Environmental Justice
In California's Lithium Valley

Understanding the potential impacts of direct lithium extraction from geothermal brine.

A document for community education

NOVEMBER 2023

EARTHWORKS

COMITE CIVICO DEL VALLE, INC.

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ACKNOWLEDGMENTS

This report is written by Jared Naimark. Research was provided by Kenneth Larsen, editing by Brendan McLaughlin, and design by Creative Geckos. The report was reviewed by experts John Hadder (Great Basin Resource Watch), James J.A. Blair (Cal Poly Pomona) and Steven H. Emmerman (Malach Consulting). Thank you to the many Comite Civico del Valle and Earthworks staff and partners who provided essential direction and feedback.

ABOUT COMITE CIVICO DEL VALLE

Comite Civico del Valle (CCV) was founded on the principle that "Informed People Build Healthy Communities" and continues to incorporate this in all partnerships, research, and civic engagement taken by our organization. CCV is a 501 (c)(3) organization with an extensive background and accomplishments that date back to our grassroots origins in 1987. Our organization was founded in Imperial County, California with the endeavor of improving the lives of disadvantaged communities by informing, educating, and engaging the community's civic participation.

CCV is a member of the Lithium Valley Community Coalition (LVCC). The LVCC is a coalition of various organizations that represent disinvested communities, rural neighborhoods, organized labor, environmental justice, and people across the Imperial Valley standing up for a just and equitable Lithium Valley future. The LVCC envisions a region with an abundance of economic opportunities for historically disadvantaged communities, with a focus on doing no harm to the environment while advancing California's ambitious climate goals. The LVCC undertakes a task to meet the needs of the communities located in Lithium Valley in an equitable, environmentally friendly, and community-conscious manner. LVCC's goal is to ensure that disadvantaged communities can be represented in an equitable manner and have a seat at the decision-making table.

ABOUT EARTHWORKS

Earthworks is a nonprofit organization dedicated to protecting communities and the environment from the adverse impacts of mineral and energy development while promoting sustainable solutions. We work with communities and grassroots groups to reform government policies, improve corporate practices, influence investment decisions, and encourage responsible materials sourcing and consumption. We expose and aim to prevent the health, environmental, economic, social, and cultural impacts of mining and energy extraction through work informed by sound science.

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Glossary

BHER	**Berkshire Hathaway Energy Renewables** Company that operates ten existing geothermal plants in Imperial Valley and is piloting lithium extraction technology.
CEQA	**California Environmental Quality Act** California law that requires public agencies and local governments to evaluate and disclose the environmental impacts of development projects.
CTR	**Controlled Thermal Resources** Company proposing to build the Hell's Kitchen geothermal power plant and lithium extraction facility in Imperial Valley.
DLE	**Direct Lithium Extraction** Type of extraction proposed in Imperial Valley that uses a chemical or physical process to remove lithium from brine.
EIR	**Environmental Impact Report** A report that analyzes a proposed project's impacts on the environment and outlines ways to avoid or minimize impacts.
EGS	**Enhanced Geothermal System** A technique for drilling geothermal wells by injecting pressurized fluid, similar to fracking.
EPA	**Environmental Protection Agency** United States government agency tasked with environmental protection.
ESM	**ES Minerals / EnergySource Minerals** Company planning to build a lithium extraction facility at the John L. Featherstone (Hudson Ranch 1) Power Plant.
EV	**Electric Vehicle** Vehicle powered by an electric motor that draws energy from a battery.
FPIC	**Free, Prior, and Informed Consent** Internationally recognized right of Indigenous peoples regarding projects affecting their lands, territories, resources, and cultural heritage. Includes the right to say "no" to a project.
Geothermal Plant	Power plant that draws heat from the earth to produce low-carbon electricity.
HCl	**Hydrochloric Acid** Hazardous material used in the lithium extraction process.
ICAPCD	**Imperial County Air Pollution Control District** Imperial County agency that sets air quality standards and mitigation requirements for development projects.

IID	**Imperial Irrigation District** Irrigation district and utility that provides water to Imperial Valley, including to proposed lithium projects.
ILiAD	**Integrated Lithium Adsorption Desorption** Proprietary technology that EnergySource Minerals plans to use for extracting lithium from geothermal brine.
ILO	**International Labor Organization** United Nations agency that sets labor standards for advancing social and economic justice.
LCE	**Lithium Carbonate Equivalent** Standard to compare the amount of battery-grade lithium a deposit can produce, assuming 100% recovery.
LVC	**Lithium Valley Commission** Commission tasked with analyzing the potential for lithium extraction in California and making recommendations to the state legislature.
MW	**Megawatts** A unit of power equal to one million watts, used to measure the output of power plants.
PEIR	**Programmatic Environmental Impact Report** A report that analyzes the cumulative environmental impacts of a land use plan that includes multiple proposed projects, rather than project by project.
PM	**Particulate Matter** Small particles, such as dust, that contribute to air pollution and are harmful to human health.
Salar	**Salt Flat** A salt flat where lithium can often be found dissolved in brine
SSKGRA	**Salton Sea Known Geothermal Resource Area** The area on the south shore of the Salton Sea that is known to contain high potential for geothermal energy, where lithium extraction projects are being proposed.

Executive Summary

Demand for lithium, used in electric vehicle batteries, is skyrocketing. Electric vehicles are important for the transition away from fossil fuels. However, mining lithium has well-documented negative social and environmental impacts.

Imperial Valley, in Southern California, is home to one of the largest lithium deposits in the world, and has been dubbed "Lithium Valley." Lithium here is dissolved in the underground brine that is used to generate electricity at geothermal power plants on the south shore of the Salton Sea. Direct lithium extraction is being promoted as more environmentally friendly than other types of lithium mining, but it has never before been used at commercial scales, and communities in Imperial Valley have raised questions about the potential impacts to land, air, water, and public health.

The goal of this report is to educate frontline communities and the public about the potential environmental impacts of lithium extraction in Imperial Valley. This is important from an environmental justice perspective, because disadvantaged communities living near proposed lithium projects already suffer disproportionately from air pollution and other environmental health hazards. Furthermore, Indigenous communities have raised concerns about potential impacts to cultural sites at the Salton Sea.

This report is based on a review of academic literature, government documents, and publicly available documents related to specific lithium projects.

Lithium is conventionally produced from mining hardrock deposits, primarily in Australia, or evaporating brine from salt flats, primarily in South America. In Imperial Valley, lithium is found in hot brine more than 1,500 feet underground in the Salton Sea Known Geothermal Resource Area, on the south shore of the Salton Sea. There are 11 geothermal power plants currently using hot brine to generate steam and produce low-carbon electricity. Direct lithium extraction projects would use technologies such as ion exchange and adsorption to directly remove lithium from the brine before the brine is reinjected deep underground into the geothermal reservoir.

There are currently three companies at various stages of developing lithium extraction projects in Imperial Valley using proprietary technology:

- Berkshire Hathaway Energy Renewables Minerals,
- Controlled Thermal Resources, and
- EnergySource Minerals.

While potential environmental impacts at each site must be analyzed individually, our review identifies five areas of potential impacts to consider:

1 **AIR QUALITY:** Construction and operation of lithium and geothermal facilities in Imperial Valley may impact already degraded air quality through emissions of particulate matter, greenhouse gases, and hydrogen chloride. While these are unlikely to meet legal thresholds that require mitigation for specific projects, it will be important to analyze the cumulative impacts as "Lithium Valley" is built out, including from vehicle trips, battery plants, and other associated infrastructure.

2 **FRESHWATER CONSUMPTION:** Lithium extraction projects will consume Colorado River water for cooling and processing. For example, EnergySource Minerals estimates that its operations will consume 3,400 acre-feet of water to produce 19,000 metric tons of lithium hydroxide per year for 30 years. This is roughly the amount it would take to cover nine football fields, one foot deep with water, every day. While the industry often makes favorable comparisons of how little water direct lithium extraction will use compared to South American operations, these comparisons are difficult to verify, due to lack of transparent data sources. Regardless, freshwater consumption needs to be analyzed in the context of climate change and possible cuts to Imperial Valley's Colorado River allocation. If the lithium industry expands to its planned capacity, it will exceed the freshwater currently allocated by the Imperial Irrigation District for non-agricultural use.

It will be important to analyze the *cumulative* impacts and cumulative pollution as "Lithium Valley" is built out, including from vehicle trips, battery plants, and other associated infrastructure.

3 **SALTON SEA DEGRADATION:** The Salton Sea is a terminal lake—a lake without an outlet—fed by drainage from agricultural fields. Due to water transfers from Imperial Valley to urban areas, evaporation now exceeds inflow, and the Sea is rapidly shrinking, exposing harmful dust contaminated by pesticides and fertilizers. If water is diverted from agriculture to lithium production, it may speed up the shrinking of the Sea. Freshwater consumption by lithium extraction projects may also limit restoration options for the Salton Sea, such as the voluntary transfer of Colorado River water recommended by a panel of independent experts. In this context, water consumption by lithium projects should be carefully analyzed and planned for in order to prevent an indirect contribution to worsening air quality through exposure of the Salton Sea lake-bed.

4 **HAZARDOUS WASTE AND MATERIALS:** Currently, geothermal operations in the region minimize waste by reinjecting spent brine back underground into the geothermal reservoir where it came from, and this practice will continue with the addition of direct lithium extraction technology. However, other elements besides lithium are dissolved in brine and will concentrate on filters, forming "filter cakes" that need to be disposed of. There is potential for this waste to include heavy metals harmful to human health such as arsenic, lead, and cadmium. For example, EnergySource Minerals estimates that 90% of its waste will be non-hazardous and disposed of in California, while 10% of its waste will be hazardous waste that will be disposed of in Arizona. Testing and disclosing of waste content, and proper storage and transport, will be critical.

5 **SEISMIC ACTIVITY:** Lithium extraction itself is unlikely to have an impact on seismic activity in the area. However, commercially successful lithium projects may lead to further geothermal development in this seismically active area. There is disagreement in the scientific literature about how geothermal development impacts seismicity, so this is an area that requires further study. New wells drilled using enhanced geothermal systems, similar to fracking, may have an impact on inducing seismic activity. Imperial Valley is already living with a baseline risk of earthquakes, so lithium extraction infrastructure should be designed with high standards for earthquake safety.

The potential environmental impacts of direct lithium extraction in Imperial Valley may prove to be less harmful than hardrock or evaporation mining. However, there are still potential adverse impacts that should be avoided and mitigated. In order to promote environmental justice, communities should be aware of these potential impacts and be able to fully participate in the environmental review process.

FIGURE 1: **At right, "Lithium Valley" is shown in the dotted red circle.**

Remote meeting of the Lithium Valley Commission in Calipatria, California. Remote meetings were hosted to allow the engagement of residents of the Lithium Valley and other surrounding communities in the Commission hearings.

Photo: Comite Civico del Valle

Introduction

Demand for lithium is expected to increase dramatically in the coming years, in large part because of its use in batteries for electric vehicles (EVs), which are booming. The need for lithium also stems from California's goal to have all new cars be zero-emission vehicles by 2035. Lithium demand is projected to grow to 280% of current reserves by 2050, with supply primarily coming from new extraction (Dominish et al., 2019). This projection is not set in stone. Improved recycling has the potential to offset new lithium mining by 25% (Dominish et al., 2021), and demand for mined lithium could be reduced even more dramatically by shifts to smaller batteries and away from private car ownership (Riofrancos et al., 2023).

New lithium extraction is being promoted aggressively around the world and in the United States, which has just one active lithium operation, at the Silver Peak mine in Nevada. Most of the lithium mined today comes from Australia and Chile, then is largely refined and manufactured into batteries in China. For this reason, the United States has designated lithium a "critical mineral" for national security, promoting new domestic lithium mining as a way to decrease the risk of supply chain disruptions (Riofrancos, 2023). For example, the 2022 Inflation Reduction Act contains provisions that make EV tax credits dependent on lithium sourced in the United States (or free trade agreement countries). The likelihood of continued high prices and government subsidies has led to a wave of speculation in new lithium projects in the United States, with investors and mining companies hoping to make huge profits.

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The likelihood of continued high prices and government subsidies has led to a wave of speculation in new lithium projects in the United States, with investors and mining companies hoping to make huge profits.

Photo: scharfsinn86/stock.adobestock.com

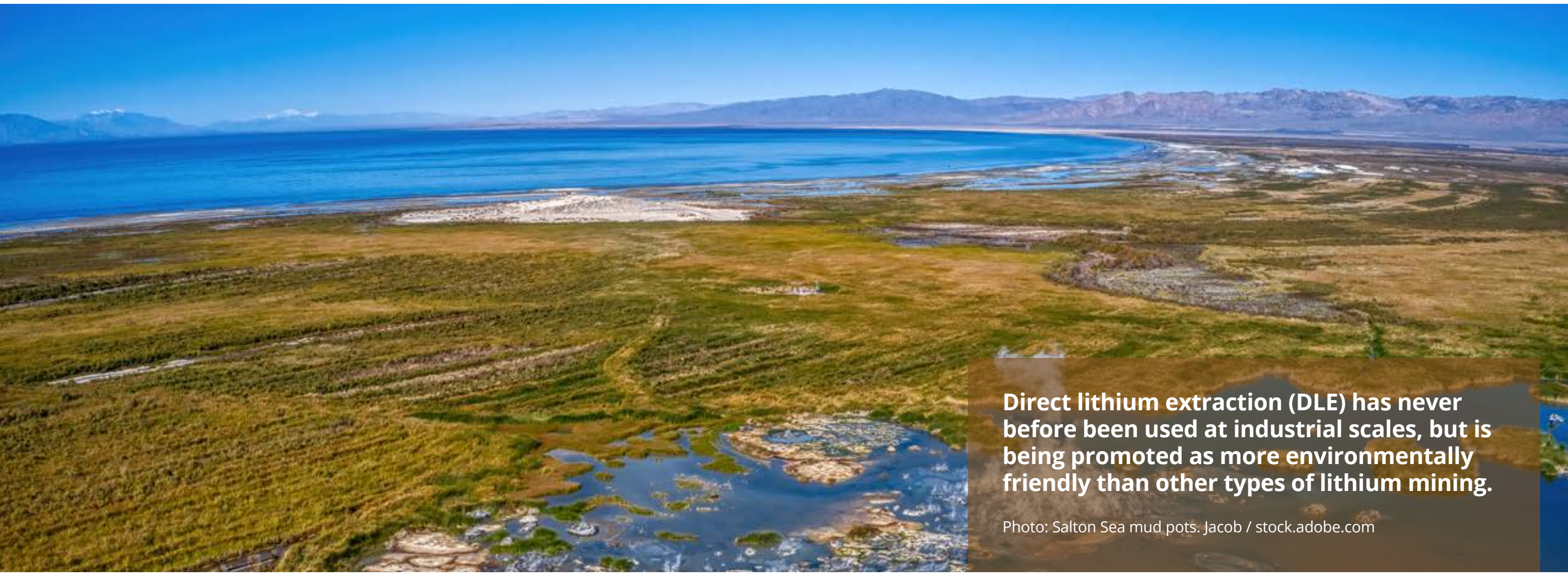
EVs are considered an important part of the solution mix for making the transition away from fossil fuels to a low-carbon economy, and for the most part, EV batteries are lithium-ion based. Lithium extraction, both hardrock mining and brine evaporation, has well-documented negative social and environmental impacts (Blair et al., 2022; Earthworks, 2021a):

1. **Creating water stress in arid environments, resulting in the pollution of air and water,**
2. **Violating the rights of Indigenous Peoples by not respecting their right to Free, Prior and Informed Consent (FPIC), and**
3. **Desecrating sacred landscapes.**

> Inadequate and antiquated mining governance complicates this further. For example, hardrock mining on public lands in the United States is governed by the severely outdated and flawed 1872 Mining Law. The law, which was passed to encourage western settlement on Indigenous lands, includes no environmental provisions, demands no royalties, and establishes mining as the highest and best use of public lands (Earthworks, 2021b).

Imperial Valley, in Southern California, is home to one of the largest lithium deposits in the world, leading investors and prospective developers to dub the area "Lithium Valley."

This lithium, along with many other elements, is dissolved in hot brine deep below ground. This brine is currently extracted through geothermal wells to generate electricity at 11 power plants, and then reinjected back underground into the geothermal reservoir where it came from. Three companies are developing projects to extract lithium at existing and new geothermal plants by using direct lithium extraction (DLE) technologies. DLE refers to a set of physical and chemical processes that would directly remove lithium from brine, similar to how a water softener removes minerals from water. DLE, which has never before been used at industrial scales, is being promoted as more environmentally friendly than other types of lithium mining (Paz et al., 2022).



Direct lithium extraction (DLE) has never before been used at industrial scales, but is being promoted as more environmentally friendly than other types of lithium mining.

Photo: Salton Sea mud pots. Jacob / stock.adobe.com

However, very little information is publicly available about how these technologies work, and their potential environmental impacts. What information is available is highly technical and written by the lithium industry itself. The Blue Ribbon Commission on Lithium Extraction in California met over 20 times between 2021 and 2022, and heard repeated questions from the public about the potential impacts of DLE on land, air, and water. Some of these questions were answered in the Report of the Blue Ribbon Commission Lithium Extraction in California published in December 2022. However, many uncertainties remain that will need to be addressed in the upcoming Salton Sea Renewable Resource Programmatic Environmental Impact Report (PEIR).

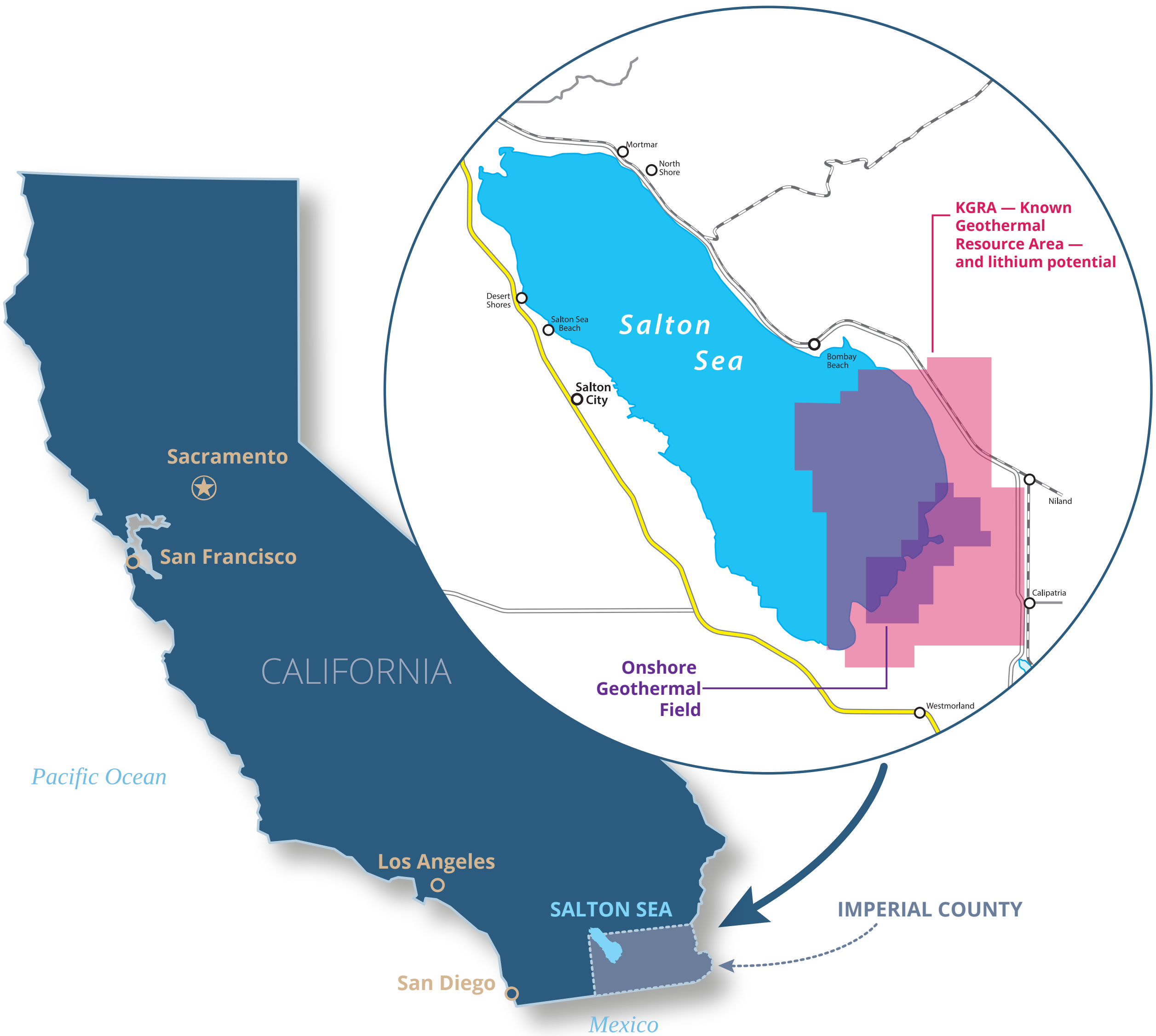


FIGURE 2. **In the circle inset map, the shaded pink area is the KGRA, the Known Geothermal Resource Area, with high lithium potential. The shaded purple is the geothermal field that has 11 geothermal plants, which have the capacity to produce about 414 MW of electricity per year.**

The Purpose of this Document

This literature review attempts to fill some of the information gaps about DLE, and is meant to serve as an educational tool for frontline communities and the public. It is intended to educate the reader about lithium, geothermal wells, and DLE technologies. It reviews potential environmental impacts of DLE from geothermal brine in the Salton Sea Known Geothermal Resource Area (SSKGRA). It is not a comprehensive assessment of all potential impacts, nor a comprehensive recounting of specific extraction technologies used by companies. The authors hope that communities will find this document a useful starting point for better understanding the potential impacts of lithium extraction so they can be informed participants in the PEIR review process.

Environmental Justice and Community Engagement

It is crucially important that communities understand the potential impacts of lithium extraction in order to advance environmental justice in the region. Disadvantaged, high-poverty Latinx communities living near the area proposed for lithium extraction in Imperial County already suffer adverse impacts from pollution from the Salton Sea and industrial agriculture. This includes high rates of asthma, likely to increase due to airborne dust from the receding Salton Sea's exposed lake-bed (Farzan et al., 2019). According to CalEnviro Screen data accessed in 2023, the census tract closest to proposed lithium extraction ranks in the 82nd percentile of communities most impacted by environmental health burdens in California. Throughout the life of the Lithium Valley Commission, these communities have raised questions about the potential impacts of lithium extraction, and voiced concerns over further exposure to environmental health hazards. Analyzing the potential benefits and risks of lithium extraction in Imperial Valley cannot be separated from the underlying context and history of disproportionate environmental impacts, as fence-line communities work towards the goal of advancing environmental justice through informed participation in decision-making about "Lithium Valley." The community's right to know about the full range of consequences of lithium extraction proposals is a key pillar of environmental justice.

Construction of dust mitigation berms at the Salton Sea.

Photo: Comite Civico del Valle

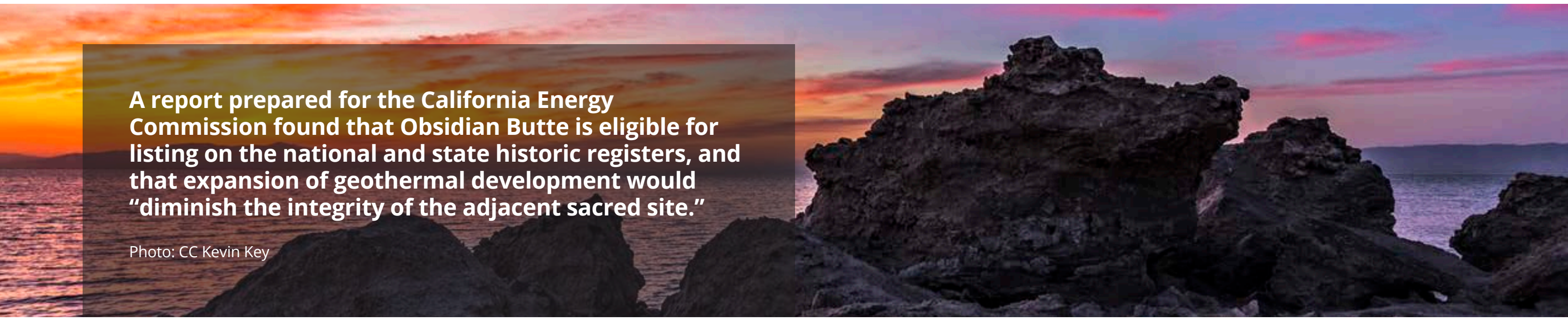
Indigenous Rights

In the United States and around the world, mining impacts disproportionately fall on vulnerable and marginalized communities, particularly Indigenous Peoples (Earthworks, 2021b). These impacts can range from destruction of sacred, cultural, and religious sites, infringement of tribal sovereignty and violation of treaty rights, and increased gender-based violence associated with "man camps" to house workers for extractive projects. Many of these impacts are irreversible, and in the case of impacts to sacred sites, impossible to mitigate. Globally, roughly 85% of lithium resources and reserves are located on or near the territories and lands of Indigenous Peoples (Owen et al., 2022). In the United States, 79% of lithium deposits are located within 35 miles of Native American reservations (Block, 2021). Even lithium deposits more distant from present-day reservations are located on ancestral territories that may hold great cultural importance for Native communities. In the United States and around the world, the projected increase in lithium mining will likely have a disproportionate impact on Indigenous communities.

The UN Declaration on the Rights of Indigenous Peoples enshrines the right to Free Prior and Informed Consent, including the right to say no to development.

Proposed lithium extraction in Imperial Valley is located in the footprint of the ancient Lake Cahuilla, ancestral lands of the Cahuilla, Kamia, Quechan, Kumeyaay, and other Indigenous Peoples (Voyles, 2021). In public comments to the Lithium Valley Commission meetings, tribal leaders raised concerns about the absence of legally required government-to-government consultation on lithium projects, possible environmental impacts, and impacts to cultural sites in the area. Of particular concern is protecting Obsidian Butte, a volcanic outcropping on the shore of the Salton Sea held sacred by multiple tribes in the area. According to Quechan and Kamia elder Preston J. Arrow-Weed, Obsidian Butte is a sacred place that should be left undisturbed (Arrow-Weed, 2022). Similarly, Carmen Lucas (Kwaaymii Laguna Band of Indians) urged protection of cultural resources at the Southeast Lake Cahuilla Active Volcanic Cultural District (Lucas, 2022). A 2010 report prepared for the California Energy Commission found that Obsidian Butte is eligible for listing on the national and state historic registers, and that expansion of geothermal development would "diminish the integrity of the adjacent sacred site" (Gates & Crawford, 2010).

The UN Declaration on the Rights of Indigenous Peoples, and other international human rights standards such as the International Labor Organization (ILO) 169 Convention, enshrine Indigenous Peoples' right to Free, Prior, and Informed Consent (FPIC) on projects affecting their lands, territories, resources, and cultural heritage. This includes the right to meaningful dialogue and the right to say "yes," "no," or "yes with conditions" to a project, and to revoke consent at any time. Thus, understanding the possible environmental impacts of lithium extraction in Imperial Valley is crucial for upholding Indigenous rights.



A report prepared for the California Energy Commission found that Obsidian Butte is eligible for listing on the national and state historic registers, and that expansion of geothermal development would "diminish the integrity of the adjacent sacred site."

Photo: CC Kevin Key

Literature Review

To better understand the potential environmental impacts of direct lithium extraction (DLE) in Imperial Valley, the authors reviewed academic literature, government documents, and publicly available documents related to specific lithium projects. The review that follows summarizes key findings, including background on the lithium brines found at the Salton Sea, an explanation of geothermal energy, how DLE technologies work, and an overview of potential impacts. We cover:

- Lithium Brines in General
- Salton Sea Geothermal Lithium Brines
- Geothermal Power Plants
- Direct Lithium Extraction, and
- Direct Lithium Extraction at the Salton Sea

Lithium Brines in General

Lithium is the lightest metal element and has a high electrochemical potential, meaning it can store a lot of energy in a battery. Lithium is a highly reactive material that does not exist in its elemental form in nature. Lithium readily forms bonds, forming lithium salts that easily dissolve in water. These elemental characteristics of lithium make it an important part of industrial processes (Evarts, 2015). Lithium is used for a variety of purposes, such as ceramic and glass production, but an estimated 80% of global lithium produced today goes to rechargeable lithium-ion batteries (U.S. Geological Survey, 2023).

Electrification of transportation and energy storage is increasing the demand for high-efficiency lithium-ion batteries worldwide (Bridge & Faigen, 2022). In the United States, lithium is classified as a "critical mineral" for strategic, consumer, and commercial industries, and a priority for the development of domestic resources (U.S. Department of Energy, 2021). Identifying and extracting lithium from national

Here is an example of evaporation ponds used to extract lithium from brine in Chile's Atacama desert.

Photo: freedom_wanted / stock.adobe.com

lithium reserves is a major focus of federal and state governments. To date, lithium production in the United States has been minimal and most lithium has been imported from Chile and Argentina (U.S. Geological Survey, 2022). Major resources of lithium are held in pegmatite deposits (a type of igneous rock), sedimentary (clay) deposits, or in brines.

Brines are increasingly important for global lithium production (Bradley et al., 2017). Continental lithium brines are found in salars, or salt flats. They are created in endorheic basins (basins from which there is no outflow to other waterbodies) where evaporation is much greater than precipitation (Munk et al., 2016). In general, these lithium brines form when water transports dissolved lithium into an endorheic basin, and then the water evaporates, leaving behind lithium and other salts. This process is repeated over lengthy periods leading to increasing salinity and lithium content within the basin, as shown in see Figure 3 (Rossi et al., 2022). The lengthy periods (thousands to millions of years) required to generate economically viable lithium deposits make this a non-renewable resource over human time-scale. Currently, lithium is extracted from salars in South America and Nevada using large evaporation ponds. New processes in lithium extraction have opened non-traditional resources for exploitation including geothermal and oilfield brines (Kesler et al., 2012).

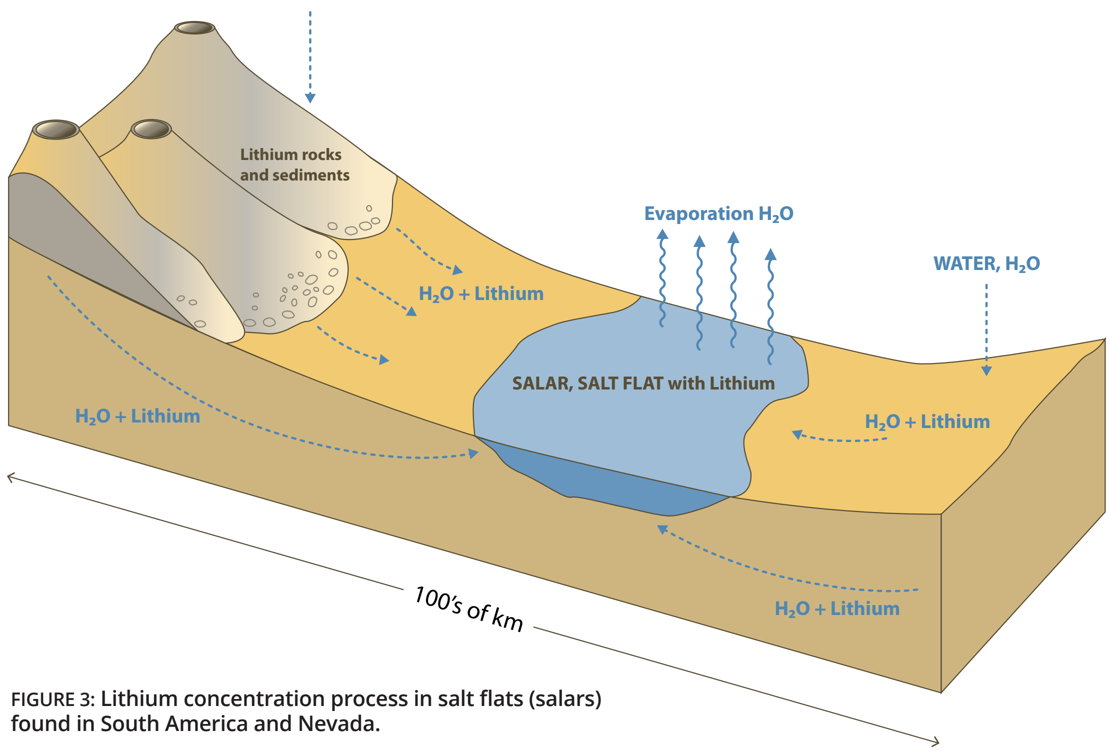


FIGURE 3: **Lithium concentration process in salt flats (salars) found in South America and Nevada.**

Adapted from Rossi et al., 2022.

Salton Sea Geothermal Lithium Brines

It is important to note that the source of lithium in the SSKGRA is not the Salton Sea itself. Rather, the lithium is dissolved in brine in the geothermal reservoir located more than 1,500 feet underground (Paz et al., 2022). The Salton Sea geothermal brine is estimated to contain lithium at concentrations ranging from 90–440 parts per million, a very high concentration compared to other geothermal fields in the United States (Stringfellow & Dobson, 2021). The portion of the brine reservoir currently exploited for geothermal energy is estimated to hold 2 million metric tons of lithium, making it one of the largest lithium reserves in the world (McKibben et al., 2021). If fully exploited, the SSKGRA is expected to be able to produce more than 600,000 metric tons of lithium carbonate equivalent (LCE) per year (Ventura et al., 2020). For reference, in 2022 global production was estimated at 737,000 metric tons of LCE, and demand is expected to grow rapidly. Because lithium can take a variety of forms, converting to LCE is the industry standard for making comparisons about the amount of battery-grade lithium a deposit can produce, assuming 100% recovery.

Research is underway to better understand how much lithium can be extracted from the reservoir, which source rocks it comes from, and how quickly it regenerates, with some estimating that the deposit could support 50–100 years of lithium production (Chao, 2022). The geothermal brine found in the SSKGRA also contains economically exploitable levels of magnesium, zinc, and high concentrations of other metals and minerals (Chao, 2020).

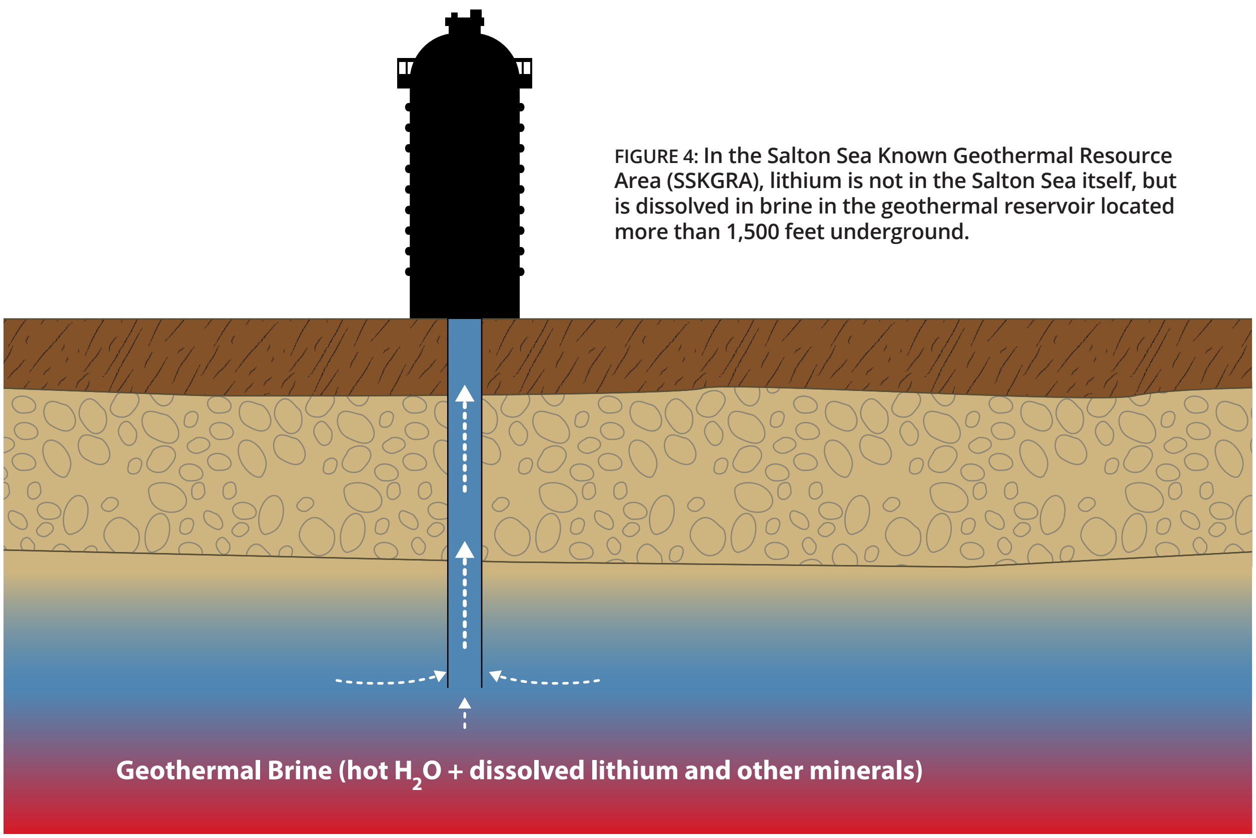


FIGURE 4: In the Salton Sea Known Geothermal Resource Area (SSKGRA), lithium is not in the Salton Sea itself, but is dissolved in brine in the geothermal reservoir located more than 1,500 feet underground.

Geothermal Power Plants

Proposed lithium extraction from SSKGRA brines would be connected to existing or newly constructed geothermal plants that extract brine from geothermal wells. In general, geothermal wells draw hot water from the earth for heating, cooling, or electrical production. The first geothermal power plant in Imperial Valley was constructed in 1982. As of 2023, there are 11 geothermal power plants operating in the SSKGRA. They are located primarily on private land, though some lease state land. These power plants have the capacity to produce 414 megawatts (MW) of electricity, roughly enough to power 300,000 homes (Paz et al., 2022). It is estimated that with new power plants, this could increase by more than six times, up to 2,950 MW, including on land that will be exposed by the receding Salton Sea (DiPippo & Lippmann, 2017).

Developing new geothermal power plants is a priority for the State of California, because they provide low-carbon, renewable, reliable energy. There are about 28 production wells in the field producing over 265 billion pounds of brine annually, and 41 injection wells reinjecting just over 220 billion pounds of produced brine (California State Lands Commission, n.d.). The difference is likely due to release of steam and removal of silica (disposed of as waste). Now, there is interest in extracting lithium from this brine before it is reinjected, both at existing and new geothermal power plants.

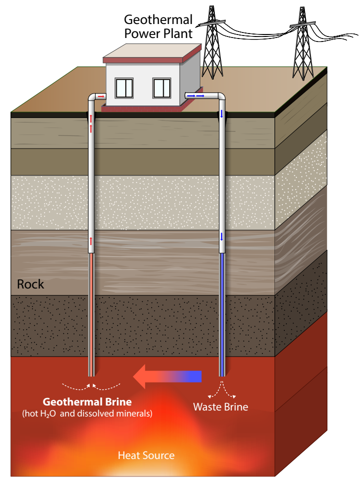


FIGURE 5: A simple overview of a geothermal plant, where wells (production wells) bring hot water or steam to the power plant to generate electricity, then the cooled water is injected back into the geothermal reservoir.

Adapted from istock.com/ttsz

One of the geothermal facilities in operation in the Lithium Valley region.

Photo: Comite Civico del Valle

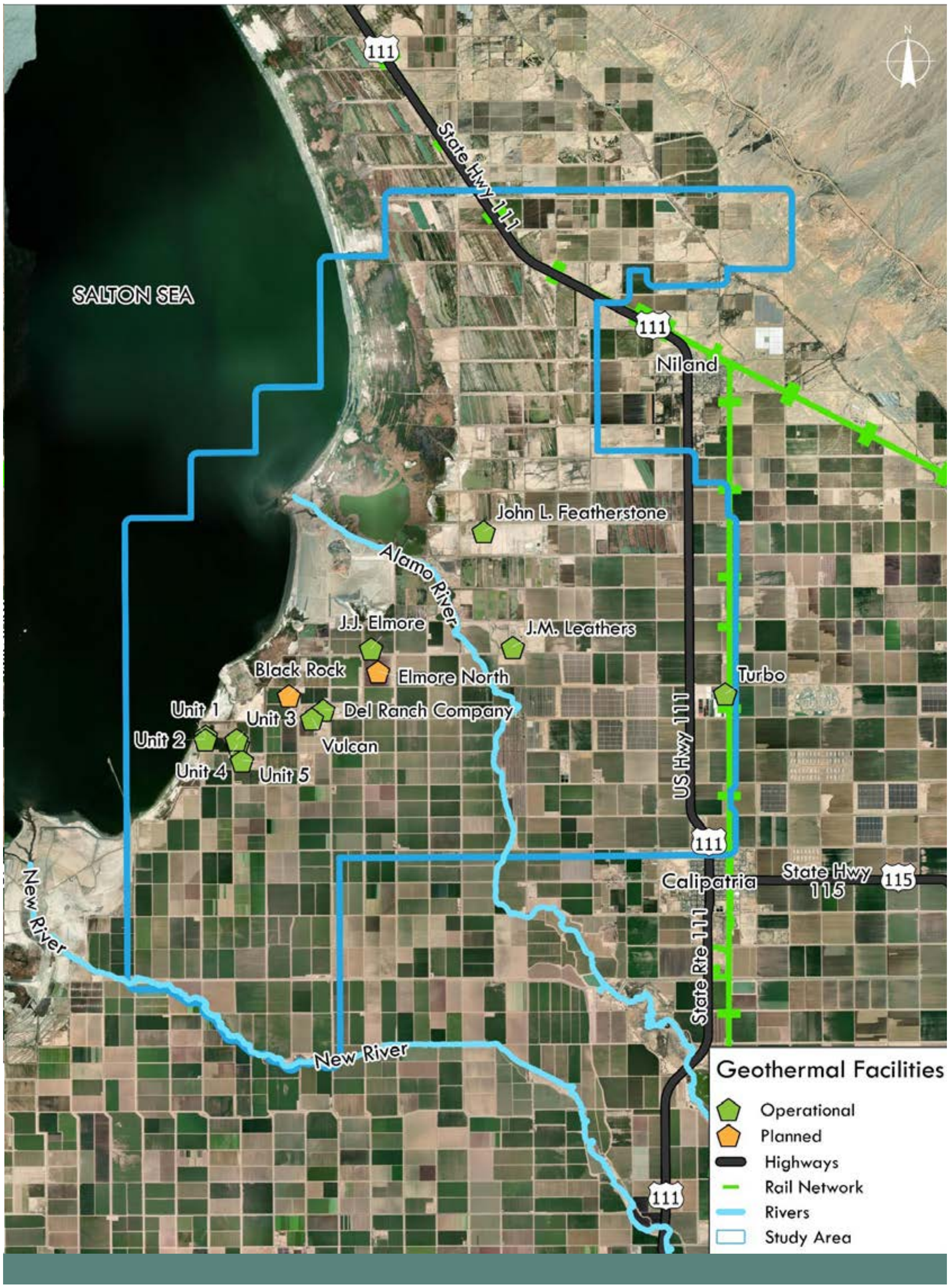


FIGURE 6: Proposed and operational geothermal plants. There are 11 operating geothermal plants as of July 2023, generating 414 megawatts (MW) of electricity, roughly enough to power 300,000 homes. It is estimated that with new power plants, this could increase by more than six times, up to 2,950 MW.

From a presentation by Imperial County, California, July 2023.

There are three main types of geothermal electrical generation systems:

- Flash steam, (used in the Salton Sea geothermal plants),
- Dry steam, and
- Binary cycle

The Salton Sea geothermal plants are exclusively flash steam power systems, as shown in Figure 7. Geothermal wells allow high-temperature water from deep underground to rise from the production well to a tank on the Earth's surface. The change from high to low pressure causes the water to "flash" to steam. This steam then drives the turbine to generate electricity. The spent brine is then injected back into the geothermal reservoir, with some solid waste being sent to a landfill. Operating these wells at the SSKGRA requires electricity purchased from the Imperial Irrigation District (IID).

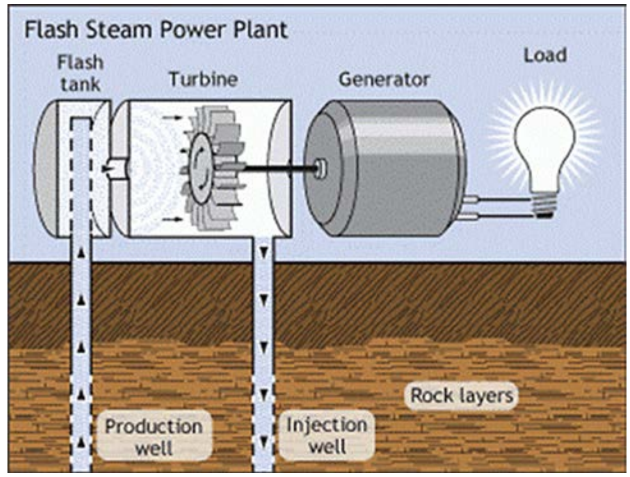


FIGURE 7: **Flash steam geothermal plant. High temperature water is pumped out from high to low pressure, causing the water to "flash" to steam, which then drives a turbine to generate electricity. The cooled, condensed water is reinjected into the geothermal reservoir.**

From U.S. Energy Information Administration, 2022.

Brine production and power generation from geothermal wells can decline over time for a variety of reasons, including loss of permeability from mineral build up. To restore and improve permeability in geothermal wells, geothermal plants often employ a form of hydraulic fracturing (fracking) where pressurized fluids are injected into the subsurface to create cracks in the rock. This process, shown in Figure 8 is called an Enhanced Geothermal System (EGS) (National Renewable Energy Laboratory, n.d.). While EGS is not currently used at the SSKGRA, it may be used in the future (Roth, 2014).

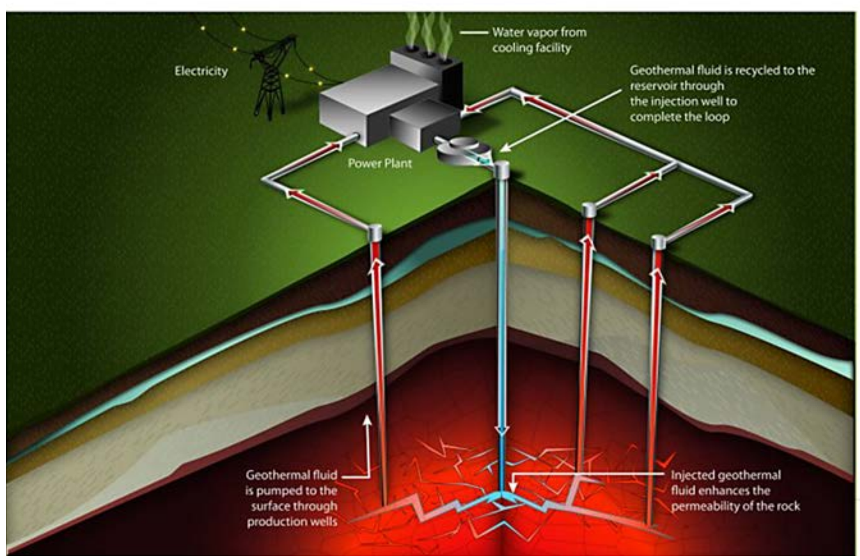


FIGURE 8: **Enhanced Geothermal System uses hydraulic fracturing (fracking) to to increase/restore the permeability of the rock allowing the water to flow more freely.**

From National Renewable Energy Laboratory, n.d.

Direct Lithium Extraction Overview

Unlike hardrock or evaporation mining, DLE does not require major disturbance of land, and has a much smaller physical footprint, so it is touted as a more environmentally friendly approach to lithium extraction (Stringfellow & Dobson, 2021). Based on the proposals at the Salton Sea to date, ion exchange in combination with adsorption are the most likely DLE technologies that will be deployed. Ion exchange technology uses a material designed to attract cations (positively charged particles) or anions (negatively charged particles). Attached selected ions are then removed, using a solvent, acid, or other transfer fluid.

Ion exchange itself is not a recent technology, but it has never been used to remove lithium from geothermal brine at commercial scales.

A familiar example of this is a water softener, which removes calcium and magnesium from water. Calcium and magnesium-rich water are passed through a "bed" that contains ion exchange resin beads which are charged with sodium ions. Calcium and magnesium replace the sodium attached to the ion exchange beads, releasing the sodium into the water.

The major difference between ion exchange used for a water softener and for lithium extraction is that the ion exchange beads need to be highly selective to lithium. The makeup of these lithium-attracting materials is generally patented and proprietary, but they would follow the same general principle (Stringfellow & Dobson, 2021). Once attached to this ion exchange bead, the lithium would be removed using an acid or base, most likely hydrochloric acid. The lithium is then transferred for further processing and filtration. The benefit of ion exchange technology is the way it selectively collects lithium, allowing anything unused to be directly disposed into the geothermal reservoir when the brine is reinjected.

Ion exchange itself is not a recent technology, but it has never been used to remove lithium from geothermal brine at commercial scales. An important application of ion exchange technologies to lithium extraction is the implementation of ion sieve technology. Ion sieves function in the same way as ion exchange beads. The major difference is the special material used to attract the lithium forms a structure that only accepts particles of a specific size or smaller (Weng et al., 2020). A simple diagram of DLE from geothermal brine is shown in Figure 9 (Stringfellow & Dobson, 2021).

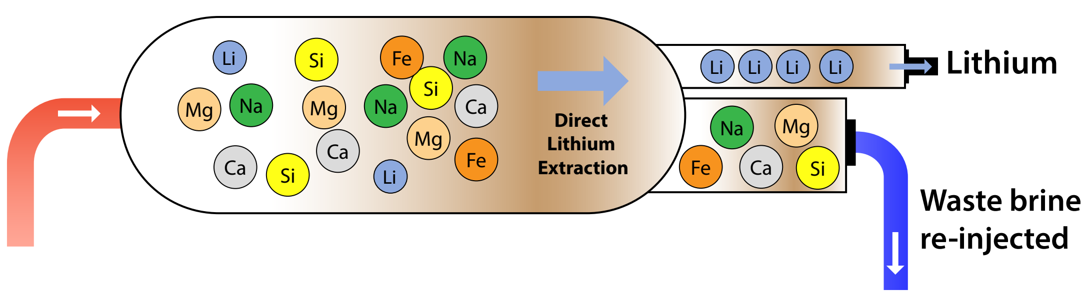


FIGURE 9: Direct lithium extraction from geothermal brine.
Adapted from Stringfellow & Dobson 2021.

Direct Lithium Extraction Proposals at the Salton Sea

Starting in 2008, Simbol Inc. in partnership with EnergySource operated multiple pilot-scale experiments at the John L. Featherstone (Hudson Ranch I) Power Plant (Harrison, 2014). The project, funded by the U.S. Department of Energy and the California Energy Commission, ceased in 2016 due to Simbol's financial troubles and a failed acquisition deal with Tesla (Roth, 2017). This, in turn, has resulted in a prolonged dispute over lithium extraction patents (Scott, 2021).

As of June 2023, there are three companies at various stages of developing lithium extraction projects near the Salton Sea:

1. **BERKSHIRE HATHAWAY ENERGY RENEWABLES MINERALS (BHER MINERALS)** wholly owned subsidiary CalEnergy operates 10 geothermal power plants in the SSKGRA. BHER Minerals started a one-tenth scale lithium demonstration project at one of their plants in 2022. According to California Environmental Quality Act (CEQA) documents, BHER planned to use ion exchange technology developed by Lilac Solutions (California Energy Commission, 2020). They are also building a demonstration plant to process lithium chloride into battery grade compounds (Scheyder, 2022). Depending on the results of these demonstrations, BHER will consider building commercial-scale DLE plants at existing, and possibly new, geothermal facilities. BHER is proposing to build three new geothermal plants: Black Rock (77 MW), Elmore North (140 MW), and Morton Bay (140 MW). These proposals do not currently include plans for lithium extraction, but such plans may be added in the future.

2. **CONTROLLED THERMAL RESOURCES (CTR)** is proposing to build a new geothermal power plant, combined with a DLE plant, in a project called "Hell's Kitchen." An Initial Study & Environmental Analysis was completed in March 2022, finding potentially significant impacts that need to be analyzed in an Environmental Impact Report (EIR). A draft EIR was published in August 2023. Previously, CTR had planned to use Lilac Solution's ion exchange technology, but Lilac pulled out due to concerns about how their technology would be able to handle the hot, corrosive brine (Ohnsman, 2022). CTR has said they are moving forward with adsorption rather than ion exchange technology (Controlled Thermal Resources, 2022b). While often used in combination, adsorption relies on a physical separation of lithium rather than depending on exchange of charged particles. According to media reports, CTR is now partnering with Koch Separation Solutions, a subsidiary of Koch Industries, for its DLE technology (Scheyder, 2022). On its website, Koch Separation Solutions describes its Li-Pro DLE technology as using adsorption beds to extract lithium, requiring fewer chemical and water inputs than other methods (Koch Separation Solutions, 2023).

3. **ENERGYSOURCE MINERALS (ES MINERALS)** is developing Project ATLiS to extract lithium at the John L. Featherstone (Hudson Ranch 1) Power Plant. The project completed its CEQA review and received a conditional use permit from Imperial County in 2021. Aiming to be operational by 2024, ES Minerals is the furthest along of the Salton Sea DLE projects. In its EIR, ES Minerals states that the lithium extraction process is proprietary (Chambers Group, Inc., 2021). Its website states it will use their proprietary Integrated Lithium Adsorption Desorption (ILiAD) processing platform (EnergySource Minerals LLC, n.d.-b).

ES Minerals holds a patent issued in 2020 valid through 2038 for a lithium removal process that details the extraction of lithium carbonate, lithium hydroxide, zinc, and manganese from Salton Sea geothermal brines (Featherstone et al., 2020). It is likely that this patented process is the ILiAD process that ES Minerals will employ in their ATLiS project. In general, ILiAD works in three steps on geothermal brine after it generates steam in the power plant, and before reinjection.

1. Remove impurities such as iron, silica, zinc, and manganese.
2. Extract lithium chloride from the brine.
3. Convert lithium chloride to lithium carbonate or lithium hydroxide.

While the ILiAD lithium extraction process is proprietary and specific to ES Minerals, all proposed DLE projects in the SSKGRA will likely follow the same general steps.

One of the new test sites developed for lithium extraction outside of Calipatria. This site is operated by Controlled Thermal Resources (CTR).

Photo: Comite Civico del Valle

Potential Environmental Impacts

This section reviews potential impacts of DLE in Imperial Valley related to:

- Air Quality,
- Freshwater Consumption,
- Salton Sea Degradation,
- Hazardous Waste and Materials, and
- Seismicity.

It draws on the general scientific literature, proceedings of the Lithium Valley Commission, and also information about specific projects from CEQA documents.

Air Quality

Imperial Valley has degraded air quality that is negatively impacting human health. Recently, air quality in Imperial Valley has exceeded Clean Air Act standards for Ozone, $PM_{2.5}$ (particulate matter smaller than 2.5 microns), and PM_{10} (particulate matter smaller than 10 microns) (California Air Resources Board, 2022). Exposure to PM_{10} and $PM_{2.5}$ has been linked to a variety of health problems including asthma, chronic coughing, difficulty breathing, irregular heartbeat, heart attacks, and premature death for those with heart and lung disease (U.S. EPA, 2016).

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Lithium extraction is anticipated to have some direct impacts to air quality, though it is not likely to meet legal thresholds that require mitigation. Of the lithium projects under development while this report was being written, only ES Minerals had published an EIR, which can be used as an example to better understand the potential impacts to air quality.

The ES Minerals EIR estimates that the project will average 16,650.91 metric tons of carbon dioxide equivalent per year. These emissions will likely be front-loaded due to construction, which are averaged over the 30-year projected lifetime of the project. These are below thresholds defined by the U.S. Environmental Protection Agency (25,000 metric tons/year) and Imperial County Air Pollution Control District (ICAPCD) (20,000 metric tons/year). This means there is no mitigation required under those regulations. Even so, estimated emissions make up 83% of the permissible emissions without mitigation, and have an impact on global climate change, which must be considered.

ES Minerals will use hydrochloric acid (HCl), injecting it into the brine as part of the mineral extraction process, which could lead to hazardous air emissions. HCl is a gas under normal temperatures, and the acid is a result of dissolving this gas in water. Thus, industrial grade HCl commonly releases hydrogen chloride gas. ES Minerals estimates it will release 7,440 pounds per year of HCl aerosols. This is below the 10,000 pounds per year threshold for reporting requirements under Section 313 of the Emergency Planning and Community Right-to-Know Act of 1986. However, according to the EIR, exposure to

HCl can cause a range of health impacts, including difficulty breathing. It is likely that other lithium projects will also use HCl. For example, CTR states in its initial study that it will use HCl as part of a process to manage silica in the brine to prevent scaling (County of Imperial Planning & Development Services Department, 2022).

The cumulative impacts on air quality from lithium extraction should also be analyzed in conjunction with potential impacts from other aspects of the lithium supply chain, such as proposed battery manufacturing in the region.

Lithium facilities will also impact air quality through day-to-day operations. For example, the ES Minerals facility will require an estimated 179 vehicle trips in and out of the plant per day during normal operations, contributing to air emissions. The model used in the ES Minerals EIR assumes that all roads for operational processes and work commuting to the site will be paved at the time of operation. However, these roads are not currently paved, and there may be additional air quality impacts from road construction or vehicle trips on unpaved roads.

Lithium production can avoid major direct impacts on air quality by limiting exposure of brine, lithium, and waste solids to wind. ES Minerals has stated they are enclosing much of their system and implementing filter processes for lithium handling and processing to avoid these impacts. However, special attention should be given to any project proposal that contains mention of exterior storage of waste materials, finished products, evaporation ponds, and brine storage ponds. Winds will blow across any exposed waste, picking up contaminants, transporting them across the valley, and exposing surrounding communities and the environment to those wind-blown contaminants.

While the estimated air emissions from ES Minerals are below thresholds for significant impact on air quality, they are close to those thresholds. Expansion of the lithium industry may have a significant additive impact on the already poor air quality in the region. The cumulative impacts on air quality from lithium extraction should also be analyzed in conjunction with potential impacts from other aspects of the lithium supply chain, such as proposed battery manufacturing in the region.

South shore of the Salton Sea near proposed DLE projects. The trenches are for dust suppression to alleviate air pollution. The green in the foreground is a wetland restoration project.

Photo: Earthworks

Water Consumption

Freshwater is required for geothermal power plants. Water pulled from the geothermal brine is reinjected back into the reservoir with small losses from transport and cooling. Often, make-up water from other sources is injected into the aquifer to limit the amount of water loss in the geothermal reservoir and prevent subsidence.

Adding DLE will consume additional freshwater as part of the lithium separation process. It is difficult to predict exactly how much water Imperial Valley DLE projects will require when they reach commercial scale, but we can estimate based on what each company has stated:

- ES Minerals estimates in its EIR that operations will consume 3,400 acre-feet of water to produce 19,000 metric tons of lithium hydroxide per year over a lifetime of 30 years (Chambers Group, Inc., 2021).
- CTR estimates in its initial study that their Hell's Kitchen project will consume 6,700 acre-feet of water per year to produce 25,000 metric tons of lithium hydroxide per year (County of Imperial Planning & Development Services Department, 2022).
- BHER has not yet estimated water consumption in environmental planning documents. However, they have stated to the Lithium Valley Commission that they plan to limit freshwater usage to 50,000 gallons per metric ton of lithium carbonate equivalent (Paz et al., 2022).

For reference, an acre-foot of water is about the amount of water it would take to flood a football field (roughly one acre in size) one foot deep. An average household in California uses ½–1 acre-foot of water per year (Water Education Foundation, 2020). For comparison, growing one acre of alfalfa in Imperial Valley can use as much as 10 acre-feet of water per year (Bland, 2023).

TABLE 1: Estimated freshwater consumption of Imperial Valley direct lithium extraction projects.

Project	Metric tons of lithium hydroxide produced / year[1]	Metric tons of LCE produced / year[2]	Acre-feet of water / year	Acre-feet water / metric ton of LCE	Gallons of water / metric ton of LCE	m^3 of water / metric ton of LCE
BHER Minerals[3]	Unknown	Unknown	Unknown	0.15	50,000	189
ES Minerals	19,000	16,720	3,400	0.20	65,170	247
CTR	25,000	22,000	6,700	0.30	97,755	370

[1]Both CTR and ES Minerals estimate their lithium production in terms of metric tons of lithium hydroxide. After extraction and refining, this is the final battery grade compound that will be sold to a buyer.

[2]To convert lithium hydroxide to lithium carbonate equivalent (LCE), the industry standard, you multiply by a factor of .880 (see https://casetext.com/statute/california-codes/california-revenue-and-taxation-code/division-2-other-taxes/part-25-lithium-extraction-tax-law/chapter-2-the-lithium-extraction-excise-tax/section-47015-conversion-to-to-lithium-carbonate-equivalent).

[3]BHER's estimate of freshwater consumption is from testimony to the Lithium Valley Commission, not from environmental analysis of a DLE project. This estimate may change in the future. As of 2023, BHER is demonstrating lithium extraction at one-tenth scale, and has not proposed commercial-scale extraction. No information is available on how much lithium BHER would produce per year at commercial scales in the future.

Note that these estimates only account for operation of lithium extraction facilities, not construction, or other steps of the lithium refining and battery production process. The majority of this water would be provided by canals managed by the IID. Some projects may use steam condensate from the geothermal process to help meet freshwater needs for lithium extraction. However, this may end up requiring additional make-up water (McKibben, 2023).

As the lithium industry in Imperial Valley expands, it may be limited by water supply. IID manages an entitlement of 3.1-million-acre feet of Colorado River water for Imperial Valley, 97% of which is used for agriculture (Imperial Irrigation District, 2023). IID has reserved up to 25,000-acre feet of water per year for non-agricultural use, which would supply proposed lithium projects. If the ES Minerals project is used as a best guess for water use, this IID allocation could support 100,200 metric tons of LCE production per year. According to the Lithium Valley Commission, proposed lithium production is projected to reach 210,000 metric tons of LCE per year, meaning water demand would exceed available non-agricultural supply as currently planned by IID (Paz et al., 2022).

According to the Lithium Valley Commission, proposed lithium production is projected to reach 210,000 metric tons of LCE per year, meaning water demand would exceed available non-agricultural supply as currently planned by the Imperial Irrigation District.

Addressing questions around water consumption is especially urgent given the impact of climate change on Colorado River water supplies. Drought, over-allocation of water resources, and historically low water levels in critical reservoirs (Lake Mead and Lake Powell) will result in re-adjusted water allocation in the near and long-term for Imperial Valley. In 2022 the Bureau of Reclamation called for cutting 2–4 million acre-feet of Colorado River water use (Short and Long Term Solutions to Extreme Drought in the Western United States, 2022). As of May 2023, California has agreed to conserve 1.6 million acre-feet by 2026, the majority of which would come from Imperial Valley (Wilson, 2023). Further cuts will likely be necessary in the future.

Proponents of DLE projects in Imperial Valley often make favorable comparisons about water consumption to lithium evaporation facilities in South America:

- BHER told the Lithium Valley Commission it will use 90% less freshwater than what is used in South America (Paz et al., 2022).
- ES Minerals' website shows it will deplete just a fraction of the water depleted at Chilean brine operations (EnergySource Minerals LLC, n.d.-a).
- CTR's brochure emphasizes it uses the most environmentally-friendly lithium production process on the planet but provides no information on water consumption (Controlled Thermal Resources, 2022a).

It is difficult to verify these comparisons due to lack of transparent data from South America. However, a recent academic review found that "many DLE technologies might require larger freshwater volumes than current evaporative practices" (Vera et al., 2023). **In fact, if we look strictly at freshwater consumption, proposed DLE projects in Imperial Valley would actually consume more water than the current evaporation mining at Salar de Olaroz in Argentina, which requires an estimated 50 cubic meters per metric ton of LCE (Vera et al., 2023).**

There is an ongoing debate about how much water is lost at South America lithium operations, not only due to freshwater consumption, but from brine evaporation itself, and the poorly understood interaction of brine with the freshwater aquifer. Some have estimated water lost through evaporation to be as much as 2,000 cubic meters per metric ton of LCE (Blair et al., 2022). When this is taken into account, DLE at the Salton Sea can be expected to deplete significantly less water.

No matter how direct lithium extraction compares to other types of lithium extraction, Imperial Valley will likely need to make tough decisions about how much freshwater to allocate to DLE and geothermal energy, agricultural use, and Salton Sea restoration.

Salton Sea Degradation

Freshwater consumption for lithium extraction may also have an impact on the Salton Sea. The lake we now call the Salton Sea has always been in the process of forming or disappearing, depending on when naturally occurring Colorado River floods filled the low-lying area known as the Salton Sink (Voyles, 2021). The current Salton Sea was formed in 1905, filling with Colorado River water often attributed to an accidental irrigation dam breach (Salton Sea Authority, n.d.). Due to the 2003 Quantification Settlement Agreement, which transferred water from Imperial Irrigation District to San Diego, the Salton Sea has been rapidly shrinking (Foruzan, n.d.). The Salton Sea currently receives 1.1 million acre-feet of water per year, primarily through drainage from agricultural fields, and this will likely continue to decrease (Salton Sea Management Program, 2022). If Colorado River water is diverted from agriculture to lithium extraction, this would contribute to the shrinking of the sea.

Freshwater consumption for lithium may also limit Salton Sea restoration options, such as the voluntary transfer of Colorado River water to the sea by incentivizing fallowed agricultural fields (Suri et al., 2022). It is also important to note that CTR holds mineral leases beyond the current shoreline, meaning future

The health of the Salton Sea is a delicate issue in the Lithium Valley region. The Sea can benefit from restoration projects funded by the lithium excise tax, but local communities are worried about extraction exacerbating the decline of the Sea.

Photo: Comite Civico del Valle

expansion of lithium projects may, to some extent, depend on the continued shrinking of the sea (Imperial Irrigation District, 2016).

Reduced inflow to the Salton Sea would likely have an indirect impact on air quality. As previously noted, Imperial Valley already faces many natural and anthropogenic (human caused) sources of air pollution, as shown in Figure 10 (Frie et al., 2019). As the Salton Sea shrinks, exposed lake bed (playa) represents an increased threat to air quality in the valley, as shown in Figure 11 (Frie et al., 2017). Years of agricultural runoff have deposited chemicals from pesticides and fertilizers in the playa sediment, and further reduction in surface water in the Salton Sea will increase emissions from exposed playa, namely, magnesium, sulfates, calcium, and strontium. These represent potential indirect emissions from lithium extraction, which should be analyzed and mitigated in a cumulative impacts analysis.

Some of the pollution impacts to the Salton Sea could be offset through restoration projects funded by California's lithium excise tax, 20% of which goes towards the Salton Sea Restoration Fund.

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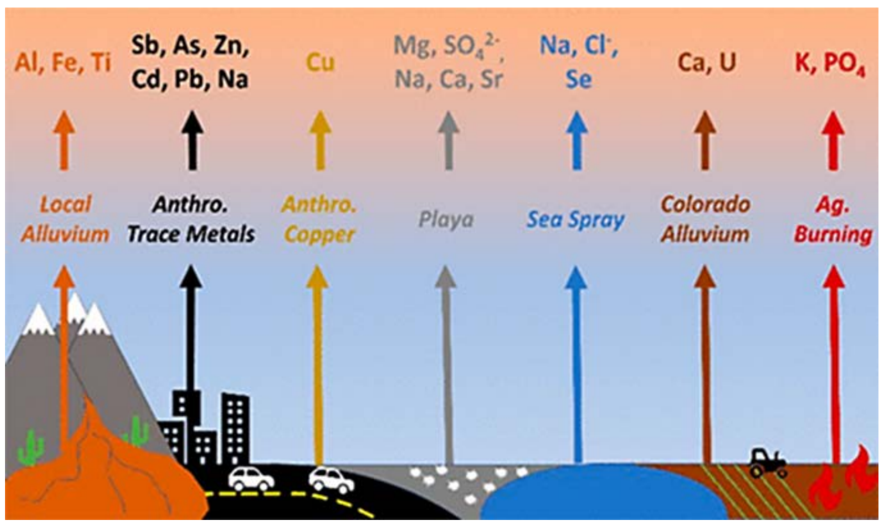


FIGURE 10: Sources of air pollution in Imperial Valley.

From Frie et al., 2019

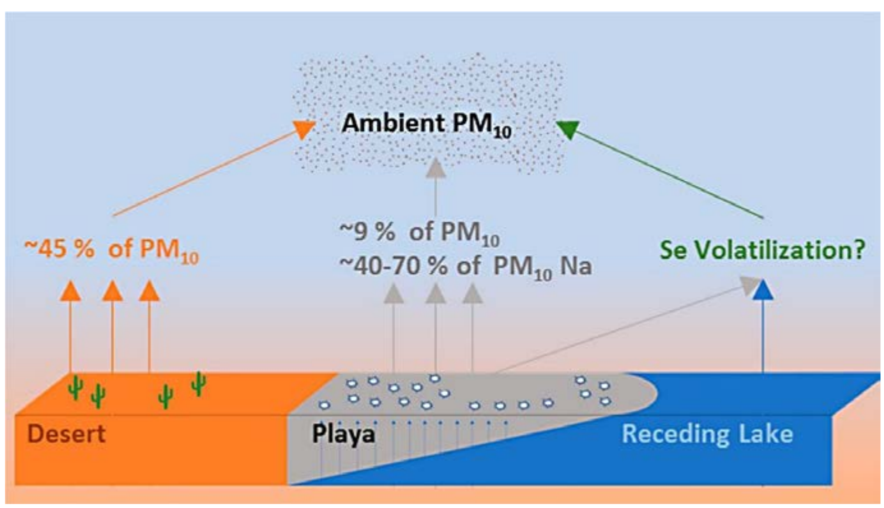


FIGURE 11: As the Salton Sea shrinks, the exposed lake bed (playa) allows contaminated dust to pollute the air with particulate pollution (PM_{10}).

From Frie et al., 2017

Hazardous Waste and Materials

Waste produced from geothermal power generation and DLE can be minimized by reinjecting spent brine deep underground back into the geothermal reservoir, in what project proponents refer to as a "closed loop." However, some solid wastes need to be managed, including arsenic, lead, iron, and silica.

Currently, geothermal operations at the Salton Sea remove iron and silica from brine before it is reinjected to prevent clogging injection wells. Iron and silica are precipitated as solid waste on filter cakes, which may also include hazardous elements from the brine such as arsenic and lead. This solid waste is tested to determine whether it is hazardous or not. BHER sends non-hazardous waste from its 10 geothermal plants to the Desert Valley Company Monofill in Imperial Valley, roughly 15 miles west of Westmorland. The 180-acre facility accepts 750 tons of Class II non-hazardous waste per day, and was recently approved to expand its disposal capacity, extending its lifetime from 2025 to 2080 (BRG Consulting, 2021). While the majority of geothermal waste is considered non-hazardous, BHER operations have been fined for improper storage, treatment, and disposal of hazardous waste, as well as discharge of wastewater with elevated levels of lead, arsenic, and copper into the Salton Sea (Cagle, 2010).

Though solid waste is tested to determine if it is hazardous, operations have been fined for improper storage, treatment, and disposal of hazardous waste, and for discharge of wastewater with elevated levels of lead, arsenic, and copper into the Salton Sea.

The addition of lithium extraction and processing on-site at geothermal plants will introduce other waste and hazardous materials.

While waste products from each DLE project will be different, the ES Minerals project can be used to better understand potential impacts. Five waste streams are identified in the ES Minerals ATLiS project EIR and associated patent:

1. **Iron (Fe) / Silica (Si) filter cake** — The Fe/Si filter cake is currently produced as part of the flash steam process and clarification (primary and secondary) of the geothermal brine. This occurs independent of lithium extraction and is a necessary step to prevent scaling and maintain power plant equipment. The Fe/Si filter cake can also contain arsenic, barium, and lead, which are harmful to human health.
2. **Calcium (Ca) / Magnesium (Mg) filter cake** — The Ca/Mg filter cake would be added as part of the process of lithium extraction. Calcium and magnesium represent a major part of the dissolved minerals in the Salton Sea geothermal brine and must be removed as part of the lithium extraction process. This is done using caustic soda (sodium hydroxide) to remove calcium and magnesium which are filtered out as hydroxides. The fate of this waste is not explicitly stated. Calcium and magnesium hydroxides can be a source of water pollution impacting pH and water hardness.
3. **Boron Ion Exchange** — Boron (B) is removed using ion exchange. The resulting waste is cycled back through the Ca/Mg precipitation process and the countercurrent ion exchange. However, the fate of the boron waste is not specified. In high concentrations boron can be toxic to plants and animals.
4. **Manganese (Mn) / Zinc (Zn) filter cake** — The Magnesium and zinc filter cake is related to the mineral extraction process and may or may not be a waste stream. Magnesium and zinc can be separated from the brine, but during the process, there are removals of other unidentified "impurities" that need to be accounted for.

5. **Residual Brine** — Residual brine is currently a waste stream of geothermal energy exploitation, but its composition would be modified with the addition of lithium extraction to the process. The residual brine would be reinjected into the geothermal reservoir.

ES Minerals plans to minimize waste by selling the Iron/Silica and Magnesium/Zinc byproducts to third-party buyers for other industrial processes. However, it is not clear if they currently have a feasible market for these products. If not sold, they will have to be managed as waste.

Some of these waste streams will contain hazardous materials. The ES Minerals EIR states that it will test materials before disposal and any hazardous materials will be disposed of at the appropriate disposal sites. They expect 90% of their waste (37,602 cubic yards) to be disposed of at the Burrtec non-hazardous landfill in Salton City. The hazardous remaining 10% (4,178 cubic yards) would be disposed of at the Copper Mountain Landfill in Wellton, Arizona. If the waste does not meet Arizona standards, it will be disposed of at an unspecified site in Nevada.

Recently, California has been criticized by environmental justice advocates for the practice of transporting hazardous waste to dump in non-hazardous facilities in states with lower standards, such as Arizona (Lewis, 2023). Greater waste transportation distances should also be factored into emissions accounting. Published values of the filter cake mineral concentrations and totals should be available and easily accessible to the public.

Waste streams from the other DLE projects will likely be similar to ES Minerals, but will require their own analysis. The Salton Sea geothermal brine contains a wide range of elements. Until waste stream concentrations and total mass are published by companies or regulatory agencies, it should be assumed that any one of these constituents could be found in the waste stream. In theory, the dissolved minerals would be reinjected back into the geothermal reservoir, and certain processes (crystallizers, clarifiers, and refining) would create solid wastes. While most of the minerals are not a direct threat to human health when dissolved in the geothermal brine, the extraction and refining processes could increase the concentration levels.

The concentrations of heavy metals such as arsenic, lead, and cadmium are of particular concern, as well as any naturally occurring radioactive materials.

The concentrations of heavy metals such as arsenic, lead, and cadmium are of particular concern, as well as any naturally occurring radioactive materials. Naturally occurring radioactive minerals do exist at low levels in the SSKGRA (Finster et al., 2015). The ES Minerals patent refers to a process for preventing the precipitation of radioactive earth metal salts (Featherstone et al., 2020). While this process is expected to continue, the addition of the Ca/Mg precipitation (both alkaline earth metals) may cause other alkaline earth metals to precipitate as they chemically react in ways similar to Ca/Mg. This is a theoretical risk pathway that has not been fully explored but could pose a risk primarily to plant, transportation, and disposal workers who work closely with this waste material for extended periods. This risk should be monitored and mitigated if lithium extraction moves forward.

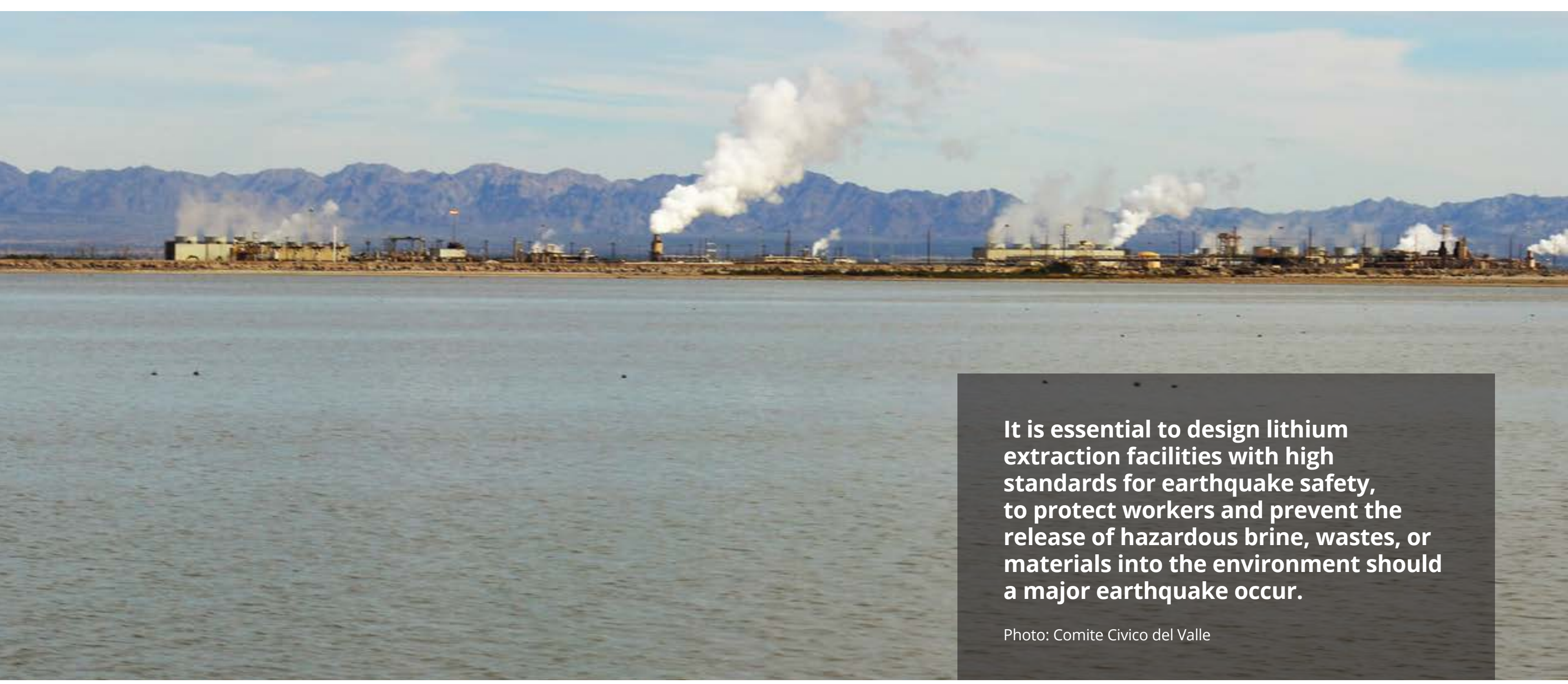
In addition to waste streams, DLE projects will use other hazardous materials in the process, such as organic solvents and sulfuric acid. Industrial complexes can work with and responsibly manage hazardous wastes and materials, but transparency and accountability are essential.

Seismic Activity

DLE from geothermal brine using current technologies, according to the best available science, will not directly affect seismic activity. However, successful lithium extraction may make geothermal power more profitable, leading to an expansion of geothermal wells throughout the SSKGRA. If drilling and maintenance of additional wells uses EGS, then it may have an impact on seismic activity. The science behind seismic risk assessment of geothermal exploitation is growing and improving, but there is still uncertainty and disagreement among scientists about the actual hazards and risks associated with EGS.

Evidence supports the theory that EGS increases the frequency of earthquakes lower than magnitude 4, also known as microquakes (Majer et al., 2007). There is emerging evidence that EGS-induced microquakes can actually reduce overall seismic risk by helping to release shear stress on the fault, thus reducing the number of high-magnitude earthquakes (Im & Avouac, 2021). There is also some evidence showing that EGS can cause earthquakes up to magnitude 5.5 with the potential for larger earthquakes (Woo et al., 2019). However, EGS and geothermal exploitation occur in areas that are already prone to earthquakes. Regardless of geothermal exploration, the areas are already at risk of earthquakes, and proximity to major faults will still be the major risk factor, with or without EGS.

Geothermal power plants have been operating safely in Imperial Valley for more than 40 years. While the exact impact of geothermal exploitation on inducing seismic activity requires more research, it is important to put this in context. Imperial Valley is currently living with a risk of major earthquakes given its proximity to the San Andreas Fault, and this risk is present with or without new lithium extraction and geothermal energy. This means it will be essential to design lithium extraction facilities with high standards for earthquake safety, to protect workers and prevent the release of hazardous brine, wastes, or materials into the environment should a major earthquake occur.



It is essential to design lithium extraction facilities with high standards for earthquake safety, to protect workers and prevent the release of hazardous brine, wastes, or materials into the environment should a major earthquake occur.

Photo: Comite Civico del Valle

Conclusion

The potential environmental impacts of DLE from geothermal brine in Imperial Valley reviewed in this report may prove to be less detrimental than traditional hardrock and evaporative lithium extraction processes. However, there are still potential adverse impacts that should be avoided and mitigated.

1. **Air pollution from direct lithium extraction will likely be below legal thresholds, but cumulative impacts still need to be addressed to protect public health.**
2. **Freshwater consumption may be a limiting factor on the lithium industry, and contribute to Salton Sea degradation and poor air quality from the exposed lake bed.**
3. **Hazardous and non-hazardous solid wastes need to be managed properly.**
4. **Facilities should be designed with high standards for seismic safety.**

Poor air quality already poses a health risk to the community and the release of additional pollutants should be addressed within this context. While emissions of air pollutants from DLE are likely to be below legal thresholds of significance that require mitigation, they may approach these thresholds. Emissions should be continually monitored, and air quality plans should be adapted as needed to protect public health. Of particular concern will be monitoring the cumulative impacts to air quality of building out the entirety of "Lithium Valley," including not just construction and operation of geothermal lithium extraction facilities but also vehicle trips, battery plants, and other associated infrastructure.

DLE and new geothermal power plants will consume significant amounts of freshwater, and the growth of the industry may be limited by availability of Colorado River water. If water is prioritized for lithium development instead of agriculture or Salton Sea restoration, this could lead to an indirect effect on air quality by speeding up the shrinking of the Sea and leading to an increase in airborne playa dust, which is harmful to human health. Given the impacts of climate change, it will be important for Imperial County and Imperial Irrigation District to plan for a future of reduced Colorado River use, and the trade-offs involved in how water is allocated should be carefully considered.

DLE projects may minimize waste by reinjecting spent brine into the geothermal reservoir and successfully marketing other brine components, such as silica, manganese, and zinc. However, both hazardous and non-hazardous solid wastes will be produced that need to be managed properly. Measures should be taken to prevent spills and contamination. Waste contents should be monitored closely, and the practice of transporting hazardous waste out of state scrutinized from an environmental justice perspective.

DLE projects are unlikely to have a direct impact on seismic activity. However, if new geothermal wells are drilled using EGS, that may have an effect on inducing seismicity that requires further study and regulation. Imperial Valley is already living with a significant risk of earthquakes, and so facilities should be designed with high standards for seismic safety.

For far too long, the Salton Sea has been written off as an unsolvable disaster, with Imperial Valley as a perpetual sacrifice zone. This cannot be the case moving forward.

To address climate change, we must transition as quickly as possible to renewable energy. But in order to achieve a just and equitable energy transition, we cannot create new sacrifice zones for lithium mining.

Past harms must be remedied, Indigenous communities' right to FPIC respected, and frontline communities must have a seat at the decision-making table, and receive benefits, rather than continued harm, from any new development.

Policies to boost recycling of lithium and require smaller battery size can help reduce the burden on mining-impacted communities. Where new lithium extraction does occur, we have an opportunity to avoid repeating the harms of the past, and instead meet the highest standards for human rights and environmental protection. Imperial Valley has an opportunity to be a leader by pursuing DLE with due diligence, responsibly heeding the concerns of frontline communities, and ensuring they equitably benefit from this transition.

Photo: Comite Civico del Valle

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