Information on the restoration of power is expected to flow from elected officials, emergency support function reports, community relations field reports, rapid needs assessment reports, and coordination center reports, and be tracked by CalOES operations. The initial estimate is expected within 6 hours of the initial incident and updated every operational period.

The next section details the expected impacts and response plan for earthquakes:

# The Earthquake Problem:

### USGS Earthquake Rupture Forecast:

A forecast issued by the US Geological Survey (USGS) reported the probability of various sized earthquakes occurring over a thirty-year period beginning in 2014. These included earthquakes in specific regions of the state and in the state as a whole. Because the statewide forecast is functionally an addition of the regional risks, the probabilities statewide are much higher. The forecasts are based on a combination of physical measurements of accumulated stress and historical patterns found in the geologic record.

Earthquakes of a magnitude 6.7 or greater are expected to be strong enough to incur significant damage in California. In places where the average architecture is not adapted for shaking, such as Oklahoma, this threshold would be lower. The earthquake magnitude scale is multiplicative; a magnitude 8 earthquake releases 32 times as much energy as a magnitude 7. A magnitude 8 earthquake will also rupture a much larger portion of a fault and affect a larger region. As such, the occurrence of small earthquakes does not do much to decrease the likelihood of larger ones, both because it would take many, many small earthquakes to release as much energy, and because sometimes earthquakes can actually shift stress onto other parts of a fault, unintentionally making a big earthquake on that section *more* likely.

The below forecast is for a thirty year period between 2014 – 2043. These values should be taken as a minimum; because it has been ten years and the largest of the forecast earthquakes in the Bay Area and on the Southern San Andreas have not yet occurred, a forecast using an estimation period beginning in 2024 would have even higher likelihoods.

**Likelihood of a damaging earthquake occurring before 2043:**

- Los Angeles area: 60%
- Southern California: 93%
- San Francisco area: 72%
- Northern California: 95%
- Statewide: 99+%

In the Bay Area, the Hayward and Rodgers Creek faults, which run from Santa Rosa to Richmond and down to Fremont, carry the highest likelihood (a 14% chance) of producing a significant earthquake. The last major earthquake on this fault was in 1868. Geologic records show the fault has ruptured with a major earthquake once every 140-170 years on average, putting us squarely in the expected range for a recurrence today. In Southern California, the

Mojave section of the San Andreas fault carries the highest likelihood (a 19% or one-in-five chance) of producing a serious quake.

### Summary of Hazard from CalOES Catastrophic Planning:

The San Andreas Fault System is a major structural feature in the region and is located at the boundary between the North American and Pacific tectonic plates. The San Andreas and Hayward faults, both elements of the San Andreas Fault System, are two of the faults considered to have the highest probabilities of causing a significant seismic event in the Bay Area. A major seismic event on these faults could cause significant ground shaking, liquefaction, landslides, and surface fault rupture. Of the earthquake fault risks in the Bay Area, the Hayward Fault is especially dangerous due to several factors. The first is its location in the heart of the region; the Hayward Fault is the single most urbanized earthquake fault in the United States. In 1868 only 24,000 people lived near the fault, while today there are more than 2.4 million. Hundreds of homes and other structures are built directly on the fault's trace, and mass transit corridors and major freeways and roadways cross it at numerous locations. Critical regional gas and water pipelines and electrical transmission lines also cross the Hayward Fault.

The unique geography of the Bay Area, with its network of earthquake faults underlying the entire region, compounds the earthquake risks to life, health, and property. Large population centers are located parallel to and surrounding both the San Andreas and Hayward faults. Additionally, communities in the Bay Area are serviced by infrastructure that is susceptible to damage from earthquakes, as nearly all the infrastructure connections that the area depends on for water, electric power, fuel, and transportation services cross one of these faults.

## Southern California Catastrophic Earthquake Plan (SCCEP):

The scenario model used for the SCCEP is based on a risk assessment of 21 major fault rupture zones in Southern California. While a M7.8 is not the largest earthquake that the Southern San Andreas Fault (SSAF) can produce nor is the San Andreas Fault the only fault to threaten the populated areas of southern California, it is the largest potential catastrophic earthquake due to its overdue recurrence interval. That risk includes:  A 93% chance of a M6.7 or larger earthquake somewhere in Southern CA before 2043 and a 17% chance of a M7.7 or larger occuring on the SSAF specifically before 2043.

### Catastrophe Model Estimates of Impacts

A 2008 exercise called the California ShakeOut Scenario simulated the effects of a M 7.8 earthquake on the southern San Andreas fault. This was integrated into CalOES's SCCEP. In 2008 dollars, the scenario estimated $200 billion in damages and loss, 1,800 deaths and 50,000 injuries. Several hundred thousand people are likely to be displaced. The 2022 HAZUS model used by CalOES for catastrophic planning finds even greater casualties, including 12,750 deaths, 178,000 casualties, 45,000 rescues. The catastrophic plan assessed the likely impact to several key factors, including housing stock, emergent human needs, and lifeline continuity. HAZUS estimates include:

- Out of a 2008 total population of 24.3 million people, 19.3 million are impacted. This includes 65% of the Native American population, 11.7 million daily commuters, and 633,000 tourists.
- 2.25 million people are expected to be displaced, with 10% of those seeking shelter. Populations requiring shelter include 56,250 with Access and Functional Needs and over 15,750 toddlers and infants. 580,000 pets would be displaced, with 58,000 of those needing shelter.
- 104,955 people would be rendered homeless in directly impacted counties.
- Initial economic impact estimates $232 billion ($68 billion business interruption, $51 billion lost economic activity and $113 billion in property damage across eight counties).
- 1,046,534 damaged buildings
- Essential facilities being reduced to less than 50% functionality on Day 1: 325 hospitals, 7,952 schools, 112 Emergency Operation Centers, 405 police stations, 1,299 fire stations.
- Debris removal totaling an estimated 80,207,500 tons requiring 3,208,300 truckloads (at 25 tons per truck): 29,676,775 tons of brick/wood and 50,530,725 tons of reinforced concrete/steel.

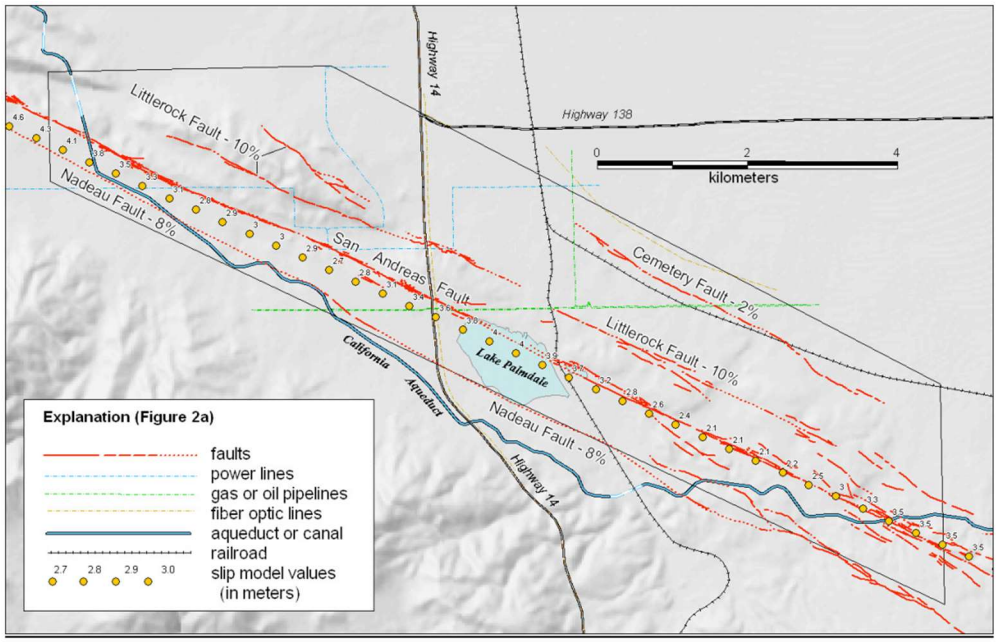
### Outages and Damage to Power Lifelines

Earthquake damage to the region's power generation facilities and natural gas infrastructure could result in long-term power supply interruptions. Potentially all components of the electrical system could suffer injury in a severe earthquake. The electrical grid is often the first system restored in earthquake response. Substations, however, have historically been the most vulnerable, requiring more extensive repair, often 6 to 12 months to replace.

Analyses for power and gas lifelines included consideration of the integrity of production facilities, near-customer transmission lines, and long distance transmission lines. The scenario earthquake ruptures approximately 200 miles of the San Andreas fault, beginning from the eastern shore of the Salton Sea, unzipping up through the Coachella Valley, and continuing northwestward to near Lake Hughes in the southwestern Mojave Desert. Objects on one side of the fault would be suddenly and violently offset by an average of 30 feet from objects on the other side, ripping up freeways, aqueducts, fiber optic cables, railroads and pipes. 6 utility systems (electric power, communications, potable water, wastewater, natural gas, crude & refined oil) have 524,530.95 miles of lines and pipes that cross the fault. In terms of power and gas, the rupture is anticipated to affect an estimated 39 petroleum and natural gas pipeline crossings and 142 overhead powerline crossings. 20% of the powerline crosses are anticipated to incur damage and 19 electrical power facilities are expected to be at least moderately damaged. Substations near fault lines will experience failures to switches, breakers, transformers, bushings, and movement of the transformer foundations. Los Angeles, San Bernardino, and Riverside counties will immediately lose all electric power. The Los Angeles Department of Water and Power (LADWP) will have roughly 80% pre-earthquake capacity if natural gas supplies are available.

Additionally, lifeline infrastructure will be impacted by the estimated tens of thousands of individual landslides triggered by the earthquake shaking, particularly where lifelines cross the

mountains through narrow passes. Transmission towers located in high-liquefaction zones will collapse.




The map above provides a zoom into the Palmdale area, showing lifelines crossing the affected fault. The colored lines represent the track of various lifelines and the gold dots mark how much fault displacement is expected at that location in meters.

In terms of residential power, an estimated 7,571,905 of households will lose power immediately. Widespread power outages can result in cascading failures that extend the power outage area east, south, and northeast of Cajon Pass to the cities of San Diego, California; Phoenix, Arizona; and Las Vegas, Nevada. These power failures could affect as many as 15 million people. Fortunately, HAZUS estimates a rapid recovery arc. In Kern and San Diego counties, 90% of power is restored within 24 hours. Out of the 7.5 million initial total, the following quantities of households will continue to be without power over time:

- Day 1: 566,000
- Day 3: 370,000
- Day 7: 170,000
- Day 30: 38,856
- Day 90: 757

**Interstate Natural Gas Supply Pipeline –** Compromised natural gas supply basins serving southern California will have cascading effects including in the Rocky Mountain production region, San Juan Basin in northern New Mexico, Permian Basin in western Texas, Western Canadian Sedimentary Basin, and in-state California production. If gas transmission service is lost, restoration could take 3 weeks to accommodate integrity testing for re-pressurizing lines. Full restoration of the natural gas distribution system could take 6 months. Interdependencies include that 90.9 % of California natural gas supply is sourced from interstate pipelines, and 43.9% of southern California electricity generation was from natural gas in 2019.

### Downstream Effects of Damage to Power and Gas:

**Fires Following the Earthquake:** Damage from the earthquake is compounded by the fires that occur due to downed power and communication lines, and ruptured gas lines. Nearly 1,600 ignitions occur, 1,200 of which require more than one engine. Paths of ingress and egress are cut off due to debris from landslides, damaged buildings and roads, and downed power lines. Responder movement is further hampered by traffic gridlock as survivors try to reunite with their families. In addition, many water mains are ruptured or damaged, requiring firefighters to rely on alternate sources of water to fight fires. A minimum of $40 billion was estimated in building damages plus $25 billion in property contents loss.

**Critical Facilities:** Power may be lost to airfields, hospitals and other health care facilities, public safety and security infrastructure, wastewater/water treatment facilities, commodity supply/distribution centers, agriculture and commercial food facilities, and public and financial service facilities, and backup power may need to be rationed.

**Aid Logistics:** Damage to transportation networks and power outages may lead to the isolation of large population areas and require immediate establishment of an airbridge for response movement, resupply, and temporary power. Shelters in outage areas will struggle to procure enough alternate power to provide safe temperatures, safe food, and communications.

**Sudden spike in fuel needs to provide power generation:** Power generation may be one of the essential fuel requirements, including power generation for critical infrastructure, health and medical facilities, shelters, RBCs, and other designated locations. A response unit co-lead by The California Department of General Services and United States Army Corps of Engineers, supported by FEMA/DOD will coordinate to provide bulk power generation capabilities for unmet needs with the ability to provide fuel support for deployed generator assets. The Governor can also sign an Emergency Order No. 6, which empowers the California Energy Commission to "hold control of petroleum stocks" as needed to ensure the health, safety, and welfare of the public. Local, state, and FEMA power generation equipment may also require fuel support from outside vendors. Deliveries must be assured 24/7.

## Bay Area Catastrophic Earthquake Plan:

### Catastrophe Model Estimates of Impacts

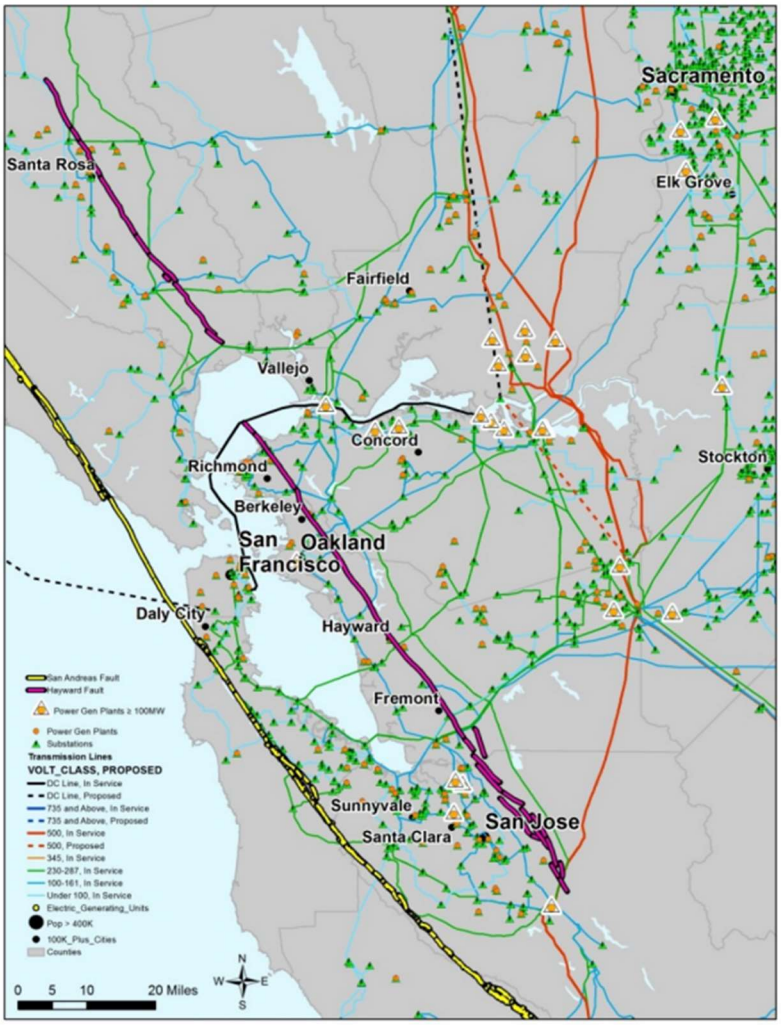
A 2017 exercise created the Haywired Scenario, a similar exploration as the ShakeOut but considering the effects of a M 7 earthquake on the Hayward Fault. The Hayward fault is considered one of the most dangerous faults in California because it both carries a high likelihood of producing a powerful earthquake and is also proximal to an urban population of 7 million people. Critical regional gas and water pipelines and electrical transmission lines also cross the Hayward Fault. The Haywired Scenario estimates 800 deaths and 16,000 nonfatal injuries resulting from shaking alone; over $82 billion in property and direct business interruption losses from shaking, liquefaction, and landslides; over 22,000 people trapped in elevators and requiring rescue; over 2,400 people requiring rescue from collapsed buildings; and loss of water service in the East Bay for 6 weeks to 6 months.

In CalOES's 2016 creation of their Bay Area Earthquake Catastrophic Plan, they also included analysis of a HAZUS model of a M 7.8 on the San Andreas Fault, approximating a repeat of the 1906 earthquake.

## Outages and Damage to Power Lifelines:

**Electrical Power**: Electrical transmission lines and towers will likely fail as a result of ground shaking from the earthquake, resulting in a loss of power for communities for weeks. HAZUS modeling indicates over half of households in the affected area would be without power for 24 hours with over 14% still without power a week later. Energized, downed electric lines will present an immediate safety hazard.

A map of electrical power distribution infrastructure included in the plan:




**Natural Gas**: Gas pipeline breaks and leaks will occur, creating hazardous conditions and fires. Gas service restoration could take longer, as many residents will unnecessarily turn off their gas service coming into their homes. Gas service personnel will have to inspect each property for leaks and relight pilot lights. Natural gas may be cut off in some communities for longer periods

of time due to difficulties in making repairs caused by limited access to damaged pipes and how the prioritization of restoration is set.

### Downstream Effects / “Secondary Hazards":

**Fires following the earthquake -** While the Southern California scenario spent time analyzing critical lifeline bottlenecks coming through the mountains to serve the LA basin, the Haywired Scenario was concerned with the local effects on power and gas delivery infrastructure. Over 400 simultaneous fires are expected to be ignited as a result of ruptured gas and electric lines, causing $30 billion in housing and commercial property loss. A report published by Mission Local in 2021 identified mass non-compliance with requirements to above-ground gas lines leading into soft-story residential buildings in San Francisco, with thousands of pipes instead being encased in concrete when foundations are poured as part of, ironically, the local seismic retrofit program. This puts gas lines out of reach for normal repairs and also massively increases the chances that they will break during a major earthquake and create explosions. Beleaguered by months-long wait times to get PG&E on site to adjust the piping, contractors have routinely opted to simply pour the concrete with the old, sometimes corroded, pipes in place in order to stay on schedule.

**Damage to petroleum infrastructure –** In a severe earthquake, the oil refining infrastructure in the Bay Area may not be fully operational, although one or more refineries may be partially functional to process and provide fuel. Partial or complete failure of refinery storage tanks is possible in areas of peak ground acceleration (PGA) or liquefaction. Oil pipelines might rupture through displacement at points where pipelines cross faults, such as the four locations where East Bay pipelines cross the Hayward Fault: Richmond, Oakland, Hayward, and Fremont. Pipelines will also be damaged by ground shaking in liquefaction areas. Jet fuel pipelines to airports could be damaged (airports have limited fuel storage capacity). Interruption of public fuel supplies through commercial gas stations is also probable due to power failure and degraded infrastructure. Although retail gas stations may have fuel in underground tanks, they will be unable to pump fuel without electric power.

**Infrastructure and Transportation Systems:** A severe Bay Area earthquake will affect all major infrastructure systems in the region. Transportation networks—including road, rail, air, and marine transportation systems—will be damaged by ground shaking, landslides, liquefaction and/or surface rupture and fault after-slip, disrupting the region’s critical supply chain. This will impede the ingress of repair crews and create lags in shipping and supply of needed parts. Also, all transportation that requires electricity to run, such as trains and electric buses, will be inoperable until power is restored.

**Logistics and Supply Chain Management:** Damage to transportation networks may lead to the isolation of large population areas and the degradation of the region’s supply chain that serves millions of residents. Affected areas will be without power, water, and communications systems for weeks or months.

The restoration of one infrastructure system is often interdependent with the restoration of others. Roadways, for instance, must often be cleared and at least minimally repaired to enable personnel and resources to access and repair other infrastructure. An organizational structure to enable information sharing and project coordination is essential for capturing opportunities for

long-term recovery presented by the disaster. The responsibility for the rebuilding/repair of infrastructure systems lies with individual public and private infrastructure owners.

**Compromised Food and Medicine Security**: Hospitals and other critical care facilities will suffer outages, limiting service delivery and the availability of medicine and medical supplies. Food supplies will dwindle rapidly and fresh food and produce will not be available in communities due to loss of electricity at grocery stores and at perishable item facilities.

**Situational Assessment:** Damage to transportation networks and communications infrastructure will pose significant barriers to being able to measure the scope of damage and needs. Public communications systems and 911 dispatch centers will be adversely impacted. The number, complexity, and magnitude of simultaneous crisis incidents will make the establishment of accurate and timely situational awareness in the first 24 hours problematic.

# Response Plans:

### Who's who:

Immediately following the incident, CalOES activates CUEA/California Energy Commission staff, who form a state multiagency coordination (MAC) group in an effort to stabilize and restore key infrastructure systems, including power and fuel. This joint group addresses specific issues that require extensive coordination, planning, prioritization of scarce resources. The goal is to enhance the effectiveness of response capabilities by sharing resources and exchanging information with private, municipal, and state players. A key enabler for restoring critical infrastructure is gaining access. Credentialing and information coordination enable physical access when travel restrictions and roadblocks are in place. The state Utility Operations Center (UOC) also establishes a regional MAC Group coordination call of executive management from infrastructure industries, who are responsible for the planning, coordination of activities, information sharing, identifying key resource shortages, etc. related to stabilizing and restoring critical services.

CalOES also expects to activate contracts for Temporary Emergency Power, and the Emergency Power Planning and Response Teams (PRTs) will identify support from FEMA, the Department of General Services, DoD, the Army Corps of Engineers, and the interstate mutual aid system. Other federal partners are also brought in to assist with response, including integrations of the Department of Energy (DOE), Edison Electric Institute, and the American Public Power Association (APPA) to augment or supplement emergency response through the National Infrastructure Protection (NIP) program.

### Restoration of Service:

What follows is a general overview of CalOES's anticipated recovery activities, sourced from multiple catastrophe plans. Widespread power outages are expected, especially during the first 30 days post-earthquake. Aftershocks will continue to break or damage infrastructure after services have been restored or repaired. In addition, damaged underground pipelines, cables, and other infrastructure components will take longer to repair than those above ground; most of San Francisco's electrical distribution system, along with portions of the systems in surrounding

areas, is underground. Despite this, for an M 7.9 San Andreas earthquake, PG&E estimates that 25 percent of power would be restored in San Francisco within 48 hours, 95 percent would be restored within one week, and 100 percent would be restored within a month.

CalOES anticipates that infrastructure repair requirements generated by a major earthquake will quickly exceed available resources and may exhaust the nation's inventory of specialized equipment. Infrastructure repair parts, such as transformers, pipes, and connectors, may be unavailable due to excess demand from multiple communities and due to manufacturing delays. The replacement of some equipment, such as equipment used for high voltage electrical transmission and distribution, may require custom manufacturing in other countries, often with substantial lead times—as long as 12 months for domestic producers, 16 months for foreign producers, and 1-5 years if there is high demand for or difficulty in obtaining specialized raw materials.

Furthermore, most energy infrastructure is privately owned and therefore ineligible for a large portion of federal funds.

# Recovery:

### Organization Plans for Recovery:

Infrastructure recovery includes more than just rebuilding existing infrastructure; it includes incorporating improvements, expanding systems to accommodate future population growth, and building in resiliency measures to mitigate damage from future earthquake events. State and federal coordination will therefore be needed to facilitate a common operating picture to maximize resources for infrastructure recovery projects that align with regional, state, and national priorities and to ensure continued communications throughout the recovery process.

Recovery will be a multimodal collaborative effort, from stakeholders and utility providers, on up to the state and federal levels. CalOES is the designated state Coordinating Agency for recovery efforts. Federal partners, including the Department of Energy (DoE) and the Department of Homeland Security (DHS), will assist in finding and issuing grants, provide technical assistance, mobilize greater regional coordination, and lower barriers to entry for additional manufacturers that can assist in increasing the production capability for manufacturing specialized equipment. The DOE and DHS can also utilize the national energy labs and private sector entities to support this type of technical assistance. It is also possible that conditions will be met to activate the Defense Production Act to prioritize manufacturing contracts and materials procurement that support disaster recovery operations.

State agencies that will be involved in rebuilding include the CPUC and the California Energy Commission. CUEA and the utilities constitute the other major players. CUEA will convene a Power Infrastructure Working Group to support strategy development, including connecting players at all levels to jointly identify opportunities for the redesign of electric systems (e.g., new technologies, increased efficiency, distributed systems); the private sector will leverage lessons learned for modular design and standardization of connections.