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## ALISO CANYON STORAGE FACILITY GEOLOGIC, SEISMOLOGIC, & GEOMECHANICAL STUDIES OVERVIEW

### Natural Gas Storage at Aliso Canyon

The natural gas that heats our homes, cooks our food, and generates much of our electricity is a naturally occurring resource composed largely of methane. Most of this natural gas comes from out of state because California does not produce enough to meet local demand. The natural gas is transported across California through large steel pipelines that eventually connect with homes, businesses, and industry.

Some natural gas must be stored close to its consumers, so it can be provided quickly and reliably to meet high demand on cold and hot days. Without nearby stored natural gas, adequate home heating and electricity for air conditioning would not be available in Southern California during high usage days.

The Aliso Canyon Gas Storage Field (Aliso Canyon) is owned and operated by SoCalGas® and is critical to providing reliable natural gas and electricity service for the Los Angeles Basin. The facility is located about 40 miles northeast of downtown Los Angeles and is the largest natural gas storage field in California. Natural gas is transported to the facility and injected through wells into a natural gas storage zone of porous rock formations about 7,000 to 10,000 feet below ground. The natural gas is injected down storage wells into the storage zone through 3- to 5-inch wide pipes called "tubing," which are surrounded by 7- to 9-inch wide pipes called "production casing." Both the tubing and production casing extend from the surface of the well down to the gas bearing rock formations. The tubing and production casing are in turn surrounded by another pipe called the "surface casing," which runs on average from the surface of the well to approximately 800 feet deep. At the surface, each well ties into a series of pipelines that are connected to the SoCalGas pipeline network.

The draft reports analyzed natural gas storage wells that have passed an extensive battery of tests required by California's Division of Oil, Gas and Geothermal Resources (DOGGR). These tests were developed in consultation with independent technical experts from the Lawrence Berkeley, Lawrence Livermore, and Sandia National Laboratories (National Labs). State regulators and industry experts have called the testing the most comprehensive safety review in the nation.

### Key Findings of the Geologic, Seismologic, and Geomechanical Studies at Aliso Canyon

As part of SoCalGas' risk assessment of the facility, DOGGR required SoCalGas to assess the potential geologic, seismologic, and geomechanical hazards at Aliso Canyon, including landslides, ground shaking, and fault displacement.

SoCalGas assembled a team of renowned experts in various scientific and engineering fields to conduct the geologic, seismologic, and geomechanical studies.<sup>1</sup> Their work plans were reviewed and approved by DOGGR and independent experts from the National Labs. Draft reports of the studies were made available to DOGGR and the National Labs on March 20, 2019. The work completed by the expert team has involved extensive scientific and engineering analyses of the wells at the facility and the facility's geology, including cutting-edge approaches to assessing potential geologic, seismologic, and geomechanical risks.

As a general matter, the studies defined the nature of hazards and a wide range of potential risks at Aliso Canyon, including landslides, ground shaking, and fault displacement. Some of the risks are an inherent part of operating any facility and living in Southern California; others are more specific to the design and operations at Aliso Canyon.

**Overall, the studies found the seismic risks at Aliso Canyon are relatively low, and indicate these risks can be reasonably managed and/or mitigated over the life of the facility.**

#### Landslides

The experts determined that landslides do not pose a significant threat to Aliso Canyon or the public at large. These risks occur largely during major rain events or earthquakes, and SoCalGas has already taken steps to "harden" its wells from this threat. A few wells were found to be in areas of potential landslide activity, and steps are already being taken to make them secure. No gas storage wells have been lost to a landslide in the facility's 46-year history.

#### Storage Zone Integrity

The experts concluded that the gas stored under Aliso Canyon is confined within the storage zone by impervious rock and other geologic structures on all sides, with the caprock and other boundaries providing good sealing properties.

## Earthquake Ground Shaking and Fault Displacement

The hazards imposed by earthquakes in the area include both ground shaking and fault displacement. Notably, all structures in Southern California face some of these hazards. The State of California does not have an earthquake design standard for underground gas storage facilities. However, the State generally requires various above-ground structures to be designed to withstand levels of ground shaking or fault displacements that correspond to an annual return period of 475, 975 or 2,475 years.<sup>2</sup> Most new buildings are required to withstand an earthquake that might be expected every 475 years; new bridges and dams every 975 years; and some essential facilities are designed to withstand even a 2,475-year event.

For ground shaking, the experts concluded that Aliso Canyon can withstand subsurface shaking expected from an earthquake on any nearby fault, including the San Andreas Fault. They considered it noteworthy that Aliso Canyon withstood the 1994 Northridge earthquake, a magnitude 6.7 event whose epicenter was only 7.5 miles away. That event caused Aliso Canyon and adjacent areas to experience some of the largest earthquake ground motions ever measured in the world. Aliso Canyon suffered only minor surface and subsurface damage, and no gas was released to the surface. Recent testing and upgrades to the operating wells at Aliso Canyon have further strengthened the facility's ability to withstand future ground shaking.

For fault displacement, the experts have determined that all of the active wells at Aliso Canyon cross the Santa Susana Fault at various depths. Modeling and testing conducted by the experts indicate that the gas storage wells at Aliso Canyon are able to withstand a 475-year event, which is the standard applied to many new buildings. Larger earthquake events associated with 975 or 2,475 return periods could damage some wells, and possibly allow gas to leak from the well system at depth.

## Flow Simulations

The experts have performed simulations to calculate the potential flow rates to surface along the Santa Susana Fault and the active wells. The studies found that Aliso Canyon's wells can withstand a 475-year event, with no well damage below the surface that would cause a leak. For the extreme, 975 and 2,475-year return periods, simulations show that wells may be damaged and:

- Gas movement does not produce any flow to surface along the Santa Susana Fault; and
- Could only potentially flow to surface along the well infrastructure.

Even in such an unlikely event, and if all active wells were damaged, the study indicates that the expected release would be approximately 1 MMscf over one year. The studies also define other gas flow scenarios and provide insights that can be used to help address these risks.

SoCalGas has submitted these draft reports for review and comment by DOGGR and the National Labs. SoCalGas has already taken several steps to mitigate these remote risks, including operating at a reduced reservoir pressure, converting all active wells to tubing-only flow, and sealing with cement and abandoning over 40% of the wells at the facility.

SoCalGas looks forward to working with DOGGR and the National Labs to finalize the studies and identify and implement additional, appropriate measures to mitigate and prevent these remote risks.

[1]The geological work was performed by Numeric Solutions of Ventura, California and Dr. Richard Schultz of Orion Geosciences of Tomball, Texas. The seismic work was performed by AECOM of Los Angeles by Drs. Paul Somerville and Hong Kie Thio, two of the most well-known seismologists in California. The landslide work was performed by Earth Consultants International, Dr. Roy Shlemon of Santa Ana, and Dr. Schultz. Strength testing of the subsurface pipe in the gas storage facility was performed by Stress Engineering of Houston, Texas under the direction of Dr. Sathish Ramamoorthy. Potential pathways for natural gas flow along wells and into the underground formations and faults were examined by Dr. Ivor Ellul of RPS, and Dr. John H. Shaw (Harvard) and Dr. Ruben Juanes (MIT) of Seismix Reservoir Management, LLC.

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These time periods are called Annual Return Periods (ARP). An ARP represents an estimate of the likelihood of an event over a given period. In this case, the ARP represents the likelihood of a seismic event with ground shaking or fault displacement that exceeds calculated levels of shaking or fault displacement over the applicable period. In other words, a 475 ARP is a 10% chance of exceedance in 50 years, a 975 ARP is 5% chance of exceedance in 50 years, a 2,475 ARP is a 2% chance of exceedance in 50 years.