Technical Memorandum

Date:	**March 21, 2024**
From:	David Blankenhorn, P.G. Hannah Clark
RE:	**Dogwood Geothermal Power Project – Geotechnical Site Assessment** 855 Dogwood Road Heber, Imperial County, California

INTRODUCTION

This Technical Memorandum provides a summary of the geotechnical conditions associated with the Dogwood Geothermal Power Project site (Site) which is located at 855 Dogwood Road in Heber, Imperial County, California (Figure 1). The proposed project facilities include a new 25-megawatt (MW; net generation) geothermal energy facility supported by a 7 MW parasitic solar energy facility (Dogwood Project); a 15 MW parasitic solar energy facility for the existing Heber 2 geothermal plant (Heber 2 Parasitic Solar Project); and, up to six geothermal production wells, one injection well, and supporting pipeline segment (Heber Field Company Wells & Pipeline Project). Below is a breakdown of the proposed developments, provided by the Applicant:

Dogwood Project (OrHeber 3, LLC) – CUP No. 23-0020

- One (1) Integrated Two Level Unit (ITLU) Air Cooled Ormat Energy Converter (OEC) generating unit
- Two (2) 25,000-Gallon Isopentane Tanks for Motive Fluid Storage
- One (1) Project substation for transmission to the grid
- Ancillary and auxiliary facilities (including, compressed air system and fire prevention system)
- A seven (7) megawatt (MW) solar photovoltaic field dedicated to the Dogwood geothermal plant
- Medium voltage cable from Dogwood solar facilities to Dogwood geothermal plant

Heber 2 Parasitic Solar Energy Facilities (Second Imperial Geothermal Company) – CUP No. 23-0021

- A fifteen (15) MW solar photovoltaic field dedicated to the Heber 2 geothermal plant
- Medium voltage cable from Heber 2 solar facilities to Heber 2 geothermal plant

Wells and Pipeline (Heber Field Company, LLC) – CUP No. 23-0022

- Up to six (6) new production wells (3 sited, 3 unsited)
- One (1) new injection well
- Brine pipelines

The total project disturbance footprint is approximately 124 acres, as provided in Table 1 below.

Table 1 – Project Disturbance Area Estimate (Acres)

Facility	*Disturbance (Acres)*
Geothermal Energy Facilities and Project Substation	5.0 acres
Solar Field and Connection Line	~95 acres
Production and Injection Wells and Connecting Pipeline	~24 acres
TOTAL	**124 acres**

Two solar fields will be developed directly adjacent to each other within the same parcel – One to provide auxiliary power to the Dogwood Project and one for the existing Heber 2 plant. One 7 MW solar photovoltaic field dedicated to the Dogwood Project (Dogwood Solar) would stand 10 feet tall. One 15 MW solar photovoltaic field dedicated to the Heber 2 geothermal plant (Heber 2 Solar) directly adjacent to the south would stand 10 feet tall. Due to their proximity and heights, Dogwood Solar, Heber 2 Solar, the XMD switch and the two proposed production wells have been analyzed below as an approximately 95-acre combined parcel. The energy generated by the combined solar facilities would be collected at an on-site XMD switch on the western edge of the site adjacent to South (S) Dogwood Road. A medium voltage distribution cable would cross Dogwood Road and be attached via trays to the existing pipeline that runs west before turning north to cross the Beech Drain and Main Canal at the existing above-ground pipeline span. The cables would span approximately 20-feet overhead across Dogwood Road and Wiloughby Road, supported by a mono-pole on either side of the respective street. The cable would continue to follow the existing pipeline alignment and connect into the new Dogwood OEC. No new footings or foundations are required for the cable trays. The Project proposes two production wells situated within the combined solar field and one situated to the north directly adjacent to an existing production well. These wells would be surrounded by chain-link fencing.

The geotechnical information provided herein was gathered from available online resources and extrapolated from the *Geotechnical Report Update* prepared by Landmark Consultants (Landmark, 2019). Landmark's report provides an update to previous geotechnical reports conducted at the Site (Landmark 2005, 2007) and reflects the adoption of the 2016 California Building Code (CBC) and Imperial County's geotechnical engineering standard of practice. In addition, desktop reconnaissance was conducted to provide an overview of the geological and geotechnical conditions at the Site including the regional geology, site soils, groundwater, seismic hazards, and stormwater infiltration potential. Collectively, this memorandum provides a comprehensive review of the Site's geotechnical conditions to support the preparation of a California Environmental Quality Act (CEQA) Initial Study/Negative Declaration (IS/ND), as opposed to an as-graded or as-built geotechnical report.

1.0 SITE DESCRIPTION

The proposed project facilities would be located within the existing fence line that accommodates the Heber 2, Heber South, and Goulds 2 facilities and in open partially disturbed agricultural plots as shown in Figure 2. The facility is situated in an area completely disturbed by existing geothermal power plant operations, and is currently maintained as a materials storage area. The combined solar field and geothermal wells would be located on agricultural plots with some existing geothermal well pad disturbance. The Project is located at an elevation of approximately 5 feet below mean sea level and the topography is relatively flat. Surrounding land uses in the project vicinity are dominated by agricultural cultivation with solar facilities directly west, a

construction/aggregates company to the south, and geothermal well pads and pipelines present throughout the local vicinity.

2.0 REGIONAL GEOLOGY

The Site is located in Imperial County which is underlain by three geomorphic provinces: the Peninsular Ranges; the Colorado Desert; and, the Mojave Desert. Each of these provinces is a naturally defined geologic region that displays a distinct landscape or landform with defining features based on geology, faults, topographic relief, and climate. The Peninsular Ranges geomorphic province occupies the southwestern portion of the Imperial County and is composed of a series of ranges separated by northwest-trending valleys. The geology of the Peninsular Ranges province is similar to the Sierra Nevada, with granitic rock intruding into the older metamorphic rocks. The Colorado Desert geomorphic province spans the majority of central Imperial County, including the Site, and is dominated by the Salton Sea and the Imperial Valley; the province is composed of a low-lying barren desert basin situated between alluvium-covered, active branches of the San Andreas Fault. The Mojave Desert geomorphic province occupies the north-central and northeastern portions of the County. The Mojave is a broad, arid region that contains isolated mountain ranges separated by desert plains (CGS, 2002).

More specifically, the Site is situated within the Salton Trough which is a structural depression resulting from large scale, regional faulting. The trough represents the northward extension of the Gulf of California and is bounded by the San Andreas Fault and Chocolate Mountains to the northeast and by the Peninsular Range and the faults of the San Jacinto Fault Zone to the southwest. The Imperial Valley is underlain by lacustrine deposits consisting of interbedded lenticular and tabular silt, sand, and clay (Landmark, 2005). The Late Pleistocene to Holocene lake deposits are estimated at less than 100 feet thick and derived from periodic flooding of the Colorado River which intermittently formed a fresh water lake, Lake Cahuilla (Landmark, 2005). Older deposits consist of Miocene to Pleistocene non-marine and marine sediments deposited during intrusions of the Gulf of California. Basement rock consisting of Mesozoic granite and Paleozoic metamorphic rocks are estimated to exist at depths between 15,000 to 20,000 feet below the surface (Landmark, 2005).

3.0 SITE SOILS

Approximately 28 soil types are found in the region of the Site (Aco, Antho, Carrizo, Carsitas, Chuckwalla, Cibola, Coachella, Fluvaquents, Gadsden, Gilman, Glenbar, Holtville, Imperial, Indio, Kofa, Lagunita, Laposa, Laveen, Mecca, Meloland, Niland, Orita, Ripley, Rositas, Salorthids, Superstition, Torriorthents, and Vint). Glenbar, Holtville, and Imperial parent spoils are formed from fine-textured, stratified alluvial basin deposits (ICPDS 2015). The clay material deposited during the formation of the Colorado River delta terrace is the original source of Holtville and Imperial parent soils. Many of the other soils were formed from fan sediment originating from large gullies created by runoff into the Salton Sea. Imperial County soils are characterized by hyperthermic soil temperature and aridic soil moisture regimes (Digital Desert, 2019).

Soils encountered during previous geotechnical investigations at the Site consist of surficial dry, very stiff lean silty clays to a depth of 4 to 5 feet bgs, stiff clays from approximately 6 to 40 feet bgs, and silty clay to clayey silt from 40 to 50 feet bgs, the maximum depth of exploration (Landmark, 2019). Soils at the Site are classified as Site Class D, which is characterized by a stiff soil profile (Landmark, 2019).

The native surface clays exhibit moderate swell potential (Expansion Index, EI =- 51-90) when correlated to Plasticity index tests (ASTM D4318) performed on native clays (Landmark, 2005). The clay is expansive when wetted and can shrink with moisture loss (drying). In their 2005 report, Landmark indicated that development

of building foundations, concrete flatwork, and asphaltic concrete pavements should include provisions for mitigating potential swelling forces and reduction in soil strength which can occur from saturation of the soil (Landmark, 2005).

In regard to corrosivity, native soil at the Site has moderate to very severe levels of chloride ion concentrations (Landmark, 2005). Chloride ions can cause corrosion of reinforced steel, anchor bolts, and other buried metallic conduits. Resistivity determinations on the soil indicate very severe potential for metal loss because of electrochemical corrosion processes (Landmark. 2005).

4.0 GROUNDWATER

The Site is located within the Imperial Valley Groundwater Basin which is bounded on the east by the Sand Hills, on the west by the impermeable rocks of the Fish Creek and Coyote Mountains, the California-Mexico border to the south, and the Salton Sea (the discharge point for groundwater in the basin) to the north (DWR, 2004).

The regional groundwater flow direction within the Imperial Valley is toward the Salton Sea, a closed basin with a surface elevation of approximately 225 feet below sea level. In the vicinity of the Site, groundwater flow is generally towards the northwest. Depth-to-groundwater at the Site typically ranges from 8 to 10 feet bgs (Landmark, 2019).

5.0 SEISMIC HAZARDS

5.1 Fault Rupture Hazard

The Imperial Valley is a seismically active area that is traversed by numerous mapped faults including the Brawley Fault Zone, San Jacinto Fault Zone (contains the Coyote Creek Fault, the Elmore Ranch Fault, and the Wienert Fault), the Elsinore Fault (contains the Laguna Salada Fault), the Imperial Fault, the San Andreas Fault Zone, and the Superstitions Hills Fault (ICPDS, 2015).

Several active and potentially active faults are situated in the vicinity of the Site as shown in Figure 3 (Landmark, 2019). Active faults are defined by the California Geological Survey as faults that have ruptured during Holocene time (within the last approximately 11,000 years). Potentially active faults are those that have ruptured during the last 1.8 million years (Quaternary time), but with no direct evidence of a movement within Holocene time. The Imperial Fault Zone is the nearest active fault zone to the Site and is situated approximately 9.4 miles to the southwest (Landmark, 2019).

Several significant earthquakes have occurred in the vicinity of the Site with corresponding surface fault ruptures and liquefaction events (McCrink et al. 2011). Four earthquakes greater than magnitude 5 were recorded near Heber between 1915 and 1979. A magnitude 7.2 earthquake, the El Mayor-Cucapah earthquake, occurred throughout southern Imperial valley in 2010.

The Site is not located within a currently mapped Alquist-Priolo Special Studies Fault Zone (CGS, 2023). Surface fault rupture is considered to be unlikely at the Site due to the well-delineated fault lines through the Imperial Valley; however, because of the high tectonic activity and deep alluvium of the region, a potential exists for a surface rupture on undiscovered or new faults that may underlie the Site (Landmark, 2005).

5.2 Ground Shaking

Ground shaking can occur during an earthquake, and its intensity is related to the proximity of the area to the fault, the focal depth, soil types, the location of the epicenter, and the size (magnitude) of the earthquake. Soils formed from alluvial deposits are more prone to ground shaking than dense materials such as bedrock.

The Site is considered likely to be subjected to moderate to strong ground motion from earthquakes in the region. Ground motions are primarily dependent on the earthquake magnitude and distance to the seismogenic (rupture) zone. Accelerations also are dependent upon attenuation by rock and soil deposits, direction of rupture and type of fault; therefore, ground motions may vary considerably in the same general area.

Design spectral response acceleration parameters are defined as the earthquake ground motions that are two-thirds of the corresponding MCE_R ground motions. In their 2019 report, Landmark classified the Site as a Seismic Design Category of D based on a Risk Category III (Landmark, 2019).

A Maximum Considered Earthquake Geometric Mean (MCE_G) peak ground acceleration (PGA_M) value was determined for the Site using the "U.S. Seismic Design Maps Web Application" (SEAOC, 2019) for liquefaction and seismic settlement analysis in accordance with 2016 CBC Section 1803.5.12 and CGS Note 48. In their 2019 report, Landmark determined a PGA_M value of 0.50g for the Site for liquefaction settlement analysis (Landmark, 2019).

5.3 Liquefaction

Liquefaction occurs when loosely packed, saturated soil or sediment at or near the ground surface loses its strength, which can lead to excessive settlement, ground rupture, lateral spreading, or failure of shallow bearing foundations (Imperial County, 2015).

The El Mayor-Cucapah earthquake (magnitude 7.2) that occurred throughout southern Imperial valley in 2010 caused widespread liquefaction near the towns of Calexico (immediately south of Heber) and El Centro (immediately north of Heber).

Liquefaction zones have not been mapped in this area (ICPDS, 2015); however, the Colorado River Delta region of southern Imperial County (including Heber) is a seismically active area. Landmark (2019) evaluated liquefaction potential at the Site using the 1997 NCEER Liquefaction Workshop methods. Due to the cohesive nature of the subsurface soils, liquefaction is not anticipated at the Site, and mitigation is not recommended (Landmark, 2019).

5.4 Lateral Spreading

Lateral spreading typically occurs as a form of horizontal displacement of relatively flat-lying alluvial material toward an open or "free" face such as an open body of water, channel, or excavation. This movement is generally due to failure along a weak plane, and may often be associated with liquefaction. As cracks develop within the weakened material, blocks of soil displace laterally toward the open face. Cracking and lateral movement may gradually propagate away from the face as blocks continue to break free.

Due to the low potential for liquefaction and the fact that the Site is not located near free faces or bodies of water, the potential for lateral spreading is considered low.

5.5 Subsidence

The Site is not located within a mapped area of known land subsidence (USGS, 2023). Due to the depth of groundwater and the fact that the Site is not located in a mapped subsidence area, the potential for subsidence is considered low.

5.7 Landslides

The Site is relatively flat, and the hazard of landslides is unlikely due to the planar topography of the Site and the region (Landmark, 2005). No ancient landslides are identified on geologic maps of the region and no indications of landslides were identified during a 2005 site investigation (Landmark, 2005).

6.0 STORMWATER INFILTRATION POTENTIAL

Encouraging stormwater infiltration by means of a stormwater management plan (SWMP) can improve water conservation by reducing evaporation and increasing groundwater recharge, as well avoiding erosion and potential damage to concrete foundations and slabs. Beneficial water quality of streams and rivers can also be maintained by preventing discharge of stormwater containing sediments and other materials. The City of El Centro and City of Imperial SMP provide best management practices (BMPs) for stormwater management by commercial businesses and industrial operations (City of El Centro and Imperial County, 2013).

Heber also has a Master Drainage Plan (established in 2006), although the town's management of stormwater defers to the Imperial County Planning and Development guidelines and the county Public Works Department. The Imperial Irrigation District board adopted the Imperial Integrated Regional Water Management Plan (IRWMP) in 2012 (GEI, 2012). The plan was developed to support the efforts to meet the County's future water resource demands while conforming to California Department of Water Resources guidelines.

Groundwater is encountered at approximately 8 to 10 feet bgs at the Site (Landmark, 2019). Onsite infiltration potential (capacity of the most limiting layer to transmit water [Ksat]) ranges from very low to moderately low at 0.00 to 0.06 inches per hour for wet, Holtville silty clay (approximately 71% of the Site) to moderately high at 0.20 to 0.57 inches per hour for wet, Imperial-Glenbar silty clay loams (approximately 29% of the Site). These soil types are also considered to be moderately well drained (NRCS, 2019). Evaporation potential is considered poor at the Site.

7.0 SITE STABILITY

The Site is located within the seismically active Imperial Valley and has the potential for ground disturbance based on soil and subsurface characteristics. Recommendations for the expansion project, including engineered design and earthquake-resistant construction complying with the latest edition of the CBC for Site Class D, are provided in Landmark's updated geotechnical report (2019).

8.0 REFERENCES

California Department of Water Resources (DWR). 2004. *Bulletin 118, Imperial Valley Groundwater Basin, Hydrologic Region Colorado River, Groundwater Basin Number: 7-30*. February 27, 2004.

California Geological Survey, Department of Conservation (CGS). 2002. *Note 36 - California Geomorphic Provinces*. Available online at: https://www.conservation.ca.gov/cgs/Documents/Publications/CGS-Notes/CGS-Note-36.pdf. Accessed on February 6, 2023.

California Geological Survey, Department of Conservation (CGS). 2023. *Information Warehouse: Regulatory Maps*. Available online at: https://maps.conservation.ca.gov/cgs/informationwarehouse/regulatorymaps. Accessed on February 6, 2023.

City of El Centro and City of Imperial. 2013. *Stormwater Management Plan*. August 15, 2013.

Digital Desert. 2019. *Ecological Sections: Mojave Desert*. Available online at: http://digital-desert.com/ecosections/322c.htm).

GEI Consultants, Inc. (GEI). 2012. *Imperial Integrated Regional Water Management Plan. Appendix C - Disadvantaged Community Needs Assessment Technical Memorandum (Working Group Draft)*. Prepared for the Imperial Water Forum. October 2012. Available online at: http://imperialirwmp.org/2013%20Updates/finalirwmp.html.

Imperial County. 2015. *Final EIR - SEPV Dixieland East and West Solar Farm Projects (SCH No. 2015051043).* December 2015.

Imperial County Planning and Development Services (ICPDS). 2015. *Baseline Environmental Inventory Report, Imperial County Conservation and Open Space Element Update*. June 2015.

Landmark Consultants, Inc. (Landmark). 2019. *Geotechnical Report Update, Heber 2 Repower Project, Heber, California*. Prepared for SIGC/ORMAT Nevada. April 2019.

Landmark. 2007. *Geotechnical Investigation, Proposed Heber South Geothermal Plant, Dogwood Road, Heber, California*. Prepared for SIGC/ORMAT. May 2007.

Landmark. 2005. *Geotechnical Report, New Turbine Generator and Cooling Tower, Heber 2 Geothermal Plant, Heber, California*. Prepared for SIGC/ORMAT. January 2005.

McCrink, T.P., Pridmore, C.L., Tinsley, J.C., Sickler, R.R., Brandenberg, S.J., and J.P. Stewart. 2011. *Liquefaction and Other Ground Failures in Imperial County, California from the April 4, 2010, El Mayor–Cucapah Earthquake*. U.S. Geological Survey Open-File Report 2011–1071 and California Geological Survey Special Report 220. Available online at: http://pubs.usgs.gov/of/2011/1071.

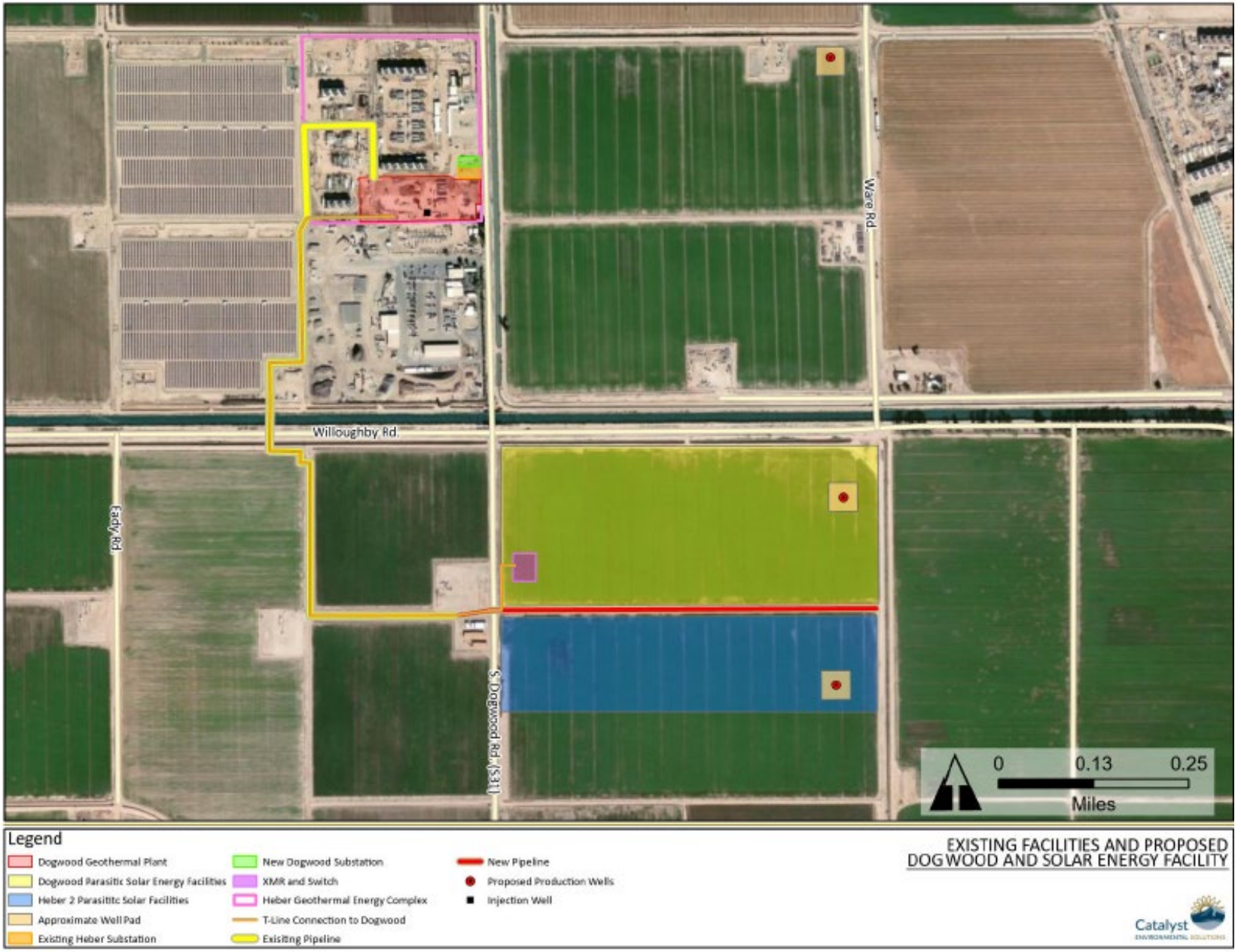
Natural Resources Conservation Service (NRCS). 2019. *Web Soil Survey, National Cooperative Soil Survey*. Report generated on June 5, 2019.

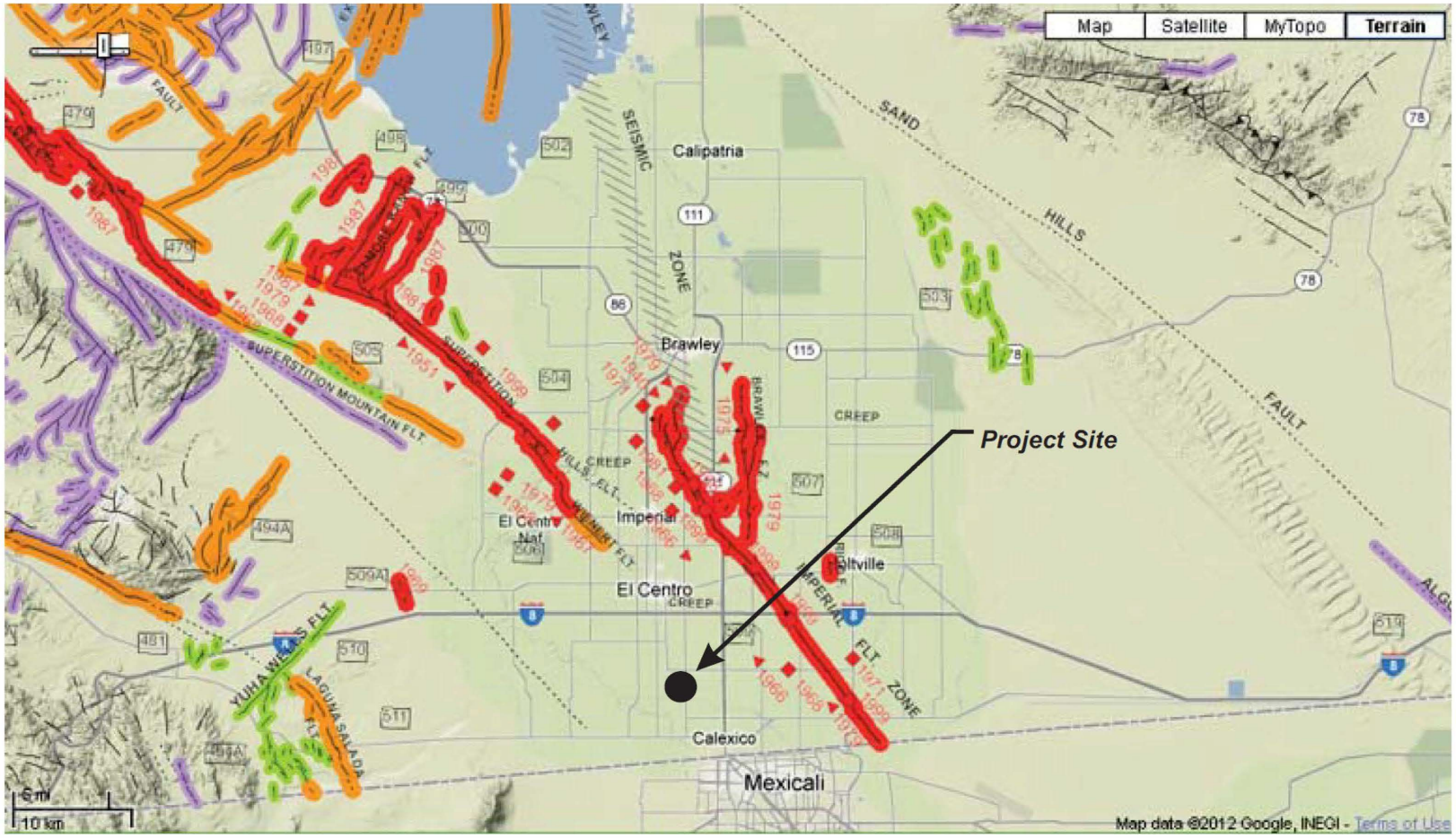
Structural Engineers Association of California's (SEAOC). 2019. *U.S. Seismic Design Maps Web Application*. Available online at: https://www.seismicmaps.org.

United States Geological Survey (USGS). 2023. *Areas of Land Subsidence in California*. Available online at: https://ca.water.usgs.gov/land_subsidence/california-subsidence-areas.html. Accessed on February 6, 2023.

Figures


Imperial
Imperial County Airport
Imperial County
Dogwood Project Boundary
El Centro
Wilsie
Anza
Heber
Calexico
Mexicali
Pueblo Nuevo
Ira Sección
Calexico Int'l Airport
El Centinela
San José
Las Palmeras
Reacomodo
Río Colorado
Fraccionamiento Cumbres
San Pedro Residencial
Provenza
Oregon
Idaho
Utah
Nevada
California
Arizona
Imperial Valley Pioneers Expy
Kumeyaay Hwy
E US Highway 98
W US Highway 98
All American Canal
Calzada Independencia
Boulevard Lázaro
Dogwood Project Location
Roads
Streams
Country Border
Project Location - Dogwood Geothermal Energy Project
Ormat Technologies
0 1.25 2.5 Miles
Catalyst
ENVIRONMENTAL SOLUTIONS


Willoughby Rd.
Eady Rd.
S. Dogwood Rd./S11
Ware Rd.
0
0.13
0.25
Miles
Legend
Dogwood Geothermal Plant
Dogwood Parasitic Solar Energy Facilities
Heber 2 Parasitic Solar Facilities
Approximate Well Pad
Existing Heber Substation
New Dogwood Substation
XMR and Switch
Heber Geothermal Energy Complex
T-Line Connection to Dogwood
Existing Pipeline
New Pipeline
Proposed Production Wells
Injection Well
EXISTING FACILITIES AND PROPOSED
DOGWOOD AND SOLAR ENERGY FACILITY
Catalyst



Source: California Geological Survey 2010 Fault Activity Map of California
http://www.quake.ca.gov/gmaps/FAM/faultactivitymap.html#

Catalyst ENVIRONMENTAL SOLUTIONS

Map of Local Faults

Figure 3