



December 3, 2021

Ms. Karlene Fine
Executive Director
North Dakota Industrial Commission
ATTN: Oil and Gas Research Program
State Capitol – 14th Floor
600 East Boulevard Avenue, Department 405
Bismarck, ND 58505-0840

Dear Ms. Fine:

Subject: EERC Proposal No. 2022-0077 Entitled “iPIPE 2.0”

Attached please find an original and one copy of the subject proposal. This proposal replaces Energy & Environmental Research Center (EERC) Proposal 2022-0050, submitted to the North Dakota Industrial Commission (NDIC) on November 1, 2021. Our corporate members are enthusiastic about continuing to explore and develop new technologies that enhance pipeline integrity and safety through iPIPE (intelligent Pipeline Integrity Program) 2.0. Prior work has vetted over 110 technologies and selected six technology companies to develop and demonstrate nine projects. iPIPE 2.0 continues the momentum to advance technologies that reduce the frequency and duration of pipeline releases.

iPIPE is breaking new ground and growing. Since initiation in 2018 with five members, iPIPE 2.0 has grown by over 50%. iPIPE was recognized for innovation and stewardship with awards from the Williston API (American Petroleum Institute) and the Interstate Oil and Gas Compact Commission, respectively. Technology projects have succeeded: INGU, Direct-C, Sateletics, and Toku are providing commercial solutions because of iPIPE development and demonstration. We have launched sensors into space that are purposed for industry and provide greater precision and accuracy. Presently, the iPIPE Program is applying artificial intelligence to enable identification of leaks at any point within a pipeline system and interpreting data to analyze risk and provide prevention measures.

The program is needed to continue our journey to an era of zero pipeline releases. A flood of emerging technologies is waiting to compete in the selection process in 2022. It is important we continue momentum and engage with rapidly advancing technology. Our membership appreciates the scouting, quick turn-around time, and hands-on aspects of the program. iPIPE is a success for North Dakota and a demonstration of North Dakota leadership. We greatly appreciate the vision of the Oil and Gas Research Program (OGRP) in electing to recommend to the North Dakota Industrial Commission funding for iPIPE.

The EERC, a research organization within the University of North Dakota, an institution of higher education within the state of North Dakota, is not a taxable entity; therefore, it has no tax liability.

iPIPE is requesting support for a 2-year program from January 2022 to December 2023. The industry contribution is \$1,050,000 to be matched with \$400,000 from the OGRP. If you have any questions, please feel free to contact me by phone at (701) 777-5201 or by e-mail at dschmidt@undeerc.org.

Sincerely,
Signed by:

189378675E9944
Darren B. Schmidt
Assistant Director for Subsurface R&D
iPIPE Program Manager

Approved by:

DocuSigned by:

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Charles D. Gorecki, CEO
Energy & Environmental Research Center

DDS/rlo
Attachments

Oil and Gas Research Program

North Dakota

Industrial Commission

Application

Project Title: iPIPE 2.0

Applicant: Energy & Environmental Research
Center

Principal Investigator: Darren Schmidt, EERC

Date of Application: December 3, 2021

Amount of Request: \$400,000

Total Amount of Proposed Project: \$1,450,000

Duration of Project: 24 months

Point of Contact (POC): Darren Schmidt

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TABLE OF CONTENTS

Abstract	4
Project Description	5
Standards of Success	11
Background/Qualifications	12
Management	12
Timetable	12
Budget	13
Tax Liability	14
Confidential Information	14
Patents/Rights to Technical Data	14
Status of Ongoing Projects	14
Success Stories	Appendix A
Membership Terms	Appendix B
Resumes and Organization Qualifications	Appendix C
Commitment Letters	Appendix D
Budget Notes	Appendix E

ABSTRACT

Objective: The goal of the intelligent Pipeline Integrity Program (iPIPE) is to advance technologies that reduce the frequency and duration of pipeline releases.

Expected Results: iPIPE has vetted over 110 technologies, completed nine technology projects, and is achieving commercial impact. The initial membership of five has grown, and iPIPE has been recognized with two awards and over 100 media mentions. iPIPE 2.0 will build on the previous success, with seven members committed to the new program and a flood of emerging technologies waiting to compete in the next technology selection event. iPIPE 2.0 will further advance technologies that can detect integrity anywhere within a pipeline system and improve the accuracy, resolution, and frequency for monitoring pipelines from space with satellites that are streamlined for the industry.

Duration: The duration of the proposed program is January 2022 through December 2023. iPIPE members are committing to 2 years of funding at \$75,000 per year per member.

Total Project Cost: The request to the Oil and Gas Research Program is for \$400,000 to be matched to \$1,050,000 from iPIPE members. Additional in-kind is also anticipated to support the program.

Participants: The Energy & Environmental Research Center; Oneok, Inc.; Enbridge Inc.; DCP Midstream; Hess Corporation; Energy Transfer; TC Energy Corporation; and Marathon Petroleum Logistics.

PROJECT DESCRIPTION

The intelligent Pipeline Integrity Program (iPIPE) 2.0 builds on the success of the initial program, which began with five members in 2018. The program is a response to Governor Doug Burgum's challenge to eliminate pipeline leaks through innovation.¹ The program has been featured in the *Pipeline & Gas Journal*, *Society of Petroleum Engineer's Journal of Oil and Gas Facilities*, the *Pipeline Technology Journal*, and the *Pipeliners' podcast*. Over 100 media mentions have included iPIPE. The Williston chapter of the American Petroleum Institute awarded iPIPE for industry innovation in 2018 and the Interstate Oil and Gas Compact Commission honored iPIPE with the Chairman's Stewardship Award in 2019. iPIPE has demonstrated new commercial capability to monitor small-diameter gathering lines that could not previously be inspected with in-line devices. This technology has been commercially deployed in North Dakota and on over 300 pipelines for 100 customers in 15 countries. Smart sensors designed to deploy on specific segments of infrastructure have been advanced by the program and are in use. The ability to monitor from space has been improved with a phased iPIPE project to interpret satellite data and find leaks from oil, produced water, and methane. This work has led to launching sensors into space that provide greater precision and accuracy. Currently, iPIPE is applying artificial intelligence and machine learning to distinguish pressure signals that enable identification of leaks at any point within a pipeline system and interpreting operation and maintenance data to analyze risk and provide prevention measures. Success stories from iPIPE projects are provided in Appendix A.

iPIPE 2.0 will build on the previous success, with seven members committed to the new program and numerous technology providers anticipating future participation. iPIPE 2.0 will further advance technologies that can detect leaks anywhere within a pipeline system, and improve the accuracy,

¹ <https://www.ndoil.org/industry-responds-to-governors-initiative-to-improve-pipeline-technology-program-funding-approved-by-north-dakota-industrial-commission/>

resolution, and frequency for monitoring pipelines from space with satellites that are purposed for the industry.

Objectives:

The goal of the program is to advance technologies that reduce the frequency and duration of pipeline releases.

The objectives to achieve the program goal are as follows:

- Select at least two projects for demonstration from the technology-scouting efforts.
- Grow industry membership.
- Foster industry collaboration through monthly member meetings and an annual member forum.
- Advance technology to commercial application and demonstrate commercial deployment.

Methodology:

iPIPE achieves program objectives through collaboration with and coordination of industry members, technical contributions, and project management. The membership meets monthly and hosts a technology selection event and an annual member forum. A significant scouting effort is conducted by the Energy & Environmental Research Center (EERC) to screen technology, invite organizations to propose projects, and select proposals for review by the iPIPE technology selection committee. Monthly meetings provide updates on projects and an opportunity to conduct member business. The EERC coordinates member business and conducts the technical work to prepare for the technology selection event, member forums, and completion of research projects. The EERC is the contracting authority with the North Dakota Industrial Commission (NDIC) Oil and Gas Research Program (OGRP) and manages agreements with the member companies. Each industry member designates a representative with voting rights who provides guidance to the program. Members vote on technology selections and program recommendations. Industry members are expected to contribute experience and be hands-on,

offering facilities in which to demonstrate technology. The EERC provides expertise, coordinates projects and contracts, and assists in technology advancement and documentation.

iPIPE increases the chances for a project to achieve commercial deployment by scouting, screening, and applying criteria for technology selection. The EERC scouts for technology, providing a service to the iPIPE members to communicate and screen organizations that may qualify for iPIPE's technology selection event. The EERC maintains a database that continues to grow and includes more than 100 pipeline technology organizations. Qualifying organizations are invited to submit a proposal for the technology selection event. A technology selection event will be completed early in 2022. Technology providers become successful applicants if they are evaluated positively relative to the following:

- Likelihood the technology will improve leak prevention or leak detection.
- Likelihood the technology will be deployed on member assets.
- Ability for the proposed demonstration to be achieved within budget and schedule.
- The quality of the methodology to achieve the objectives and the scientific merit.
- Likelihood the demonstration will advance the technology toward commercialization.
- The technology provider is providing a high value to the program (in-kind support).

iPIPE members determine support for technology demonstrations based on the quantity and quality of proposals relative to program budget and objectives. The EERC contracts and manages technology projects with the awarded providers. Progress is discussed at monthly meetings, and decisions relative to the program are determined. Upon completion of projects, the EERC issues a report to members and updates the OGRP. Annual member forums are used to discuss technology and provide networking among organizations.

Organizations are eligible to join iPIPE if they are operators of wells or gathering, transmission, or distribution pipeline systems. Program terms are detailed in Appendix B. Contributions are provided annually at \$75,000 per organization per year. Member obligations are designated in an invoice

agreement between the EERC and the organization. Each industry organization selects a representative with one vote on any matter submitted to the EERC for a vote of the members. The representative may vote by proxy. Quorum is achieved by majority. The order of business for iPIPE meetings includes an agenda provided 1 week in advance to notify the membership of upcoming decisions. The meeting is called to order, a quorum is determined, and previous meeting minutes are read and approved. The membership is provided an update on projects, program finances, program development, and membership. Unfinished business, new business, and any other business for the good of the order is conducted followed by adjournment.

Anticipated Results:

iPIPE 2.0 is expected to build on previous success. Three technology selection rounds completed in the previous program are summarized in Table 1. Over 110 technologies were screened to ultimately produce nine projects with six companies after adjusting selections. iPIPE 2.0 will leverage the existing technology pool and conduct a technology selection event within the program. Technology selection is anticipated to produce a similar number of projects with a sharpened focus based on experience.

Table 1. Technology Screening and Selection

Date:	May 2018	Oct 2018	Oct 2019	Oct 2020	
	First Round	Second Round	Third Round	Fourth Round	Total
Invited:	7	21	62	58	120+
Proposals:	7	10	14	24	55
Presented:	7	9	8	10	34
Selected:	2	4*	2	2	10

* Two selections were unable to agree upon terms, so contracting did not occur.

Proposals presented to iPIPE 2.0 will include technologies that achieve a step-change in leak detection and leak prevention technology. iPIPE 2.0 will continue to advance applications for artificial intelligence and machine learning for internet of things devices and for satellite image-processing software. iPIPE 2.0 will build on our satellite experience to monitor pipelines from space with products that are streamlined for the industry. Sensors that provide greater accuracy and resolution are

anticipated to be launched in the next program. These additional launches are critical to increasing the frequency and speed of data collection specific to pipelines. The program is also anticipating operators of drone-based technology to propose projects that use beyond visual line of sight (BVLOS) and take advantage of North Dakota's investment in BVLOS infrastructure.

Efforts will continue to market and grow the program to add additional members and revenue. iPIPE 2.0 will begin with seven members and with an objective to grow membership, which provides additional revenue for technology demonstrations. iPIPE 2.0 will provide monthly meetings and an annual member forum to facilitate industry collaboration. Technologies are expected to achieve commercial deployment because of advancements from iPIPE support. Results from projects will be documented program reports.

Facilities: iPIPE members own and operate oil and gas pipelines and facilities, which are provided to demonstrate selected technologies. The EERC offers over 54,000 ft² of demonstration facilities that can accommodate a variety of technologies. The space allows for custom construction of new pilot-scale components to fit client needs.

Resources: The EERC provides direct labor, including a program director, a project director, a program manager, and project support for iPIPE activity. Additional support is provided through contract specialists, administrative support, and communications personnel. Personnel are dedicated throughout the program. Industry organizations provide a representative with direct input to program direction and manage additional specialized support for technology projects. Industry support is provided in kind. iPIPE offers significant value to participants in which technology providers are required to provide in-kind cost share. Support is subject to the technology provider's offering and capabilities.

Techniques to Be Used, Their Availability and Capability: The EERC provides technical expertise and field-sampling experience for off-site demonstrations. Mechanical design and modeling of equipment

and machinery is completed in-house, and the EERC machine shop provides fabrication capability. The EERC employs over 250 people available for technology projects.

Environmental and Economic Impacts while Project is Underway:

No environmental releases occurred during the previous program, and future work is not expected to impact the environment or require environmental permitting. Project demonstrations utilize local services, resulting in some local economic stimulation.

Ultimate Technological and Economic Impacts:

The advancement of technology to safeguard pipeline infrastructure and continuously improve leak detection and leak prevention is vital to North Dakota's economy. The oil and natural gas industry in North Dakota accounted for more than \$40 billion in gross business volume, nearly 60,000 jobs, and over \$3.8 billion in state and local tax revenues in 2019, according to the North Dakota Petroleum Foundation.² Pipeline infrastructure is critical to North Dakota's economy to competitively transport oil, produced water, gas, and natural gas liquids (NGLs). North Dakota is among the top three oil producers in the United States, producing over 1.1 million barrels of oil per day, 1.6 million barrels of produced water per day, and 3 billion cubic feet of gas per day, which includes approximately 700,000 barrels per day of NGLs.³ The demand for pipeline infrastructure is projected to grow, and iPIPE has invested over \$4 million to accelerate leak prevention and leak detection technologies. Continuing with iPIPE 2.0 will bolster existing efforts, incubate new emerging technologies, and provide the innovation needed to remain competitive.

² www.nd.gov/news/studies-highlight-impact-oil-and-gas-industry-north-dakotas-economy-counties#:~:text=The%20oil%20and%20natural%20gas%20industry%20in%20North,the%20industry%E2%80%99s%20substantial%20impact%20on%20North%20Dakota%E2%80%99s%20economy

³ www.ndoil.org/wp-content/uploads/2021/09/Thursday_Kringstad-NDPC-Annual-Meeting-Sep-23-2021.pdf

Why the Project is Needed:

As the chairman of the Industrial Commission, Governor Doug Burgum has stated, “We have a goal of zero leaks and spills.”⁴ This aspiration is yet to be achieved, and iPIPE 2.0 allows the continuation of the journey to an era of zero pipeline releases. iPIPE 2.0 is aligned with North Dakota’s initiatives to deliver robust economic diversification in unmanned aircraft systems and energy technology. Focusing on innovation, the program accelerates the growth and commercialization of technology specific to pipelines. A flood of technology providers is anticipating the next technology selection event; without iPIPE 2.0, momentum would be slowed and a North Dakota-based program to engage industry and technology entrepreneurs would cease to exist. It is important for iPIPE 2.0 to continue technology development, which ultimately decreases the risks facing the industry. Artificial intelligence, machine learning, satellite, and drone-based technologies are developing rapidly. iPIPE 2.0 is needed to provide the collaborative industry direction that streamlines the deployment of these technologies. The membership appreciates the technology scouting, quick turn-around time, and hands-on opportunity that iPIPE provides. The program has the track record and experience to continue success and cannot continue without the support of the OGRP.

STANDARDS OF SUCCESS

- **Technology Scouting** – The EERC will maintain a database of over 100 technology providers. Scouting efforts should result in at least ten successful invitations for proposals for the technology selection event.
- **Technology Selection** – Commercial deployment is expected for a percentage of the technologies supported by the program.
- **Deployment** –The iPIPE team will work to grow the present membership.
- **Membership** – The iPIPE team will work to grow the present membership

⁴ <https://news.prairiepublic.org/local-news/2019-12-18/eerc-led-project-aims-to-reduce-oil-spills>

- **Recognition** – The program will achieve recognition in industry journals or through awards.
- **Reporting** – The EERC delivers program reports to the OGRP and members according to a program schedule.

BACKGROUND/QUALIFICATIONS

With support from NDIC through the OGRP, the organizations participating in iPIPE 2.0 include Hess Corporation; Oneok, Inc.; Enbridge Inc.; DCP Midstream; Energy Transfer; TC Energy Corporation; MPLx; and the EERC. Industry members operate pipelines and include interstate assets. Organizational qualifications and resumes of key personnel are provided in Appendix C. The EERC’s team of dedicated professionals have decades of experience in technical disciplines, research contracts, project management, communications, and government affairs.

MANAGEMENT

iPIPE is managed by Darren Schmidt, Program Director; Austin McRae, Project Director; Michelle Olderbak, Program Manager; and project advisors, Tom Doll and Michael Warmack. The EERC is the contracting authority with the OGRP and engages in contracts with the technology providers. The EERC enters into agreements with the iPIPE members that outline the obligations of both parties. The EERC is obligated to the iPIPE membership and is responsible to align membership and OGRP priorities. The EERC manages project milestones and tracks progress, including financial monitoring and reporting to all parties. iPIPE coordinates and conducts a technology selection event and annual member forum and ensures that activities are on schedule by conducting monthly meetings. iPIPE projects are conducted under contracts with technology providers that specify project milestones tied to financial support.

TIMETABLE

The project period is January 2022 through December 2023, as shown in the timetable in Figure 1. Project activities and member commitments are for 2 years. The technology selection event will be planned for Quarter (Q) 2 2022. Technology selection is necessary early in the schedule to allow time to

Activity	2022				2023			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Technology Selection		*						
iPIPE Member Forum				*				*
Program Update to the OGRP				*				*
Quarterly Reporting	*	*	*	*	*	*	*	*
Comprehensive Final Report								*
Technology Contracting Period								
Member Financial Commitments	*				*			
Decision for Ongoing Program							*	
Completion of All Technology Projects								*

Figure 1. Project timetable.

complete demonstrations. Events are staggered as new members may join later. A decision regarding continuance and wrap-up is scheduled for the third quarter in 2023.

BUDGET

The total cost of the proposed effort is \$1,450,000 as shown in Table 1. \$400,000 is requested from the OGRP. Cost share is provided by iPIPE members totaling \$1,050,000. The program is expected to grow in membership and member contributions. In-kind cost share has not been specified in the proposal; however, in-kind cost share will occur on behalf of technology suppliers and from member support provided for technology demonstration. Current partner organizations have expressed a desire to continue participation in the program. Letters of commitment can be found in Appendix D, and contract modifications are in process with TC Energy, Enbridge, and Oneok. A budget is provided below. Budget notes can be found in Appendix E.

Project Associated Expense	NDIC Share (Cash)	Member Share (Cash)	Total Project
Labor	\$231,026	\$199,345	\$430,371
Travel	\$20,837	\$0	\$20,837
Supplies	\$8,420	\$0	\$8,420
Subcontractors - Technology Selection	\$0	\$700,000	\$700,000
Communications	\$135	\$340	\$475
Printing & Duplicating	\$147	\$315	\$462
Food	\$1,500	\$0	\$1,500
Laboratory Fees & Services			
EERC Graphics Services	\$2,835	\$0	\$2,835
Total Direct Costs	\$264,900	\$900,000	\$1,164,900
Facilities & Administration	\$135,100	\$150,000	\$285,100
Total Cash Requested	\$400,000	\$1,050,000	\$1,450,000

TAX LIABILITY

The EERC, a department within the University of North Dakota, is a state-controlled institution of higher education and is not a taxable entity; therefore, it has no tax liability to the state of North Dakota or any of its political subdivisions.

CONFIDENTIAL INFORMATION

No confidential information is included in this application. Confidentiality regarding research activity conducted under the program is handled in separate agreements between the EERC and the parties.

PATENTS/RIGHTS TO TECHNICAL DATA

No patents or rights are identified for reservation in the application.

STATUS OF ONGOING PROJECTS

The EERC is currently engaged in nine OGRP-funded projects as shown in Table 2. These projects are ongoing and current on all deliverables.

Table 2. Current and Ongoing Deliverables

Project Title	Contract Award No.
NDIC Emerging Issues	G-000-004
iPIPE: The Intelligent Pipeline Integrity Program	G-046-88
Underground Storage of Produced Natural Gas – Conceptual Evaluation and Pilot Project(s)	G-049-092
PCOR Initiative to Accelerate CCUS Deployment	G-050-96
Improving EOR Performance Through Data Analytics and Next-Generation Controllable Completions	G-050-97
FERR 3.2 – Produced Water Management Through Geologic Homogenization, Conditioning, and Reuse	G-051-101
Bakken Production Optimization Program 3.0	G-051-98
Hydrogen Energy Development for North Dakota	G-054-105
Field Study to Determine the Feasibility of Developing Salt Caverns for Hydrocarbon Storage in Western North Dakota	G-054-104



APPENDIX A

SUCCESS STORIES: SATELYTICS AND INGU

iPIPE SUCCESS STORIES

iPIPE projects are listed below. Highlighted is feedback from technology providers regarding commercial application and technology advancement. iPIPE projects are diverse, including advanced pipeline sensors, in-line detection, monitoring from space via satellites, and preventative technology. iPIPE 2.0 will build on the experience gained and continue advancing leak prevention and detection in North Dakota.

Direct-C: Direct-C provides a technology that can be used anywhere along pipelines or production equipment and is especially useful in high-consequence areas where additional monitoring is desired. The technology is applied where point sensors would miss leak detection. The sensor can identify a leak when a fluid interacts with the intelligent paint (mix of polymers and nanoparticles) that is applied to the sensor. The devices provide remote alarming through cellular and satellite communications.

“Participation in iPIPE allowed Direct-C to greatly advance our technology by providing the opportunity for product installations in the field. No amount of bench testing can simulate some of the unexpected challenges once products are in the field for extended periods of time. We were fortunate to have two great iPIPE partners (Goodnight Midstream and Hess) who allowed us to install our products, provided feedback, and helped us deal with unexpected events.

Based on the field data received, Direct-C was able to enhance our installation methods, product hardware, and alarm algorithms – all of which has made for a better end-product for our customers.

After our successful completion of the iPIPE program, Direct-C was engaged by an iPIPE member to monitor numerous locations of their network in North Dakota.

We have continued growing across the US with multiple customers and now have installations in Alaska, Alabama, Georgia, Louisiana, Maryland, Texas, New Jersey, Pennsylvania, plus many monitoring sites in Canada and Europe.”

INGU Solutions Pipers®: INGU provides a technology that enables in-line inspection of gathering lines that do not typically benefit from conventional pigging and inspection operations. The sensor can examine wall thickness and deposits and can detect leaks. The sensor is a golf ball-sized (1.5-inch), free-flowing, adjustable weight, sensor that measures pressure, temperature, position (acceleration/rotation), magnetic fields, and acoustics.

Feedback from INGU indicated that iPIPE has provided the following:

- *Unique opportunity to demonstrate the Pipers capability in operational pipelines*
- *Real-world experience of the capabilities of Pipers in operational pipelines*
- *Verification and further development of launch and receive methods*
- *Opportunity to validate repeatability between free-floating and cleaning pig deployments*

INGU has deployed commercially in North Dakota and inspected over 300 pipelines for over 100 customers in 15 countries and built a network of nine agents.

Satelytics – An Eye in the Sky: Satelytics specializes in obtaining and interpreting satellite data to monitor assets and find leaks. Data can also be acquired from aircraft and drones. iPIPE members have learned what satellite technology can provide to our industry, and present work is exploring the ability to monitor and measure land movement and erosion at river crossings using stereo pair imaging.

Feedback from Satelytics regarding commercialization:

“We often state that iPIPE was beneficial in providing copious amounts of data to train our algorithms. With 3 years of weekly monitoring, our algorithms were provided with an extensive training opportunity.”

Satelytics has deployed commercially in North Dakota on the Pelican Pipeline system.

“Satelytics has engaged in numerous deployments outside of North Dakota since participation in iPIPE. BP has numerous projects with us worldwide focused on methane measurement, leak detection, chemical measurement, and carbon accounting. Duke Energy became our largest customer this month, monitoring a large portion of their East Coast footprint for methane emissions. We currently have more than a dozen active projects with companies such as BP, Duke, South Florida Water Management District, ACRT, Fortis (Canada), Central Hudson Gas & Electric, Washington Gas, First Gas (New Zealand), Pelican Pipeline, Southern Company, ADNOC (Abu Dhabi), SoCalGas, ItalGas (Italy), Oxy, Dominion Energy, and others. A partnership of Duke Energy–Accenture–Microsoft is actively promoting the use of Satelytics under an agreement with us.”

OSK (Orbital Sidekick): OSK provides an industry-purposed solution for monitoring from space. OSK’s advanced hyperspectral sensors provide greater accuracy and precision than presently deployed technology. OSK intends to populate a satellite constellation and develop tools that provide near-real-time data frequency that meets commercial demand. iPIPE launched into space with OSK on June 30, 2021. Commissioning and first imaging are presently under way.

TOKU: TOKU provides point-pressure sensors and high-frequency data collection coupled with machine learning to identify and locate leaks anywhere in a pipeline network. Through iPIPE, this project is working to distinguish operational signals from leaks using artificial intelligence that can expand our ability to “see” the pipeline beyond traditional pressure sensing. Two iPIPE members participated in demonstration, with one member purchasing instruments for the advanced internet of things (IoT) capability.

Pipeline-Risk: Pipeline-Risk provides a machine learning, artificial intelligence system that can be used to predict points of failure in a pipeline before they occur. This project is exploring how asset data can be processed to advance risk assessment.



INTELLIGENT PIPELINE INTEGRITY PROGRAM



SUCCESS STORY No.1

iPIPE Selection of Satelytics

In May 2018, iPIPE held its first technology selection event, hosting seven technology providers from around the world. The technologies presented included novel external leak sensors, advanced drone-based pipeline monitoring, miniaturized smart pigs, and earth-orbit monitoring solutions. iPIPE members openly expressed excitement in the first round of technology choices, saying that they would fund every one if they had the financial resources to do so.

Of these first seven emerging technologies presented, iPIPE selected two technologies for its inaugural efforts to assist in development of new tools for pipeline operators: Satelytics and Ingu Solutions' Pipers®.

Satelytics is a cloud-based software suite that applies proprietary algorithms to multispectral imagery, resulting in the identification, location, and measured concentrations of chemical constituents. Satelytics applies artificial intelligence and machine learning to positively identify liquid pipeline leaks. Satelytics is able to process data from a variety of sources, including satellites, drones, stratospheric balloons, airplanes, fixed cameras, or any combination of data sources.



Figure 1. Example of Satelytics Leak Detection

Three Phases of Development Activities with iPIPE

Satelytics has achieved repeated success with iPIPE, obtaining something the program did not anticipate: three successive awards for development activities. After three phases of development work to mature the product, iPIPE members believe that Satelytics can be an effective tool for use by pipeline operators.

Phase I (2018)

- ▶ Feed existing hydrocarbon detection algorithms with a large quantity of data over 16 weeks.
- ▶ Provide groundtruthing to improve algorithm accuracy.
- ▶ Develop new brine detection algorithm.

Phase II (2019)

- ▶ Continue improving accuracy of hydrocarbon algorithm.
- ▶ Feed data to new brine algorithm.
- ▶hone the functionality of a new mobile platform to enable use in low cellular coverage areas.

Phase III (2020)

- ▶ Continue improving accuracy of hydrocarbon and brine algorithms.
- ▶ Investigate accuracy in winter months.
- ▶ Explore use of hyperspectral instruments.
- ▶ Demonstrate drone data pathway.

Real World, Real Results

During three separate 16-week monitoring campaigns, iPIPE subjected Sateletics to blind tests that simulated leaks of varying sizes, shapes, locations, and fluid types. Sateletics performed well, and the data provided served to validate the capabilities and limits of Sateletics technology.

During these campaigns, iPIPE members also experienced real leaks from pipelines and other oilfield hardware. Sateletics also captured these leaks, resulting in significantly diminished cleanup costs. In one instance, the pipeline operator (who is also a founding member of iPIPE) reported that the identification of a 400 barrel leak, because it was caught early, potentially saved the company more than a million dollars in remediation costs that would have resulted had the impacted soil continued to grow in size.

Thus, the mission of iPIPE — to put new tools into the toolbelts of pipeline operators — had its first success. This tool has been validated with real-world results, both staged and inadvertent. The members of iPIPE are pleased that their efforts have helped to develop this advanced tool.

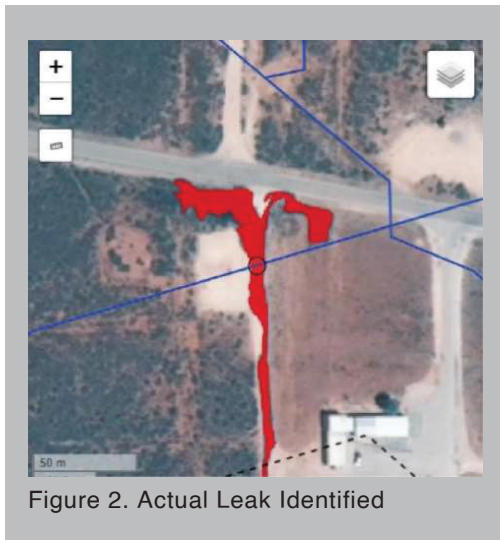


Figure 2. Actual Leak Identified

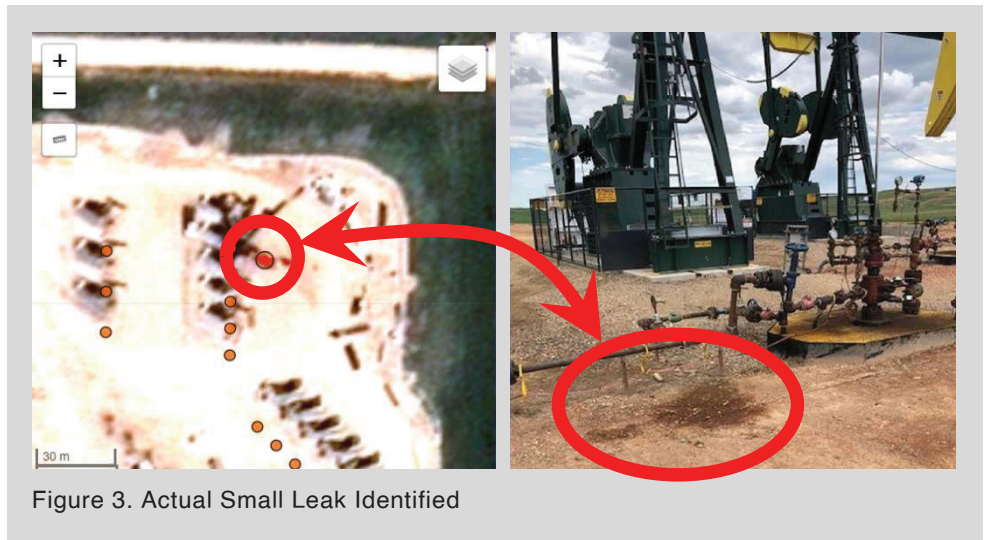


Figure 3. Actual Small Leak Identified

iPIPE Development Leads to a Potential Global First?

Sateletics has achieved repeated success with iPIPE. Each year of success has matured the technology to the point where it is now ready for wide-scale commercial application, due, in part, to the efforts of iPIPE members to co-develop this technology.

In fact, several iPIPE members are now behind an effort to apply Sateletics monitoring of oil and gas assets across the state of North Dakota using a first-of-a-kind model that shares costs across many oil and gas companies to achieve a service cost approximately equivalent to currently used aerial services for monitoring of pipelines and oilfield assets. This approach promises not only cost neutrality, but also greatly improved accuracy and history functions to positively identify ownership and history of issues revealed by Sateletics. The model will likely spread to other areas of the nation once the commercialized application proves beneficial in North Dakota.

For more information, please contact Darren Schmidt at dschmidt@undeerc.org or at 701.777.5201

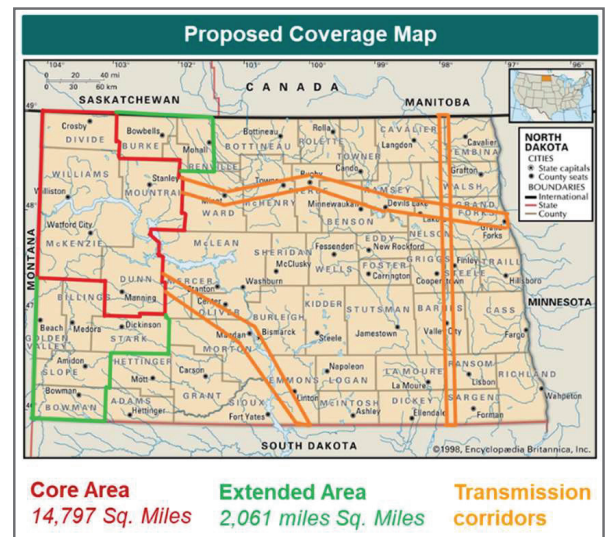


Figure 4. Proposed Areas for Commercial Monitoring

iPIPE Selection of Ingu Solutions

In May 2018, iPIPE held its first technology selection event, hosting seven technology providers from around the world. The technologies presented included novel external leak sensors, advanced drone-based pipeline monitoring, miniaturized smart pigs, and earth-orbit monitoring solutions. iPIPE members openly expressed excitement in the first round of technology choices, saying that they would fund every one if they had the financial resources to do so.

Of these first seven emerging technologies presented, iPIPE selected two technologies for its inaugural efforts to assist in development of new tools for pipeline operators: Satelytics and Ingu Solutions' Pipers®.



Figure 1. Piper® Sensor

INGU Solutions' technology uses miniaturized in-line sensors called Pipers® to detect leaks, magnetic features, geometric defects, and deposits that threaten pipeline performance and safety. Piper is an in-line inspection tool particularly suitable for small diameter (less than 8-inch diameter) pipelines. Measurement capabilities include:

- Pressure
- Temperature
- Leak Detection
- Flow dynamics
- Magnetic features
- Isometry/Piggability

Development Activities with iPIPE

With support from iPIPE members, Ingu Solutions deployed Pipers in 13 unique, active, operating pipeline segments in North Dakota in 2018 and 2019 (see Table 1). This set of challenges provided Ingu Solutions with extensive insight on the myriad permutations of hardware configurations possible, which added greatly to Ingu Solutions' knowledge base and commercial readiness. This set of challenges also helped Ingu Solutions to refine the logistical aspects of Pipers deployment, recovery, data retrieval, and data analysis, thus advancing the technology to commercial readiness. This effort embodied the true spirit of the iPIPE program: codevelopment of promising new technologies.

Real World, Real Results

The trials conducted by Ingu Solutions in iPIPE member pipelines resulted in improvements in the product and eventual validation of the sensors as a commercially ready tool. During iPIPE deployments, Pipers identified a staged leak (acoustic measurement, Figure 2), mapped subtle magnetic differences in composite pipeline segments (magnetic measurement, Figure 3), identified pipeline joint locations (magnetic measurement), measured approximate XYZ location of pipelines (inertial measurement), and measured thermal profile of the fluids carried (temperature measurement).

Table 1. iPIPE Pipeline Deployments of Pipers

Pipeline Operator	Pipeline Description
Hess Corp.	6", nonmetallic, crude oil
Equinor	8", metallic, crude oil
Equinor	6", nonmetallic, produced water
Goodnight Midstream	6", nonmetallic, produced water
Hess Corp.	6", metallic, high-pressure natural gas
Goodnight Midstream	6", nonmetallic, produced water
Oasis Midstream	4", nonmetallic, produced water
Equinor	8", nonmetallic, produced water
Andeavor	6", metallic, crude oil
Oasis Midstream	6", metallic, crude oil
Hess Corp.	6", metallic, crude oil
Hess Corp.	6", nonmetallic, crude oil
Equinor	8", nonmetallic, produced water

These trials also highlighted potential new uses for Pipers, discovered through close cooperation between Ingu Solutions and iPIPE members. During one deployment, the sensors detected a malfunctioning valve that indicated open but was actually nearly closed. Because this was a manual valve with a malfunctioning indicator, this problem may have gone unnoticed for months, resulting in significant costs due to increased net energy consumption required to pump fluids through the nearly closed valve.

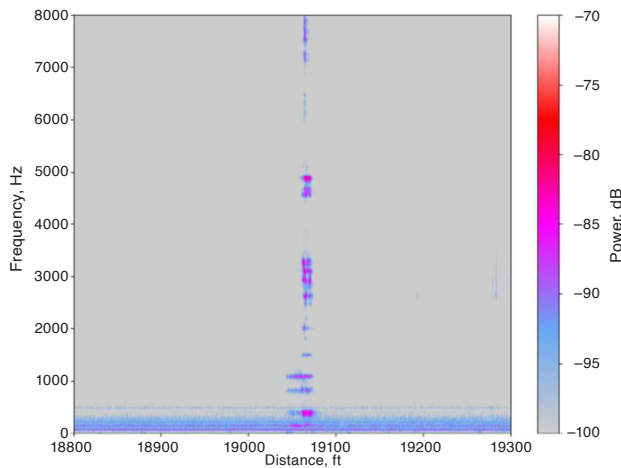


Figure 2. Audio spectrogram indicating leak

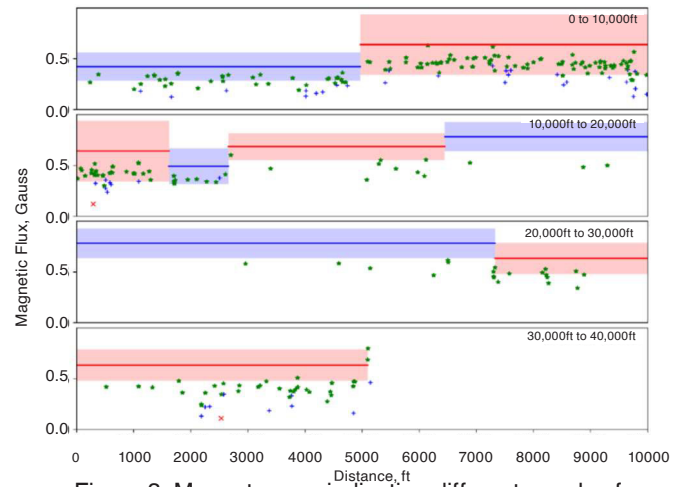


Figure 3. Magnetogram indicating different spools of composite pipeline



Figure 4. Deployment of Piper



Figure 5. Retrieval of Piper

INGU Solutions also demonstrated exceptional flexibility in the ability to insert and retrieve the sensors from a wide variety of challenging pipeline hardware configurations (Figures 4 and 5). iPIPE Development Leads to Commercial Success for Ingu Solutions.

Several iPIPE members have now indicated intent to contract commercially for Pipers service as a result of INGU Solutions' success with iPIPE. iPIPE is proud of this success story: iPIPE is filling the empty slots in the toolbelts of pipeline operators.

For more information, please contact Darren Schmidt at dschmidt@undeerc.org or at 701.777.5201

iPIPE is Filling Empty Slots in the Tool Belts of Pipeline Operators.

Partial List of Articles and Media Highlighting iPIPE:

Updated October 25, 2021

Title	Date	URL
Industry Responds to Governor's Initiative to Improve Pipeline Technology; Program Funding Approved by North Dakota Industrial Commission		https://www.ndoil.org/industry-responds-to-governors-initiative-to-improve-pipeline-technology-program-funding-approved-by-north-dakota-industrial-commission/
Satelytics Selected to Participate in the intelligent Pipeline Integrity Program (iPIPE)	5/18/2018	https://mailchi.mp/satelytics/satelytics-chosen-to-participate-in-iPIPE-project?e=922473135e
ND Implements Intelligent Pipeline Project	5/22/2018	http://northamericanshalemagazine.com/articles/2380/nd-implements-intelligent-pipeline-project
North Dakota Governor Doug Burgum Provides Remarks This Morning at the Williston Basin Petroleum Conference in Bismarck, Thanks Hess and the Industry for Innovation Through iPIPE Program.	5/23/2018	https://twitter.com/HessCorporation/statuses/999315208261853185
North Dakota Pipeline Leak Detection Initiative Announced	5/25/2018	https://extension.psu.edu/north-dakota-pipeline-leak-detection-initiative-announced
New Consortium Sets Goal of Improving Pipelines	5/26/2018	https://www.mrt.com/business/oil/article/New-consortium-sets-goal-of-improving-pipelines-12941971.php
Industry Responds to Governor's Initiative to Improve Pipeline Technology; Program Funding Approved by North Dakota Industrial Commission	5/26/2018	https://www.oilandgasonline.com/doc/industry-governors-initiative-pipeline-program-north-dakota-industrial-commission-0001
New Consortium Sets Goal of Improving Pipelines	5/27/2018	https://www.timesunion.com/business/oil/article/New-consortium-sets-goal-of-improving-pipelines-12941971.php
Principal Engineer Jay Almlie Discusses the iPIPE Program on Energy Matters Radio	5/31/2018	https://www.youtube.com/watch?v=ZQuwsK0z2aM
North Dakota Selects Ingu Solutions for Demonstration of Cutting-Edge Leak Detection and Prevention Technology for Oil and Gas Pipelines	5/31/2018	https://ingu.co/iPIPE/
Leak Detection Project Kicks Off This Summer	6/1/2018	https://myemail.constantcontact.com/Here-are-the-week-s-top-North-Dakota-energy-stories-.html?soid=1102657032033&aid=NpwT2Ynl17c
How a Canadian Solution to Detecting Pipeline Leaks Is Being Used in North Dakota	6/5/2018	https://www.bnnbloomberg.ca/video/how-a-canadian-solution-to-detecting-pipeline-leaks-is-being-used-in-north-dakota~1410402
iPIPE Program Helps Solve Pipeline Leaks in ND	6/6/2018	http://www.kfyrtv.com/content/news/iPIPE-Program-helps-solve-pipeline-leaks-in-ND--484747291.html
Startup Uses Small Sensors to Check North Dakota Oil Pipes	6/10/2018	https://www.alvareviewcourier.com/story/2018/06/10/interesting-items/startup-uses-small-sensors-to-check-north-dakota-oil-pipes/37406.html
Sensors to Monitor Oil, Brine Gathering Lines Coming to ND	6/12/2018	https://www.westfargopioneer.com/news/science-and-nature/4459638-sensors-monitor-oil-brine-gathering-lines-coming-nd
Pipe Sensors to Monitor Gathering Lines	6/12/2018	https://bismarcktribune.com/business/local/pipe-sensors-to-monitor-gathering-lines/article_cd64586c-1d52-52df-83e6-b661d3b95f0a.html
Startup Uses Small Sensors to Check North Dakota Oil Pipes	6/21/2018	https://www.apnews.com/9d65538034a24711a4a84d4e2bb38efe
Startup Uses Small Sensors to Check North Dakota Oil Pipes	6/21/2018	https://www.usnews.com/news/best-states/north-dakota/articles/2018-06-21/startup-uses-small-sensors-to-check-north-dakota-oil-pipes
Startup Uses Small Sensors to Check North Dakota Oil Pipes	6/21/2018	https://m.washingtontimes.com/news/2018/jun/21/startup-uses-small-sensors-to-check-north-dakota-o/
iPIPE: Taking a Bite Out of Leaks	6/25/2018	http://blogs.und.edu/und-today/2018/06/taking-a-bite-out-of-leaks/
iPIPE: Taking a Bite Out of Leaks	6/29/2018	http://www.northdakotaagconnection.com/story-state.php?Id=688&yr=2018
Industry Demonstrates Commitment to Stopping Pipeline Leaks	7/17/2018	http://northamericanshalemagazine.com/articles/2444/industry-demonstrates-commitment-to-stopping-pipeline-leaks

Title	Date	URL
Testing of New Pipeline Inspection Device Begins in Bakken	7/18/2018	https://www.spe.org/en/ogf/ogf-article-detail/?art=4404
Testing of New Pipeline Inspection Device Begins in Bakken (Link Not Active)	7/18/2018	https://www.spe.org/en/print-article/?art=4404
6 Companies Collaborating on Pipeline Leak Detection	8/15/2018	https://www.willistonherald.com/news/companies-collaborating-on-pipeline-leak-detection/article_bbce3194-a098-11e8-8bac-1b765123019e.html
More Skin in the Game: New Technology to Find, Fix Leaks	8/20/2018	https://pgjonline.com/magazine/2018/august-2018-vol-245-no-8/features/more-skin-in-the-game-new-technology-to-find-fix-leaks
Burgum Highlights Oil Industry's Progress, Challenges at ND Petroleum Council's Annual Meeting in Fargo	9/25/2018	https://www.governor.nd.gov/news/burgum-highlights-oil-industry%E2%80%99s-progress-challenges-nd-petroleum-council%E2%80%99s-annual-meeting
Burgum Highlights Oil Industry's Progress, Challenges at ND Petroleum Council's Annual Meeting in Fargo	9/25/2018	https://votesmart.org/public-statement/1287849/burgum-highlights-oil-industrys-progress-challenges-at-nd-petroleum-councils-annual-meeting-in-fargo#.XDz9tVxKjE
The Digital Oilfield: How Digital Technologies Are Changing the Oil Industry in ND and Nationwide	9/30/2018	http://www.prairiebusinessmagazine.com/business/energy-and-mining/4506605-digital-oilfield-how-digital-technologies-are-changing-oil
Progress for Partners Key to Energy & Environmental Research Center		https://www.ndliving.com/content/progress-partners-key-energy-environmental-research-center
API Banquet Salutes Stars of Bakken Oil and Gas	11/19/2018	https://www.willistonherald.com/news/api-banquet-salutes-stars-of-bakken-oil-and-gas/article_a006f78e-eb98-11e8-a353-abe9fc1170fc.html
Energy Matters: iPIPE Receives Industry Innovation Award	12/3/2018	https://www.youtube.com/watch?v=L2lEr2Xu4aw
Energy Matters with iPIPE	12/12/2018	https://www.satellytics.com/blog/oil-gas-solutions/2018-energy-matters-with-iPIPE/
Developing Technology to Prevent Pipeline Leaks	1/3/2019	https://mydigitalpublication.com/publication/?i=547462&p=&pn=#(%22issue_id%22:547462,%22page%22:34)
Innovative Pipeline Consortium Marks New Highlights	1/8/2019	http://undeerc.blogspot.com/2018/12/innovative-pipeline-consortium-marks.html
2018 State of the State Address	1/23/2019	https://www.governor.nd.gov/events/2018-state-state-address
North Dakota Eyes Expanded Use of Drones for Oil and Natural Gas Operations	2/8/2019	https://www.naturalgasintel.com/articles/117347-north-dakota-eyes-expanded-use-of-drones-for-oil-and-natural-gas-operations
The Crude Life Interview: Joe Dancy, Energy Expert & Educator	5/18/2019	http://www.thecrudelife.com/podcast/the-crude-life-interview-joe-dancy-energy-expert-educator/
The Big Data Revolution: Detecting Pipeline Leaks, Encroachments and More Using Satellites	6/15/2019	https://www.pipeline-journal.net/journal/pipeline-technology-journal-32019
Energy Matters Radio: iPIPE	9/6/19	https://youtu.be/4tTA_WEMl8
iPIPE Program Assisting in Detection of Pipeline Leaks in the Pipeline & Gas Journal September Edition (Page 50-52)	9/10/2019	https://www.nxtbook.com/nxtbooks/gulfpub/pgj_201909/
iPIPE Receives IOGCC Chairman's Stewardship Award for Environmental Partnership	9/10/2019	https://www.am1100theflag.com/news/10755-iPIPE-receives-iogcc-chairman%E2%80%99s-stewardship-award-environmental-partnership
iPIPE Receives Chairman's Stewardship Award	9/10/2019	http://undeerc.blogspot.com/2019/09/iPIPE-receives-chairmans-stewardship.html
iPIPE Receives Chairman's Stewardship Award	9/13/2019	https://www.willistonherald.com/news/business/iPIPE-receives-stewardship-award/article_e7c45bf0-d636-11e9-b069-739139b5d75b.html
API Award Winner Shares What Recognition Has Meant	10/14/2019	https://www.willistonherald.com/news/oil_and_energy/api-award-winner-shares-what-recognition-has-meant/article_ec10b56a-eecc-11e9-a94a-0f17a0778d95.html
AI Raising Drone Game in Oil, Gas but FAA Challenges Remain	10/15/19	https://www.naturalgasintel.com/articles/119892-ai-raising-drone-game-in-oil-gas-but-faa-challenges-remain
Almlie and Helms: Where Innovation Leads, Regulation Follows	10/18/19	https://trib.com/opinion/columns/almlie-and-helms-where-innovation-leads-regulation-follows/article_ee198ef8-05aa-599f-9df9-67bfd8492bc0.html
Shared on Drilling Info's Social Media Site: Almlie, Helms: Innovation Leads, Regs Follow	10/20/19	https://www.grandforksherald.com/opinion/columns/4728897-Almlie-Helms-Innovation-leads-regs-follow
Almlie, Helms: Innovation Leads, Regs Follow	10/20/19	https://www.grandforksherald.com/opinion/columns/4728897-Almlie-Helms-Innovation-leads-regs-follow

Title	Date	URL
Where Innovation Leads, Regulation Follows	10/21/19	https://bismarcktribune.com/opinion/letters/where-innovation-leads-regulation-follows/article_6018311c-49fd-5744-b815-2a485b881e59.html
Bakken Backers E-Mail: Almlie, Helms: Innovation Leads, Regs Follow	10/25/19	https://www.grandforksherald.com/opinion/columns/4728897-Almlie-Helms-Innovation-leads-regs-follow
Cleanup Continues after Keystone Pipeline Oil Spill near Edinburg, ND	11/4/19	https://www.grandforksherald.com/news/accidents/4754456-Nearly-half-of-the-oil-has-been-recovered-in-Keystone-Pipeline-incident-says-TC-Energy
ND Keystone Spill about Half Recovered, Official Says	11/4/19	https://www.bemidjipioneer.com/business/energy-and-mining/4755069-ND-Keystone-spill-about-half-recovered-official-says
DAPL 2.0 Pipeline – Doug Burgum, North Dakota Governor (governor mentioning iPIPE on “what’s on your mind”)	11/7/2019	https://www.am1100theflag.com/news/12229-11719-dapl-20-pipeline-doug-burgum-north-dakota-governor
Previewing the PSC’s DAPL 2.0 Expansion Hearing	11/11/2019	https://www.am1100theflag.com/news/12320-previewing-psc%E2%80%99s-dapl-20-expansion-hearing
Oasis Petroleum’s Jared Iverson Talks about the Next 20 years in the Bakken	12/4/2019	https://www.willistonherald.com/news/oil_and_energy/oasis-petroleum-s-jared-iverson-talks-about-the-next-years/article_2368a346-16f1-11ea-81ad-d3443353be3e.html
DCP Midstream LinkedIn Mention	~Sept 2019	https://www.linkedin.com/posts/dcp-midstream_dcp-wearcdcp-transformation-activity-6577940399116038144-orkp/
iPIPE Looks to Enhance Pipeline Safety	12/17/2019	https://www.kfyrtv.com/content/news/iPipe-looks-to-enhance-pipeline-safety-566298741.html
Burgum, Sanford Reflect on Significant Progress Made During Administration’s Third Year	12/19/2019	https://www.thedickinsonpress.com/incoming/4830773-Burgum-Sanford-reflect-on-significant-progress-made-during-administration%E2%80%99s-third-year-Site-and-date-announced-for-2020-State-of-the-State-address
Burgum, Sanford Reflect on Significant Progress Made During Administration’s Third Year	12/19/2019	https://www.nd.gov/news/burgum-sanford-reflect-significant-progress-made-during-administrations-third-year
Companies Aim to Prevent, Detect Pipeline Leaks with New Technologies	1/5/2020	https://bismarcktribune.com/bakken/companies-aim-to-prevent-detect-pipeline-leaks-with-new-technologies/article_0cac7e82-c49a-5c86-9267-ad8beb5b9799.html
Podcast: iPIPE with Jay Almlie — Real Technology, Real Pipelines, Real Progress	1/7/2020	https://pipelinerspodcast.com/episode-109-iPIPE-jay-almлие/
iPIPE Welcomes New Consortium Member	1/10/2020	https://mailchi.mp/undeerc/news-release-iPIPE-receives-chairmans-stewardship-award-585605
DAPL Owner Joining North Dakota’s iPIPE Consortium to Help Advance Leak Detection Technology	1/13/2020	https://www.willistonherald.com/news/regional/dapl-owner-joining-north-dakota-s-iPIPE-consortium-to-help/article_ab8d13a8-3652-11ea-9117-ef358444f87f.html
Energy Transfer Joins Pipeline Spill Consortium	1/14/2020	https://bismarcktribune.com/bakken/energy-transfer-joins-pipeline-spill-consortium/article_5f983ae5-109c-596e-a254-f09974b1f8c1.html
iPIPE Welcomes New Consortium Member: Dakota Access Pipeline	1/16/2020	http://undeerc.blogspot.com/2020/01/iPIPE-partnership-welcomes-new-member.html
TC Energy Will Join North Dakota’s iPIPE Consortium to Help Advance Leak Detection	1/16/2020	https://www.willistonherald.com/news/oil_and_energy/tc-energy-will-join-north-dakota-s-iPIPE-consortium-to/article_2a52fa3e-38b7-11ea-aca2-23bf860113c.html
iPIPE Partnership Welcomes New Member: TC Energy	1/16/2020	http://undeerc.blogspot.com/2020/01/iPIPE-partnership-welcomes-new-member.html
Podcast: iPIPE — Inside the Tech Pitch with Jay Almlie	1/21/2020	https://pipelinerspodcast.com/episode-111-iPIPE-tech-pitch-jay-almлие/
Enbridge Joins Consortium Evaluating Next-Generation Technology in the Pipeline Industry	1/27/2020	https://www.enbridge.com/stories/2020/january/iPIPE-consortium-evaluating-next-generation-pipeline-technology
Monique Roberts LinkedIn Post	1/29/2020	https://www.linkedin.com/posts/monique-roberts-81a84527_pipelinesafety-iPIPE-pipelineintegrity-activity-6628411257315741697-cUBx/
iPIPE Mentioned in 2019 State of the State Address	1/29/2020	https://www.youtube.com/watch?v=5vkkqT6DaE Link to 1:02 time: https://youtu.be/5vkkqT6DaE?t=3731
Bakken Oil, Gas to Energize North Dakota’s Global Impact, Governor Says	2/3/2020	https://www.naturalgasintel.com/articles/120930-bakken-oil-gas-to-energize-north-dakotas-global-impact-governor-says
iPIPE with Jay Almlie on the Pipeliners Podcast: Episode 111	2/4/2020	https://pipelinerspodcast.com/episode-113-iPIPE-operators-perspective-brian-epperson-greg-tilley/
iPIPE on Energy Matters Radio (beginning at 9:15)	2/15/2020	https://www.am1100theflag.com/news/14840-2-15-20-energy-matters-hour-1#volume

Title	Date	URL
iPIPE on the Pipeliners Podcast: Episode 115	2/18/2020	https://pipelinerspodcast.com/episode-115-iPIPE-vendor-perspective-john-van-pol-sean-donegan/
On the Path to Zero Pipeline Spills	2/27/2020	http://blogs.und.edu/und-today/2020/02/on-the-path-to-zero-pipeline-spills/
iPIPE with Jay Almlie on the Pipeliners Podcast: Episode 117	3/2/2020	https://pipelinerspodcast.com/episode-117-iPIPE-high-tide-floats-all-boats-jay-almлие/
iPIPE with Jay Almlie on the Pipeliners Podcast: Episode 119	3/17/2020	https://pipelinerspodcast.com/episode-119-future-technology-today-jay-almлие/
Pipelines Take on Their Biggest Enemy	3/30/2020	https://www.hartenergy.com/exclusives/pipelines-take-their-biggest-enemy-186778?mkt_tok=eyJpIjoiTjFek5UUmIOekEzTW1WbSIsInQiOiJUNINxSmidiOHAWN081ZFdrTjRZRG0yK2FvdEIIUXM3TnFpSndSbnE5NUhjZ0NlakxVNFdwMONUVFwvcmM5UW9hd0g0RFc5T3ROc3JiR0xWXC9uckFnQ3RFRUpNTW1oQlcreFBPQnRDblBBZFhLU0F5bVE4Nk92WHhock1wS1lrRUt5In0%3D
UND Today: Engineering Students Team Up with Industry	4/2/2020	http://blogs.und.edu/und-today/2020/04/engineering-students-team-up-with-industry/
Orbital Sidekick Helps iPIPE Consortium With Pipeline Monitoring Project	11/19/2020	https://www.satellitetoday.com/iiot/2020/11/19/orbital-sidekick-helps-ipipe-consortium-with-pipeline-monitoring-project/
iPIPE Selects Orbital Sidekick as Partner for Pipeline Monitoring Project	11/19/2020	https://www.prnewswire.com/news-releases/ipipe-selects-orbital-sidekick-as-partner-for-pipeline-monitoring-project-301177019.html
Orbital Sidekick Secures \$16 Million Series A to Commercialize Hyperspectral Satellite Monitoring Solutions for Energy and Defense Sectors	4/13/2021	https://www.prnewswire.com/news-releases/orbital-sidekick-secures-16-million-series-a-to-commercialize-hyperspectral-satellite-monitoring-solutions-for-energy-and-defense-sectors-301267276.html
DAPL owner joining North Dakota's iPipe Consortium to help advance leak detection technology	5/4/2021	https://www.willistonherald.com/news/regional/dapl-owner-joining-north-dakotas-ipipe-consortium-to-help-advance-leak-detection-technology/article_ab8d13a8-3652-11ea-9117-ef358444f87f.html
Smart Pipelines? (iPIPE) incentivizes private industry to create smarter & safer pipelines	5/17/2021	https://www.kxnet.com/news/smart-pipelines-ipipe-incentivizes-private-industry-to-create-smarter-safer-pipelines/
Orbital Sidekick to Launch Hyperspectral Satellite for Oil, Gas, Mine Monitoring	6/15/2021	https://investableuniverse.com/2021/06/15/orbital-sidekick-hyperspectral-imaging-oil-gas-mining-defense/
Hyperspectral imaging satellite, currently being evaluated by iPIPE consortium, will be aboard SpaceX flight	6/30/2021	https://www.enbridge.com/stories/2021/june/hyperspectral-imaging-satellite-latest-pipeline-monitoring-technology-officially-out-of-this-world
Latest Pipeline Monitoring Technology Is Officially Out of This World	6/30/2021	https://www.csrwire.com/press_releases/725086-latest-pipeline-monitoring-technology-officially-out-world
Latest Pipeline Monitoring Technology Is Officially Out of This World	6/30/2021	https://news.yahoo.com/latest-pipeline-monitoring-technology-officially-180608431.html
iPIPE Launches into Space	7/6/2021	https://blog.undeerc.org/2021/07/06/ipipe-launches-into-space/
iPIPE to Get Images from Space Satellite to Aid Leak Detection Effort	7/9/2021	https://www.ndenergy.org/Newsletter/Fireworks-Festival/State-Sues-Biden-Over-Lease-Ban
North Dakota's iPIPE goes to space!	7/13/2021	https://www.kxnet.com/news/state-news/north-dakotas-ipipe-goes-to-space/
SpaceX launch carried an innovative piece of the Bakken into outer space	8/4/2021	https://www.willistonherald.com/news/oil_and_energy/spacex9-launch-carried-an-innovative-piece-of-the-bakken-into-outer-space/article_65a3ca42-f539-11eb-9257-636de96ec0bd.html



APPENDIX B

MEMBERSHIP TERMS

MEMBERSHIP TERMS

- Mission:** The mission of iPIPE is to direct, develop, fund, and demonstrate emerging technology to improve pipeline integrity, systems, and operations for leak prevention and detection of gases and liquids.
- Eligibility:** Operators of wells and gathering, transmission, or distribution pipeline systems.
- Voting Rights:** Each organization to have one vote on any matter submitted to the Energy & Environmental Research Center (EERC) for a vote of the members.
- Termination:** A member organization may be suspended or expelled, for cause, by a vote of not less than 3/4 of the members, provided notice of such action is provided in writing and the member organization has had a chance to be heard. A member organization may be suspended if found in default with respect to financial obligation to iPIPE by majority vote of the participating members.
- Resignation:** Members may resign at any time with notice in writing; previous payment is not reimbursable.
- Reinstatement:** Upon written request, a former member may be reinstated upon such terms as deemed appropriate by the membership.
- Fees:** \$75,000 per year (expected 2-year commitment, provided in commitment letter).
- Member obligations:** Provided in invoice agreement.
- Number of members:** Five-member minimum.
- Meetings:** Member meetings occur monthly and are held online, and the quorum requirement is a majority. Technology selection event: the location is to be decided and a maximum of three individuals from each member company may attend with one voting representative. The voting representative from each member company will lead in discussion with the technology providers. A member forum meeting is designed to share insights among iPIPE members, which occurs annually. Location and attendance are decided by the membership.



APPENDIX C

RESUMES AND ORGANIZATION QUALIFICATIONS



DARREN D. SCHMIDT

Assistant Director for Subsurface R&D

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Principal Areas of Expertise

Mr. Schmidt's principal areas of interest and expertise include oil and gas facilities, production, injection, well stimulation, enhanced recovery, power generation, and renewable technologies.

Education and Training

B.S., Mechanical Engineering, West Virginia University, 1994.
Registered Professional Engineer (Mechanical and Petroleum).

Research and Professional Experience

February 2021–Present: Assistant Director for Subsurface R&D, EERC, UND. Mr. Schmidt leads a team focused on research, development, and commercialization related to efficient and clean fossil fuel production, utilization, carbon management, and alternative fuels and renewable energy.

2016–January 2021: Principal Engineer, Research and Technology, Equinor, Williston, North Dakota. Mr. Schmidt provided leadership for Equinor's research portfolio in the Bakken/Williston Basin, with a focus on low carbon. He developed a project focused on reducing flaring in which a patent application was filed. Earlier work included leading a team to develop CO₂ used in well stimulations. Through Equinor's involvement with the North Dakota Oil and Gas Research Program, research was completed to address requirements surrounding crude oil vapor pressure. Mr. Schmidt worked closely with Equinor's Williston office regional manager to support operations including serving as the regulatory liaison for the emergency response team.

2013–2016: Completions Engineer, Statoil Completions, Williston, North Dakota. Mr. Schmidt served as a completions engineer for Williams County, with a strong focus on safe operations. He led a successful program in 2015 to use 10% produced water in Statoil hydraulic fracturing operations. He was responsible for hydraulic fracture designs, quality of operations, implementing new procedures, enforcing standard operating procedures, and approving field work. He mentored interns and completions related research projects to improve performance.

2012–2013: Technical Advisor, Weatherford Fracturing Technologies, Williston, North Dakota. Mr. Schmidt provided leadership to the Williston district to ensure job quality, safety, personnel management, education, and training. He supported revenue; provided intelligence; conducted marketing; provided urgent response to customers, field services, and client-based technical assistance; and ensured quality reporting. He also provided technical guidance to the district stimulation fluids laboratory.

2008–2012: Senior Research Advisor, EERC, UND. Mr. Schmidt was responsible for procurement and execution of research projects related to the Bakken Formation in the Williston Basin. Projects included utilization of associated gas in drilling operations, laboratory investigation of conductivity associated with proppants, fracturing fluids, and rock formations, enhanced production from coal bed methane, geologic storage of CO₂, and oil-field drilling, production, and workover operations. Additionally, Mr. Schmidt was an advisor to distributed biomass gasification development and contributed to the organization's revenue through research proposals, publications, and intellectual property.

1998–2008: Research Manager, EERC, UND. Mr. Schmidt's responsibilities included securing research contracts, managing projects, and performing engineering tasks in the areas of cofiring and biomass power systems, including combustion, fluidized-bed, gasification, microturbine, and internal combustion engine generators; energy efficiency; ground-source heat pumps; hydrogen production from biomass; and researching the behavior of biomass in combustion systems relative to ash fouling and trace elements.

1994–1998: Mechanical Engineer, Research Triangle Institute (RTI), Research Triangle Park, North Carolina. Mr. Schmidt's responsibilities included serving as project leader for a \$3M Cooperative Agreement with the U.S. Environmental Protection Agency (EPA) to demonstrate electricity production using a 1-MW wood gasification technology. Significant experience included permit, design, installation, operations, and reporting. Other activities at RTI included support of marketing activities and coauthoring publications.

Summer 1993: Internship, EERC, UND, Grand Forks, ND. Mr. Schmidt supported combustion and coal ash studies.

Summer 1992: Internship, Foster Wheeler Development Corporation, Livingston, New Jersey. Mr. Schmidt supported gasification research and development.

Professional Activities

Appointed Member, North Dakota Oil and Gas Research Council
Cochair, North Dakota Petroleum Council Technology Solutions Group
Section Chair, Williston Basin Society of Petroleum Engineers

Publications

Mr. Schmidt has authored or coauthored over 80 peer-reviewed and other professional publications.

Patents

Method and Apparatus for Supply of Low-Btu Gas to an Engine Generator. U.S. Patent 8,460,413, June 11, 2013.

Application of Microturbines to Control Emissions from Associated Gas. U.S. Patent 8,418,457, April 16, 2013.

Hydrocarbon Gas Recovery Methods. U.K. Application No. 2009516.2, filed June 22, 2020.



T. AUSTIN MCRAE

Research Engineer, Integrated Petroleum Systems
Energy & Environmental Research Center (EERC), University of North Dakota (UND)
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Principal Areas of Expertise

Mr. McRae's principal areas of interest and expertise include petroleum industry operations and support, specifically well stimulation; enhancing coordination between energy industry and environmental efforts through improved technology, practice, and understanding; and advanced energy technologies.

Education and Training

B.S., Petroleum Engineering, Colorado School of Mines, Golden, Colorado, 2014.
Proficient in the use of Microsoft Office Suite, Baker Hughes Job Monitoring Programs, Windows XP, 7, 8, 10.
Certifications include SafeGulf, SafeLandUSA, and Core Compliance (PEC Safety) and Baker Hughes Engineer Development Program and Stimulation Technical Academy.

Research and Professional Experience

2016–Present: Research Engineer, Integrated Petroleum Systems, EERC, UND. Mr. McRae's responsibilities include process engineering and design for wellsite operations, pipeline transport, environmental science related to oilfield operations, and operation of pilot-scale carbon capture systems. In September 2020, he was named Co-Project Manager of the Intelligent Pipeline Integrity Program (iPIPE) at the EERC, an industry-led consortium whose focus is to contribute to the advancement of near-commercial, emerging technologies to prevent and detect leaks from gathering pipelines. Since 2018, he has served as Chief Technology Scout for iPIPE, the primary contact for interested technology developers. Accomplishments have included:

- Searching for and identifying the most promising emerging technologies.
- Assessing the fit of potential technologies with the program and communicating iPIPE goals to technology providers.
- Helping technology providers understand how to address the needs of member companies with their products.
- Assisting engaged technology providers in honing their proposals to meet member expectations.
- Offering project support, as needed, particularly in the field.

2016: Supply & Logistics Coordinator – AmeriCorps National Service Member, SBP (formerly St. Bernard Project), New Orleans, Louisiana/Columbia, South Carolina. Mr. McRae worked directly with project managers to ensure all active home construction sites and field personnel received necessary materials and support; managed warehouse stock, tools, and materials while

assisting in procurement of nonstock items; and assisted in delivery and transport of all items.

Accomplishments included:

- Assisting the team with a cross-town warehouse move, including new layout design, vehicle logistics, and storage construction.
- Improving vehicle safety within the organization through implementation of experience best practices and increased load securement awareness.
- Creating safer construction sites through the application of affordable security measures specifically intended to deter intruders at all times and better secure valuable tools and resources overnight.

2014–2015: Stimulation/Field Engineer, Permian Basin, Baker Hughes Pressure Pumping, Artesia and Hobbs, New Mexico/Odessa, Texas. Mr. McRae's responsibilities included ensuring technical product and service delivery through laboratory and field testing, technician management, on-site job monitoring, and customer interaction; analyzing job results; and generating post treatment and regulatory reports. Accomplishments included:

- Enhancing service delivery by pumping and changing between multiple fluid systems as needed based on customer request and preference.
- Avoiding nonproductive time (NPT) by anticipating customer requests and having additional products available on location for critical or experimental wells.
- Managing jobs from beginning to end on locations throughout the Permian Basin, treating multiple formations using slickwater, crosslinked, produced water, acid, and hybrid systems.
- Maintaining and promoting an interdependent safety culture regardless of customer or location, resulting in zero injuries or incidents while present or involved.

2013: Roustabout, Champion Oilfield Service, Wiggins, Colorado. Mr. McRae collaborated with a multifunctional team to construct and maintain oilfield infrastructure for operators in the DJ Basin. Projects included building tank batteries, repairing compressors and pumping units, and creating flow lines from wellhead to separators, batteries, and sales lines. Accomplishments included:

- Minimizing hydrocarbon gas emissions into the atmosphere through thorough pipe testing, inspection, and repair before installing underground and connecting to the live system.
- Conducting operations in the safest possible manner, resulting in zero injuries to self or team as well as minimal waste and litter to environments surrounding construction sites.

2012: Construction Office Coordinator, St. Bernard Project, New Orleans, Louisiana. Mr. McRae coordinated and communicated between multiple on-site and centrally located project managers to ensure smooth rehabilitation and repair of homes for people most adversely affected by Hurricane Katrina, including interfacing with local government agencies, obtaining permits, and ensuring projects met codes and standards.

Professional Activities

Member, Society of Petroleum Engineers

Publications and Presentations

Has authored or coauthored several professional publications.



MICHELLE R. OLDERBAK

Senior Project Management Specialist

Energy & Environmental Research Center (EERC), University of North Dakota (UND)
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701.777.5145 (phone), 701.777.5181 (fax), molderbak@undeerc.org

Principal Areas of Expertise

Ms. Olderbak's principal areas of interest and expertise include data reduction and interpretation as well as data presentation for report preparation.

Education and Training

A.A.S. (Administrative Secretary), Northwest Technical College, East Grand Forks, 1995.

Research and Professional Experience

2006–Present: Senior Project Management Specialist, EERC, UND. Ms. Olderbak serves as a liaison between the Director of Energy Systems Development, Associate Vice President for Research, several principal engineers, and associated internal EERC personnel as well as with external clients and associates; assists project managers and their groups in preparation of program plans, proposals, and topical and periodical reports; initiates procedures for efficient operation and work flow among research supervisors, managers, and clerical workers; establishes and maintains the Director of Energy Systems Development's administrative filing system; coordinates meetings and travel arrangements; performs extensive administrative support activities; and is responsible for coordinating the Director of Energy System Development's projects at all levels and facilitating communication with group.

2000–2006: Technical Research Assistant, Environmental Technologies Research Division, EERC, UND. Ms. Olderbak is responsible for data collection, organization, tracking, and storage; preliminary data reduction and interpretation as well as presentation for report preparation; first review of draft reports, including organizing data, editing, and proof-reading for format and content; and administrative duties, including coordinating Senior Research Manager's projects at all levels and facilitating communication among Environmental Technologies group members.

1997–2000: Research Information Associate, Environmental Technologies Research Division, EERC, UND. Ms. Olderbak served as a liaison between the Senior Research Manager and internal EERC personnel as well as with clients and associates worldwide; assisted project manager and group in preparation of program plans, proposals, and topical and periodical reports; produced charts, graphs, and data displays by obtaining, compiling, and presenting information in an appropriate format; initiated procedures for efficient operation and work flow among research supervisors, managers, and clerical workers; established and maintained Senior Research Manager's administrative filing system; coordinated meetings and travel arrangements; and performed general administrative support activities for the entire group.

1996–1997: Research Information Associate, Administrative Resources, EERC, UND. Ms. Olderbak’s responsibilities involved interacting with professional staff and performing a variety of duties to meet deadlines for researchers and other personnel; working with Editing, Graphics, and Workflow Coordinator to produce internal and external correspondence; formatting and producing state and federal forms, technical reports, proposals, and other documents; assisting in gathering and coordinating graphics, producing slides, and other technical information.

Publications

Ms. Olderbak has coauthored several professional publications.



THOMAS E. DOLL

Principal Petroleum Engineer

Energy & Environmental Research Center (EERC), University of North Dakota (UND)
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 701.777.5190 (phone), 701.777.5181 (fax), tdoll@undeerc.org

Principal Areas of Expertise

Mr. Doll's principal areas of interest and expertise include petroleum engineering and project, engineering, and general management. Throughout his career with oil and natural gas exploration companies, Mr. Doll has been directly responsible for the design and permitting, with various state and federal agencies, of drilling sites and wells; primary producing, secondary, and tertiary wells; facilities; and infrastructure. Mr. Doll, as Supervisor of the Wyoming Oil and Gas Conservation Commission, performed duties that included the interpretation and enforcement of statutes, rules, and regulations over oil and natural gas activities, including but not limited to, drilling, production, secondary and tertiary projects, and the plug, abandonment, and reclamation of wells, wellsites, and infrastructure. In that capacity, Mr. Doll was directly involved with the U.S. Environmental Protection Agency Underground Injection Control Program rules and permitting requirements, under Wyoming's primacy, for fresh and produced water injection and for carbon dioxide injection in enhanced oil recovery (EOR) projects. Mr. Doll drafted rules adopted by the Commission for Carbon Sequestration Financial Assurance and for Hydraulic Fracturing Disclosure, the first state to require chemical compound disclosure prior to and posttreatment.

Education and Training

B.S., Petroleum Engineering, University of Wyoming, 1971.

Registered Professional Engineer:

- Wyoming, PE 3543, February 1981
- North Dakota, PE 1829, February 1976

Research and Professional Experience

2012–Present: Principal Petroleum Engineer, EERC, UND, Grand Forks, North Dakota. Mr. Doll's responsibilities include working under contract with the Plains CO₂ Reduction (PCOR) Partnership for carbon capture, utilization, and sequestration (CCUS) for the Cedar Creek Anticline in southeastern Montana, including project, drilling, completion, and production optimization of the Bakken Formation in North Dakota and Montana, as well as providing EERC petroleum engineering input for various projects such as the Bell Creek CO₂ EOR project.

2009–2012: Supervisor, Wyoming Oil and Gas Conservation Commission, Casper, Wyoming. Mr. Doll's responsibilities included managing a state agency with 40 employees and a biennial budget of \$9.5 million. Mr. Doll authored and implemented Commission rules on well stimulation including hydraulic fracturing chemical compound disclosure; participated in a carbon sequestration financial assurance task force and authored the Commission's carbon

sequestration unitization rule to meet a legislative mandate; prepared and presented oil and natural gas information at over 60 educational forums such as professional meetings and federal and state government agency meetings, including formal testimony to the House Energy and the Environment Subcommittee and the Department of the Interior, at various public, academic, and industry forums; and enforced Commission rules and regulations through field inspections, hearings, and show cause actions to ensure compliance.

2008–2009: Independent Petroleum Engineering Consultant. Mr. Doll was recognized as an expert witness as a registered Professional Petroleum Engineer for the Wyoming Oil and Gas Conservation Commission hearings and prepared an Underground Injection Control (UIC) Permit for Wyoming Department of Environmental Quality (WDEQ) Water Quality Division (WQD) approval for a client to complete a nonhazardous waste disposal well in Crook County, Wyoming.

1997–2008: District Manager, Williams Production RMT (now WPX Energy), Gillette, Wyoming. Mr. Doll provided management, engineering, and supervision of the Powder River Basin asset, including management of the development and exploitation of coalbed natural gas resources on leasehold in the Powder River Basin, serving as Senior Petroleum Engineer; Project Manager; and Drilling, Regulatory, and Land Manager during the period and providing coordination/communication with joint venture partner counterparts for over 6600 coalbed natural gas wells producing over 505 MMcfd.

1989–1997: General Manager, Fluor Daniel (NPOSR), Inc. Mr. Doll provided general management, engineering management, and field operations management of Fluor Daniel (NPOSR) personnel and contractors of the Naval Petroleum Reserve Number 3, under contract to the U.S. Department of Energy (DOE) in Casper, Wyoming; managed all aspects of activities including conventional oil and gas production, gas reinjection for pressure maintenance, enhanced oil recovery via steamflood, polymer enhanced waterflood and fireflood operations, and directional and slant-hole drilling including a gas liquids extraction plant; and initiation of new technologies testing under typical oil field conditions through the Rocky Mountain Oil Field Testing Center (RMOTC).

1987–1989: Project Manager; TIORCO, Inc. (The Improved Oil Recovery Company), Wyoming, Montana, South Dakota, and Colorado, based in Gillette, Wyoming (see 1984–1986).

1986–1987: Independent Petroleum Engineering Consultant, Petroleum Engineering/Chemical Consultant, Gillette, Wyoming. Mr. Doll provided chemical and monitoring for wells producing up to 25% hydrogen sulfide with potential for severe tubular and surface facilities corrosion, and provided a postmortem report and to DOE via operating contractor John Brown Engineering at the Naval Petroleum Reserve No. 3 polymer augmented waterflood.

1984–1986: Project Manager; TIORCO, Inc. (The Improved Oil Recovery Company), Wyoming, Montana, South Dakota and Colorado, based in Gillette, Wyoming. Mr. Doll provided engineering supervision and technical monitoring, oversight, and reporting of chemically augmented injection projects for various independent oil companies to maximize oil recovery

through cost-effective improved injectivity, sweep improvement, reduced produced water quantity, and injected water quality control.

1983–1984: Director of Engineering (Acting), DOE, Casper, Wyoming. Mr. Doll was the Acting Director of Engineering for the DOE Naval Petroleum and Oil Shale Reserves in Colorado, Utah, and Wyoming. He provided supervision/direction to three engineers and support staff at Teapot Dome Naval Petroleum Reserve No. 3 and Anvil Points Oil Shale Reserve and provided technical and engineering oversight of the operating contractor to DOE, Lawrence-Allison and Associates West (LAAW).

1983–1983: Drilling Engineer, LAAW, Casper, Wyoming. LAAW contracted to DOE to operate the Naval Petroleum Reserve No. 3 in Casper, Wyoming; provided well design and daily field engineering oversight of drilling well operation on a DOE-owned rig; and identified severe steel tool joint wear to failure caused by aluminum drill pipe in a compression-rig picked up steel drill pipe, and a shallow drilling program was initiated.

1981–1983: Petroleum Engineering Consultant, Clausen Operating Company, Douglas, Wyoming. Mr. Doll provided supervision and direction of eight on-site operations consultants for conventional oil and gas drilling, workovers, and production operations in the Powder River Basin; 18-month petroleum engineering contract to John Brown Engineering and LAAW at DOE's Naval Petroleum Reserve No. 3 for engineering design and fieldwork for injectivity testing followed up with a pilot project; and wellbore, well site, and facilities design, specification, and construction supervision and drilling supervision with resultant implementation of a polymer-augmented waterflood pilot at Naval Petroleum Reserve No. 3.

1980–1981: Petroleum Engineer, WYOCO Petroleum, Walcott, Wyoming. Mr. Doll provided engineering management and field supervision of a field supervisor and roustabout for a small independent oil and gas producer in the Southwestern Hanna Basin; evaluation of Niobrara oil shale production problems and low-Btu natural gas production problems; and provided analysis and recommendations to management.

1977–1980: Petroleum Engineer, Louisiana Land and Exploration Company, Denver, Colorado. Mr. Doll provided drilling and production engineering and field operations design, specification, implementation, and oversight in the northern Rocky Mountains and California. Tasks included preparation of AFE cost estimates and reserves estimates; well economic evaluation for proposed wells in the leasehold area, working directly with geoscientists in prospect evaluation and providing Monte Carlo economic simulations for management decision making; managed and directed consultants during wildcat drilling, providing an on-site drillstem test and logging evaluation and for long string cementing; and on-site management and direction of consultants on well completions and stimulations.

1974–1977: Petroleum Engineer, Amerada Hess Corporation, Williston, North Dakota, and Tulsa, Oklahoma, including production engineering based in Williston, North Dakota. Mr. Doll was responsible for 350 producing oil wells on the Nesson Anticline in northwestern North Dakota and drilling engineering based in Tulsa, Oklahoma. Responsible for design, implementation, oversight, and management of wildcat and infield drilling programs in the

central Alberta overthrust, onshore California directional drilling, and Williston Basin field expansion in North Dakota; and reserves/reservoir engineering in Tulsa, Oklahoma, responsible for reserves reporting companywide, operated and nonoperated properties.

1971–1974: Petroleum Engineer, Halliburton Services, Rock Springs, Wyoming. Mr. Doll was responsible for engineering support to cementing, hydraulic fracture stimulation, acidization, and drillstem testing for the major service contractor in western Wyoming, northern Colorado, and eastern Utah.

Publications

Mr. Doll has authored and coauthored numerous publications and presentations.



MICHAEL P. WARMACK

Principal Oil and Gas Facilities Engineer

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Principal Areas of Expertise

Mr. Warmack has more than 38 years of experience in production, operations, facilities design and installation, chemical treatment and optimization, and hands-on experience in multiple engineering disciplines.

Education and Training

B.S., Chemical and Petroleum Refining Engineering, Colorado School of Mines, 1981.

Research and Professional Experience

2021–Present: Principal Oil and Gas Facilities Engineer, EERC, UND. Mr. Warmack serves on EERC project teams and works with EERC clients to improve the development and production of domestic energy. He supports the planning, design, selection of materials/treatment programs, costing, reporting, and/or upgrade/retrofit efforts related to production facilities optimization for unconventional oil plays; injection, production, and recycle infrastructure associated with enhanced oil recovery (EOR)/incremental oil recovery (IOR) in conventional and unconventional oil and gas plays; infrastructure associated with capture and injection of CO₂ for geologic storage; and other emerging challenges associated with oil and gas injection/production processes.

2015–2020: Denbury Resources, Plano, Texas. Mr. Warmack was directly involved with Denbury’s CO₂ operations within the Delhi enhanced oil recovery (EOR) and natural gas liquids (NGL) facilities (Delhi, Louisiana), and Tinsley EOR unit (Tinsley, Mississippi). Positions held included the following:

Facilities and Optimization Engineer – Delhi EOR Unit

- Provided engineering support on operations for the Delhi EOR and NGL facilities.
- Provided recommendations and designs for facility upgrades (EOR facility), new equipment installation (EOR and NGL facilities), programming changes to plant operations, and operational changes within facilities. Efforts resulted in increased operational run time of plant and field operations while providing more efficient separation through the plant.
- Worked with vendor on the operations of the NGL plant, resulting in equipment upgrades and increasing run time of the plant from 85% in 2018 to 95% in 2019.
- Initiated monthly mechanical integrity and chemical reviews of plant and field operations.
- Designed and installed oil line to a third-party crude blending facility, resulting in additional revenues without costs to the unit.

Facilities and Optimization Engineer – Tinsley EOR Facility

- Provided detailed engineering review and recommendations for reducing chemical treatments on injection wells and improving the operations of the Tinsley EOR facility. Recommendations reflected the development of maximum operating rate of the EOR facility in terms of momentum, culminating in a \$9.2 million investment to upgrade the plant. After the completion of plant upgrades, injection well treatments were reduced from 40+ treatments/month to ~1 per month while reducing treating chemical expenses by approximately \$2.4 million per year.
- Led engineering review on reduced injection occurring in the field. Provided detailed analysis on the injection system resulting in the recommendation to improve flow in two major distribution lines.
- Instituted monthly mechanical integrity and chemical treating reviews on field operations.

2001–2015: Chaparral Energy, Oklahoma City, Oklahoma. Mr. Warmack was directly involved with Chaparral’s EOR operations in the Texas and Oklahoma Panhandle areas, northeast Oklahoma area, and primary production activities in the Oklahoma and Texas Panhandle areas. Positions held included the following:

Facilities Advisor/Facilities Manager (2011–2015)

- Provided project management and engineering oversight for Chaparral’s largest CO₂ development that included a grassroots 68-mile CO₂ pipeline and a grassroots CO₂ capture facility to serve a new EOR project in northeast Oklahoma.
- Directly responsible for facility design and integration within all of Chaparral’s ongoing and developing EOR projects, resulting in alternative design of field facilities to replace underperforming equipment.
- Initiated standardization of facility designs within EOR projects for compression, water facilities, CO₂ pumps, and cooling facilities.
- Directly involved with developing and maintaining Chaparral’s EOR budget, including full field project development costs.
- Recognized as a key contributing team member by leading Chaparral in achieving its initial and highest monthly oil production level of 1 MMBO in May 2014.

Operations Manager/Operations Engineer (2001–2011)

- Directly responsible for the development of Chaparral’s CO₂ expansion programs within active and three new EOR projects within the Oklahoma and Texas Panhandle areas. Development work included well intervention, facilities design and installation, chemical reviews on ongoing operations, drilling and completion programs, WAG design and implementation, and land work support. Chaparral’s CO₂ expansion programs realized an increase in gross production of over 5100 BOPD from the units involved.
- Directly responsible for securing CO₂ sourcing from Arkalon ethanol plant in Liberal, Kansas, resulting in the development of a grassroots CO₂ capture facility adjacent to the ethanol plant.
- Directly responsible for the development, installation, and monitoring of three pipeline projects in the southwest Kansas and the Oklahoma and Texas Panhandle areas to service new CO₂ projects.

- Instituted a chemical squeeze treatment on submersible pump installations to stem scaling of the downhole equipment. Treatments resulted in increasing run time of submersible pumps from less than 3 months to 18 months.
- Recognized by Chaparral as a key personnel asset within its EOR operations during Chaparral's financial presentations.

1999–2001: WoodGroup ESP, Oklahoma City and Purcell, Oklahoma. Mr. Warmack held the following positions:

Alliance Manager (2000–2001)

- Directly responsible for alliance with Kerr McGee for submersible pump installation and operation.
- Instituted new design parameters on submersible pump installations that dramatically increased the run time of the installed equipment. This design resulted in savings of over \$1 million per year to Kerr McGee. Recognized by Kerr McGee for the savings to its operations.
- Developed a plan for continuous improvement concerning submersible pump installations based upon review of equipment installations and cooperation of WoodGroup's personnel and Kerr McGee's Failure Analysis Team.

Reliability Engineer (1999–2000)

- Directly responsible for the investigation into failures on domestic and international customer equipment. Provided summary reports of findings with proposed solutions to prevent future reoccurrence.
- Directly responsible for the investigative review on WoodGroup's operating standards, equipment upgrades, and modifications.
- Provided engineering support to in-house quality control on procured and manufactured equipment.

1997–1998: Lead Field Engineer, Occidental Petroleum, Maracaibo, Venezuela. Mr. Warmack's activities included the following:

- Supervised staff of up to 15 field personnel engaged in completions, nondrilling workovers, and downhole operations.
- Coordinated fieldwork with Maracaibo office and camp personnel for workover and production operations, submersible equipment design and installation, and workover rig movements.
- Recognized as a key asset in ongoing operations through sale of operations from Occidental to Union Texas Petroleum to Arco and British Petroleum.

1981–1997: Occidental Petroleum and prior subsidiaries, Oklahoma City, Oklahoma. Mr. Warmack's activities included the following:

- Directly involved with ongoing EOR projects in the central Oklahoma area that included design of a grassroots EOR project in an acquired unit for plant and field facilities. Instituted a new design for a CO₂ distribution system within the field.
- Implemented a Failure Analysis Team (FAT Team) to extend run time of submersible pump installations within the company's EOR operations. The FAT Team consisted of operating personnel, a chemical supplier, and a submersible pump supplier. Work from the FAT Team

resulted in extending run times of submersible pumps from 15 months to over 24 months within 2 years, resulting in reduced operating and equipment costs.

- Led the successful acquisition efforts on two producing properties valued at \$3.0 million. Directly involved with the unsuccessful acquisition of two companies.
- Continuously enhanced production base from wells ranging in depths from 3000 to 15,000 feet through workover programs, recompletions, stimulations, and changes in artificial lift equipment. Developed and instituted a program for having a pipeline connection installed prior to frac treatments, resulting in better completions and higher production from wells.
- Developed a multistage frac design in vertical wells using bullet perforations, reducing frac time by 50% and resulting in savings of over \$250,000 per job.
- Selected by Oxy to serve on a worldwide ESP team to enhance the run time and use of ESP equipment.

Publications

Mr. Warmack has coauthored numerous professional publications.

ORGANIZATION QUALIFICATIONS

- **Energy & Environmental Research Center** – The EERC is recognized as one of the world’s leading developers of cleaner, more efficient energy to power the world and environmental technologies to protect and clean our air, water, and soil. Our mission is to provide practical, pioneering solutions to the world’s energy and environmental challenges. Our team of more than 250 scientists, engineers, and finance, operations, and other support professionals work together to develop practical solutions to critical global issues. Our comprehensive research portfolio comprises a wide array of services tailored to meet each client’s needs. We have worked with more than 1300 clients in 53 countries worldwide from Fortune 500s to small start-ups. Trusted, dynamic working relationships with industry, government, and research organizations provide the foundation for bringing cutting-edge science and engineering technologies together to resolve critical global challenges.
- **Hess Corporation** – Hess has operated in North Dakota continuously since 1951 and is one of the state’s largest oil and gas producers. Hess operates upstream and midstream facilities both north and south of Lake Sakakawea, which includes over 3000 miles of gathering pipelines for oil, gas, and produced water. The referenced gathering systems were installed over a wide range of years and are constructed of various materials from carbon steel, polypropylene, fiberglass, and FlexSteel. Hess is proactively researching alternative technologies that can be used to economically provide early leak detection and that will aid in determining the integrity of its in-service gathering systems.
- **Oneok, Inc.** – Oneok is a leading midstream service provider and owner of one of the nation’s premier natural gas liquids (NGLs) systems, connecting NGL supply in the Rocky Mountain, Midcontinent, and Permian regions with key market centers and an extensive network of natural gas gathering, processing, storage, and transportation assets. Oneok is a Fortune 500 company headquartered in Tulsa, Oklahoma, and is included in the S&P 500.
- **Enbridge Inc.** – Enbridge moves about 25% of the crude oil produced in North America, transports nearly 20% of the natural gas consumed in the United States, and operates North America’s third-largest natural gas utility by consumer count. Enbridge was an early investor in renewable energy and has a growing offshore wind portfolio. Core businesses include liquids pipelines, natural gas pipelines, gas distribution and storage, and renewable energy. Enbridge Inc. is headquartered in Calgary, Canada, and has a workforce of more than 12,000 people, primarily in the United States and Canada. Enbridge (ENB) is traded on the New York and Toronto stock exchanges.
- **DCP Midstream** – DCP Midstream is a Fortune 500 natural gas company operating a strong and diversified portfolio of logistics, marketing, gathering, and processing assets across nine states. Headquartered in Denver, Colorado, it is one of the largest natural gas processors in the United States, with over 90 years of industry leadership. The owner of DCP’s general partner is a joint venture between Enbridge and Phillips 66.

- **Energy Transfer** – Energy Transfer is celebrating 25 years as the U.S. midstream energy leader. Cofounded in 1996 by Kelcy Warren and Ray Davis, Energy Transfer is now one of the most diversified, publicly traded energy infrastructure partnerships in the country, with more than 90,000 miles of pipeline and associated infrastructure traversing 38 states and Canada, international offices in Canada and Beijing, and nearly 10,000 employees. Energy Transfer Partners operates an 1195-mile system, including the Dakota Access and ETCO pipelines, that enables up to 1.1 million barrels per day to be safely transported from North Dakota’s Bakken and Three Forks Formations.
- **TC Energy Corporation** – For more than 70 years, TC Energy has operated pipelines, storage facilities, and power generation plants that support Canada, the United States, and Mexico. Its facilities operate safely, reliably, and quietly. Core operations include carbon-free energy solutions, 57,900 miles of natural gas pipeline, 653 billion cubic feet of natural gas storage, 3000 miles of hydrocarbon liquids pipelines, and seven power generation facilities with a capacity of 4200 megawatts. Its corporate office is headquartered in Calgary, Alberta.
- **MPLx** – MPLx is a diversified, large-cap master limited partnership formed by Marathon Petroleum Corporation that owns and operates midstream energy infrastructure and logistics assets and provides fuels distribution services. MPLx’s assets include a network of crude oil and refined product pipelines; an inland marine business; light-product terminals; storage caverns; refinery tanks, docks, loading racks, and associated piping; and crude and light-product marine terminals. The company also owns crude oil and natural gas gathering systems and pipelines as well as natural gas and NGL processing and fractionation facilities in key U.S. supply basins. Its headquarters are in Findlay, Ohio.



APPENDIX D

COMMITMENT LETTERS

October 14, 2021

Mr. Brent Brannan
Director
Oil & Gas Research Program
State Capitol, 14th Floor
600 E Boulevard Ave.
Dept.405
Bismarck, ND 58505-0840

Subject: Program Entitled "iPIPE – intelligent Pipeline Integrity Program"

Dear Mr. Brannan:

DCP Midstream ("DCP") is submitting this letter in support of the proposal for iPipe program funding submitted to the Oil and Gas Research Program (OGRP) by the Energy & Environmental Research Center (EERC). DCP is an active participant in iPIPE, including a funding commitment of \$75,000 per year during the term of the membership. We believe that iPipe's research accelerates innovation for pipeline integrity, as shown through the various technologies that have been carefully evaluated and proven to be beneficial to the industry, such as Satelytics and INGU Solutions. The technology used for leak prevention, detection, and remote sensing is rapidly advancing due to the use of machine learning and artificial intelligence, as well as satellite and drone technologies. The next phase of this program, referred to as 'iPIPE 2.0' will build on the program's successes, grow industry participation in developing pipeline integrity technology, and assist in the adoption of new technology by industry.

DCP, in collaboration with other members of the iPIPE consortium, has committed \$75,000 per year to the iPipe program if such funds are matched by the OGRP. DCP's funding commitment is accompanied by a commitment of in-kind support for project demonstrations at facilities selected by the iPipe membership. However, the success of the iPipe program depends on the additional funding requested from OGRP. DCP is pleased to provide support for the iPipe 2.0 proposal being submitted by the EERC and hopes that the OGRP will also support this industry-led research program by matching the funds contributed by the iPipe member companies.

Sincerely,



Greg Tilley
Director Pipeline Corrosion



October 29, 2021

Mr. Brent Brannan
Director
Oil & Gas Research Program
State Capitol, 14th Floor
600 E Boulevard Ave.
Dept.405
Bismarck, ND 58505-0840

Subject: Program Entitled "iPIPE 2.0"

Dear Mr. Brannan:

This letter is provided to convey Energy Transfer's intent to fund and actively participate in iPIPE in accordance with the proposal submitted to the North Dakota Oil and Gas Research Program (OGRP). We believe this industry-led research builds on our previous success and accelerates innovation for pipeline integrity. The program advances pipeline technology for leak prevention, detection, and remote sensing in which the landscape of machine learning, artificial intelligence, satellite, and drone technologies are rapidly advancing. Continuing the program builds on these successes, grows participation, and assists the adoption of new technology.

Energy Transfer, in collaboration with other members of the iPIPE consortium, is committing \$75,000 per year for the proposed program to be matched with OGRP support. iPIPE members are committed to providing in-kind support for project demonstrations at facilities decided by the membership. Energy Transfer's commitment is contingent on the award of matching funds from NDIC's Oil & Gas Research Program and other pipeline operators participating in the program.

Sincerely,

A handwritten signature in black ink, appearing to read 'K. Grant Ruckel'.

K. Grant Ruckel
Vice President, Government Affairs

October 4, 2021

Mr. Brent Brannan
Director
Oil & Gas Research Program
State Capitol, 14th Floor
600 E Boulevard Ave.
Dept.405
Bismarck, ND 58505-0840

Subject: Program Entitled "iPIPE – intelligent Pipeline Integrity Program"

Dear Mr. Brannan:

This letter is provided to convey Hess Corporation's intent to fund and actively participate in iPIPE in accordance with the proposal submitted to the North Dakota Oil and Gas Research Program (OGRP). We believe this industry-led research builds on our previous success and accelerates innovation for pipeline integrity. The program advances pipeline technology for leak prevention, detection, and remote sensing in which the landscape of machine learning, artificial intelligence, satellite, and drone technologies are rapidly advancing. Continuing the program builds on these successes, grows participation, and assists the adoption of new technology.

Hess Corporation, in collaboration with other members of the iPIPE consortium, is committing \$75,000 per year for the proposed program to be matched with OGRP support. iPIPE members are committed to providing in-kind support for project demonstrations at facilities decided by the membership. Hess Corporation's commitment is contingent on the award of matching funds from NDIC's Oil & Gas Research Program and other pipeline operators participating in the program.

Sincerely,



Brent Lohnes
General Manager-North Dakota
Hess Corporation

October 14, 2021

Mr. Brent Brannan
Director
Oil & Gas Research Program
State Capitol, 14th Floor
600 E Boulevard Ave.
Dept.405
Bismarck, ND 58505-0840

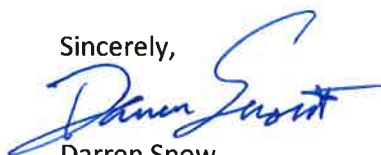
Subject: Program Entitled "iPIPE – intelligent Pipeline Integrity Program"

Dear Mr. Brannan:

This letter is provided to convey Marathon Petroleum Logistics (MPLX) intent to fund and actively participate in iPIPE in accordance with the proposal submitted to the North Dakota Oil and Gas Research Program (OGRP). We believe this industry-led research builds on our previous success and accelerates innovation for pipeline integrity. The program advances pipeline technology for leak prevention, detection, and remote sensing in which the landscape of machine learning, artificial intelligence, satellite, and drone technologies are rapidly advancing. Continuing the program builds on these successes, grows participation, and assists the adoption of new technology.

MPLX, in collaboration with other members of the iPIPE consortium, is committing \$75,000 per year for the proposed program to be matched with OGRP support. iPIPE members are committed to providing in-kind support for project demonstrations at facilities decided by the membership. MPLX commitment is contingent on the award of matching funds from NDIC's Oil & Gas Research Program and other pipeline operators participating in the program.

Sincerely,



Darren Snow

MPLX, North West Area - Director

Marathon Petroleum Logistics

From: Snow, Darren J.
Sent: Friday, November 19, 2021 10:52 AM
To: Olderbak, Michelle R. **Cc:** McRae, Austin; Schmidt, Darren;
Subject: RE: [EXTERNAL] RE: iPIPE program 2022+

iPIPE,
Per the discussion today MPLX is committed to iPIPE for 2022 and 2023.

Energy Transfer

From: Tripp, Garry L
Sent: Wednesday, December 1, 2021 3:58 PM
To: Schmidt, Darren
Subject: [EXTERNAL]-RE: support email

CAUTION: This message originated from outside of the organization. Do not click links or open attachments unless you recognize the sender and know the content is safe.

Energy Transfer recognizes iPIPE 2.0 will be conducted over a 2-year program period and support the program as provided in Energy Transfer's originally submitted letter.



Garry L. Tripp
Sr. Director – Technical Services Support
Technical Services
Energy Transfer

DCP Midstream

From: Tilley, Gregory H
Sent: Wednesday, December 1, 2021 5:24 PM
To: Schmidt, Darren
Subject: RE: [EXTERNAL]RE: support email

DCP Midstream recognizes iPIPE 2.0 will be conducted over a 2-year program period and support the program as provided in DCP Midstream's originally submitted letter.

Greg Tilley, PMP
Director Pipeline Corrosion

Building Connections to Enable Better Lives

Enbridge

From: Phil Martin
Sent: Wednesday, December 1, 2021 4:15 PM
To: Schmidt, Darren
Subject: [EXTERNAL]-RE: revised proposal

CAUTION: This message originated from outside of the organization. Do not click links or open attachments unless you recognize the sender and know the content is safe.

Hi Darren,

Yes, I can confirm at Enbridge we are currently working through the procurement process for the iPIPE 2.0 2-year program proposal.

Phil

Phil Martin MBA,ISP
Manager, TIS PCSLD Leak Detection

ENBRIDGE INC.
10175 101 St NW, Edmonton, Alberta T5J OH3
enbridge.com
Safety. Integrity. Respect. Inclusion.



APPENDIX E
BUDGET NOTES

BUDGET NOTES

ENERGY & ENVIRONMENTAL RESEARCH CENTER (EERC)

BACKGROUND

The EERC is an independently organized multidisciplinary research center within the University of North Dakota (UND). The EERC is funded through federal and nonfederal grants, contracts, and other agreements. Although the EERC is not affiliated with any one academic department, university faculty may participate in a project, depending on the scope of work and expertise required to perform the project.

INTELLECTUAL PROPERTY

The applicable federal intellectual property (IP) regulations will govern any resulting research agreement(s). In the event that IP with the potential to generate revenue to which the EERC is entitled is developed under this project, such IP, including rights, title, interest, and obligations, may be transferred to the EERC Foundation, a separate legal entity.

BUDGET INFORMATION

The proposed work will be done on a cost-reimbursable basis. The distribution of costs between budget categories (labor, travel, supplies, equipment, etc.) and among funding sources of the same scope of work is for planning purposes only. The project manager may incur and allocate allowable project costs among the funding sources for this scope of work in accordance with Office of Management and Budget (OMB) Uniform Guidance 2 CFR 200.

Escalation of labor and EERC recharge center rates is incorporated into the budget when a project's duration extends beyond the university's current fiscal year (July 1 – June 30). Escalation is calculated by prorating an average annual increase over the anticipated life of the project.

The cost of this project is based on a specific start date indicated at the top of the EERC budget. Any delay in the start of this project may result in a budget increase. Budget category descriptions presented below are for informational purposes; some categories may not appear in the budget.

Salaries: Salary estimates are based on the scope of work and prior experience on projects of similar scope. The labor rate used for specifically identified personnel is the current hourly rate for that individual. The labor category rate is the average rate of a personnel group with similar job descriptions. Salary costs incurred are based on direct hourly effort on the project. Faculty who work on this project may be paid an amount over the normal base salary, creating an overload which is subject to limitation in accordance with university policy. As noted in the UND EERC Cost Accounting Standards Board Disclosure Statement, administrative salary and support costs which can be specifically identified to the project are direct-charged and not charged as facilities and administrative (F&A) costs. Costs for general support services such as contracts and IP, accounting, human resources, procurement, and clerical support of these functions are charged as F&A costs.

Fringe Benefits: Fringe benefits consist of two components which are budgeted as a percentage of direct labor. The first component is a fixed percentage approved annually by the UND cognizant audit

agency, the Department of Health and Human Services. This portion of the rate covers vacation, holiday, and sick leave (VSL) and is applied to direct labor for permanent staff eligible for VSL benefits. Only the actual approved rate will be charged to the project. The second component is estimated on the basis of historical data and is charged as actual expenses for items such as health, life, and unemployment insurance; social security; worker's compensation; and UND retirement contributions.

Travel: Travel includes project review meetings, annual membership forums, technology selection event, and site visits. Travel costs are estimated and paid in accordance with OMB Uniform Guidance 2 CFR 200, Section 474, and UND travel policies, which can be found at <http://und.edu/finance-operations> (Policies & Procedures, A–Z Policy Index, Travel). Daily meal rates are based on U.S. General Services Administration (GSA) rates unless further limited by UND travel policies; other estimates such as airfare, lodging, ground transportation, and miscellaneous costs are based on a combination of historical costs and current market prices. Miscellaneous travel costs may include parking fees, Internet charges, long-distance phone, copies, faxes, shipping, and postage.

Equipment: If equipment (value of \$5000 or more) is budgeted, it is discussed in the text of the proposal and/or identified more specifically in the accompanying budget detail.

Supplies: Supplies include items and materials that are necessary for the research project and can be directly identified to the project. Supply and material estimates are based on prior experience with similar projects. Examples of supply items are chemicals, gases, glassware, nuts, bolts, piping, data storage, paper, memory, software, toner cartridges, maps, sample containers, minor equipment (value less than \$5000), signage, safety items, subscriptions, books, and reference materials. General purpose office supplies (pencils, pens, paper clips, staples, Post-it notes, etc.) are included in the F&A cost.

Technology Selection Subcontracts: Technology selection subcontracts are funds provided to companies that are selected by the iPIPE 2.0 technology selection committee. The committee will meet on three occasions during the program period to select projects based on criteria and budget. The EERC will subcontract to the designated companies.

Professional Fees: Not applicable.

Communications: Telephone, cell phone, and fax line charges are included in the F&A cost; however, direct project costs may include line charges at remote locations, long-distance telephone charges, postage, and other data or document transportation costs that can be directly identified to a project. Estimated costs are based on prior experience with similar projects.

Printing and Duplicating: Page rates are established annually by the university's duplicating center. Printing and duplicating costs are allocated to the appropriate funding source. Estimated costs are based on prior experience with similar projects.

Food: Expenditures for project partner meetings where the primary purpose is dissemination of technical information may include the cost of food. The project will not be charged for any costs exceeding the applicable GSA meal rate. EERC employees in attendance will not receive per diem reimbursement for meals that are paid by project funds. The estimated cost is based on the number and location of project partner meetings.

Professional Development: Fees are for memberships in technical areas directly related to work on this project. Technical journals and newsletters received as a result of a membership are used throughout the development and execution of the project by the research team.

Operating Fees: Operating fees generally include EERC recharge centers, outside laboratories, and freight.

EERC recharge center rates are established annually and approved by the university.

Laboratory and analytical recharge fees are charged on a per sample, hourly, or daily rate. Additionally, laboratory analyses may be performed outside the university when necessary. The estimated cost is based on the test protocol required for the scope of work.

Graphics recharge fees are based on an hourly rate for production of such items as report figures, posters, and/or images for presentations, maps, schematics, Web site design, brochures, and photographs. The estimated cost is based on prior experience with similar projects.

Shop and operations recharge fees cover specific expenses related to the pilot plant and the required expertise of individuals who perform related activities. Fees may be incurred in the pilot plant, at remote locations, or in EERC laboratories whenever these particular skills are required. The rate includes such items as specialized safety training, personal safety items, fall protection harnesses and respirators, CPR certification, annual physicals, protective clothing/eyewear, research by-product disposal, equipment repairs, equipment safety inspections, and labor to direct these activities. The estimated cost is based on the number of hours budgeted for this group of individuals.

Engineering services recharge fees cover specific expenses related to retaining qualified and certified design and engineering personnel. The rate includes training to enhance skill sets and maintain certifications using Webinars and workshops. The rate also includes specialized safety training and related physicals. The estimated cost is based on the number of hours budgeted for this group of individuals.

Geoscience services recharge fees are discipline fees for costs associated with training, certifications, continuing education, and maintaining required software and databases. The estimated cost is based on the number of hours budgeted for this group of individuals.

Software solutions services recharge fees are for development of customized Web sites and interfaces, software applications development, data and financial management systems for comprehensive reporting and predictive analysis tools, and custom integration with existing systems. The estimated cost is based on prior experience with similar projects.

Freight expenditures generally occur for outgoing items and field sample shipments.

Facilities and Administrative Cost: The F&A rate proposed herein is approved by the U.S. Department of Health and Human Services and is applied to modified total direct costs (MTDC). MTDC is defined as total direct costs less individual capital expenditures, such as equipment or software costing \$5000 or more with a useful life of greater than 1 year, as well as subawards in excess of the first \$25,000 for each award.

Cost Share: Cost share will be provided in the form of cash from \$75,000 yearly membership fees provided by seven industry partners, for a total of \$1,050,000.