# SURFACE MINE CLOSURE THAT INCLUDES SEASONAL THERMAL ENERGY STORAGE AND RELATED ASSETS

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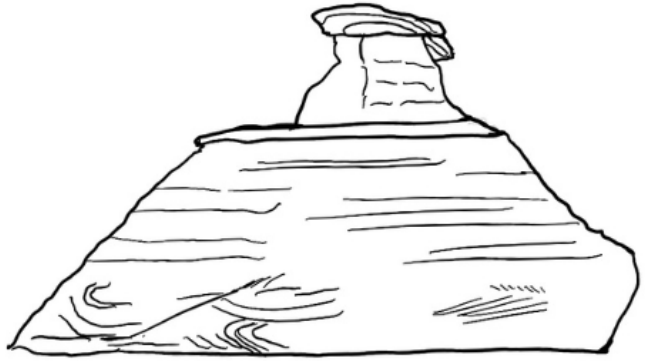

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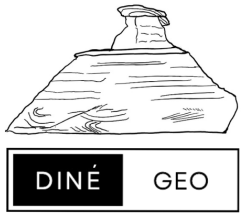
# My “Energy Transition”




## My Career

- Thermochronology =
  rock tT histories and heat flow
- Natural systems
- Oil & Gas, Mining, Research

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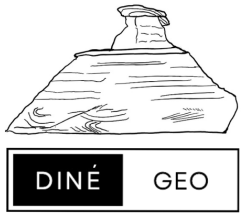


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## This Talk

- Seasonal Thermal Energy Storage = rock tT histories and heat flow
- Simulated geothermal systems
- Mining

# My “Energy Transition”

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- Thermochronology = rock tT histories and heat flow
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***Chakurian, A.M. et al., 2003**, Timing constraints of gold mineralization along the Carlin Trend utilizing apatite fission-track, 40Ar/39Ar, and apatite (U-Th)/He methods. Economic Geology.*

***Hickey, K.A., et al., 2014**, The brevity of hydrothermal fluid flow revealed by thermal halos around giant gold deposits: Implications for Carlin-type gold systems. Economic Geology.*

*+ many others*

## This Talk

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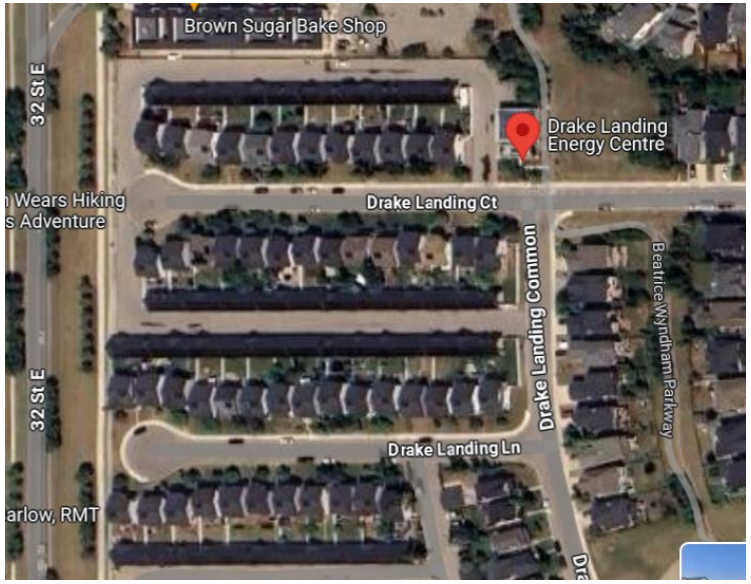
**Drake Landing Solar Community, Alberta, Canada**



# Proposed Mine Closure Business Model
## Simulated Geothermal System

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**Seasonal thermal energy storage at mine sites** can reliably receive large amounts of excess renewable energy during periods of over-abundance.

The Washington Post

**Rooftop solar panels are flooding California's grid. That's a problem.**

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By Shannon Osaka

Updated April 22, 2024 at 11:07 a.m. EDT | Published April 22, 2024 at 6:30 a.m. EDT

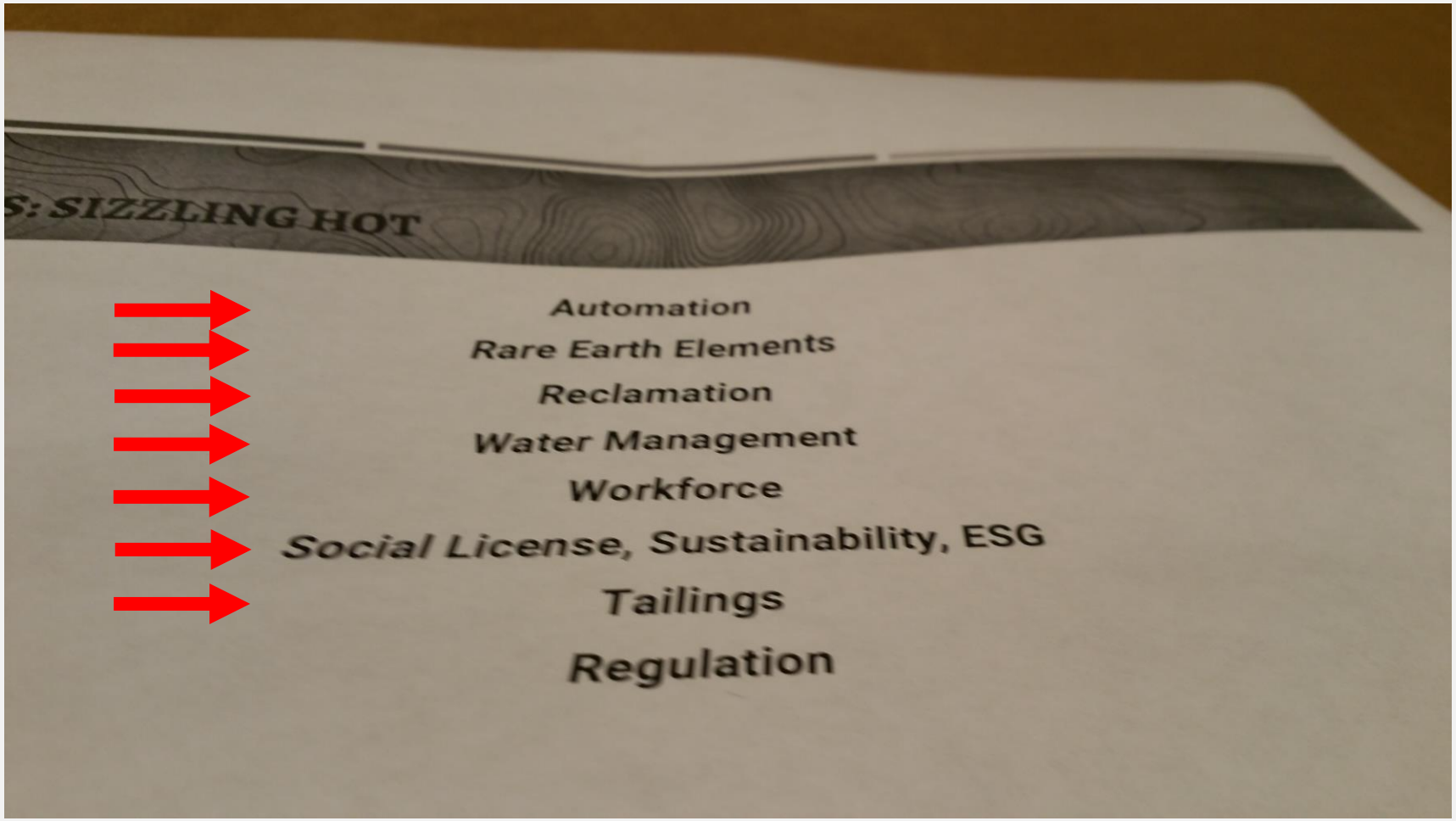
https://www.washingtonpost.com/climate-environment/2024/04/22/california-solar-duck-curve-rooftop/

# Mining Engineers
## Improved Mining Business Models

**Society for Mining, Metallurgy & Exploration**

2021 Coal & Energy Division Executive Committee Meeting

**Thermal → Energy Storage**




https://www.smenet.org/What-We-Do/Our-Values,-Vision-and-Mission

# Mining Communities
## New Mining Business Models Wanted

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Los Angeles Times

By Sammy Roth
Climate Columnist
Photography by Robert Gauthier

April 16, 2024 3 AM PT

### Red state coal towns still power the West Coast. We can't just let them die

AP

U.S. NEWS

### Judge rules against tribes in fight over Nevada lithium mine they say is near sacred massacre site

BY SCOTT SONNER
Updated 4:27 PM PDT, November 16, 2023

https://www.latimes.com/environment/story/2024-04-16/red-state-coal-towns-still-power-the-west-coast-we-cant-just-let-them-die
https://apnews.com/article/lithium-mine-tribes-climate-energy-lawsuit-nevada-7a65eee7d78d93a1e44e3f8e10445143

# Drake Landing Solar Community, Alberta
## Simulated Geothermal System

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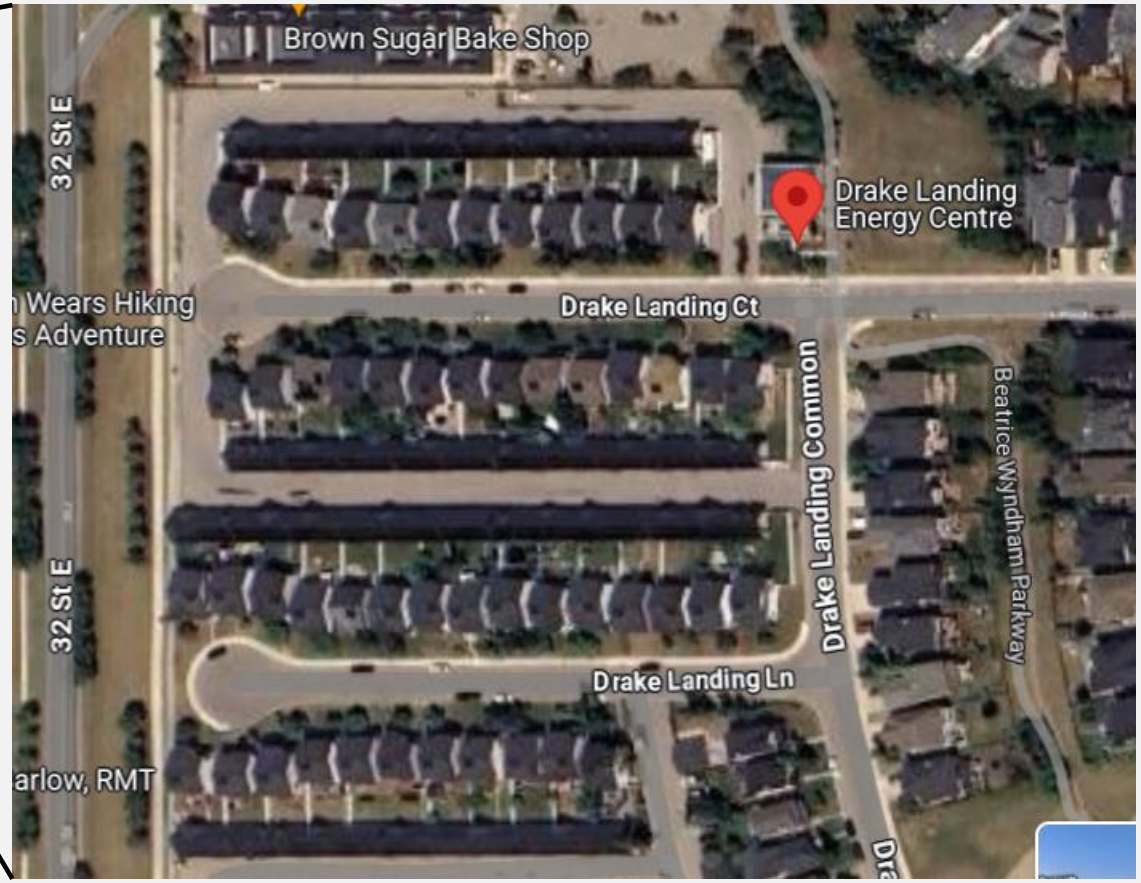
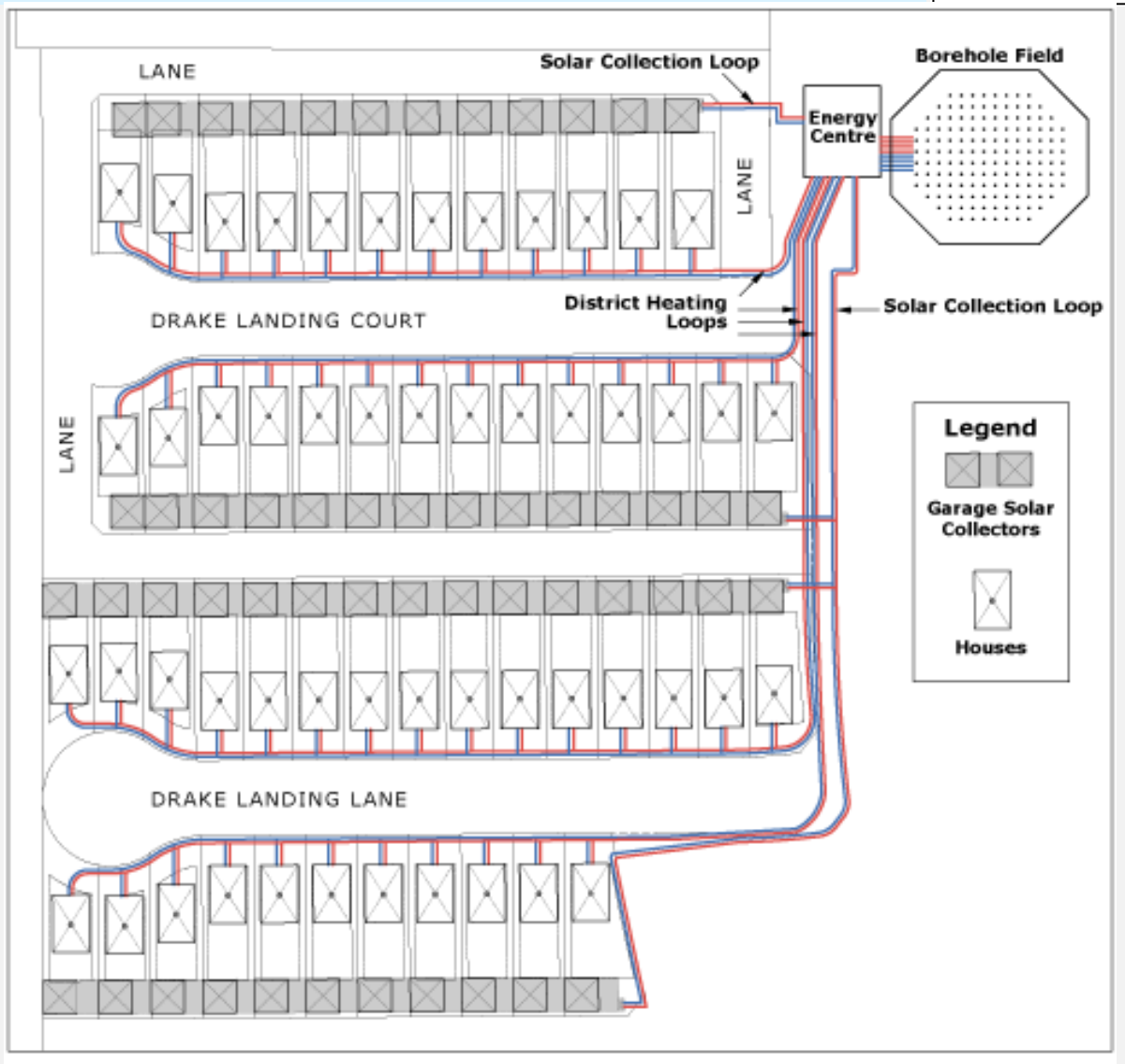



https://www.dlsc.ca/

# Drake Landing Solar Community, Alberta
## Simulated Geothermal System

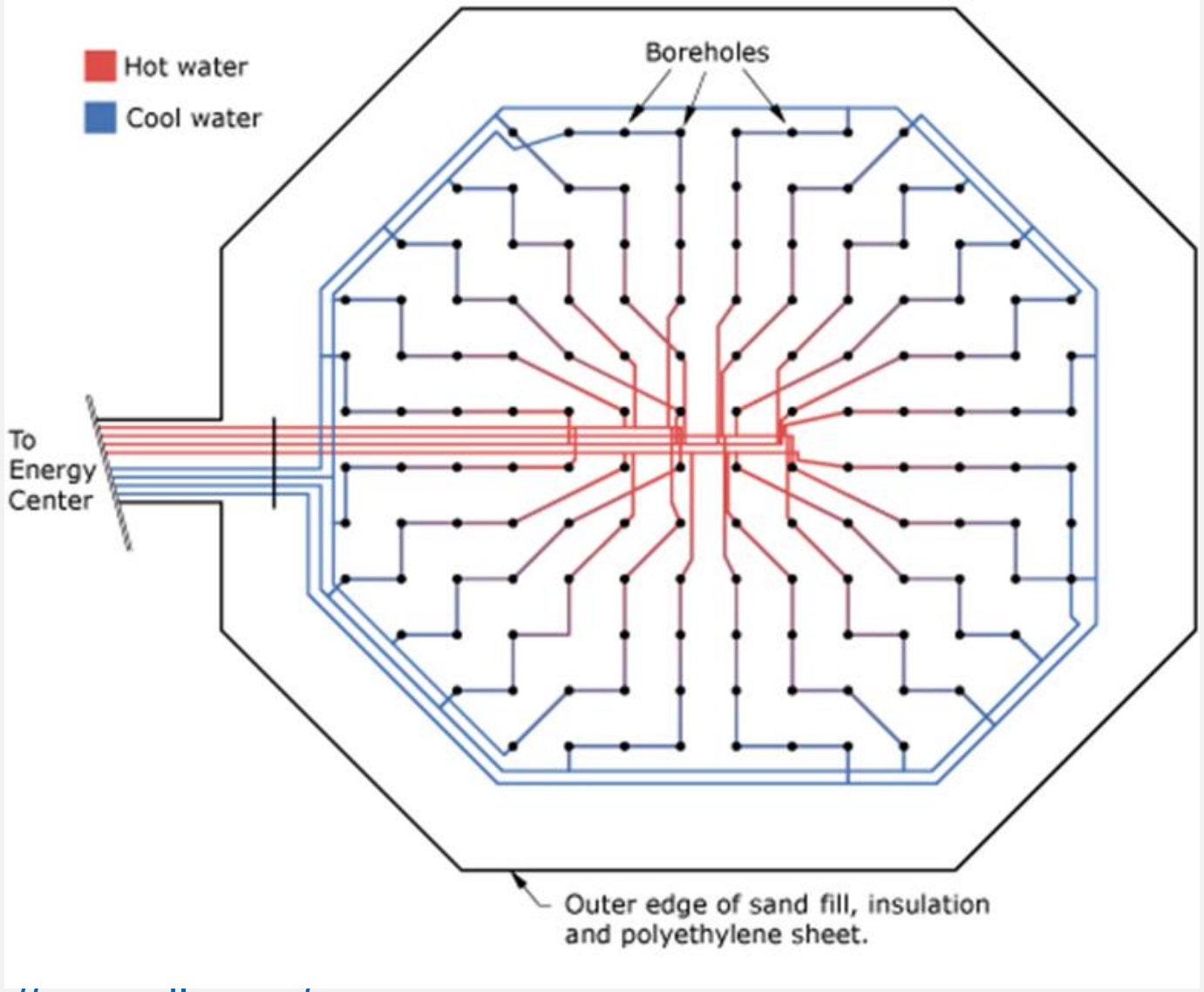
- 52 homes ±1600 $ft^2$
- 798 flat-plate glazed collectors 2.45m x 1.18m
- Energy Center (in/out)
  - Solar Collector loops
  - District Heating loops
  - Borehole Thermal Energy Storage loop




https://www.dlsc.ca/

# Drake Landing Solar Community, Alberta
## Simulated Geothermal System

- 144 boreholes 35m depth, spaced 2.25m on center
  - 24 strings of 6 boreholes
  - 4 circuits covering 4 quadrants
  - center to outer edge heat flow
  - outer edge encapsulated and insulated
- Connected to Energy Center

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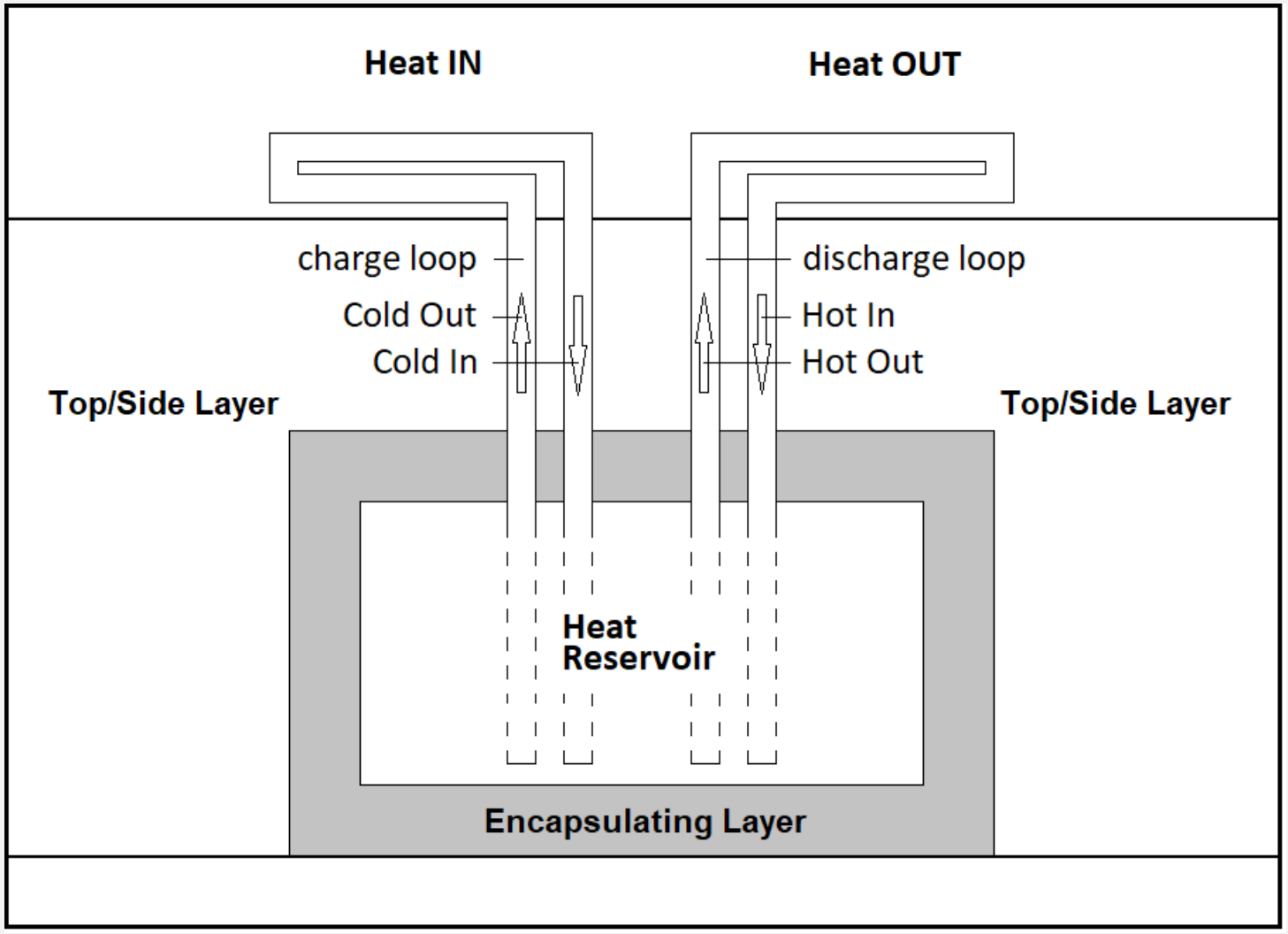
### Renewable Energy

solar PV
solar thermal
wind

### Thermal Energy Storage




### Energy User

building heat
greenhouse heat
electricity

# Proposed Mine Closure Business Model
## Simulated Geothermal System

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| Available Mine Rock | Lithology |
| --- | --- |
| overburden | lithology 1 |
| tailings | lithology 2 |
| etc. | mixture 1 |
| | etc. |

sieve →

| Size Fraction |
| --- |
| boulder |
| gravel |
| sand |
| clay |
| unsorted |
| etc. |

each →

| Physical Property |
| --- |
| mass |
| density |
| porosity |
| heat capacity |
| thermal conductivity |
| temperature range |
| etc. |

# Proposed Mine Closure Business Model
## Simulated Geothermal System

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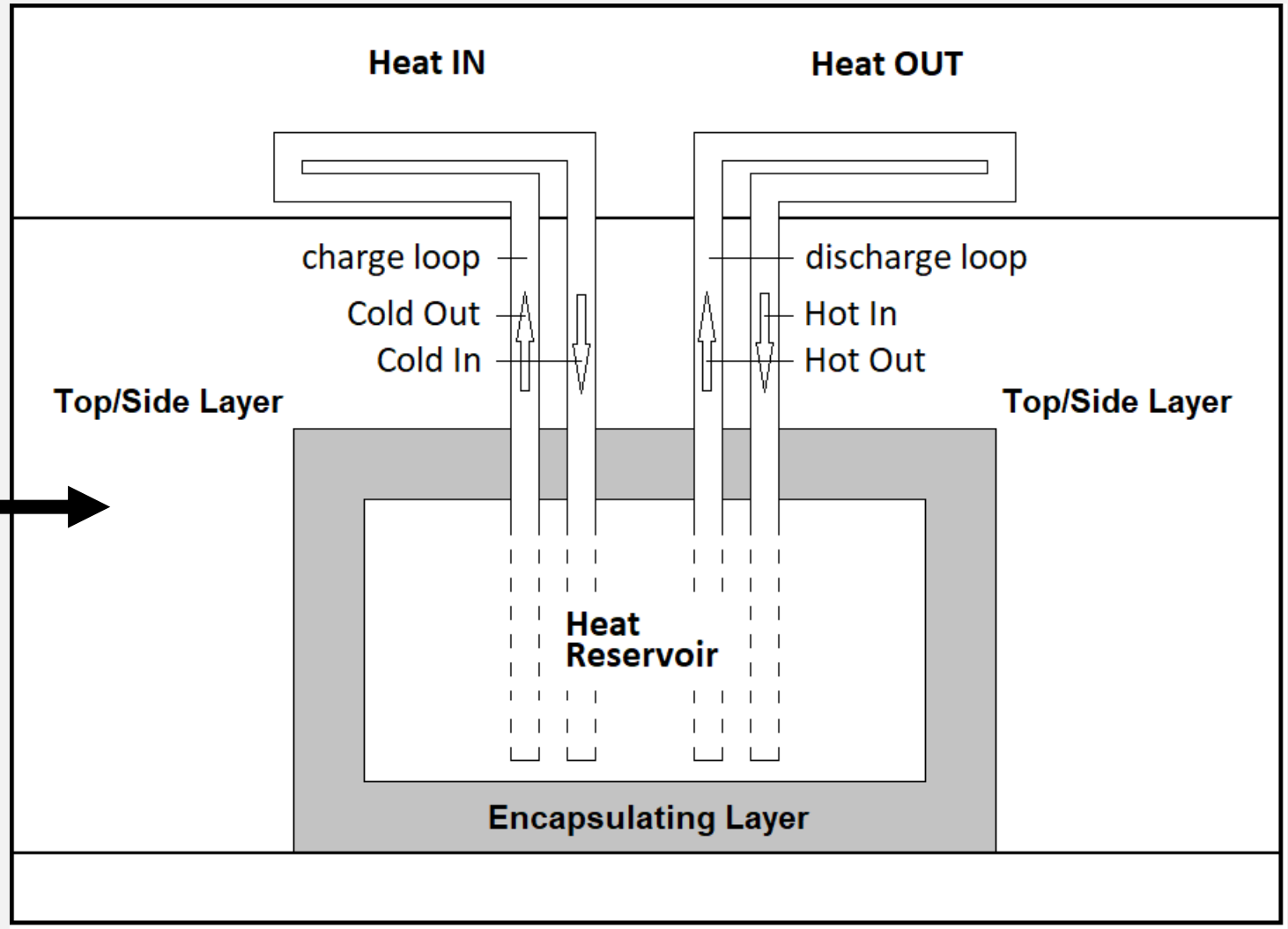
**Available Mine Rock**
- ➔ Size Fraction
  - ➔ Physical Properties
    - ➔ Arrange in 3D

**Thermal Energy Storage**



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### How Much Capacity for Storing Heat?

**1 tonne of mine rock**

**heat capacity**
1000 J $kg^{-1}$ $°C^{-1}$

**T increase**
1000 °C

**mass**
1000 kg = 1 tonne

**energy per tonne**
278 kWh $tonne^{-1}$

**250 MW Power Plant**

**energy output**
250 MW = 250000 kW

**duration**
1 y = 8766 h

**total energy**
$2.2 \times 10^9$ kWh

**tonnes of rock heated 1000°C**
$7.9 \times 10^6$ tonnes

# Westmoreland Rosebud Mine, Colstrip, MT

## Coal Strip Mine - active

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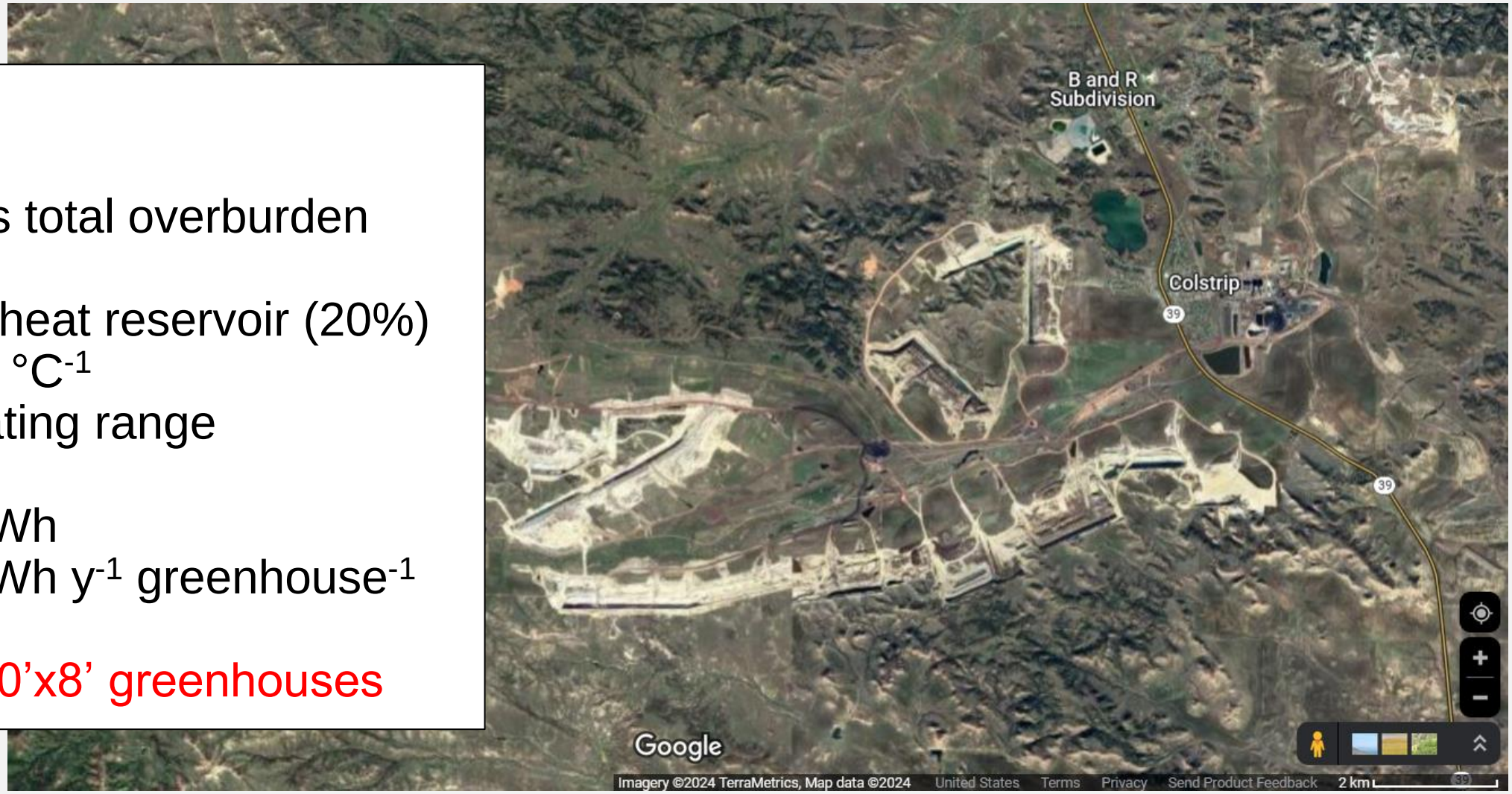
### Each Year

- 30M tonnes total overburden

- 6M tonnes heat reservoir (20%)
- 1000 J $kg^{-1}$ $°C^{-1}$
- 40°C operating range

- 6.7 x $10^7$ kWh
- 1.2 x $10^5$ kWh $y^{-1}$ $greenhouse^{-1}$

- ~560 40’x20’x8’ greenhouses




https://westmoreland.com/westmoreland-rosebud-mining-llc/

# NTEC Navajo Mine, Fruitland, NM
## Coal Strip Mine - active

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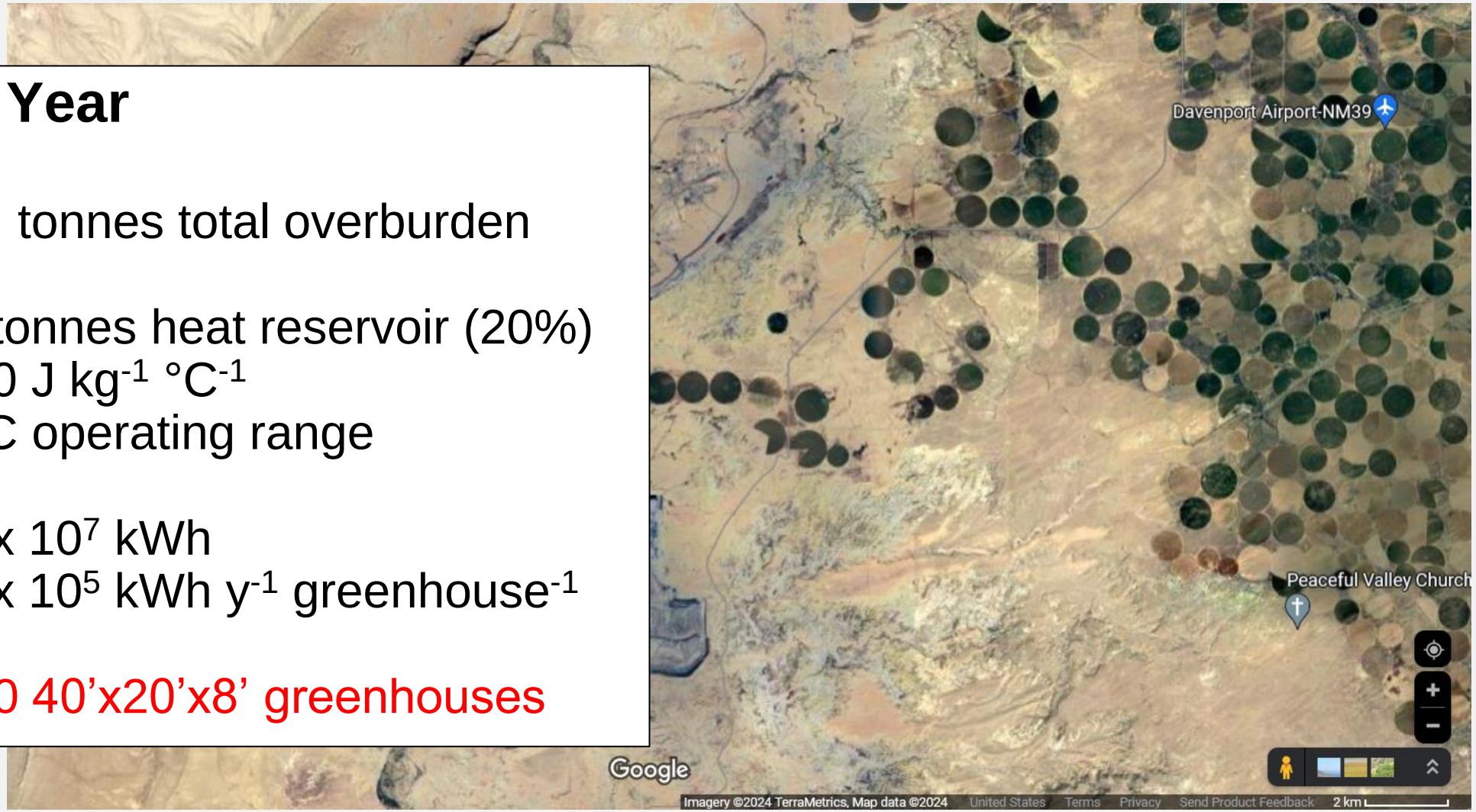
**Each Year**

- 20M tonnes total overburden

- 5M tonnes heat reservoir (20%)
- 1000 J $kg^{-1}$ $°C^{-1}$
- 40°C operating range

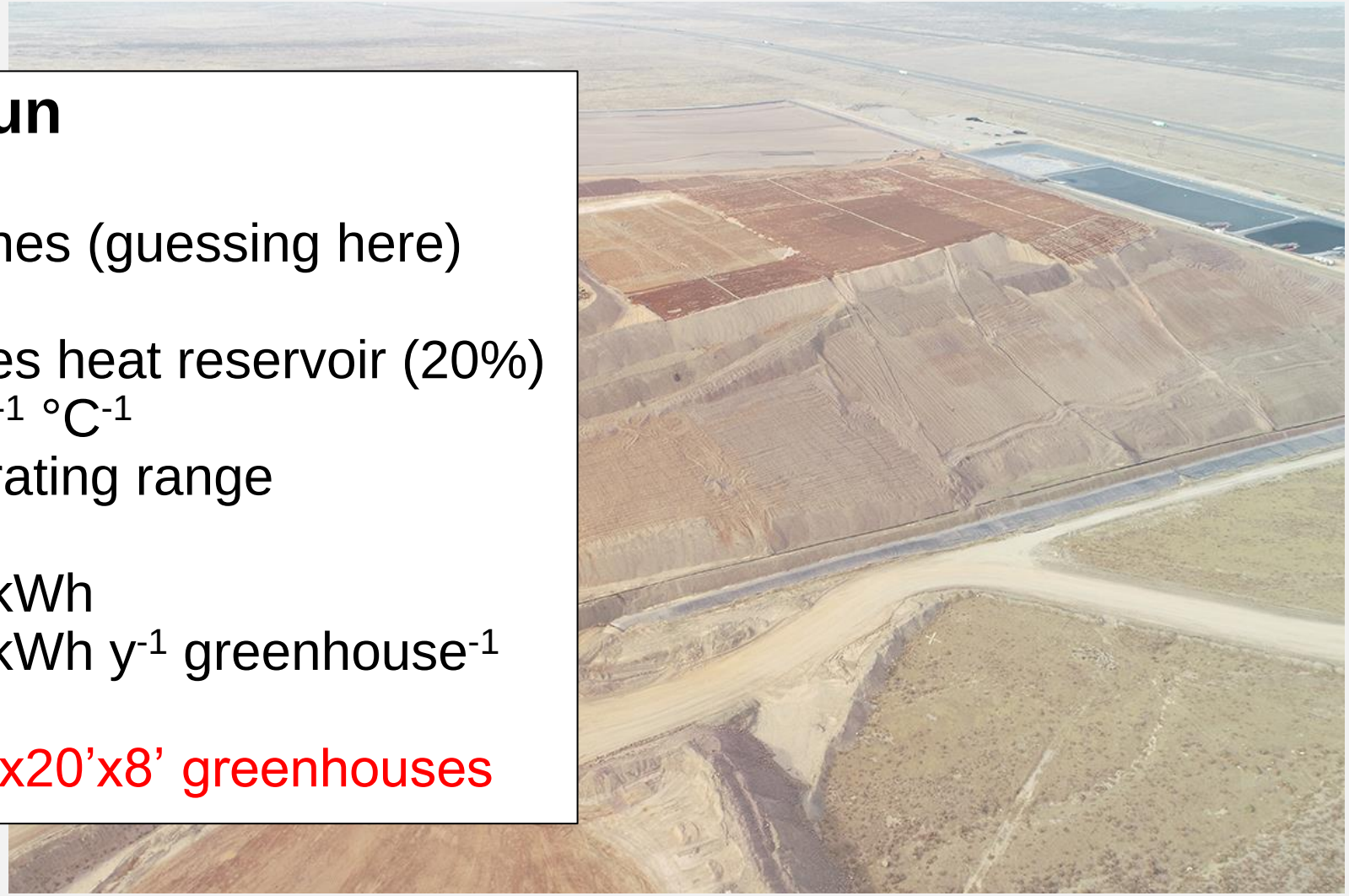
- 4.4 x $10^7$ kWh
- 1.1 x $10^5$ kWh $y^{-1}$ greenhouse$^{-1}$

- ~400 40’x20’x8’ greenhouses




https://navenergy.com/navajo/

# Argonaut Florida Canyon Mine, NV
## Open Pit with Heap Leach Pad - active



**Just for Fun**

- 143M tonnes (guessing here)

- 29M tonnes heat reservoir (20%)
- 1000 J $kg^{-1}$ $°C^{-1}$
- 40°C operating range

- $3.2 \times 10^8$ kWh
- $1.1 \times 10^5$ kWh $y^{-1}$ $greenhouse^{-1}$

- ~2900 40’x20’x8’ greenhouses

https://www.argonautgold.com/English/assets/operations/Florida-Canyon/default.aspx

# Lithium Americas Thacker Pass Mine, NV
## Open Pit with ongoing Backfill - planned

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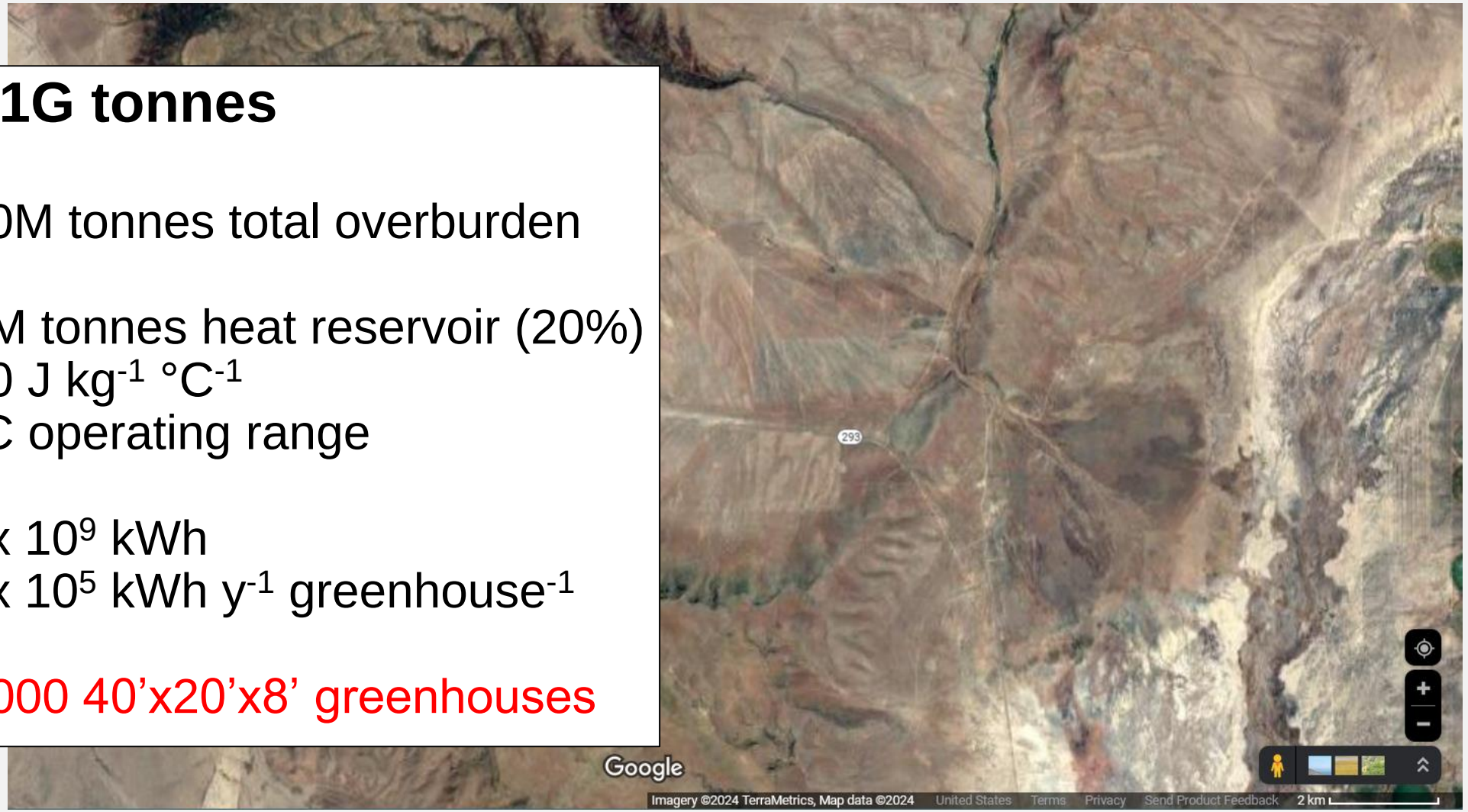
**After 1G tonnes**

- 1000M tonnes total overburden

- 200M tonnes heat reservoir (20%)
- 1000 J $kg^{-1}$ $°C^{-1}$
- 40°C operating range

- $2.2 \times 10^9$ kWh
- $1.1 \times 10^5$ kWh $y^{-1}$ $greenhouse^{-1}$

- ~20000 40’x20’x8’ greenhouses




https://lithiumamericas.com/thacker-pass/overview/default.aspx

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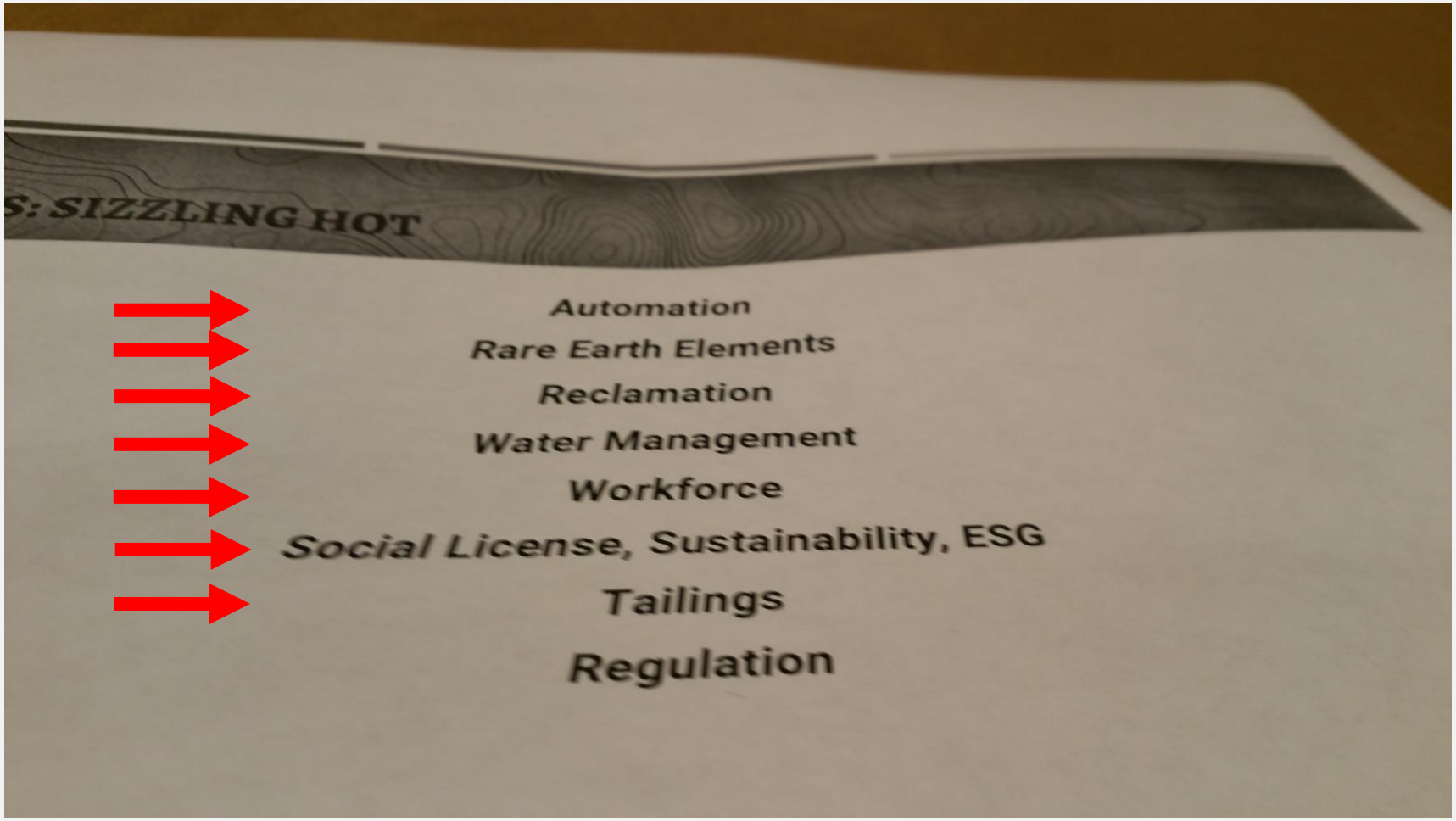


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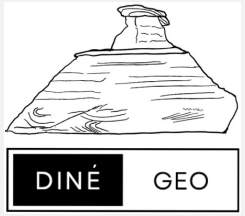


| **Mining 2021 Sizzling Hot:** | **Thermal Energy Storage:** |
|---|---|
| • Automation | sieve rock, 3D print rock structures |
| • Rare Earth Elements | coal ash: massive, REE-rich, heat capacity |
| • Reclamation | an asset |
| • Water Management | heap leach pad with energy storage function |
| • Workforce | long-term, post-mining jobs with dignity |
| • Social License… | tailored to local needs |
| • Tailings | tailings: massive, heat capacity |
| • Regulation | no comment |

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# Thank You!

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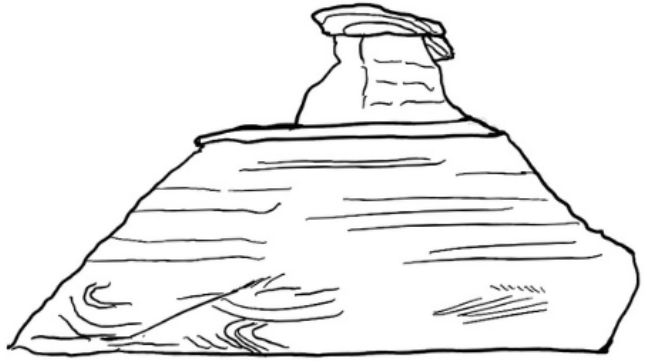

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# About DinéGEO LLC

**Vision:** Most people appreciate some of the scientific complexity of the world around them

**Mission:** To connect state-of-the-art geological sciences with people

**Services:** Geological and Educational Services

Mrs. Kaelyn White, Owner
Mr. Benjamin Craig, Manager
Dr. Ray Donelick, Senior Scientist

DineGEOLLC@gmail.com
raymond.apatite@gmail.com

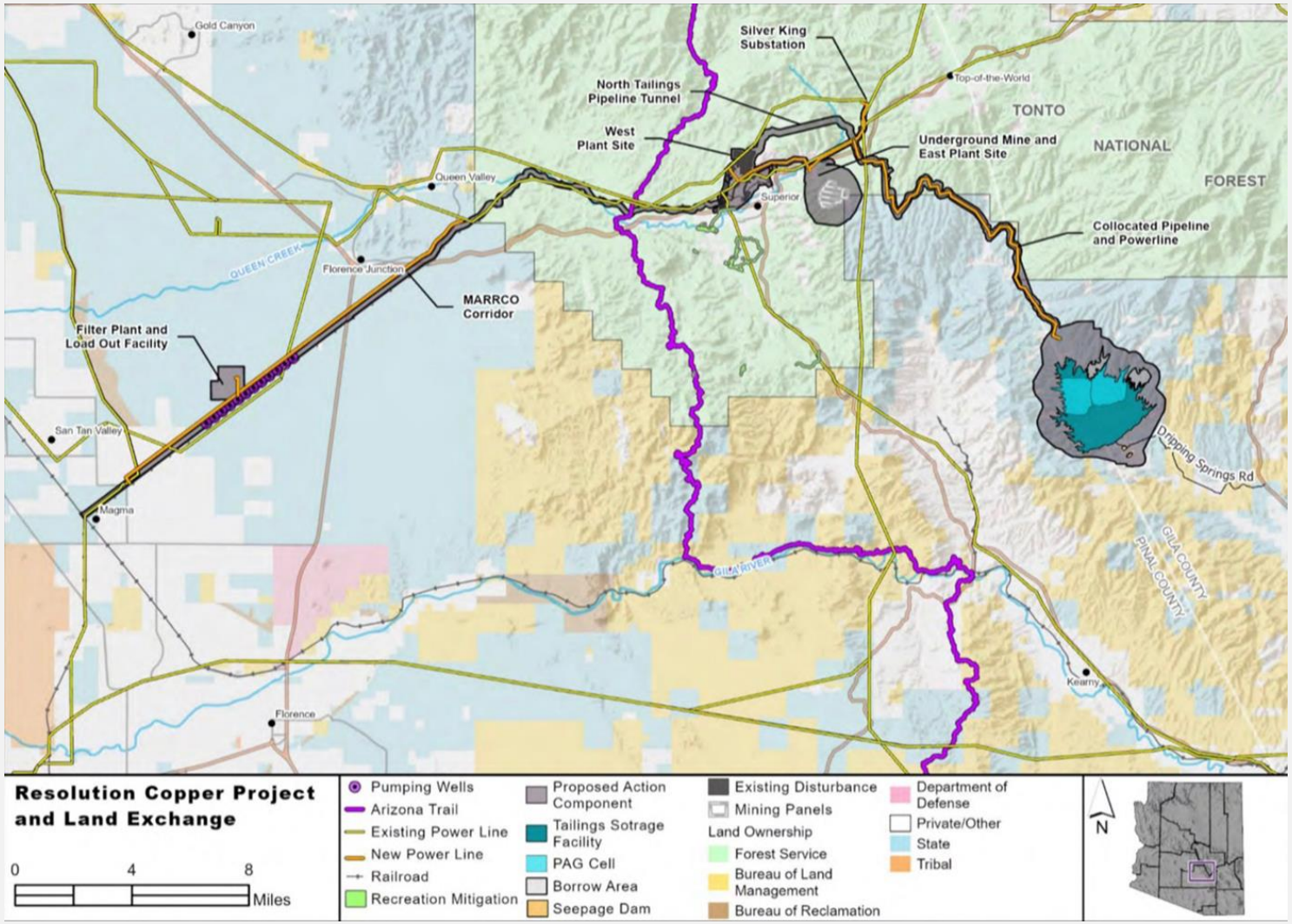
Chicken Rock, Salina Springs, AZ, The Navajo Nation

# Peabody Kayenta Mine Complex, AZ
## Coal Strip Mine - reclamation


https://storymaps.arcgis.com/stories/eb1a9eaa0db1467dabfe616f02c1a53c

# Rio Tinto/BHP Resolution Copper Mine, AZ

## Underground, Tailings - planned




https://desertreport.org/the-resolution-copper-mine/

# Whitehorse Copper Mine, Yukon Territory

Open Pit - inactive

text/

# UCM Inc. Usibelli Coal Mine, AK

Coal Strip Mine - active

text/