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Subject: Comments of Curtis Oldenburg and Robert J. Budnitz on draft UGS regulations

Dear Alan,

We present below 14 comments and related recommendations on risk management that stem from our review of the California underground gas storage (UGS) risk management plans (RMPs) required in the emergency regulations. We hope there is still time for DOGGR to consider these comments in finalizing the new UGS regulations.

Comment #1. Risk Management Plan rigor

We suggest that the risk management plan requirements be made more specific with respect to the expected degree of rigor of the risk assessment carried out and the level of risk that each facility should attempt to stay below. The risks that the facility poses to various risk endpoints (such as worker safety, health of the offsite population, release of methane, property damage, etc.) need to be dealt with separately.

Text extracted from proposed regulations:

1726.3. Risk Management Plans.

(a) For each underground gas storage project, the operator shall submit a project-specific Risk Management Plan to the Division for review and approval. The Risk Management Plan shall demonstrate to the Division's satisfaction that stored gas will be confined to the approved zone(s) of injection and that the underground gas storage project will not cause damage to life, health, property, or natural resources. In accordance with subdivision (b), the Risk Management Plan shall evaluate threats and hazards associated with operation of the

underground gas storage project and identify prevention protocols that effectively address those threats and hazards. The Risk Management Plan shall also specify a schedule for submitting updates to the risk assessment and prevention protocols to the Division. The Division may, in its discretion, require additional data, additional risk assessment, or modification of prevention protocols. The Division will review the Risk Management Plan periodically, but not less than once every three years. Risk assessment and prevention protocols in the Risk Management Plan shall be consistent with and additional to any other existing requirements.

(b) The Risk Management Plan shall include a description of the methodology employed to conduct the risk assessment and identify prevention protocols, with references to any third-party guidance followed in developing the methodology. The methodology shall include at least the following:

- (1) Identification of potential threats and hazards associated with operation of the underground gas storage project;
- (2) Evaluation of probability of threats, hazards, and consequences related to the events;
- (3) Identification of possible prevention protocols to reduce or monitor risks, including evaluation of the efficacy and cost-effectiveness of the prevention protocols;
- (4) Selection and implementation of prevention protocols;
- (5) Documentation of the risk assessment process, including description of the basis for selection of prevention protocols;
- (6) Data feedback and validation throughout the risk assessment process; and
- (7) Regular, periodic risk assessment reviews to update information and evaluate the effectiveness of prevention protocols employed, which shall occur not less than once every three years and in response to changed conditions or new information.

Regarding the level of rigor, it is not stated in the draft regulation that the risk assessment needs to be quantitative. We recommend that the new regulations require that the risk assessment needs to be quantitative, i.e., it should be a quantitative risk assessment (QRA). E.g., the draft under b(2) specifies,

“b(2) Evaluation of probability of threats, hazards, and consequences related to the events;”

We suggest this be changed to, “Quantitative or semi-quantitative evaluation of probability of threats, hazards, and consequences related to the events;”

We emphasize that the QRA recommended here need not be an exhaustive probabilistic risk assessment requiring multiple person-years of effort for every conceivable failure scenario. Instead we recommend that the QRA be a formal and practical risk assessment for the most important risk categories and failure scenarios. The QRA services currently offered by several engineering consulting companies can provide the adequate rigor.

Comment #2. Risk Management Plan level of risk

Regarding the level of risk that each facility should stay below, the draft regulation states,

“The Risk Management Plan shall demonstrate to the Division’s satisfaction that stored gas will be confined to the approved zone(s) of injection and that the underground gas storage project will not cause damage to life, health, property, or natural resources.”

This seems too vague to us. We suggest that the regulation specify that risk targets or goals need to be developed for each risk endpoint. These risk targets or goals would not be firm limits but would instead express a strong although not an enforceable expectation. The process of developing these risk targets needs to begin soon, either led by the industry or by a government agency with broad stakeholder input. DOGGR would then review these targets and goals and would approve the agreed-upon targets or goals. If the facility demonstrates in its QRA that it is below its risk targets or goals in each category, then the risk management plan will have demonstrated to the Division's satisfaction that stored gas has been confined...

Comment #3. Training of personnel

Under 1726.3 (c), the proposed regulation includes the requirements for,

“(13) Safety training for on-site personnel.

(14) An equipment maintenance program that includes training and proactive replacement of equipment at risk of failure so as to ensure safe operation.”

We believe that the area of managing the human factor component of safe UGS operation requires more attention in the regulations. To this end, we recommend that regular training of the operating and maintenance crew using written procedures be implemented at UGS facilities state-wide. If it is to be in a California regulation rather than a voluntary industry-wide undertaking, we further recommend that the requirement be placed in the Risk Management Plan section of the draft new California UGS regulations.

Comment #4. Database of off-normal occurrences

Reporting of emergencies and leakage is mentioned in various places in the proposed regulations.

1726.3.1 Emergency Response Plan

c(5) Protocols for emergency reporting and response to appropriate government agencies;

1726.7 Monitoring Requirements

3(E)(f) for immediately reporting leaks to the Division.

1726.9 Well Leak Reporting

(b) If a gas storage well has a reportable leak, then the operator shall immediately inform the Division.

We recommend that reporting be expanded beyond the requirements to inform DOGGR. Specifically, we recommend that reports and analysis of all off-normal occurrences (including equipment failures, human errors in operations and maintenance, and modest off-normal events and maintenance problems) be submitted for inclusion in a database of off-normal events. Submissions should be under a no-fault protocol, and the database be made publicly available to enable others to derive lessons-learned from it. If it is to be in a California regulation rather than a voluntary industry-wide undertaking, we further recommend that the requirement be placed in the Risk Management Plan section of the draft new California UGS regulations.

Comment #5. Risk Management Plans – Recommended Content and Level of Detail

The DOGGR draft regulation states:

[from 1726.3(b)] The Risk Management Plan shall include a description of the methodology employed to conduct the risk assessment and identify prevention protocols, with references to any third-party guidance followed in developing the methodology. The methodology shall include at least the following:

- (1) Identification of potential threats and hazards associated with operation of the underground gas storage project;*
- (2) Evaluation of probability of threats, hazards, and consequences related to the events.*

In our opinion, the words “threats,” “hazards,” and “consequences” in the above text do not provide the necessary guidance as to what the risk assessment methodology needs to include. The last word, “events,” presumably refers to incidents such as failure scenarios, but it is not clear.

The approach generally taken by the community of risk-analysis experts for an engineered facility consists of identifying the major off-normal failure (i.e., accident) scenarios, one-by-one. Failure scenarios are the incidents including their precursors and side effects that need to be prevented from occurring either with too high a frequency or associated with too large end-point consequences, or some combination. The use of the word “probability” is good, and serves to specify a degree of quantification that is needed for QRA.

We recommend the following draft language to address the above concerns:

[proposed for 1726.3(b)] The methodology shall include at least the following:

- (1) Identification of the most important potential accident scenarios associated with operation of the underground gas storage project, based on a detailed description of the characteristics of each facility (number of wells, age, operating scheme, etc.)*
- (2) Evaluation of the frequency (for example, the annual probability) of each such accident scenario, and the range of consequences associated with it, including estimates of the uncertainties in the numerical values;*
- (3) For each important accident scenario, identification of the principal equipment failures, the principal external initiating events if any (earthquakes, flooding, above-ground industrial accidents, etc.), the principal operational errors, and other aspects that contribute to each accident scenario, and for each a description and quantification of its role relative to other contributors in the evolution of the scenario;*
- (4) For each scenario leading to an accidental release, identification of the important engineered or natural features that affect the extent of the various end-point consequences, and a quantification of their relative roles, including an estimate of the uncertainties in the quantification.*

The above language will serve to clarify more specifically what a successful facility-specific RMP should look like. It should make it clear that a QRA is expected including an estimate of the uncertainties in the numbers, and must describe each important contributor in a way that

supports later Risk Management Plan Elements (see below), such as comparisons with acceptable risk levels, decisions on further monitoring or analysis, decisions on intervention, etc. Although each facility can select its own approach and methodology, the DOGGR regulations should seek to ensure that sufficient rigor and thoroughness are used across all facilities in California.

Comment #6. Human and organizational factors

The current DOGGR draft regulation emphasizes hardware failure issues (and corresponding monitoring activities) over analysis of human and organizational factors in the risk profile for any given facility. We recommend that the regulations be written to explicitly address the importance and role of human and organizational factors as well as safety culture, to the extent that these can contribute to risk at UGS facilities. DOGGR could follow the State of California's Department of Industrial Relations' (DIR) Occupational Safety and Health Standards Board and adopt or adapt the two new "Human Factors" and "Safety Culture" elements in the recently revised and updated Cal/OSHA Process Safety Management for Petroleum Refineries (Cal-OSHA, 2017.)

Comment #7. Risk-based monitoring, data collection, and reporting

The DOGGR draft regulation under 1726.3(c)(3) calls for the Risk Management Plan to incorporate mechanical-integrity testing, 1726.3(c)(4) calls for corrosion monitoring, 1726.3(c)(5) calls for monitoring of casing pressure and several other parameters, 1726.3(c)(7) deals with reservoir integrity, and 1726.3(c)(8) deals with formation of hydrates; etc.

We recommend that DOGGR require risk-based monitoring, data collection, and analysis rather than prescriptive monitoring. The risk assessment will provide the basis for scenario-by-scenario analysis of how much risk and uncertainty can be reduced by various monitoring, data collection, and analysis activities. Risk analysis that identifies optimal interventions is especially useful for low probability high-consequence failure scenarios. As written, the RMP requirements lack mention of the link that should be made between risk analysis and requiring monitoring, data collection, and/or analysis. For each monitoring or data-collection activity described in the RMP, there should be a risk-based reason along with stated justification for its (i) frequency, (ii) level of detail, and (iii) accuracy or level of uncertainty in the measurements.

Comment #8. Linking intervention to failure scenarios

The draft DOGGR regulations lack language linking intervention protocols to the various failure scenarios. The relevant language in the DOGGR draft regulation states:

[from 1726.3(b)] The Risk Management Plan shall include a description of the methodology employed to conduct the risk assessment and identify prevention protocols. The methodology shall include at least the following:

- (1)*
- (2)*
- (3) Identification of possible prevention protocols to reduce or monitor risks, including evaluation of the efficacy and cost-effectiveness of the prevention protocols;*
- (4) Selection and implementation of prevention protocols.*

This text lacks a direct link to the organizing principle of the various failure (accident) scenarios. The RMP must include a description of the decision-making process including criteria for undertaking interventions of various types. We understand that the details will not be available because failures and interventions are highly situation-dependent, but language should be included in the RMP to satisfy DOGGR that there are defensible decisions for intervention, sometimes as prevention and sometimes as mitigation. Note further that we recommend that the words “prevention protocols” be replaced by “intervention protocols” everywhere in regulatory subsection 1726.3(b), because as noted intervention can involve either prevention or mitigation, or some combination.

We recommend in 1726.3(b) above be changed so that (3) and (4) read as follows, where the proposed additional new language is in *italics*:

- (3) Identification of possible *intervention* protocols to monitor the facility’s safety culture to reduce or monitor risks, including evaluation of the efficacy and cost-effectiveness of the *intervention and prevention protocols, linked to the specific failure (accident) scenario(s) affected by each proposed protocol*;
- (4) Selection and implementation of *intervention and prevention protocols, linked to the specific accident scenario(s) affected by each proposed protocol*.

Comment #9. Emergency response plan

We recommend that the RMP include an emergency response plan that establishes requirements and expectations based on a thorough understanding of the given facility’s risk profile.

Comment #10. Documenting the results

We recommend that the RMP include a description of the documentation that is required, how to access this documentation (e.g., locations at which documentation is filed), and what form the RMP documentation exists in. Depending on the circumstances, certain documentation requirements may be specified, and others suggested.

Comment #11. Plan modifications

We recommend that the RMP include a section on what needs to be done in terms of documentation and approval for modifications to be made in the RMP. For example, there should be provision made for very small changes without need for DOGGR approval, but also the possibility of more significant changes with approval.

Comment #12. Capability to forecast site-specific and release-specific transport and fate of releases

We recommend that each operating UGS facility in California be required to possess, or have access to, the capability (through analysis) to forecast in near-real-time the transport and fate of a large release of natural gas to the environment, and also to forecast the impact of such a release on workers, the local population, and the broader environment. This could be either a

requirement embodied in a government regulation or a requirement developed and implemented by the industry itself. The capability could be maintained within each operating company or be provided by contractual arrangements offsite. Alternatively, and preferably, California could assume responsibility for this capability. The National Atmospheric Release Advisory Center (NARAC) at Lawrence Livermore National Laboratory in Livermore, CA is a national support and resource center for emergency planning, real-time assessment, emergency response, and detailed studies of atmospheric releases. It is recommended that California establish an assistance relationship with NARAC that would allow NARAC to activate upon request from the Governor's Office.

Comment #13. Regular peer review or auditing of new DOGGR regulations

We recommend that agencies with jurisdiction should develop an independent and mandatory peer review or audit program for the new DOGGR regulations. It is a common practice in many fields to evaluate the effectiveness of regulations, in particular those that may have been newly developed, on a regular basis by peer review teams or auditing teams. For example, the Groundwater Protection Council (GWPC) organizes peer reviews of the Class II Underground Injection Control Program in certain states to which the U.S. EPA has delegated regulatory authority.

This auditing is recommended for the following reasons: (1) it is important that all elements of the new regulations are revisited after a few years of implementation to ensure that the latest science, engineering, and policy knowledge is reflected to provide an acceptable level of safety, (2) it is important to ensure that these regulations are consistently applied/enforced across all storage facilities and are thoroughly reviewed for compliance, (3) it is important to independently evaluate whether an appropriate safety culture has been fully embraced by operators and regulators, and finally (4) it is important to assess whether the regulator has the necessary expert knowledge to conduct a rigorous review of the regulatory requirements.

The peer reviews would follow development of a consistent set of audit protocols to be applied across all storage facilities, in regular intervals (i.e., five years). This review should be the responsibility of a lead agency designated by the Governor's Office. Review teams would be selected from a broad set of experts and stakeholders, such as regulators from related fields in other states, academia, consultants, and environmental groups. Results from the mandatory review should be published in a publicly available report with an opportunity for public comment.

Comment #14. Leak reporting threshold

We recommend that leakage be quantified and measured in flow units rather than concentration units. The regulation language is as follows:

1726.9. Well Leak Reporting.

(a) For the purposes of this section, and for the purposes of Public Resources Code sections 3183 and 3184, "reportable leak" means:

(1) A leak from a gas storage well that is above 50,000 parts per million by volume total hydrocarbons, as measured using methodology that the operator has demonstrated will provide consistent and reliable measurements, such as US EPA Reference Method 21;

(2) A leak from a gas storage well that is above 10,000 parts per million by volume total hydrocarbons, as measured using methodology that the operator has demonstrated will provide consistent and reliable measurements, such as US EPA Reference Method 21, for more than five days; or

(3) Any leak that poses a significant present or potential hazard to public health and safety, property, or to the environment.

(b) If a gas storage well has a reportable leak, then the operator shall immediately inform the Division.

(c) The requirements of this section are in addition to, and do not supersede, any other requirements for reporting or responding to leaks from a gas storage well.

Note in the above that concentration units (e.g., 50,000 parts per million by volume, and 10,000 parts per million by volume) are specified as threshold levels of leakage, but leakage is fundamentally a flow process that needs to be quantified in emission units or flow units, e.g., mass per second, or mass per second per unit area, etc. The suggested method is listed as US EPA Reference Method 21 (<https://www3.epa.gov/ttnemc01/promgate/m-21.pdf>), but that very method states that the method is for locating and classifying leaks, not for quantifying emissions, as follows:

“This method is intended to locate and classify leaks only, and is not to be used as a direct measure of mass emission rate from individual sources.”

The criticism here of using concentration rather than flow units to provide a reporting threshold is that ambient winds or rain or other local atmospheric disturbances can act to disperse leaking gas and thereby affect the measured concentration. We strongly recommend that methods be developed to measure and quantify the emission or flow rate. For example, standard concentration-measuring devices such as FLIR cameras can be used to locate or identify leaks, but the actual quantification of the strength of the leak in flow units should be quantified by other means, e.g., <https://heathus.com/wp-content/uploads/hiflow.pdf>.

Sincerely,

A handwritten signature in black ink, appearing to read "E. M. O'Leary". The signature is fluid and cursive, with a long, sweeping tail that extends to the right.