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Re: Review Comments on book, "GAS MIGRATION, Events Preceding Earthquakes", by Leonid F. Khilyuk, George V. Chilingar, Bernard Endres, John O. Robertson, Jr.; published by Gulf Publishing Company, Copyright 2000.

TO WHOM IT MAY CONCERN:

In October of 2007, I was requested by Sacramento Natural Gas Storage, LLC, ("SNGS") to review the referenced book and provide 1.) technical review comments on specific issues raised in the text; and 2.) professional opinions concerning the relevance of those issues to the underground natural gas storage project that SNGS is in the process of developing in Sacramento, California. Following are my technical review comments and professional opinions.

First, I have personal knowledge of two of the co-authors, Chilingar and Robertson, from classes I attended with them at the University of Southern California's School of Petroleum Engineering. Both of these individuals have continued their affiliation with USC and currently serve on faculty, in addition to their international consulting services. Endres is not personally known to me, nor can I find any academic or professional credentials for the claimed qualifications as an environmental consultant, or a safety engineer, or as a geologic specialist. Khilyuuk is not known to me personally, but his credentials are well established as a mathematical modeling consultant.

Introduction and General Comments

The intent and purpose of the text is reflected in the authors' opening statement in the Preface: "*Gases migrating to the earth's surface provide crucial information regarding the state and evolution of the structure and tectonics of our planet. By listening to and analyzing "whispering" gases, locations of intense tectonic activity can be identified and areas of potential natural disasters delineated, such as volcanic eruptions, tsunamis, and earthquakes.*" In deed it is this seismic and geologic focus and associated mathematical models on forecasting natural disasters that are the essence of the book. Relative to this current review assignment, only one of the 28 chapters, e.g., 19 of 350+ pages, discusses "Hazards of Gas Storage Fields".

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The authors also state in their Preface that, "The migration of gas to the surface from oil and gas formations is a problem that greatly affects those surface areas where human activity exists. Underground gas storage facilities and oil fields have demonstrated a long history of environmental gas migration problems." These thoughts on underground storage facilities for natural gas will be the focus of this report.

Issues Raised by the Text, Relative to Underground Natural Gas Storage Facilities

1. *"The migration of gas to the surface from oil and gas formations is a problem that greatly affects those surface areas where human activity exists". (Page xv)*

This statement must be separated into some constituent parts to be fully understood. First, the problems that may result from migration of gas to the surface from oil fields are significantly different than those that may result from gas migration from "dry" or natural-gas-only fields. Some of the gaseous substances emanating from oil fields are considered toxic, while those emanating from natural-gas-only fields are not. Please note that the proposed SNGS storage facility will re-utilize a depleted reservoir that did not contain or produce oil.

Second, while gas migrating to the surface from oil or gas fields that are usually thousands of feet below the surface through natural faults, could theoretically create hazards, the probability of such migration is extremely low. In addition, as the authors point out on page 255, *"In summary, diffusion, as a mechanism working on a molecular level, can move free gas toward the surfaced. The process, however, is a very slow one, occurring over geologic time. Gas held in solution also does not move freely toward the surface. Although the process is slow, all gas eventually migrates to the surface."* As they cite in Table 17-1, the Time to Reach the Surface for Methane, i.e., natural gas, from a typical depth of 1,740 meters is 140,000,000 years. By the authors' admission, *"Clearly, vertical molecular diffusion of gas from petroleum reservoirs buried at depths around 1,700 m (5,600 feet) is not the mechanism responsible for the volumes of gas observed in surface soils over oil fields (see Gurevich et. Al., 1993)"*. With respect to the SNGS facility, which is located at a depth of approximately 3750 feet: if one uses the author's formula, the time required for natural gas to reach the surface from the SNGS facility through natural pathways is calculated to be approximately 94 million years.

Third, the only relevant pathway for natural gas to reach the surface after escaping from an underground natural gas storage facility, is up through the man-made wellbore or alongside those wellbores. The authors cite the *"breakdown of cement and the seals that block the vertical migration of fluids and gases in the wellbores and their annular space"* as the primary cause of vertical gas migration. While it is true that cement can deteriorate, the cements used today in such applications are

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much stronger and impervious to such deterioration. In fact a literature search and the authors' text cite no examples of problems caused at the surface by such deterioration of cement along wellbores at the 36 depleted reservoir facilities that have been created in the last 20 years. With respect to the SNGS facility, there is a near-zero probability that the cement used to anchor and protect the wellbore will deteriorate and result in leakage of natural gas to the surface at any time during the 50+ year life of this facility. In addition, the design of the SNGS facility and their "best management practices" will include constant monitoring of each well for any leakage. Manual inspections of wells for leakage will be conducted on a no-less-than monthly basis.

Finally, the authors make mention of poorly plugged and abandoned wells as a means of gas migration from reservoirs to the surface. Leakage through improperly abandoned wells has indeed been a problem from time to time throughout California, and for a variety of reasons. The requirements for properly plugging and abandoning a well in California are promulgated and enforced by the State's Division of Oil, Gas and Geothermal Resources ("DOGGR"), an organization for which I served as the State Oil and Gas Supervisor. The current regulations are rigid, specific, and enforced by the Division. Inspections are performed prior to the Division's sign-off on any P&A'd well. Relative to the SNGS facility, the seven wells that were drilled for the extraction of natural gas from the Florin field were all properly plugged and abandoned under the current stringent regulations. There have been no incidents of leakage reported in the last 15+ years. In addition, I have recommended to SNGS that they have an on-site testing done at each of the original well sites, in conjunction with representatives from the DOGGR, to determine if any leakage of natural gas is found. SNGS has committed to have these inspections of the accessible old well sites performed within the next 30 days. This empirical evidence will provide unequivocal answers to the question of, "Are the old wells currently leaking?". Furthermore, SNGS has committed to physically testing these old wellsites on a monthly basis during the first six months of operation of the storage facility, and no less than quarterly throughout the 50+ year life of the facility.

Attached are detailed comments about specific issues raised in the subject text.

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In summary, the text may have some significant value to seismologists and geophysicists who are concerned with predicting occurrences of earthquakes and other seismic events. The text has little relevance to underground natural gas storage facilities in the real-world of today. Those same points have even less relevance to the specific case of the storage facility proposed by SNGS.

Very truly yours,



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3/17/08

Claims of “Gas Migration”, Events Preceding Earthquakes”

Claim

1. *“Underground Storage Facilities have demonstrated a long history of gas migration problems”.*

Response

Not consistent with the facts, even as presented in the book.

Relevance to SNGS Project

LITTLE RELEVANCE

1. The book cites existence of over 300 of these facilities in the United States. More than 150 depleted reservoir storage facilities that were designed more than 50 years ago are still operating in the U.S. They collectively represent over 18,000 years of operating history. Eight (8) gas migration incidents were cited by the author. Using the book’s data, the resultant probability of a migration problem would be calculated to be 0.04, or 4/10 of one percent.
2. Gas migration from one underground formation to another does not constitute a threat to public health and safety. In two of the “dangerous” incidents cited, the gas simply migrated to another formation and remained trapped underground.

2. *“Experience has shown that using depleted oil fields for gas storage facilities can create a serious risk of explosions and fires, especially when located in urban settings.”*

As the problems encountered at the El Segundo and Montebello facilities demonstrated, the most common problem associated with using a depleted oil field for natural gas storage is leakage from improperly plugged & abandoned wells.

IRRELEVANT

1. SNGS is not using a depleted oil field for its storage. Rather, it is a formation that produced “dry”, i.e., no oil, natural gas.

Claim

3. *“One must consider the following in designing underground gas storage facilities: (1) the presence of faults and fractured zones, (2) lithology and structure of the overlying formations, and (3) breakdown of cement and the seals that block the vertical migration of fluids and gases in the wellbores and their annular space.”*

Response

SNGS concurs with these design criteria.

Relevance to SNGS Project

RELEVANT

1. SNGS has spent a quarter of a million dollars to have the formation reviewed by some of the best geologists, geophysicists, and petroleum engineers in the world. There are no active faults in the area; there are no fracture zones; and the overlying formation is solid and non-fractured.
2. The original production wells were sealed, i.e. “plugged and abandoned” in the late 1980’s, in accordance with current standards maintained by, and under the supervision of the State of California’s Division of Oil, Gas and Geothermal Resources (DOGGR). There have been no leaks reported of any of those 7 wells. As a “best management practice”, SNGS intends to physically test the accessible old well sites on a monthly basis during the initial injection period of the new facility, and will thereafter test the wellsites for leaks no less than quarterly.
3. The six new injection/withdrawal wells that will be drilled by SNGS will be constructed using the newest and most technologically advanced methods and materials, and will meet or exceed the standards established by the State and Federal governments. The new wells will be monitored for leaks 24-hours per day.

Claim

4. *"In fact, it is impossible to assume that the vertical migration of natural gas to the surface from the gas storage reservoir will never occur".*

Response

Although highly unlikely, concur that no one can properly assume that natural gas will, or will not, migrate to the surface from a reservoir.

Relevance to SNGS Project

RELEVANT

1. There are two ways that natural gas can migrate to the surface from an un-depleted, naturally-occurring reservoir; or a storage facility: naturally-occurring pathways or man-made pathways. In either case, such migration would cause the CPUC and the DOGGR to mandate an immediate shutdown of the facility. It should also be noted that such "migration" would be a result of leakage of valuable inventory that would never be tolerated by the operator of the facility.

a. Naturally-occurring pathways, i.e., fractures and faults. As noted before, there are no fractures or faults in the Florin field formation. Furthermore, and as will be explained in more detail later, SNGS will not be allowed by the DOGGR to operate the facility at pressures greater than the original pressure of the gas field, and therefore the risk of creating new fractures or pathways is eliminated. Operating at this not-to-exceed maximum pressure is also a requirement of SNGS's best-management-practices, as SNGS does not want to knowingly increase the risk of destroying a facility that cost tens of millions of dollars to create.

Claim

4. (continued)

5. *“These storage fields operate under large pressure fluctuations, dictated by seasonal variation in the demand for (and usage of) natural gas. Sometimes these cyclic storage pressures exceed the original oil field reservoir pressure.”*

6. *“Today, the risks of injury from fire and/or explosions have increased because a greater percentage of the land is now covered, not permitting the gas to escape into the atmosphere”.*

Response

It is true that the pressure in the storage facility will vary, though the author does not specify what is considered to be a “large” variation.

To be of relevance, the structures would have to be built above the gas’ pathway to the surface, i.e., a fracture, or fault, or the wellbore.

Relevance to SNGS project

b. Man-made pathways, i.e., new wells. The SNGS wells will be monitored 24 hours per day for leaks. Any leaks will be cause for immediate shutdown of operations and corrections will be made before resuming operations..

IRRELEVANT

1. As long as original maximum pressure of the formation is not exceeded, and the current pressure is not reduced, the variability of pressures poses no threat to the protective overlying structure.

2. The “cyclic storage pressures” will not be exceeded, as that condition will be prohibited by both the DOGGR’s operating permit and by SNGS’s best-management-practices.

IRRELEVANT

1. There are no fractures or faults leading from the formation, 3800 feet below the surface, to the surface.

2. There are no structures above the wellbores that would keep the gas from escaping to the atmosphere.

Claim

7. *"All of the previous discussion relating to gas migration from oil fields to the surface is applicable to the concerns associated with underground gas storage facilities" ... "(3) problems related to carcinogenic chemicals present in the natural gas (e.g., benzene and toluene, and added odorization agents)."*

Response

Claim is not factual. There are no carcinogenic chemicals in the natural gas that is stored in an underground storage facility, because the storage facilities hold only gas that is "pipeline quality", because that is how the gas gets to the facilities. Benzene and toluene can be found in naturally-occurring or "raw" gas that is extracted from the earth, but they are removed before the gas can be delivered into a pipeline. Furthermore, the mercaptan odorization agent used by virtually all major pipelines, including PG&E, is not considered to be carcinogenic.

Relevance to SNGS Project

IRRELEVANT

- 1.SNGS will not be storing any "raw" gas that might contain benzene or toluene.
2. The odorization agent, e.g., mercaptan, is placed in the gas before it enters any pipeline as a safety measure required by the Federal government. Mercaptan, is not considered to be a carcinogenic agent. Please note that the odorization agent is in the natural gas that is brought into every home and business that uses natural gas for heating, cooking, manufacturing, etc.

8. *"It should be remembered that an explosion hazard exists with an air-natural gas mixture if the content of natural gas is 5% to 15%."*

Concur with the statement. However, to create the cited concentrations, an enclosed space, such as a home or building is required. When outdoors, the gas rises and dissipates naturally, and the slightest breeze will dissipate the natural gas very rapidly, making it difficult to build up such concentrations.

IRRELEVANT

The SNGS facility will have no enclosed facilities that would facilitate natural gas buildups.

Claim

9. *El Segundo Oil Field. "Gas that was stored here in the early 1970's migrated into the adjoining geologic formations. Gases were detected in a nearby Manhattan Village, California, housing development that was under construction. As a result, the construction was stopped."*

Response

Problems associated with storage of natural gas in abandoned oil fields are not directly applicable to storage projects in non-oil-field, dry-gas only, reservoirs. However, as noted by the author, when the leakage from the storage facility was experienced, the storage project was "shut down".

Relevance to SNGS Project
IRRELEVANT

1. The SNGS project does not involve a depleted oil field.
2. If gas migrates from a storage facility to "another formation", it does not generate a threat to public health and safety. Regardless of that threat, such migration also generates an economic loss for the storage facility operator. No storage operator has ever continued to operate a storage facility when it was "leaking".

10. *Honor Rancho and Tapia Oil Fields. Castaic gas storage is located in the depleted Castaic Hills Oil Field.*

Both of these fields are known to be heavily faulted. As noted before, the problems associated with storage of natural gas in abandoned oil fields are not directly applicable to storage projects in non-oil-field, dry-gas only, reservoirs. However, although not mentioned by the author, when the leakage from the storage facility was experienced, the storage project was shut down.

IRRELEVANT

1. The SNGS project does not involve a depleted oil field.
2. If gas migrates from a storage facility to "another formation", it does not, generate a threat to public health and safety. Regardless of that threat, such migration also generates an economic loss for the storage facility operator. No storage operator has ever continued to operate a storage facility when it was "leaking".

Claim

11. Montebello Gas Storage Field. "The gas company stores large volumes of natural gas...using the Montebello Oil Field in California. ...Prior to converting the Montebello Oil Field to a gas storage facility, many of the wells in this field had been abandoned using standards that were less stringent than those required at present. The oil field also contains several fault planes, which are potential paths for gas migration. ...Many of these gas seepages appeared to be associated with poorly abandoned wells...."

12. Playa Del Rey Gas Storage Field. (a) "The Playa Vista proposed surface development and gas storage project is located over a portion of the depleted Playa Del Rey Oil Field. (b) This field was discovered in 1929 and was in production until the pilot storage project was initiated in 1942. . (c) The State of California Division of Oil and Gas (DOG) has reported lateral migration away from the produced area of several million cubic feet of gas to the north and west...It was estimated in 1953 by the DOG that 25% of the injected gas migrated to an adjoining oil field. (d) in 1990, the gas company vented approximately 300,000 cubic feet of natural gas into the air each month. (e) It appears that gas is not only escaping from the surface production facilities, but also

Response

As noted before, the problems associated with storage of natural gas in abandoned oil fields are not directly applicable to storage projects in non-oil-field, dry-gas only, reservoirs. However, poorly abandoned wells can certainly result in migration of gas to the surface. When the leakage from the abandoned wells was detected, the utility took action to acquire the affected properties and corrected the problems. Consequently, the facility continues to operate today, with no further leakages detected.

(a).As noted before, the problems associated with storage of natural gas in abandoned oil fields are not directly applicable to storage projects in non-oil-field, dry-gas only, reservoirs. (b) The standards and technology used for drilling wells nearly 80 years ago were far more lax and unsophisticated than those of today. In addition, many of the original wells had the steel casings removed during the World War II war effort. (c) The several million cubic feet of natural gas reported by the DOG amounted to approximately 6% of the total volume of the storage field. In the 1940's, without the seismic studies of today, establishment of storage fields was done largely by "experiment", and the development of empirical evidence, i.e., trial and error.

Relevance to SNGS Project
IRRELEVANT

- 1.The SNGS project does not involve a depleted oil field.
2. The seven "abandoned" wells associated with the Florin gas field were properly "plugged and abandoned", in accordance with current DOGGR regulations.
3. The SNGS facility's Florin gas field contains no fault planes.

LITTLE RELEVANCE

1. The SNGS project does not involve a depleted oil field.
2. The seven "abandoned" wells associated with the Florin gas field were properly "plugged and abandoned", in accordance with current DOGGR regulations.
3. The volumes of storage that can safely be kept in the Florin field have been established by a team of scientists, engineers, and geophysicists, using sophisticated and proven means and methods—not trial and error.
4. SNGS is not using an oil field for storage and therefore will not be venting

Claim

12. (continued)

migrating up along faults and abandoned wells from the storage reservoir. (f) Analysis of this escaping gas showed that it is a dry gas of thermogenic origin. "

Response

(d) The venting of natural gas into the air was associated with the operation of the oil field and had nothing to do with the storage field. (e) The author's claim that "it appears" that gas is not only escaping from the surface production facilities but also migrating up along faults and abandoned wells from the storage reservoir has no possible basis in science or fact—natural gas cannot be seen; and actual testing of such gases by licensed, professional scientists and engineers revealed conclusively that the gas "escaping" to the surface was actually native, naturally-occurring, thermogenic-produced, natural gas—not pipeline quality, stored gas. (f) The author's statement that the "escaping gas" showed that it is a gas of thermogenic origin is absolutely correct, although it appears to be contrary to his argument. Thermogenic gas is by definition, natural gas that is produced from the decaying of organic materials, and is known as "raw gas". Such gas has a significantly different chemical makeup from cleaned, pipeline-quality natural gas, which is what is stored in the Playa Del Rey gas storage facility.

Relevance to SNGS Project

natural gas into the atmosphere each month.

5. There is no evidence, nor has there ever been any report, of any thermogenic or naturally-occurring raw gas, at the surface in the area of the SNGS project.

Claim

13. Huntsman Gas Storage. "The Huntsman Gas Storage Field was a depleted 4,800 feet deep gas field prior to its conversion to gas storage. Gas leakage occurred from this field into the adjoining oil and gas producing field several miles away. ...a large lateral gas migration occurred through the barrier (fault), which several experts had thought to be impermeable. The gas company purchased gas from the oil company..."

Response

The gas company began operation of the storage field more than 40 years ago, without solid scientific data on the capacity of the storage facility. The total capacity for storage was determined through "trial and error", and at some expense to the utility. It should be noted that the gas migration was to another geologic formation, not the surface.

Relevance to SNGS Project

IRRELEVANT

SNGS has obtained reliable data on the maximum volume of natural gas that can be safely held in the Florin reservoir. Its "best-management-practices" include the practice of not contracting to sell firm storage services for more than 93% of the total capacity.

14. Mont Belvieu Gas Storage Field. "In October 1980, a serious gas leak developed in a salt dome gas storage field beneath Mont Belvieu, Texas...The gas seepage was detected when an explosion ripped through the kitchen in a house..."

The Mont Belvieu storage facility is not a storage field, as stated by the author. Rather it is a salt dome storage facility that uses a hollow cavern in the salt to store the natural gas. Whereas depleted gas fields use permeable sandstone formations to store the gas, the salt cavern storage is hollow cavern, frequently the size of the Empire State Building, where gas is held at pressures of 3,000 or 4,000 pounds per square inch. The characteristics of such facilities are significantly different than those of depleted gas fields such as SNGS intends to use. No explanation of how the gas traveled from the salt cavern to the surface was provided. It is also strange that the author claims that the gas that caused the explosion contained ethane, propane and butane, when such elements are not allowed in pipeline-quality gas, which is what was being stored at Mont Belvieu.

IRRELEVANT, INDETERMINATE

Performance and histories of salt cavern storage and depleted gas reservoirs should only be compared with great care, as their operating characteristics are significantly different. Depleted reservoirs have a far better safety record that has been developed over the last 90 years.

Claim

15. Leroy Gas Storage Facility. "The Leroy Gas Storage project ...drilled the first well in the summer of 1951. Additional wells were drilled and completed in 1970 and 1972. The gas leaked from this storage to the surface and was, overall, a result of corrosion problems in wellbores and migration of gas along the fault plane. The gas leakage was confirmed by identification of the formation gas bubbles in the adjacent creek and pond. The rates of gas loss to the project was estimated to be ...;(formula cited."

Response

As noted, some of the wells at the Leroy Field were completed with technologies that are over 50 years old and are now obsolete. The highly permeable sand in the field was loosened and was extracted with the stored natural gas and, over time, deteriorated the wellbore, leading to the cited leakage.

Relevance to the SNGS Project

IRRELEVANT

1. The Florin Field that will be used by SNGS has a sandstone formation that is hard, but permeable. Little sand was reported to have been extracted with the original gas taken from the field.
2. The SNGS wells will be monitored 24 hours a day for leaks.
3. There are no fault planes in the Florin Field.

RECOMMENDATIONS FOR GAS STORAGE

Claim

"It has been determined that gas will start leaking to the surface from an underground storage project within 50 years after initiating the project."

Response

This is an utterly absurd and unsubstantiated claim. There is no documentation of such a "determination", and the author offers none. Quite to the contrary, there are more than 150 underground natural gas storage facilities in the U.S. that have been operating for more than 50 years without any reported incidents of leakage of natural gas from storage facilities to the surface.

Relevance to the SNGS Project

IRRELEVANT

Claim

"No structure should be built over gas storage sites. The soil gas should be continuously monitored for the presence of natural gas."

Response

The empirical evidence of the last 90 years indicates that the author's personal prohibition of "no building" is without cause or basis in fact. The concept of monitoring for the presence of natural gas in the soil in an occupied area has merit.

"No structures should be built over abandoned oil or gas wells."

SNGS concurs.

IRRELEVANT

SNGS is not building any structures over the old gas wells that were properly plugged and abandoned in the late 1980's. SNGS does not own the property where the old abandoned wells are located and therefore has no control over decisions to be made by those property-owners.

"Continuous gas monitoring should be conducted for the presence of natural gas around all wells penetrating the gas storage reservoir."

SNGS concurs.

RELEVANT.

SNGS has committed to regular monitoring of the original/abandoned wells for the presence of natural gas; and will monitor its new injection/withdrawal wells for leaks on a 24-hour a day basis.

"Health hazards upon exposure to natural gas must be evaluated annually, particularly if the gas contains benzene, toluene, and mercaptans."

The effects of exposure to toxic substances should be evaluated by qualified healthcare personnel immediately, not on an annual basis. The natural gas stored by SNGS will not contain benzene or toluene. The stored

RELEVANT (Mercaptan only)

Only the SNGS employees will have the potential for exposure to mercaptan. The SNGS best-management-practices and safety practices will address the issue.

Claim

Response (continued)

gas will contain mercaptan, which is required in all natural gas delivered in PG&E pipelines. Mercaptan is currently found inside the gas pipes in every household in Sacramento that has natural gas service from PG&E. The mercaptan is used as a “safety device” to alert humans to the presence of any leakage from appliances or the pipes themselves.

Relevance to SNGS Project

CHAPTER 20. HAZARDS OF GAS STORAGE FIELDS

CONCLUSIONS

Claim

"To avoid the possible catastrophic events described in this chapter, a fundamental awareness and understand of gas migration, paths of migration, and associated hazards is required. It is necessary to monitor and evaluate:

(1) soil gas content

There has been no detectable occurrence of native or naturally-occurring, i.e., thermogenic natural gas, on the surface in the area of the SNGS project. Monitoring could therefore be effectively limited to occupants of the area notifying authorities and/or SNGS if sulfur-like odors are detected outside of structures, i.e., coming from the soil.

RELEVANT

SNGS will include in its Emergency Response Plan, the means of notification of any observance of natural gas in the soils in the areas of concern

(2) the rate of gas migration to the surface

Same discussion as above, as a leakage of gas from the storage facility would be detectable because of the smell of the mercaptain, i.e., sulfur-like odor, that is purposely placed in the pipeline-transported gas.

RELEVANT

(Same discussion as above)

(3) oil and gas production from the underlying oil fields

There will be no oil or gas production from the underlying oil field because the field to be used by SNGS is not an oil field.

IRRELEVANT

Relevance to SNGS Project

CONCLUSIONS (continued)

<u>Claim</u>	<u>Response</u>	<u>Relevance to SNGS Project</u>
(4) older improperly abandoned oil wells	There are no old, improperly abandoned oil wells associated with the SNGS project. There are also no old or improperly abandoned gas wells, as the seven original production wells were all plugged and abandoned in accordance with current standards of the California division of Oil, Gas and Geothermal Resources (DOGGR) within the last 20 years.	IRRELEVANT
(5) <i>all oil field operations that produce fractures and free gas, and predict possible environmental complications associated with these operations.</i>	There are no oil field operations associated with the SNGS project.	IRRELEVANT

**CHAPTER 28. CONCLUSIONS
OF THE BOOK, "GAS MIGRATION
Events Preceding Earthquakes"**

<u>Claim</u>	<u>Response</u>	<u>Relevance to SNGS Project</u>
<i>"Some applications of the work by the writers are as follows:</i> <i>(1) Methodology for detection of increased danger of upward gas migration and surface gas leakage due to oil and gas production and variation in time of seismic-tectonic processes;</i> <i>(2) Formulation of new earthquake precursors directly linked to current seismic-tectonic activity in the area of oil and gas production based not only on variations in seismic activity, but also on the analysis of environmental phenomena related to oil production;</i> <i>(3) Increase in the gas leakage and gas concentration in soils may also indicate formation of vertically and subvertically oriented fractures over oilfields, which may be caused by reservoir compaction and consequent ground subsidence.</i> <i>Hence, monitoring of gas leakage at the earth's surface can be used as an additional indicator of possible increases in ground subsidence over oil fields and aquifers, and of movements along faults due to tectonic activity that could render faults more or less permeable."</i>	<p>SNGS will not be producing oil or gas.</p> <p>SNGS will not be producing oil or gas.</p> <p>The SNGS project does not involve any oil fields.</p> <p>The SNGS project does not involve any oil fields.</p>	<p>IRRELEVANT</p> <p>IRRELEVANT</p> <p>IRRELEVANT</p> <p>IRRELEVANT</p>