thu 5/6/21	Thu 5/6/21	29		0%
32		2 Upload Report and PPT	Mon 5/10/21	Mon 5/10/21		Varinia	0%
33		3 Project presentation	Tue 5/11/21	Tue 5/11/21	31	Anton,Mikah,Varinia	0%



	Task Mode	Name	Leveling Delay	Duration	Start	Finish	Successors	Resource Names	Add New Column
0		Safewater Solutior	0 edays	123 days?	ed 3/31/21	ue 5/11/21			
1		Alameda Point Re	0 edays	112.13 day	Ned 3/31/21	Fri 5/7/21			
2		Treatment train	0 edays	30 days?	Ned 3/31/21	Sat 4/10/21			
3		Treatment Tr	0 edays	7.13 days	Ned 3/31/21	Fri 4/2/21	10	Anton,Varinia	
4		Deliverable T	0 edays	0 days	Wed 4/7/21	Wed 4/7/21			
5		Treatment Tr	0 edays	13.13 days	Fri 4/2/21	Tue 4/6/21	10	Mikah,Anton	
6		Deliverable T	0 edays	0 days	Fri 4/9/21	Fri 4/9/21			
7		Treatment Tr	0 edays	7.13 days	Wed 4/7/21	Fri 4/9/21	10	Mikah,Varinia,A	
8		Deliverable T	0 edays	0 days	Sat 4/10/21	Sat 4/10/21			
9		Alternative t	0 edays	13.13 days	Mon 4/5/21	Fri 4/9/21		Anton,Mikah,Va	
10		Review of all tra	0 edays	0 days	Sat 4/10/21	Sat 4/10/21	12,14,16	Mikah,Varinia,A	
11		Cost Models	0 edays	18 days	Sun 4/11/21	Sat 4/17/21			
12		Cost model T	0 edays	16.13 days	Sun 4/11/21	Fri 4/16/21	19,13	Varinia	
13		Deliverable C	0 edays	0 days	Sat 4/17/21	Sat 4/17/21			
14		Cost model T	0 edays	16.13 days	Sun 4/11/21	Fri 4/16/21	19,15	Mikah	
15		Deliverable C	0 edays	0 days	Sat 4/17/21	Sat 4/17/21			
16		Cost model T	0 edays	16.13 days	Sun 4/11/21	Fri 4/16/21	19,17	Anton	

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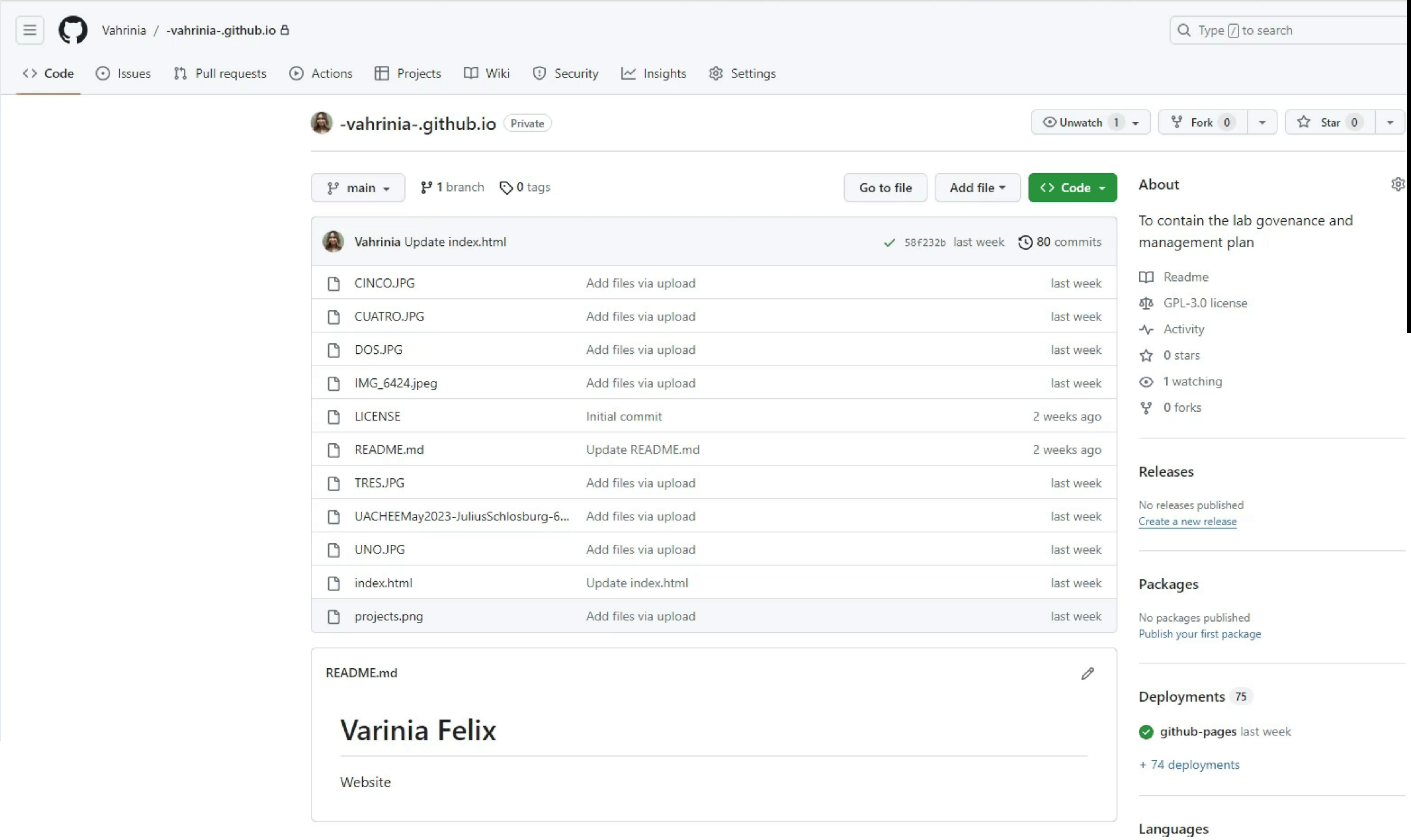
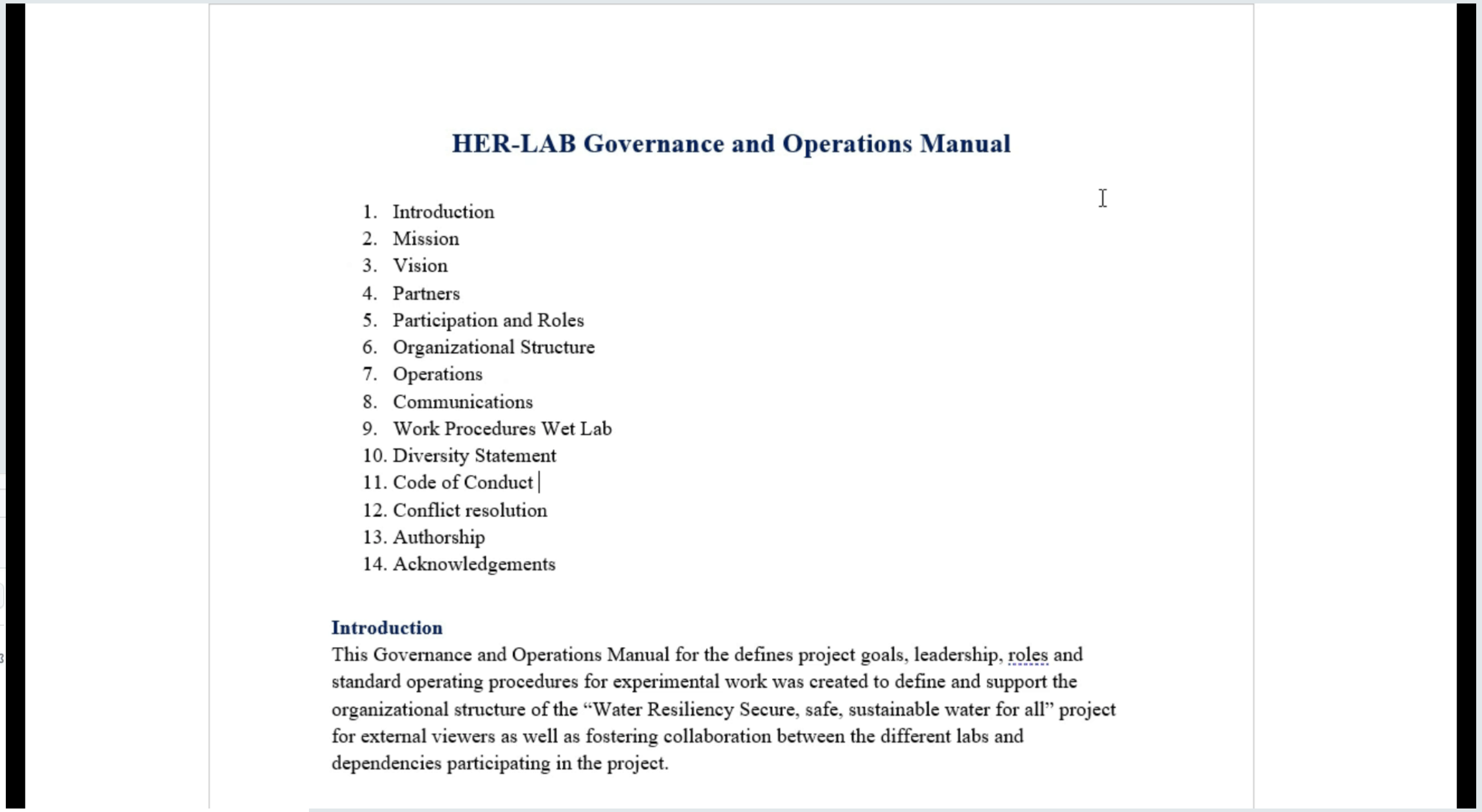
Lab Governance Version Control





HER-LAB Governance and Operations Manual

1. Introduction
2. Mission
3. Vision
4. Partners
5. Participation and Roles
6. Organizational Structure
7. Operations
8. Communications
9. Work Procedures Wet Lab
10. Diversity Statement
11. Code of Conduct
12. Conflict resolution
13. Authorship
14. Acknowledgements

Introduction

This Governance and Operations Manual for the defines project goals, leadership, roles and standard operating procedures for experimental work was created to define and support the organizational structure of the "Water Resiliency Secure, safe, sustainable water for all" project for external viewers as well as fostering collaboration between the different labs and dependencies participating in the project.

Evolving Document

GitHub

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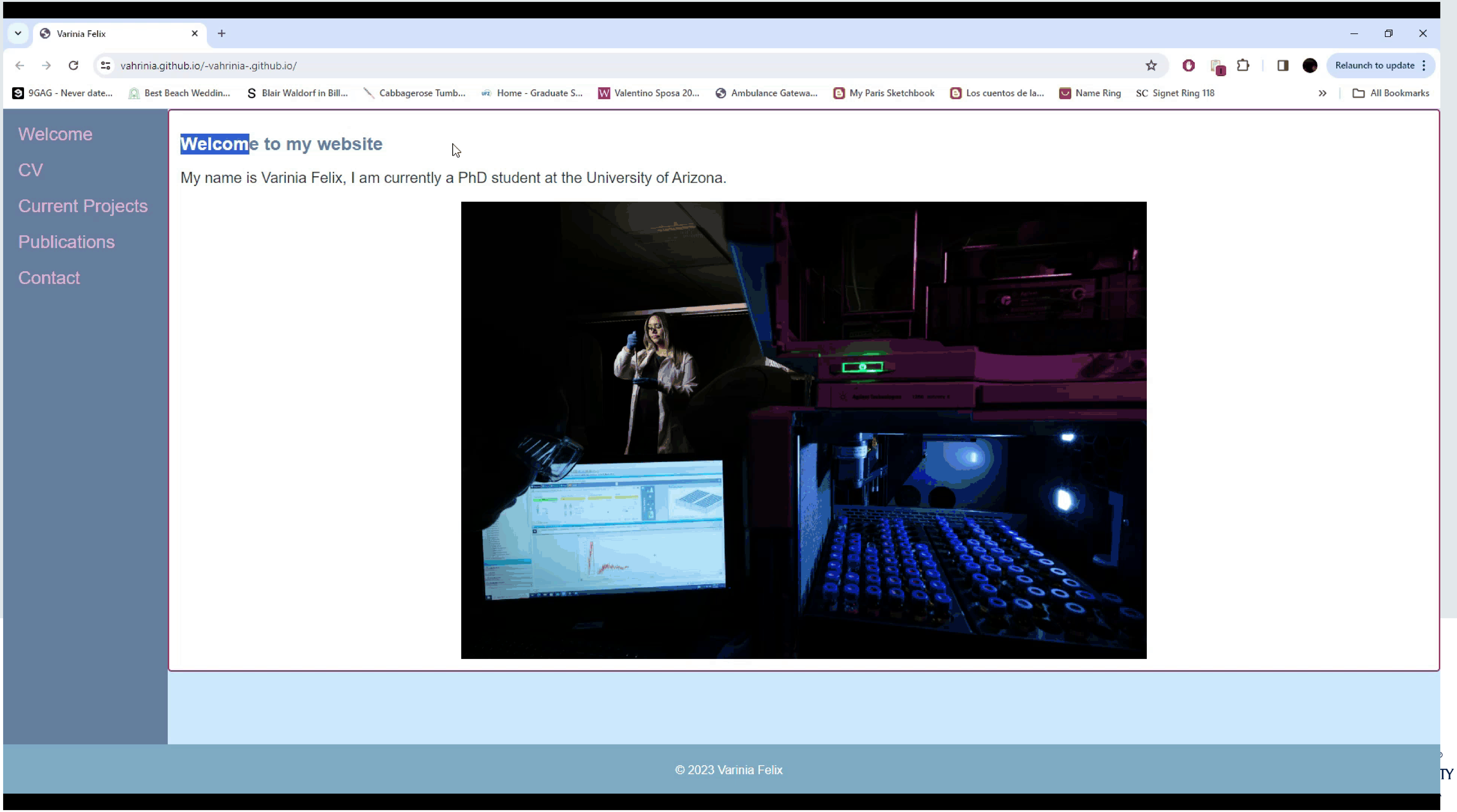
Personal Website using GitHub



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R4R Mentors

Program Leads

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Tina L. Johnson, DSI
Maliaca Oxnam, DSI
Anna Seiferle-Valencia, AIR

Instructors

Jeff Gillan, CyVerse
Carlos Lizárraga, DSI
Chris Reidy, UITS
Tyson Swetnam, CyVerse

CyVerse Mentors

Michele Cosi
Jeff Gillan
Tyson Swetnam

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Q&A

Feedback is appreciated

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