

# An Additional Review by I2M Associates, LLC

(I2M Archives, see Reviews, page 4)

## Key to Comments:

Black = Original Report Content

Yellow = Particular Words or Phrases Requiring our Response.

[Red] = I2M Associates Mining Group Comments

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## Review in Question:

Vol. 1.12

# Report: Uranium Mining in Texas: Why is it Done that Way?

By:

Ronald L. Sass, Ph.D., Fellow in Global Climate Change

Dated: March 28, 2011

*James A. Baker III Institute for Public Policy, Rice University*

[Summary: The report cited above represents an example of the end result of the insidious way a plaintiff-oriented attorney takes advantage of a highly respected university to further their own goals in a case against a specific uranium mining company in Texas. In this case, litigation was taken up a number of years before by an attorney whose reputation and livelihood focused on cases representing people living around major industrial complexes, and who filed generally frivolous lawsuits against large corporations with “deep pockets” ([more](#)). The attorney needed legitimate, or what appeared to be expert-witness support, to have any chance of success. Some of the issues involved were addressed in 2004 by one of the reviewers ([more](#), p.25).

### *Origin of Issues: TCEQ vs. EPA*

Over the years of such cases, experts have come from the Environmental Engineering Department of a highly respected university in Houston, Texas, although many were not well qualified as professional geoscientists licensed in the state of Texas to practice geoscience before the general public or to legitimately opine on geoscience. However, after many years of employing such experts, the attorney appears to have been subsequently rewarded (and thereby vetted with or without also donating a gift to the subject university) with an appointment as a Professor-in-Practice in the Department to teach environmental law and associated subjects. He apparently then engaged a Fellow of the Baker Institute in the subject case, the author of the above subject report, Dr. Sass, as an “expert” witness on matters related to mining and the geosciences. In 2011 and later, Dr. Sass used material provided by the subject attorney for his review and testimony and then produced the subject Baker Institute report.

During this period, a major disagreement developed between the U.S. EPA and the Texas Commission on Environmental Quality (TCEQ) ([more](#)). In the cited letter to EPA, the TCEQ expressed concern by the unsubstantiated statement in the EPA letter that was based on EPA's experience with other (unnamed or cited) in situ mining projects, whereby EPA believed there was a high likelihood that, following mining activities, residual waste from mining activities would remain in the exempted aquifer:

*“EPA had not shared this experience with TCEQ on any of the in situ uranium mining projects in Texas. There have been 43 Class III injection well permits issued for uranium mining in Texas. After completion of mining, restoration and reclamation activities, concurrence from the United States Nuclear Regulatory Commission is required to approve the final decommissioning, including groundwater restoration, of an in situ uranium mine. There has not been one instance of documented off-site pollution of a USDW from in situ uranium mining activities. TCEQ apprises EPA of pending permit actions. EPA has never commented to TCEQ that a pending permitting action for an in situ uranium mining project would*

*lead to the contamination of a USDW outside of an exempted aquifer. EPA has never informed TCEQ that the authorized UIC program is out of compliance with the Safe Drinking Water Act because Class III injection well operators are failing to protect USDWs or groundwater outside of exempted aquifers. Nor has EPA notified TCEQ that EPA was intending to take an enforcement action against a Class III injection well operator for failing to protect USDWs as required by TCEQ permit or rule.*

*It appears that EPA may be swayed by the unsubstantiated allegations and fears of uranium mining opponents and their attorney who have contacted EPA regarding TCEQ's program revision. The TCEQ has not been invited to those discussions nor provided any opportunity to refute any allegations about TCEQ's UIC program, permits are subjected to extensive public notice and participation requirements, and TCEQ apprises EPA of pending permit actions.*

*EPA has never commented to TCEQ that a pending permitting action for an in situ uranium mining project would lead to the contamination of a USDW outside of an exempted aquifer. EPA has never informed TCEQ that the authorized UIC program is out of compliance with the Safe Drinking Water Act because Class III injection well operators are failing to protect USDWs or groundwater outside of exempted aquifers. Nor, has EPA notified TCEQ that EPA was intending to take an enforcement action against a Class III injection well operator for failing to protect USDWs as required by TCEQ permit or rule, It appears that EPA may be swayed by the unsubstantiated allegations and fears of uranium mining opponents who have contacted you regarding TCEQ's program revision. The TCEQ has not been invited to those discussions nor provided any opportunity to refute any allegations about TCEQ's UIC program....”*

As will be highlighted later in this review, Dr. Sass, a chemist/biologist (A Fellow in Climate Change?), opined as an expert in the subject case on geoscience issues and later prepared the above subject report as a product of the Baker Institute. His report contains information that specifically impacts human health of the general public and the environment, and represents a clear example of Dr. Sass practicing geoscience before the public without a license in the state of Texas (in a court of law and in his report that is available to the general public), much of which is either wrong and/or poorly understood. Similar, poorly understood language has also found its way into proposed EPA regulations.

#### *Response to the Alienation of the EPA*

The ramifications of the above dispute between TCEQ and the EPA has evolved further into regulations being proposed by EPA in 2012 (with subsequent revisions in the *Federal Register*, Vol. 80, No. 16 / Monday, January 26, 2015 / proposed Rules, pp. 4156-4187, referred to as 40 CFR, first version of 2014: [Part 192](#)), many of the details and claims contained therein also reflect a similar lack of understanding and history of in situ uranium mining in Texas and elsewhere in the U.S., and deserves a separate critical review. Some of the deficiencies present in Part 192 appear to have also been inherited from the Sass report or from other litigation documentation from the subject case, some of which will be addressed below.

Suffice it to state here for now, that the Part 192 document is widely flawed technically (some of the items have been highlighted in the above Part 192 reference link, e.g., page 37 (a flawed and irrelevant, and discounted report from Australia (Mudd ([2009](#)))), and pages 40, 52-53, and 58-59, to identify some of the most egregious topics discussed). It contains unusually detailed and superfluous discussions that suggests an underlying agenda similar to that which appears to be insinuated by the Obama Administration's management of the U.S. Energy Information Agency (EIA) and its discounting uranium mining and nuclear power development in general, while overly promoting wind and solar activities in the U.S. in the energy reports of the EIA.

We conclude that this is an underlying “political” theme also perpetuated by the EIA over the period from 2010 to 2015 in downplaying data and associated representations associated with uranium and nuclear power, while exaggerating claimed development of solar and wind energy progress without presenting the economic basis of: a) actual costs of electricity, b) operations and maintenance costs, and 3) the need for a grid-based

energy source to provide back-up electricity for such "new" technology ([more](#), pp. 10 and 21).

Part 192 places an unnecessary burden on a relatively small industry that has been under scrutiny in Texas at least for many years without one incident of groundwater contamination of a private or public drinking water supply caused by in-situ uranium mining. For example, p. 4157 (or the Federal Register version of the Part 192 discussions presented by EPA proposes to require 30 years or so of monitoring and modeling, which are clearly beyond the scope of reasonable regulations, and p. 4164 through at least p. 4170 contain multiple incorrect statements, or exaggerations of the impact of the geological and/or hydrogeological conditions.

Recently, Rempp (December, [2016](#)) reported that the U.S. Nuclear Regulatory Commission has been conducting widespread reviews regarding possible changes to 40 CFR Part 192, which addresses uranium and thorium mining. This regulation was first issued in 1983 and was last revised in 1995.

As indicated above, EPA is proposing an update to the rule that would require in-situ uranium mining companies to test the water quality for 14 specific parameters prior to mining the area and then to restore water quality to pre-mining conditions after mining is concluded. Companies would also have to monitor the groundwater for 30 years after it has been deemed restored and stable. However, there are also provisions that the time frame can be shortened if the analysis shows that there is a 95% certainty that the water quality is stable for three consecutive years.

The EPA has held three nation-wide public hearings on the proposed changes in Part 192, and the review of the rules change continues to make its way through the federal government. But a number of additional issues remain within Part 192. Here are some more of the specific issues, also cited by page number in the subject issue of the Federal Register:

p. 4171: Center column. 2<sup>nd</sup> paragraph: Use of "milling" to describe chemical extraction process is inappropriate jargon and misleads by implying generation of a solid waste.

P. 4172: Well drilling does not typically affect water chemistry if installation is carried out according to the prevailing standards, and if groundwater sampling procedures in terms minimizing drawdown and turbulence in the well during sampling, along with appropriate QA/QC practices for all samples, which become part of the data record for each sample collected.

p. 4176: Sec. E, 3<sup>rd</sup> column: Up-gradient groundwater, before ISR implementation, during extraction, and post extraction, would remain relatively undisturbed geochemically, maintaining the same level of redox state throughout the period of the ISR program. Low redox groundwater would be expected to continue flowing through the roll-front zone with some minor perturbations. In the unlikely event that some changes did occur, the required downgradient monitoring over the years of site activity should detect any changes with sufficient time to act appropriately to maintain acceptable water quality in the aquifers down the hydraulic gradient.

p. 4177: A 30-year period of monitoring is excessive for ISR sites. Long-term monitoring should continue only until the hydrochemistry has stabilized, which will be evident as the data are collected, usually within the standard 5-year interval of evaluation for restoration, and even with a 95% certainty that the water quality is stable for three to five consecutive years.

There are too many issues remaining within the proposed Part 192 to discuss further here, but they are remarkably similar to those errors/exaggerations discussed above and below in the subject Sass report. Such claims of incidents (or even conjectures of fears) of such contamination have been exaggerated within the litigation brought by the attorney, perpetuated via the Sass report, and reflected as "potential threats" in the

proposed Part 192 discussions, but many claims are without basis in fact or appropriate geoscience. This indicates that the EPA personnel responsible for writing up the proposed Part 192 are not fully cognizant of roll-front processes or industry practices. We will endeavor to illustrate such processes when appropriate.

#### *Roll-Front Uranium Processes and Distribution*

We have concluded that the uranium industry has performed the appropriate response to restoring sites in south Texas (see Anthony and Holmes (2014) and Pelizza (2015)). Furthermore, industry research is making progress in understanding the subsurface hydrogeochemistry of former in-situ mines in south Texas and is focusing on possible natural attenuation processes or perhaps, enhanced natural attenuation. If confirmed, this could preclude the necessity for long-term monitoring and restoration methods with attenuation processes involving uranium and other related constituents. Such processes re-establish the preexisting reduced environment (where all metals return to mineral forms) in the areas where in-situ recovery activities were once in operation.

For scale, it should be noted that the area of the mining zone (for in situ recovery operations) is generally not more than a few tens of feet wide, and after the mining fluids have been removed, the surrounding reduced environment would invade and overcome partially oxidized areas where uranium mineralization was solubilized in preparation for withdrawal to the surface for processing.

The uranium ore bodies occur much like oblong beads on a sinuous string, the latter representing the oxidized-reduced interface where biogeochemical activities are in flux, i.e., in the process of forming by-products (uranium mineralization) or beads by a few special bacteria and geochemical reduction. The roll-front structure is a reversed "C", (see Campbell and Biddle, 1977, pp. 6, 7, 34, 35), and Campbell, *et al.*, 2007, pp. 2, 3, 7, 9). The string only carries the beads (or masses) of mineralization where biogeochemical conditions were favorable for the deposition of uranium. Hundreds of miles of the interface would not be suitable for significant mineralization of uranium. This would be because either biologic conditions were unsuitable for the propagation of the bacteria population in sufficient quantities, or other bacteria species overwhelmed and killed off the special bacteria capable of producing uranium as byproducts ([more](#)).

This could also be located where the hydrogeochemical conditions were not favorable, i.e., carbon source, needed for optimum bacterial activity, porosity of the host sandstone decreased or increased to the extent groundwater flow was not optimal for creating the environment for mineralization, and agents introduced from outside the system were introduced by natural means. Such agents could be oil, natural gas or, more likely, hydrogen sulfide gas likely entered from below along faults zones.

In several deposits in south Texas (including one in Live Oak County (Campbell, *et al.*, 2007, p. 4)), portions of the uranium roll-front system have been invaded by such agents where sediments that became part of the ore zone were re-reduced. This results in stark mineralogical and color changes of the drilling samples, and creates conditions that can fill the pore spaces causing reduction of preexisting porosity with new minerals such as calcite or other associated minerals. If this happened in the area of a known ore body, recovery factors generally decrease significantly.

Where optimum conditions exist, roll-front uranium ore bodies can be developed if the ore-forming conditions were especially favorable, where uranium grades and lateral mass continuity could create economic uranium ore bodies capable of being mined by the well-known in situ recovery methods.

The point to be made here is that such uranium mineralization and associated orebodies are not numerous along the single interface string in south Texas because favorable conditions only come together occasionally, as is evident from the exploration conducted earlier focusing on shallow lithologic units in

Texas. The shallow units have been mined. Those deposits of potential value remaining occur in the deeper aquifers, and these appear to be few in number of those zones of mineralization that meet the criteria to be deemed economic and suitable for mining by in situ recovery.

At depth, the sheer volume of reduced sediments would easily move in to overwhelm any oxidizing fluids introduced via in situ recovery operations and would certainly re-establish a stable, reduced environment, while immobilizing and precipitating any metals in solution. Remediation on the surface and removal of the introduced fluids should not require more than a few years of state or federal regulation.

### *Conclusions*

Starting with the above Goliad County litigation, this matter was stirred into a State of Texas-U.S. EPA disagreement by an overly aggressive plaintiff attorney, and further stimulated by an Obama Administration intent on promoting renewable energy while being hostile to nuclear-power development (and associated uranium mining). We conclude that this disagreement resulted in proposed new federal regulations, and taken all together, constitute as what appears to many as a well-choreographed, large-scale plan to mislead the general public, and to hinder the development of an important natural resource, the use of uranium of which is climate friendly when used to fuel nuclear power plants for generating electricity along the U.S. power grid.

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**Update (January 9, 2016):** EPA has decided to: a) drop the 30-year monitoring requirement of ISR projects, b) install standard RCRA requirements, c) add specific criteria for termination of long-term stability monitoring, d) drop gross alpha particle activity from the list of constituent concentration standards, e) allow more flexibility for the NRC or Agreement States to determine constituent concentration standards on a site-specific basis, and f) clarify how these UMTRCA-based standards are complementary but separate from Safe Drinking Water Act requirements. (see [EPA Announcement](#)).

### **Now turning to the subject Sass 2011 report:**

Under **Section I. Introduction**.....page 3: in [Sass 2011](#) report:

“The most common method employed along the Texas Gulf Coast is called in-situ leaching (ISL). This method leaves the main body of the ore in place and removes the uranium by dissolving it in an appropriate solvent and then pumping it out of the ground. The solvent most commonly used is oxygen-saturated water containing an acid such as sulfuric acid or a base such as sodium bicarbonate.”

[The author displays a clear lack of knowledge and terminology involved in in-situ uranium recovery in referring to leaving the main body of the ore in place, whereas the ore is the uranium, and to claiming that sulfuric acid or sodium bicarbonate are used in the recovery process, whereas they are not used in Texas, but are used in Australia and Kazakhstan as indicated in the available literature available on-line. Only oxygen and carbon dioxide are used in Texas. Leaching solution should be referred to as a “lixiviant”, not a solvent. These statements render the Sass comments irrelevant and in error.]

"This type of matrix generally has associated groundwater."

**[Another sophomoric pretense of understanding of subsurface conditions by Sass....Uranium deposits amenable to ISR mining are always associated within groundwater. ]**

"ISL methods are attractive when the ore is of low grade and other methods are too expensive to be profitable."

**[ISL (actually called ISR) is not only attractive for low-grade uranium ore grade but also for medium- and high-grade ore. There are a number of factors involved in determining profitability of a uranium mining venture. Sass appears to be oblivious to these factors.]**

"The downside is that the associated groundwater away from the ore body could be contaminated."

**[Another sophomoric pretense of understanding of subsurface conditions by the author....The ore occurs within and always associated in groundwater. The ISR process maintains a series of cones of depression to prevent groundwater from flowing outside the mining area. The contamination of groundwater away from the ore body is a blanket, unsubstantiated assertion by Sass.]**

Bottom of first paragraph ....page 3:

"Although in-situ leaching is highly regulated both by the state and by the federal government, the regulations that have been followed for more than 30 years appear to be faulty and do not adequately protect the local groundwater from excessive contamination by uranium and radium. Showing that to be true is the main focus of this paper."

**[The claims highlighted are without foundation or basis, and illustrates the agenda of the author or whoever provided input to the author on these matters related to anti-uranium mining. Such statements should be referenced or discussed in more detail.]**

Top of page 4:

My interest in ISL mining and its problems was originally generated in response to a legal question concerning the validity of reported baseline values of certain chemical constituents, primarily uranium and radium, in the groundwater within a proposed mining permit boundary.

**[The question arises here as to why was the author (a chemist/biologist and Fellow in Climate Change by training and experience) asked to opine on geological and hydrogeological matters in the subject litigation? One answer might be so that the attorney could site a source addressing the specific issues of the case from a highly respected university, without concern for whether or not the source was qualified to opine on such matters.]**

Under **Section II. Uranium Mining in Texas** ...pages 4 to 8 of report:

“The story begins in the Trans-Pecos region of West Texas. Uranium occurs naturally within the rocks that form the Earth's crust, particularly in granite, volcanic ash, and volcanic lavas. Some deposits occur as uranium-rich veins that formed within granitic magmas, but many deposits are formed when oxidizing groundwater leaches uranium from igneous rocks. The uraninite ore (UO<sub>2</sub>) found in the sand layers of the Texas coastal plains is derived from uranium brought to the Earth's surface during intense volcanic activity in the Trans-Pecos region during the mid-Cenozoic era, approximately 48 million years ago. Over the following few million years, the volcanic ash and rock fragments eroded, mixing with sediments that eventually blanketed the Gulf coastal plain. **Uranium enriched groundwater, traveling perhaps a few feet per year, transported its radioactive cargo to where it was eventually precipitated between 15 and 30 million years ago in chemically reducing zones.** A reducing zone in the **aquifer strata** is **caused by significant amounts of sulfide (iron pyrites, for example) and/or organic material (natural gas and/or oil).** When **the moving groundwater** encounters the reducing materials in this zone, the soluble uranium undergoes a chemical reaction with these materials and precipitates in the pores of the sand, forming an **ore deposit.** These reducing zones are commonly found in areas **such as fault zones** where **decaying organic products collect and react to remove the oxygen from the system.** Soluble metal sulfates such as iron sulfate are also reduced to ores such as **pyrite that can also cause soluble uranium salts to precipitate as uraninite ore.** The ore remained, **hidden by its chemical nature,** until it was discovered just over a half century ago. All the while, the precipitated uranium ore was very slowly radioactively decaying through a series of elements, **including radium,** and finally to inert lead.”

**[The author has cited no technical sources for the geological discourse above, or in many sections of this report, and is opining based on his own opinion of such issues presented to the general public in the subject report of the Baker Institute. Aside from the fact the author is practicing geoscience without a license, the author's apparent Ph.D. in chemistry/biology could have provided a basis for his testimony regarding the biogeochemical processes involved in uranium's precipitation in “roll-front” deposits (Campbell, *et. al.*, 2007) but he chose not to discuss this important aspect or was not sufficiently aware of the basic issues involved.**

**The author even cited the above paper (top of page 9 of his report), but apparently didn't read it or comprehend the subject matter. If he had he would have been made aware that “roll-front” processes are driven by bio-geochemical processes, but as a biologist he missed or chose to avoid such considerations in his discussions of the chemistry of the processes. Particularly, there is no discussion of how the uranium was mobilized.**

**Sass does not consider that other reducing agents in much greater mass than pyrite in the aquifer, such as organic matter, is more likely the source of electrons for reduction of molecular oxygen in groundwater. Iron sulfate in any significant mass to create pyrite is not present on the oxidized side of the roll-front systems. He doesn't provide discussions or considerations on this important process to support his generalized assertions.**

**Regarding the geochemical discussion by Sass, he is obviously not aware that dissolved uranium is not occurring as a salt in the groundwater solution but as dissolved uranium oxide species and/or complexes with**

other aqueous ionic species, and only requires a reducing environment to precipitate within the porous media of the sandstone.

The likely purpose of his reference to faults is to reinforce the common adversarial assertions that growth faults are avenues for vertical or lateral migration of contaminants released by in situ mining beyond the regulated production areas threatening the drinking water in the aquifer used in the general area around mining projects. It should be noted that there has never been such a case of groundwater contamination reported via fault-related vertical migration to either the state or federal agencies, or discussed in the technical literature. Assertions by Sass are incorrect and without foundation or relevancy.

Further, and regarding other issues, why would organic products collect in a fault zone as asserted by Sass? Any such statements are incorrect on the basis that the zones change character with time and would be destructive of any organic products. Any in situ recovery circuit extending across a growth fault would be controlled by the induced flow from injection to production well. Groundwater flow is under total hydraulic control within the production areas.

The statements by author Sass are additional indications that he not only is continuing to practice geoscience in his discussions, he is also purporting to practice hydrogeology in discussing groundwater flow and in discussing the geological nature of the “reducing zone” and the process involved in uranium mineralization while making errors in fact and in interpretation, all without a single reference but opining with pretense of knowledge on the subjects involved.

The author uses the terms “ore deposit” incorrectly when he should have used “uranium mineralization” without projecting the connotation that the mineralization could be mined at current prices and costs to produce yellowcake. This is one of many indications that the author is pretending to know about such subjects but fails to understand the reality of uranium mineralization and mining. He attempted to downplay uranium operations in Texas but failed to mention the dramatic increase in uranium price and production in Texas during the period of 2009 to 2011.

In 2011, the earthquake in Japan caused serious damage to one plant and shuttering of all other nuclear power plant operations in Japan for safety inspections and clean-up, which created an oversupply of nuclear fuel and a major drop in price that has lasted since 2011. With the re-start of Japanese plants a few years ago, and with the rapid increase of new nuclear power plant construction in China, India, Korea, Russia, U.S., and 22 other countries, the prices (both spot and contract) are poised to increase to pre-Fukushima uranium prices are trending higher than before. The author chose to represent a negative view of the uranium mining industry in Texas, a view that was false and designed to reflect on the financial health of the industry. Actually, the uranium industry was very active in 2011 (Campbell, *et al.*, [2011, Mid-Year and Annual UCOM Reports.](#))

Sass discusses “reducing zones” but uranium mineralization is not usually found in the fault zones of the Gulf Coast, nor where “decaying” organic products collect and react to remove the oxygen from the system. The author doesn’t seem to recognize the difference between uranium deposits and uranium mineralization, the latter extending beyond South Texas into north Texas, and likely into Mexico. Whether such mineralization has formed in sufficient volume and grade to create an orebody suitable to recover by ISR or surface mining, remains to be seen. High-grade uranium in “roll fronts” is already known in the Brookshire area just west of Houston, Texas, and anomalous uranium and radium concentrations have been reported by the U.S. Geological Survey in the Houston, Texas area (Campbell, *et al.*, [2015](#), pp 22-25)

The uranium (and radium) anomalies are well known in the west-Houston area and are present in the Houston drinking water supplies from the Evangeline Aquifer, which is equivalent to the Goliad Formation, which hosts the uranium deposits to the south that are the subject of the litigation discussed above. The question then



arises that what industry is to be held accountable and culpable for the uranium (and daughter products such as radium, etc) known to be widespread in specific, well-known sedimentary units at depth along the Texas Gulf Coast? If no one, then what can be done about these natural contaminants in the groundwater in west Houston and elsewhere? There are home filters that can remove uranium and radium if operated and maintained properly. If radon gas is also reported in significant volumes, then venting at the private or MUD well is an appropriate solution to the problem. See Case History of Houston MUD investigations of excess natural gas ([more](#)).

Sass also claims that “soluble metal sulfates such as iron sulfate are also reduced to ores such as pyrite that can also cause soluble uranium salts to precipitate as uraninite ore”. These statements are patently false, misleading, and apparently misunderstood by the author; see (Campbell, *et. al.*, [2007](#), Figure 3 and associated references). Iron sulfates, etc. are reduced along with the uranium. The presence of pyrite is not the cause of uranium being reduced and precipitated.

There are at least 32 items over the next 16 pages of the author’s report carrying remarkably similar flaws, errors in knowledge, and lack of understanding of the issues involved. One that stands out deals with establishing a baseline database designed to indicate if and when uranium and radium might escape in the groundwater from the mining area. Aside from the fact that no reports have ever been reported to the state or federal governments that contaminants have escaped from any the ISR mining operations to date (as known by the reviewers of this subject report by Sass), establishing a rigorous procedure is an appropriate step to ensure such detections can be recognized in the future and measures taken to remediate the problem, should such develop.

The author spends many pages in an attempt to convince the reader that there is something wrong with the current State or Federal regulations regarding the establishment of a reliable baseline water-quality sampling and analysis of the resulting hydrochemical data. The author continues his attempts to practice geology before the general public, hydrogeology and even associated hydrochemistry by attempting to show that the current methods of establishing an ISR mine’s baseline of water quality parameters are in error, which they are not.

Aside from the fact that drilling does introduce some oxygen during the process of sampling, the impact is minor and the impact is quickly dissipated within the subsurface environment around the borehole. The results pale into insignificance, when compared to the small differences in concentrations relative to the very low concentrations of uranium and radium.

The confusion developed many years ago when the state mistakenly used the drinking water standard of the time as the baseline for pre-1980 ISR operations. This was later corrected by setting the actual pre-mining groundwater conditions surrounding the deposit to be mined as the appropriate background against which to judge if any excursions occur, which none have occurred to date.

This was neither acceptable to government nor industry because as knowledge grew about the behavior of the “roll-front” deposits, the more complex the “roll-fronts” configurations became. This presented problem as to where to place the boundary sentinel monitoring wells, and where to sample to establish a baseline database of groundwater hydrochemistry used to identify excursions of mining process liquids (groundwater) from within the regulated mining area.

These issues were known before 1977 in industry but were not understood widely by the regulatory community and hence were not reflected in the regulations promulgated at the time (see Campbell and Biddle, [1977](#), pp 33-36; and Campbell, *et al.*, [2007](#), pp 6-9.

The work of Hall, [2009](#), who was cited inappropriately in the Part 192 EPA discussions, concluded that:

“...in Texas, ISR mines are characterized by high baseline arsenic, cadmium, lead, selenium, radium, and uranium. After mining and restoration, for those well fields that reported “final values” in TCEQ records, more than half of the PAAs had lowered levels of many elements, including some that dropped below MCL.”

We concur with the view that Hall’s USGS report has been misunderstood by a number of readers. Anthony and Morris ([2014](#)) represents a mining industry’s view (Uranium Energy Corp. (UEC) of the report and discusses the important distinction between Amended Values and the Final Restoration Values. As the data in their paper shows, Final Restoration Values are invariably lower than Amended Values and they reflect the level of restoration actually achieved. There are just a few instances where the final restoration value is slightly higher than the amended value, and this could be due to typographical errors because final restoration values and stability values are intended to be at or below Amended Values.

A second misconception is that restoring to baseline somehow turns the groundwater into a quality that is fit for human consumption. This is not true. One of the key points made by Anthony and Morris is that all of the sites considered in the Hall USGS report significantly exceeded the primary drinking water standard for radium and nearly every site exceeded today’s primary drinking water standard for uranium. Therefore, returning groundwater quality to baseline does not make the water fit for human consumption. But their key question was whether the groundwater was effectively restored to baseline use and whether there are any negative public health impacts. Contrary to the claims of some (including those Sass (in the report under review here)), the data clearly support the industry’s long and successful legacy of effective groundwater restoration, meeting state and federal regulations (see [URI’s](#) response ([more](#)) to the George Rice ([2006](#)) Report).

Six issues were identified that remain to be discussed in Sass’s Section II. All involve incorrect assumptions, a lack of understanding of the processes involved or a blatant bias to advance the author’s and attorney’s litigation agenda. These will be treated at a later date if needed but we do not assume the responsibility in this review of informing the author, or the attorney, regarding the litany of errors, mistakes, obfuscation, and biased content present in this section of the report reviewed herein.]

Under **Section III. The Chemistry of Uranium Mining** .....pages 8 through 13:

[Fifteen issues were identified in Section III during this review. All involve incorrect assumptions, a lack of understanding of the processes involved or a blatant bias to advance the author’s and attorney’s litigation agenda. We do not assume the responsibility in this review of informing the author, or the attorney, regarding the litany of errors, mistakes, obfuscation, and biased content present in this section of the report reviewed herein. However, below are a few summaries of these issues:

One of these issues: such as p. 9, 3<sup>rd</sup> paragraph, transport does not generally occur over hundreds of miles in Texas coastal plain sediments. Sass provides no supporting reference to validate his assertion.

Another issue: p. 10, first paragraph, for Sass’ statement of “ambient conditions of hydrogen ion concentration, pH, ...” is misleading, as pH and Hydrogen ion concentration (activity) are the same.

Another issue: p. 10, last paragraph, feature 1. Hydrogen ions are not “used up”. It is the oxygen and uranium

that exchange electrons with oxygen combining with hydrogen ions to form water molecules. Sass mischaracterizes a relatively simple redox reaction. Description of the process is very poorly described and contains a contradiction in the subject paragraph, e.g.,  $\text{UO}_2$  is soluble, and in a previous paragraph,  $\text{UO}_2$  is stated as being “relatively insoluble. This represents a lack of fundamental knowledge of chemistry on the part of the author. This error continues into the first statement on page 11, characterizing  $\text{UO}_2$  as being insoluble.

Another issue: p. 11, first paragraph. This equation is useless without knowing the concentrations of significant parameters such as bicarbonate, phosphate, iron, and others for the construction of this equation.

Another issue: p. 11, 3<sup>rd</sup> paragraph, The author uses the term “oxygen tension” rather than partial pressure. Oxygen tension is a medical term and is improperly used in this context. Also, there is no purpose to presenting uranium equilibrium at 750 bar pressure and a temperature of 270 degrees centigrade. This is of no value as data to apply in any way to shallow groundwater conditions.

Another issue: p. 11, 4<sup>th</sup> paragraph, terms like “radio-decomposition” and “extremely radioactive” are inaccurate and misleading; should be referred to as radioactive decay products.]

Under **Section IV. The Goliad Uranium Project** .... pages 13 through 18:

[Seven major issues were identified in Section IV during this review. All involve incorrect assumptions, a lack of understanding of the processes involved or a blatant bias to advance the author’s and attorney’s litigation agenda. Five of these issues will be treated but we do not assume the responsibility in this review of informing the author, or the attorney, regarding the litany of additional errors, mistakes, obfuscation, and biased content presented in this section of the report reviewed herein.

The first of these issues: p. 13, 2<sup>nd</sup> paragraph, additional drilling expands knowledge of the size and grade of the natural resource; it does not increase the size of the resource.

Another issue: p. 15, 3<sup>rd</sup> paragraph, Sass presents three time series for a data set of monitor wells and discusses a “trend” for three data points in time which is unacceptable statistically as for a Mann-Kendall trend analysis to be adequate, typically eight time-series data points are required. Conclusive arguments without sampling statistics and QA/QC are invalid.

Another issue: p. 15, last paragraph, Sass presumes that oxygen was introduced into the formation during drilling and conditioning of the well, however, he presents no evidence or data that oxygen was introduced or that its stability in the aquifer was long enough to affect redox sensitive species in the groundwater. This is an untested, unproven hypothesis that does not allow a conclusion to be drawn from these observations. Also, no discussion of sampling procedures of the wells and QA/QC of samples are discussed to determine if proper techniques of micro-purge pumping of each well was performed until fugitive parameters such as temperature, pH, specific conductance, dissolved, oxygen, and redox potential were stable enough to collect the representative sample of the groundwater at each screened location in the aquifer.

Another issue: p. 16, first paragraph, Sass states that some 150,000 gallons of produced water was removed in two aquifer tests and returned to the formation after absorbing atmospheric molecular oxygen when stored at the surface. Thus Sass supposes that all this oxygenated water was returned to the aquifer, changing the redox state sufficiently to dissolve uranium from the solid phase, although he has no data of oxygen in groundwater or produced water, nor was any post aquifer test groundwater hydrochemistry data provided.

In fact, the produced water (after processing plant) was injected into a registered disposal well in a much deeper formation, thus his assertion that the oxygenated produced water caused dissolution of uranium in the

aquifer is completely false and deserves no further consideration.

Further, the data of subsequent samples for dissolved uranium include no presentations of complete chemical analyses of the groundwater and presumes to present viable trend analyses using only 3 time-series data points. To show that a geochemical condition exists that can cause a significant change in dissolved uranium in groundwater would require complete data from each well, including redox species, QA/QC from those analyses, and a time series of data of at least eight series of samples to assess statistically valid trends in the data collected. As presented, these results are insufficient to make any conclusions about trends of dissolved uranium.

Another issue: p. 17, 2nd paragraph, the conclusion presented in the first sentence and beyond that methods used are unacceptable is itself biased and unacceptable as no data of groundwater redox states are provided showing dissolved oxygen and oxidation reduction potential, and insufficient time series data are used to assess trends inappropriately. Subsequent arguments based on his geochemical analysis of a possibly impacted groundwater resource are inappropriately drawn and should be considered as mere speculations and assertions unsupported by requisite data analyses, and thus the conclusions and recommendations of these suppositions are biased and should be ignored as being incorrect and irrelevant as stated in the Sass report.]

Under **Section V. Additional Considerations Relating to Other Similar Mines** ..... pages 19 through 20:

[Six additional issues were identified in Section V during this review. All involve incorrect assumptions, a lack of understanding of the processes involved or a blatant bias to advance the author's and attorney's litigation agenda. These will be treated at a later date if needed. We do not assume the responsibility in this review of informing the author, or the attorney, regarding the litany of errors, mistakes, obfuscation, irrelevant, and biased content present in this section of the report reviewed herein.]

Under **Section VI. Conclusions** .....page 21

The author simply concludes conclude that, "because of a flawed recommended drilling procedure, oxidation of uranium ore bodies regularly occurs during baseline concentration measurements to obtain a mining permit. Introduced oxygen causes uranium ore to dissolve, thereby artificially elevating concentrations of uranium in water samples from the test well locations. The process of dissolving uranium also liberates radium that would otherwise remain in the intact ore body.

[The principal conclusion of the author indicates that he does not understand the issues involved, or has manufactured such nonsense as legal misdirection for purposes currently unknown. Baselines for ISR mining operations are simply established by drilling a number of monitoring wells within and surrounding the anticipated operations at depths equivalent to (and above and below) the unit(s) being mined followed by sampling the groundwater at time intervals to be stipulated by rule or regulation. As mining then continues, sampling of the sentinel monitoring wells also continues. In the event of an excursion (or change in hydrochemistry) that could be related to the mining operation, although highly unlikely, remedial pumping systems would be installed to hold the excursion fluids from moving out of the mining area.

It should be noted that in the many of years of ISR operations, no ISR operations have reported an excursion. And since the early 1950s, uranium has been continually mined initially by open-pit mining followed by

conventional milling to produce “yellowcake” which is processed to produce fuel for nuclear power plants. In the early 1970s, a new environmentally sensitive means of extraction was developed in South Texas addressing concerns about the disturbance of the surface of the land, dewatering portions of the aquifer to enable men and equipment to work beneath the surface, and later forming vast areas of mill tailings from the processing of ores. It was at this time that South Texas gave birth to In-Situ Recovery (ISR) and the U.S. has since been the ISR center of the western world with the technology now also being applied elsewhere in the world.

UEC ([2015](#)) has gathered aerial photos compiled from archived and recent photographs, as well as satellite imagery over a decade of licensed ISR operations in South Texas. In each case, groundwater was restored consistent with baseline quality and approved by the TCEQ. Subsequently, each wellfield and all associated physical structures and equipment were reclaimed and the land returned to the surface owner for “unrestricted use.” Surface reclamation was regulated and final approval was overseen and approved by the TCEQ. These illustrations show either cleared land supporting cattle operations and/or reclaimed brush suitable as nature habitat.

Background baseline sampling goes one step further into providing protection around the ring of sentinel monitoring wells by creating a sampling database. These data serve as a basis for closure after mining indicating that the oxygen has been removed as much as possible through chemical adjustment of groundwater hydrochemistry in the mined area thus creating reducing conditions which decreases the migration of metals and other constituents. Similar, but more practical issues were addressed almost 10 years ago regarding the typical concerns of citizens living in the general area of the in situ uranium mining operations ([more](#).)]

Then finally, the author states that ....“There is a high probability that the test well water is contaminated with a concentration of uranium higher than the true baseline value due to the presence of oxygen in the test well and subsequent reactions. It is simply inappropriate to disrupt the system in order to obtain baseline data.”

[It should also be noted that the conditions in the area surrounding all water wells change during a period of pumping and then return to the so-called “static” (actually dynamic) water-level conditions, as would be anticipated with the above “test” well and associated calculations of the author. Also, the change in hydrochemistry would likely be statistically small and likely not repeatable with additional sampling because of the re-establishing of physio-chemical equilibrium within the groundwater system. In a preliminary study of a shallow underground uranium mine in Wyoming (Morton Ranch), one of the reviewers examined the difference in hydrochemistry between the oxidized side and reduced side of the “roll front” (Campbell and Biddle, [1977](#)). See Table 1 below:

Based on this preliminary data, the hydrochemistry of  $U_3O_8$ , copper, strontium, iron (Total), and pH show remarkable differences between the groundwater within naturally oxidized sediments and for samples from within reduced sediments (see table below). However, without a complete assessment and comparison of the groundwater chemistry from within and around other roll-front uranium deposits, the implications are only preliminary but consistent with expectations.

The problem is that the reduction interface boundary is often difficult to locate on the surface because of the sinuous nature of the boundary. Establishing baselines can become problematic (see Campbell and Biddle, 1977, Figure 1b (PDF page 5) and Campbell, *et. al.*, [2007](#), page 7) because sentinel monitoring wells surrounding production areas may be installed through an unanticipated interface boundary and away from

the production area has only partially developed but has elevated hydrochemistry as an indication that the natural biogeochemical cells are active. This condition would be likely apparent while drilling the sentinel monitoring wells. Districts may have slightly different hydrochemistry, but there would be similarities to that generally reflected in the table below.

**Table 1**  
**Morton Ranch Underground Uranium Mine, Wyoming**  
**Preliminary Hydrochemical Survey\*\*\***

(From Campbell & Biddle, 1977, p.8)

Groundwater Constituent Sampled:	Oxidized Zone of "Roll Front":	Reducing Zone of "Roll Front":
U <sub>3</sub> O <sub>8</sub> (ppb)	175	11
SO <sub>4</sub> (ppm)	186	191
Cu (ppb)	1-9 **	66
Co (ppb)	1-9 **	ND*
As (ppb)	1-9 **	1-9**
Se (ppb)	1-9 **	1-9**
Sr (ppb)	1,500	450
Fe (Total) (ppb)	1-9 **	200
pH	6.2	6.7

\*Not Detected

\*\* Threshold of Detection

\*\*\* Groundwater Samples Obtained after Achieving Stable Field Parameters from Two Developed Monitoring Wells Screened in Mineralized Part of the Aquifer.

A comprehensive multi-state study of the hydrochemistry in areas of potential uranium mineralization was conducted during the [NURE program](#) of the mid-1970s (the data from which are now administered by the U.S. Geological Survey). These data clearly show that uranium and other radiogenic constituents exceed drinking water MCLs occur over wide areas, not just in areas where uranium has been mined or is about to be mined. Groundwater quality can vary widely, Even in areas of known uranium deposits and districts in the U.S. where roll-front and other types of uranium deposits are known or suspected.. In the Houston, Texas area, for example, uranium, radium and radon have been reported in the drinking water by the U.S. Geological Survey and others that exceed drinking water MCLs (see Campbell, *et al.*, 2015, pp. 22-25).]

In his closing statement of his report he states that "better and less invasive methods can be developed that will ensure accurate baseline values of uranium and radium concentrations in the groundwater of the ore-body containing aquifer."

[Sass concludes with an unintelligible plea for less invasive methods to determine baselines. We conclude that existing state and established current federal regulations are sufficient to describe baseline values of uranium and whatever radium (and radon), reported by monitoring well sampling sites surrounding the known uranium mineralization, and that Sass has exaggerated the impact of drilling on establishing reliable pre-mining baseline hydrochemical surveys. Further, the existing exploration/production hole abandonment regulations are sufficient to seal the aquifer (and zone lateral to the mineralized zone).

**However, the most disturbing aspect of the Sass report is his blatant attempt to practice geoscience by distributing false information that impacts the human health of the general public and the environment, with the likely encouragement of the attorney involved. The Sass report illustrates that the author had neither the proper training nor experience or background to deal appropriately and accurately with the geological and hydrogeological principles involved in the litigation against the Texas uranium mining company. The report should therefore be discounted as irrelevant and immaterial to the issues involved.]**

**Original report by R. L. Sass:** <http://i2massociates.com/downloads/SassUraniumMining-032811Full.pdf>

Note 1: I2M reserves the right to make additions, revisions, and updates to reviews. Only the current version presents the Associates' positions on the matters discussed above.

Note 2: The opinions expressed in the comments presented in response to the published articles above are those of the individuals who conducted the reviews and not necessarily those of the owner of I2M Associates, LLC.

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