Technical Reviewers' Rating Summary

Proposal Number G-50-03 Application Title Study to determine th Submitted By ATCO Energy Solution
Request For $1,047,500.00 Total Project Costs $2,095,000.00

Section A. Scoring

Statement	Weighting Factor	G-50-03A	G-50-03B	G-50-03C	Average Weighted Score
1. Objectives	9	**4**	**3**	**3**	**27**
2. Achievability	7	**4**	**3**	**3**	**21**
3. Methodology	8	**4**	**2**	**3**	**24**
4. Contribution	8	**3**	**3**	**3**	**24**
5. Awareness / Background	5	**4**	**1**	**2**	**10**
6. Project Management	3	**4**	**3**	**2**	**9**
7. Equipment / Facilities	2	**3**	**2**	**3**	**4**
8. Value / Industry - Budget	4	**4**	**2**	**3**	**12**
9. Financial Match - Budget	4	**4**	**3**	**2**	**12**
Average Weighted Score		**190**	**126**	**138**	**151**
	Total: 50				**250 possible points**

OVERALL RECOMMENDATION

FUND	**X**		
FUNDING TO BE CONSIDERED			**X**
DO NOT FUND		**X**	

Section B. Ratings and Comments

1. The objectives or goals of the proposed project with respect to clarity and consistency with North Dakota Industrial Commission/Oil and Gas Research Council goals are:

   The objectives of the salt cavern study are very consistent with the OGRP goals and purposes. The proposal objectives align with the following OGRP goals: -Promote efficient, economic, and environmentally sound exploration, development, and use of North Dakota's oil and gas resources. - Preserve and create jobs involved in the exploration, production and utilization of North Dakota's oil and gas resources. -Maximize the market potential for oil, natural gas, and the associated byproducts produced therewith -Develop baseline information that will lead to other projects, processes, ideas, and activities.
   - Reviewer: G-50-03A
   - Rating: 4

   The concept of identifying locations that may be suitable for salt cavern development for hydrocarbon storage to support petrochemical industry investment is consistent with the goals and objectives of the OGRC.
   - Reviewer: G-50-03B
   - Rating: 3

The goal is to determine the viability of solution mining storage cavities within existing underground salt formations in the Williston basin, for the purpose of storing feedstock natural gas liquids, and the products of a potential petrochemical industry. Access to this type of storage is beneficial in attracting the petrochemical industry to the area.
- Reviewer: G-50-03C
- Rating: 3

2. With the approach suggested and time and budget available, the objectives are:

The proposed approach, timeline, and budget all appear reasonable to accomplish the stated objective. Additional efficiencies may be gained through collaboration with ND Geological Survey staff and existing assets (core samples, mapping, etc)
- Reviewer: G-50-03A
- Rating: 4

Given the amount of money being requested by the applicant, there would certainly be a large enough budget available to support the proposed objectives.
- Reviewer: G-50-03B
- Rating: 3

Budget and timing seems reasonable, with possible limiting factor of timing coordination with an existing oil well drilling operation that is located in the proposed area of investigation for salt cavern solution mining.
- Reviewer: G-50-03C
- Rating: 3

ATCO is committed to collaborating with the North Dakota Geological Survey team throughout the project to streamline information exchange and complete the project efficiently. Prior to submitting the proposed study for OGRC funding, ATCO completed preliminary work to evaluate the potential for development of salt caverns in North Dakota. During this preliminary work, ATCO consulted with the North Dakota State Geological Survey staff and reviewed the information available for the salt core that resides in the State’s core library. Coordination of salt core retrieval from a well that is being drilled for oil production would result in significant cost savings over drilling a well explicitly for the salt study. During the project, ATCO will actively work with producer companies in the area to identify potential drilling targets that would coincide with the area of interest for cavern development.
- Applicant

3. The quality of the methodology displayed in the proposal is:

The proposed methodology is well outlined and appropriate for the stated goals. Additional application references to existing NDGS geologic expertise and Core Library assets would have been beneficial.
- Reviewer: G-50-03A
- Rating: 4

There could be more clarity with respect to the number of potential salt cavern development areas that they intend to evaluate. For example, they state that they are going to obtain and review seismic data to correlate with well logs to confirm the salt zone extents, but they don't give any clarification with respect to how many locations they may be able to evaluate. Given that they are only planning on collecting core from one location, I would be concerned that the goal of the Phase 2 effort more focused on identifying and verifying the suitability of a single location that they can target for further commercial development by ATCO, rather than on performing a more detailed assessment of possible locations across western North Dakota. For

example, the costs for collection of core from a single location are quite high. Have they evaluated the potential availability of core or drill cuttings from the core library? Cuttings could be used to assess the mineralogy of various salt formations from multiple locations to assess their suitability for solution mining. There is no mention of whether or not they will assess the available of the water supplies needed for solution mining, which is a critical component of solution mining.
- Reviewer: G-50-03B
- Rating: 2

The methodology provided doesn't provide a high level of detail in regard to the actual testing and modeling that will be performed.
- Reviewer: G-50-03C
- Rating: 3

In its preliminary evaluation, (completed prior to this application), ATCO worked with NDGS to determine if there are any existing salt cores in the library and found that there is only one core from a zone of salt in Western North Dakota. The single salt core is from a zone and location that is not favorable for cavern development. ATCO also worked with Neset Consulting to obtain salt drill cuttings from a well that was being drilled for oil. The cuttings indicated good, clean salt, and validated the log interpretation for the area, however are too small and not suitable for the geomechanical testing. Evaluation of drill cuttings from other future wells could be a valuable tool to correlate with logs. Phase 1 will focus on areas where this prior work conducted by ATCO (in advance of the application) identified salt deposits that fall within the minimum thickness, minimum areal extents, and maximum depth required for salt cavern development. There are currently fewer than ten potential locations identified as optimal for further evaluation. Further, the areas of focus include assessment of access to surface infrastructure required to sustain a hydrocarbon storage business, including: water, rail, and pipelines. Phase 1 will refine the geological mapping for the salts, will develop preliminary cavern mining models to determine the size and shape of potential caverns based on the thickness of the salt layers, and will develop geomechanical models to assess the stability of the potential caverns and identify any required changes to the potential cavern size and shape to ensure their stability. Phase 2 is designed to build upon the results obtained in Phase 1 and will require obtaining physical data from the salt formation to verify the results generated in Phase 1. The actual rock and salt cores will be tested to determine their strength, and other physical properties to be used in the cavern development models. The proposal to focus on a single salt location is due to the significant cost of the seismic and core collection and testing work. Data obtained from the Phase 2 work would be used to validate the general models developed in Phase 1.
- Applicant

4. The scientific and/or technical contribution of the proposed work to specifically address North Dakota Industrial Commission/Oil and Gas Research Council goals will likely be:

   The contribution of the proposed work has the potential to be extremely significant as value-added opportunities are explored in ND, but due to the requested confidentiality timeline, the conclusions would not be available for close to seven years from project initiation. That extended timeline certainly lessens the near-term significance.
   - Reviewer: G-50-03A
   - Rating: 3

   The results of the Phase 1 effort would provide a significant scientific and technical contribution to the state and to the oil and gas industry if the results were made publicly available sooner than the 5 year confidentiality period requested by the applicant. The results of Phase 2 would also have value, but they appear to be so focused on further verifying a single location that the effort would be better suited for private funding, not state funding,

especially if the results are not disclosed in a timely manner.
- Reviewer: G-50-03B
- Rating: 3

This is a new area of research in the North Dakota portion of the Williston basin, although solution mining of salt bearing formations has occurred in the past. The most significant contribution will be identification of optimal prospect areas for the salt caverns, which may have a significant impact on the placement of petrochemical plants, gathering systems, etc.
- Reviewer: G-50-03C
- Rating: 3

Bulk storage capability for hydrocarbons is important for value-add petrochemical development. ATCO has requested an extended confidentiality period due to the long lead time needed for the development of the petrochemical industry and the significant financial commitment that ATCO will be making to the study. Earlier disclosure of the results of the study would compromise the value to ATCO of its contribution by making commercially sensitive information available to potential competitors. By participating in the Study with ATCO, the State will leverage the expertise of ATCO and its consultants to obtain detailed information on the process of developing salt caverns, and the cavern potential in North Dakota, on a cost shared basis. ATCO is open to discussing a four year confidentiality period from the start of the study, or specific provisions to ensure portions of the results which may be commercially sensitive have a longer confidentiality period while general results (such as salt mapping) could be made public.
- Applicant

5. The background of the principal investigator and the awareness of current research activity and published literature as evidenced by literature referenced and its interpretation and by the reference to unpublished research related to the proposal is:

   The background and experience of the applicant is above average. The applicant’s existing storage assets in Canada provides the needed experience to properly execute the proposal’s goals.
   - Reviewer: G-50-03A
   - Rating: 4

   Aside from a brief statement in the abstract about how the applicant believes that they may have identified some salt formation locations suitable for development of caverns, the authors make no reference to the geology of the Williston Basin. They don't discuss the potential suitability of any specific salt deposits or locations in the Williston Basin for solution mining, and, despite the fact that several studies have been performed on the geology of various salt deposits in the Williston Basin (i.e. - Nordeng, 2009; Fever and Fever, 2005), they reference none of the existing literature. Similarly, the authors do not reference any of the existing literature that describes the geologic criteria for solution mining of salt deposits for gas and/or compressed air storage. There are no references to any literature or existing studies cited in the proposal.
   - Reviewer: G-50-03B
   - Rating: 1

   Bob Armstrong, and ATCO Energy Solutions, Inc., have extensive experience with salt cavern storage of natural gas liquids in their operations in Alberta, Canada.
   - Reviewer: G-50-03C
   - Rating: 2

   In the development of both its preliminary work leading up to this application and the scope of the proposed study, ATCO relied heavily on published papers and presentations including: •

Notable Salt Intervals, Williston Basin ND, by Travis Stolldorf et al, 2019 • Salts in the Williston Basin, by Fever and Fever, 2005 • Compressed Air Energy Storage Feasibility in North Dakota, by Dakota Salts, 2011 • A Geologic Study to Determine the Potential to Create an Appalachian Storage Hub for Natural Gas Liquids, by Appalachian Oil and Natural Gas Consortium at West Virginia University, 2017 ATCO is not aware of any studies conducted by others for the purposes of developing salt caverns for hydrocarbon storage in North Dakota. Please refer to ATCO's response to Question 3 for additional comments on the general results of the preliminary work conducted by ATCO. Results from ATCO's preliminary study were not referenced in the application as the information is confidential and commercially sensitive.
- Applicant

6. The project management plan, including a well-defined milestone chart, schedule, financial plan, and plan for communications among the investigators and subcontractors, if any, is:

The outlined schedule and financial outline are appropriate for the proposed work. The separation of the work into two phases is very beneficial. More details would be helpful as to how a determination will be made whether to proceed to Phase 2.
- Reviewer: G-50-03A
- Rating: 4

There are no milestones listed in the proposal text. They state that regular communications will be held, but not with who.
- Reviewer: G-50-03B
- Rating: 3

Reasonable, but generic description of management process. Unclear what will occur with remainder of funding after phase 1, if results are not favorable for proceeding to phase 2. The majority of the budget funding commitment requested from the NDIC OGRP is assigned to phase 2 of the project.
- Reviewer: G-50-03C
- Rating: 2

ATCO will maintain regular communications and reviews with its consultants to ensure that the project remains on schedule and budget. Phase 1 is anticipated to take approximately 4 months and ATCO will provide a report to the OGRC upon completion of Phase 1 with a recommendation on whether or not to proceed with Phase 2 of the project. ATCO can also provide any interim communications or reports to the OGRC as deemed necessary (i.e. monthly update reports). If Phase 2 proceeds, ATCO will provide a report at least quarterly to the OGRC on progress of the project with a final report upon completion. The decision to proceed to Phase 2 will depend on several key factors. First, this decision will be dependent on the identification of at least one area as suitable for salt cavern development. Suitability for salt cavern development will be based on a number of critical factors including subsurface characteristics and location relative to enabling infrastructure like water, rail and pipelines. Second, Phase 2 will also be dependent on the availability of a drilling rig to 'piggyback' collection of salt and rock cores. The time required to find an available drilling rig has been estimated and is included in the schedule provided in the application . Finally, the decision on when to proceed to Phase 2 will also be dependent on the status of commercial interest in building salt cavern storage in North Dakota. Should ATCO decide not to proceed to Phase 2, this would not detract from the benefits that State would realize from the Phase 1 work, including information to support attracting petrochemical and other industries requiring salt cavern storage. If Phase 2 of the project does not proceed, then the earmarked funding would be available to the State to support other initiatives. ATCO assumes that the funding for Phase 2 would not be provided until Phase 1 has been completed.
- Applicant

7. The proposed purchase of equipment and the facilities available is:

While no major equipment or facilities are included in the budget, some concern exists as to any potential cost and time savings that the applicant may realize by utilizing existing core and drilling cuttings at the NDGS Core Library.
- Reviewer: G-50-03A
- Rating: 3

No equipment is being purchased through this effort. The applicant assumes that they will be able to identify an oil and gas producer who will allow them to collect core during their existing Bakken well drilling operations. Given that the applicant states in the abstract that in general, most of the deposits in the state aren't geologically suitable for salt cavern development but that they have identified some locations that might be suitable, it seems to imply that there are a limited number of locations where the concept might work. Hoping that they can find a producer in the right location that is drilling a well that will allow them to pause their drilling activities so that they can collect core is a risky assumption.
- Reviewer: G-50-03B
- Rating: 2

Doesn't appear to require any equipment or facility purchase.
- Reviewer: G-50-03C
- Rating: 3

The assumption that ATCO can work with a producer to ‘piggyback’ on core collection is an acceptable and manageable risk. We have allotted several months in the schedule to find a willing producer and obtain the cores. If this proves unfeasible, then Phase 2 would likely not proceed as the cost to ATCO of drilling a dedicated well for core retrieval ($3-$4 million dollars) would be difficult to justify given the commercial uncertainty. If a potential commercial cavern opportunity could be secured, ATCO would request funding from the State to participate in drilling the test well to complete the Phase 2 objectives. Ultimately, ATCO believes all parties involved would gain beneficial information from Phase 2 of the study. The majority of Phase 2 costs would be incurred upon commencement of drilling following identification of a producer willing to support core sampling. If drilling doesn’t proceed then the costs not incurred for the remaining portions of Phase 2 would be available to the State to re-direct to other funding opportunities. ATCO assumes that the funding for Phase 2 would not be provided until Phase 1 has been completed.
- Applicant

8. The proposed budget “value”1 relative to the outlined work and the commitment from other sources is of:

The applicant, and proposed consultants, have a tremendous amount of expertise and could provide very good value for the industry and government of ND. The budget figures appear to be in line with industry standards.
- Reviewer: G-50-03A
- Rating: 4

The value of the Phase 1 work is consistent with the allocated budget amount. The budget value of the Phase 2 scope of work is not very high when you consider the overall value to the state and the fact that the applicant is unwilling to share results for a period of 5 years. This is not consistent with the immediate need for solutions to address produced gas flaring issues and curtailed oil production. Also, it appears as though the overall goal of Phase 2 is to verify the suitability of a single location. It seems like the costs for conducting a detailed assessment of a single location should be assumed by the private sector or commercial entity that intends on developing the site.

- Reviewer: G-50-03B
- Rating: 2

The value of the project is reasonable, but the 5 year request for confidentiality is significantly longer than most projects. However, it is understandable, considering the long lead time they may be facing in regard to approval of a petrochemical plant needing the construction of a salt cavern.
- Reviewer: G-50-03C
- Rating: 3

The development of salt caverns, and a petrochemical industry, is not a short term solution to flaring or curtailed oil production. The ability to develop salt caverns supports the potential for a petrochemical industry, which would enable increased oil production and bring significant economic benefit to North Dakota in the longer term. As the petrochemical industry is a significant consumer of ethane, a Petchem industry in the state would greatly alleviate the pipeline constraints, which should translate to long term flaring reductions. In order to confirm that salt caverns can be developed economically and with acceptable levels of risk, the results from Phase 2 of the study are required . The Phase 1 results will determine if developing salt caverns is possible. The Phase 2 results will lead to significantly higher confidence in cavern development potential and costs, which will be a major consideration for a petrochemical company to invest in North Dakota. ATCO has designed the study to minimize costs where possible, including selecting a single field location for the Phase 2 work even though more than one suitable location for cavern development may be identified. The results from the Phase 2 work at a single location can be applied to other locations in the vicinity and used to support the assessment of salt cavern potential in other areas.
- Applicant

9. The “financial commitment”2 from other sources in terms of “match funding” have been identified:

The applicant’s financial commitment is the minimum 50%. Additional value is provided by the applicant’s existing position in the industry and the team of consultants that have been selected.
- Reviewer: G-50-03A
- Rating: 4

The cost share for the proposed effort is exactly 50% of the overall cost. The cost share will be provided primarily in the form of cash by ATCO, with a small amount of in-kind cost share.
- Reviewer: G-50-03B
- Rating: 3

Their contribution to the project cost requires the inclusion of estimated in-kind value for their services to reach the minimum required 50% matching contribution.
- Reviewer: G-50-03C
- Rating: 2

ATCO proposes that the results of the study will significantly advance the State’s knowledge of the process and potential to develop salt caverns for storage and that this will contribute to the broader State goals of expanding the hydrocarbon value-add industries in North Dakota. The ATCO team brings substantial working knowledge of salt cavern development and operations and will be integrating the works of the individual consultants to develop the overall assessment and conclusions about the feasibility of developing salt caverns in North Dakota.
- Applicant

1 “value” – The value of the projected work and technical outcome for the budgeted amount of the project, based on your estimate of what the work might cost in research settings with which you are familiar. A commitment of support from industry partners equates to a higher value.

2 “financial commitment” from other sources – A minimum of 50% of the total project must come from other sources to meet the program guidelines. Support less than 50% from Industrial Commission sources should be evaluated as favorable to the application; industry partnerships equates to increased favorability.

General Comments

From a research perspective, the application has significant potential to answer some key questions as ND continues to pursue value-added NGL opportunities. The one significant hurdle is the extended confidentiality timeline. In the “Standards of Success” section, the applicant notes, “These results can be immediately used for economic development and by the state’s industrial commission to attract value-added investment to the state.” The extended confidentiality request pushes the public release of the results out five years, on top of the roughly two years it would take to fully complete the work. This timeline significantly reduces the value to ND, as gas capture and NGL value-added investments are immediate needs and cannot wait seven years before information is publicly available. Along with the concerns surrounding the confidentiality window, the other two items that may need addressing include; 1) the potential inclusion or collaboration with the NDGS to streamline existing state data and knowledge transfer, 2) A clear method of determining the necessity of Phase 2 after the initial Phase 1 work is complete. With the items above addressed, I would recommend funding the project.
- Reviewer: G-50-03A

The primary shortcoming of the proposed work is the applicant's request to keep the results of the effort confidential for a period of 5 years following completion of the study. Thus, given the proposed 20 month duration of the effort, it would be almost 7 years until the results of the study were made public. Given the urgent and critical need for solutions to help the industry meet the state's gas capture requirements, including gas storage and petrochemical industry development, keeping the results of the proposed work confidential for that length of time would not help to address the short term needs of the state and the oil and gas industry. The overall concept of evaluating the feasibility of salt cavern development in western ND is a good idea and would be a good use of OGRC resources. Phase 1 is consistent with that concept, and the proposed effort would provide value to the state and to the oil and gas industry, IF the results were made publicly available within 1 year following completion of the work. The value provided by Phase 2 is questionable, given that it appears to be focused on identifying and further evaluating the suitability of a single site for salt cavern development. This seems like the type of work that should be funded by the private sector and not a good use of OGRC dollars. My overall recommendation for this effort is "Do Not Fund".
- Reviewer: G-50-03B

This project has the potential to produce important data, necessary to encourage the entry of a petrochemical industry to North Dakota, but some discussion may be warranted regarding the extended confidentiality period. Even better would be the inclusion of a petrochemical industry partner, and a commitment from an oil and gas well operator concerning the coring activities.
- Reviewer: G-50-03C