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PROJECT FINAL REPORT

Instructions:

- **Please note that making changes to the project without prior written consent from the funder(s) could constitute sufficient grounds for termination of funding.**
- This report must be a stand-alone report, *i.e.,* must be complete in and of itself. Scientific articles or other publications cannot be substituted for the report.
- A signed electronic copy of this report must be forwarded to the funders' representative on or before the due date, as per the investment agreement.
- A detailed, signed statement of revenues received and expenses incurred during the entire funding period of the project must be submitted along with this report, as per the investment agreement.
- For any questions regarding the preparation and submission of this report, please contact the funders' representative.

Section A: Project overview

1. Project number: 2016F053R
2. Project title: Evaluation of enhanced nitrogen-use efficiency products;
3. Abbreviations: EEF - enhanced efficiency nitrogen fertilizer; AAF - Alberta Agriculture and Forestry**; CRF -** controlled-release fertilizers; CRU - Controlled-Release Urea; AFFIRM - Alberta Farm Fertilizer Information Recommendation Manager
4. Project start date: (2016/06/01)
5. Project completion date: (2019/03/31)

6. Final report submission date: (2019/04/17)	
7. Research and development team data	
a) Principal Investigator:	
Name	**Institution**
Diana Staley	InnoTech Alberta
b) Research team members (List all team members. For each new team member, *i.e.*, joined since the last report, include a personal data sheet. Additional rows may be added if necessary.)	
Name	**Institution**
Bonnie Drozdowski	InnoTech Alberta
Len Kryzanowski	Alberta Agriculture and Forestry
Tom Jenson	International Plant Nutrition Institute
Miles Dyck	University of Alberta
Karen Haugen-Kozyra	Viresco Solutions
Candace Vinke	Viresco Solutions

Section B: Non-technical summary (max 1 page)

There is a growing interest by agricultural producers in western Canada to utilize enhanced efficiency nitrogen (N) fertilizer (EEF) products. These products can potentially reduce fertilizer application rates while increasing yield through better synchronization of the nitrogen supply with crop demand, in addition to potentially reducing damage to seedlings under specific growing conditions and management practices. A need was identified to demonstrate to producers in Alberta under which conditions EEF products are agronomically and economically effective. The objective of the project "Evaluation of Enhanced Nitrogen-Use Efficiency Products" was to compile and synthesize current and past information on EEF usage in western Canada to assist producers to evaluate yield, environmental and economic benefits of EEF product application, and to better understand soil properties and cropping systems that improve productivity.

An extensive collection of literature and data to-date on EEF products usage in Western Canada, was collated into a literature summary and EXCEL database. The two major categories of EEF products are controlled-release fertilizers (CRFs) and stabilizer products (urease inhibitors and nitrification inhibitors). Both categories of EEF products produce mixed results in terms of agronomic impact. For example, the literature on Controlled-Release Urea (CRU) appears to show a likely benefit when fertilizer is seedrow applied or fall banded. In addition, CRU tends to be beneficial in moist conditions, on irrigated land and when growing canola. The research on stabilizer products shows that fall-applied urea, even with nitrification inhibitor treatments, is unlikely to match spring applied urea in terms of yield or N retention; however, fall-applied treated urea commonly outperforms untreated fall-applied urea. Furthermore, like CRFs, stabilizer products are beneficial in moist conditions, on irrigated land and when fertilizer is seedrow applied.

A considerable amount of research has been conducted on the use of EEF products since initiation of this project in 2016. Nearly 10,000 entries of data from multiple researchers on 4 types of EEF products and 6 crops were collated into the dataset which will significantly contribute to the ability of researchers and producers to analyze the agronomic and economic costs and benefits of EEF products. The new data collected within this project is being integrated into the *Alberta Farm Fertilizer Information Recommendation Manager* (AFFIRM) decision support tool. AFFIRM is a support tool developed by the Government of Alberta that uses an agro-economic model to provide nitrogen recommendations for Alberta conditions. AFFIRM offers a wide range of scenarios for producers to run, and this EEF dataset will play a significant role in making the EEF product scenarios more robust. Also, by contributing to the AFFIRM platform, the project data will become part of a continuously updated database that will provide the most up-to-date information available on EEF products as well as be accessible by the widest audience of producers in Alberta.

Given that both types of EEF products identified require additional costs to the producer, it is currently unclear if the agronomic efficiency improvements justify the added costs. Once the data collated in this project is integrated into the AFFIRM tool and economic scenarios are run, a complete cost benefit analysis can be completed to inform producers of the value of the products.

Section C: Project details

1. Background (max 1 page)

Describe the project background and include the relevant scientific and development work providing the impetus for the current project.

Enhanced efficiency N fertilizer (EEF) products are engineered fertilizer products that strive to reduce nutrient losses and increase fertilizer efficiency. These products are designed to supply available N over a longer period to better coincide with plant nutrient demand or stabilize nutrients in the soil, preventing nutrient loss. Some EEF products have been shown to improve yield under certain environmental conditions (Gagnon et al., 2012). By delaying nutrient availability and reducing losses, in some environments, fall-applied EEFs may be as efficient as spring-applied conventional fertilizers, by reducing N losses from leaching, and reducing greenhouse gas (GHG) emissions (Awale and Chatterjee, 2017; Gagnon et al., 2012; Li et al., 2012, 2016; Malhi et al., 2001). EEF products may also improve fertilizer use efficiency by minimizing nutrient loses via leaching or volatilization (Gagnon et al., 2012; Rawluk et al., 2001; Romero et al., 2017; Watson et al., 1994). Under ideal conditions, EEF products may help maximize nutrient uptake by plants while minimizing leaching losses by supplying nutrient quantities proportional to plant requirements. This can provide a more consistent and sustained flow of nutrients that matches plant development while also reducing the cost for fertilizer re-applications. Additionally, EEF products may be applied directly or adjacent to the seedling root zone at planting with little risk of root damage in comparison to the damage caused when conventional fertilizers are applied adjacent to the seedling root zone (Jacobs and Timmer, 2005).

There is a growing interest by agricultural producers in western Canada to utilize EEF products, however cost benefit analysis is required to enable producers to make effective decisions about incorporating the products into their farm plans. To date, there was not enough data available for robust modeling and cost benefit analysis. Compilation of research data to inform model development and scenario testing for inclusion in cost benefit analysis will significantly contribute to producer's ability to evaluate the benefits of incorporating EEF products into their business.

2. Objectives and deliverables (max 1 page)

Project Phase	Objective and Deliverables	Deliverable Status/Modifications from Original
Phase I – Compilation of EEF product literature and data	**Objective:** To complete a comprehensive literature search and outreach program to collect EEF product information and data. **Deliverables:** **1. Database of past and current EEF research data.** **2. A literature review report.**	• **Comprehensive literature review** on EEF products is included as a final report and includes: a summary of data collected on EEF products in western Canada; a review of the EEF products available in Alberta and the associated application rates; recommended timing. • **EEF Data Spreadsheet** – Data took much longer to acquire than anticipated. Data was still being provided late February 2019 to incorporate into the dataset. This database was provided to **Alberta Agriculture and Forestry (AAF)** to broaden the scope of information currently used as part of the AFFIRM decision support tool.
Phase II – Economic cost-benefit-analysis and overall benefit analysis	**Objective:** Complete a cost benefit analysis for the use of EEF products using data collected from Phase I. **Deliverables:** 1) A tool is developed/modified to calculate the profitability of applying EEF products based on key variables such as fertilizer prices, fuel prices, cropping system, expected yields, weather conditions, labour costs, ownership cost of machinery and buildings, and crop grain marketing prices. 2) A summary of the economic and environmental costs and benefits.	• Preliminary analysis with a subset of the data collected for the project indicated that creation of a new, unique tool for calculating the profitability of applying EEF products would be unnecessary and result in duplication of efforts. The project team determined that it would be more appropriate and cost effective to incorporate the data into the updated AFFIRM decision support tool given that the model has been developed and thoroughly tested and producers are already familiar with its use. • AAF is currently integrating the data into the AFFIRM tool with an anticipated completion timeline of early summer 2019. Economic scenarios will be ran by the project team after data integration and a complete cost benefit analysis will be completed to update the "Guidance on EEF Products".
Phase III – Consultation with Stakeholders	**Objective:** Garner feedback from key stakeholders on the literature review, database and economic analysis to determine the most practical and useful mechanism for producers to evaluate the use of EEP products. **Deliverables:** 1) Guidance protocol for the use of EEF Products.	• The literature review and database were reviewed by the project advisory committee. It was determined that AFFIRM would be updated with the data collated by the project team. The cost-benefit analysis will be provided in the extension material once the new EEF data is integrated into AFFIRM completely. Additional stakeholder consultation will be completed after data is fully integrated into AFFIRM. • A preliminary guidance protocol for the use of EEF products is provided and will be updated following the scenario testing with AFFIRM and posted on the AAF website.
Phase IV – Final report, extension materials and recommendations	**Objective:** Compile all information into a final report which include knowledge and data gaps identified for EEF products and recommendations for future research directions. **Deliverables:** 1) Comprehensive final report. 2) Extension materials	• A draft PowerPoint presentation for extension and outreach provides information based on the literature review and contains placeholders for the articles for submission and the economic analyses that will be completed once the new data has been fully integrated into the AFFIRM tool. • Additional extension materials and outreach will be completed according to the timeline provided in the final report and will include presentations to producer groups, and articles in industry communication magazines.

3. Research design and methodology (max 4 pages)

Phase I - Compilation of EEF product literature and data

The objective of Phase I of the project was to complete a comprehensive literature search and outreach program to collect EEF product information and data for use in subsequent phases of the project.

Literature Review

For this review, detailed searches through multiple resources including conference proceedings; electronic journals; industry, government and public reports; and, the Internet were completed to find literature related to enhanced efficiency N fertilizer (EEF) products. An emphasis was placed on the collection of literature from peer-reviewed journal articles and industry publications where the research was conducted in western Canada and specifically any experiments with a focus on Alberta; however, some relevant research from eastern Canada and the United States was included. Searches on the Internet included the use of general search terms encompassing Boolean and iterative search strategies to capture a broad swath of literature. Once collected, resources and abstracts were reviewed to determine whether documents met the inclusion criteria.

Inclusion criteria: Specific key words used during literature review included: Enhanced Efficiency Fertilizers, Western Canada, Controlled Release Urea, Nitrous Oxide Emissions from Enhanced Efficiency Fertilizers, Nitrification Inhibitors, Urease Inhibitors, Yield Impacts, Performance of Enhanced Efficiency Fertilizers and combinations of the above terms.

Exclusion criteria: Documents that were not in English, or documents related to EEF products but outside of the scope of the western prairies were generally excluded from the review. Patents and conference abstracts were excluded from all searches. No documents were excluded based on the date of publication; however, where literature was abundant, an emphasis was placed on the collection of literature from the most recent years (2015 to 2019).

The Internet and the Google scholar search engine were used to conduct general searches of peer-reviewed publications, reports, and industry-related publications. More specific searches were conducted using Compendex (scientific and technical engineering research), ISI Web of Science (high impact scientific articles and conference proceedings), University of Alberta Education and Research Archive (repository for University-related intellectual property), and ProQuest (Master and Doctoral theses and dissertations) databases. Once appropriate and applicable articles were found, citation lists were reviewed to identify any literature relevant to the topic area, missed within the primary literature search.

Data Compilation

An original list of over 20 researchers was compiled from industry, academia, not for profit and government (provincial and federal) organizations to request data from research studies conducted using EEF products in western Canada. Although 50% of the individuals contacted by the principal investigator responded positively to the request for data, it was identified in the March 2017 Interim report that one of the biggest challenges that may impact the success of the project was data collection. Academic, industrial and government researchers were reluctant to share research data prior to peer-review publication in 2016/17. There were several researchers that were in the final process of submitting their results for peer-review publication in 2017 who had indicated that they would be willing to share them post-publication submission. However, by June 2018 only 1 researcher had provided data.

Between September and December 2018, the project team worked with Viresco Solutions to re-engage with researchers to request data for inclusion in the project. A list of key contacts for consultation was established by the project team and individuals were contacted by Viresco Solutions researchers through email and followed up with through telephone meetings. A list of individuals contacted and the associated meeting dates is provided in the table below. A letter of support was provided by InnoTech Alberta for inclusion in the correspondence between Viresco and researchers which provided researchers with background to the project and assurance that

the data would not be publicly released without their written consent and would only be used to inform the AFFIRM model behind the scenes. An EXCEL database template was provided as a reference for the desired data types being requested for inclusion. An example of the email correspondence is provided below.

The Enhanced Efficiency Fertilizer (EEF) Database currently contains over 10,000 entries of yield data from 12 different EEF studies covering five EEF products: controlled release urea (ESN), SuperU, Instinct, eNtrench and N-Serve. For each data point, at a minimum, the site, growing season, source, crop, fertilizer product, application rate and yield are recorded. In some cases, additional information on placement, timing, N uptake and nitrous oxide is captured. Furthermore, site soil and environmental data was collected on nitrate N, bulk density, soil pH, soil organic matter, hot KCl, soil EC, soil texture, soil moisture, growing season precipitation, irrigation and any other relevant information shared by the researchers. The database would still benefit from additional data on non-ESN EEF products, nitrous oxide emissions and comprehensive placement and timing data. Furthermore, the project team is aware of ongoing studies on yield and nitrous oxide impact in Alberta and Saskatchewan as well as past studies from Brian Beres at the University of Alberta, Rich Farrell at the University of Saskatchewan and Mario Tenuta at the University of Manitoba that would be beneficial to include. Furthermore, there were two researchers that the project team was unable to contact: David Burton and Ron Degenhardt. Additional efforts to reach out to these individuals may prove beneficial.

Dear XX,
We're reaching out to you because we've been contracted to finish off a study commissioned by InnoTech Alberta and funded by the Alberta Funding Consortium, on the agronomic, economic and environmental performance of Enhanced Efficiency Fertilizer products in W. Canada. The study began in earnest in 2016 and I believe you chatted with Dani Degenhardt in that timeframe about some work you were doing at the time. InnoTech will now work with us to complete the study by March 2019. The project steering committee comprises Bonnie Drozdowski and Diana Staley from InnoTech Alberta, Len Kryzanowski and Symon Mezbahuddin from Agriculture and Forestry, Miles Dyck from UofA and Tom Jensen from IPNI.

The intent of the study is to compile the existing science on EEF products in western Canada, with the goal of understanding the agronomic, economic and environmental performance of EEF products under different environmental conditions, soil conditions, and cropping systems. A Literature Review, and a supporting Database will facilitate the production of a decision support system for the use of EEF products in Alberta, using AFFIRM. Len and Symon will be working with us to adapt and broaden out the tool to accommodate the existing science.

Please see the attached spreadsheet for the desired data types that AFFIRM uses as part of its modeling. Although you may not have all the data pieces required, this will help guide our discussion with you on what available research you may have to contribute to the project. Since the last reach-out occurred in 2016, it is our hope that you have been able to publish some of your work since then, and/or would be willing to submit some near-term analysis that you are preparing for publication. If you agree to share information and data, InnoTech will provide written assurances that the data you provide will be used to compile a database that will not be shared publicly but used to inform the AFFIRM model behind the scenes.

Please let us know your availability for this coming week of November 26 to 30. Thanks very much for your cooperation – if the dates above don't work for you, please send us some available times the following week (December 3 to 7th).

Karen and Candace

Viresco Solutions
End-to-end sustainability

Name	Meeting	Commitments	Status
Doon Pauly, AnF & Eric Bremer, Western Ag	Yes (Nov. 28th)	Will share data on ESN from their fertigation study and from their dry bean research; end of December; send report before then.	Received
Jennifer Owen, Xiying Hao and Brian Beres (AAFC)	Yes (Nov. 28th)	Jennifer shared an article published in CJPlSciPlant and will look at AAF's spreadsheet and include the data she has for Jan 2019	Received data from Jennifer Owen and currently working with Brian Beres to incorporate additional data
Miles Dyck, UofA	Yes (Nov. 29th)	Will share report from Fertilizer Canada and fill in AAF's spreadsheet as best he can with the data he has - end of Dec '19	Received
Tai MClellan Maaz	Yes (Nov. 29th)	Will share her data from study in Western Canada (mid Jan) and review the literature review/reference list to identify gaps; willing to review Lit review	Unfortunately, IPNI was closed part way through the project and therefore data was not received, nor lit review reviewed
Laurel Thompson nee Perrot, Lakeland College, nee UofA	Yes (Nov. 29th)	Shared the data she and Sheri has for N applied on Barley and will also share article on data published in Agronomy	Received
Guillermo Hernandez-Ramirez	Yes (Nov. 29th)	Has two datasets that he will share end of December and also will think about recent publications we should consider for lit review; Second dataset by private co. – data sharing agreement may be needed	Received
David Burton	No response	Has a dataset that tested multiple EEF products on spring wheat that she can share	Received
Sheri Strydhorst	Yes (Dec. 6)		Received
Mario Tenuta	No response		
Rigas Karamanos	Yes (Dec. 18)		Traveling out of the country and was unable to provide data in time
Xiying and Brian	Referred us to Jennifer		
Reynald Lemke	Referred us to Rich		
Ron Degenhardt	No response		
Rich Farrell	No response		

Phase II – Economic cost-benefit-analysis and overall benefit analysis

A preliminary economic analysis was completed with the initial dataset obtained in 2016 which clearly indicated that more data was required to inform an effective cost benefit analysis. Originally the project team had proposed to develop an Excel spreadsheet calculator to calculate the profitability of applying EEF products based on key variables such as fertilizer prices, fuel prices, cropping system, expected yields, weather conditions, labour costs, ownership cost of machinery and buildings, and crop grain marketing prices. However, it was determined in September 2018 that the AFFIRM decision support tool would be the most appropriate resource to use for evaluation of EEF products.

As a result of the difficulty in obtaining data from researchers, integration of the data into AFFIRM has only recently been initiated by Alberta Agriculture and Forestry. Once the data has been integrated into the tool, Viresco will work with AAF to compile a series of case studies, utilizing the newly added EEF database derived from this project. The case studies will look at the economic returns and sensitivity of the model to changes in variables such as soil moisture, crop yields, N rate and fertilizer costs. The

outcomes of the scenario analyses will be built into extension materials (See Appendix D in the attached report for a detailed plan) and shared with industry and producer groups to give a clearer picture of the circumstances under which EEF products may be beneficial. The advantage of the database being housed by a government body is that there is a commitment to incorporate additional data as it becomes available. Over the long term, a plan that may involve an open-source database, will be developed. This is important as it is expected that the updated version of the nitrous oxide emission reductions approach will depend on AFFIM to calculate baseline GHG emissions. More information on this will be available later this year when the updated protocol is released.

Phase III and IV – Consultation with Stakeholders and Extension

The following extension materials will be created by Viresco Solutions, per their contract with InnoTech Alberta, and according to the timeline found below (See Section 9 for specifics):

1. A finalized "Guidelines for Use" document that provides a summary of conditions under which EEF products should be considered.
2. A Powerpoint presentation summarizing the findings of the literature review and case study scenario analysis.
3. Two articles for submission to agricultural related publications (e.g. Western Producer, Top Crop Manager, Grainews, Grainswest, IPNI Better Crops, etc.). One of the articles will be on the updated AFFIRM model and the other will be on the results of the cost-benefit analysis (including case studies). The articles will be targeted to producers and are planned for August 2019.
4. An updated check-list of Nitrous Oxide Emission Reductions protocol (NERP) requirements (once the new protocol is released) (see current NERP check-list in Appendix G).

The completion of the above extension materials will take place once Alberta Agriculture and Forestry has fully updated AFFIRM based on the new dataset provided. The data will be cleaned and formatted and utilized in the Harmsen-Mitscherlich equation, which sets the coefficients for use in AFFIRM. A tentative timeline is presented in the Table below.

	Week																	
	April				May					June				July				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Project Extension Plan																		
Integrating Data in AFFIRM for Preliminary Model Validation for EEF Products																		
Completion of Sensitivity Analysis																		
Incorporation of Sensitivity Analysis Results into Guidelines for Use Document and PowerPoint presentation																		
Present PowerPoint to Industry and Producers[1]																		
Complete and Submit Two Articles																		
Update Check List of NERP Requirements[2]	TBD																	

[1] One to two in-person presentations, plus webinar presentation(s)

[2] The protocol is currently under revision; contingent on release of updated protocol (TBD) Viresco Solutions will provide an update to NERP requirements if they are release in the upcoming year.

4. Results, discussion and conclusions (max 8 pages)

Unique Knowledge Generated

Enhanced efficiency nitrogen fertilizers (EEF) can better synchronize nitrogen supply with crop demand, and as a result more farmers are becoming interested in utilizing these types of products for both agronomic and economic reasons. This project compiled the research and data behind EEF products in western Canada as well as significantly contributed to the unique decision support tool available to Alberta farmers, *Alberta Farm Fertilizer Information and Recommendation Manager* (AFFIRM). AFFIRM is a well recognized platform that can help producers make fertilizer application decisions, however, its past ability to make recommendations around EEF products was limited. This project will significantly enhance AFFIRM's ability to make recommendations to farmers on EEF products due to a much larger database, with more information per entry on a greater diversity of EEF products from a wider range of researchers. With funding from this project, the database now has over 10,000 entries on yield responses from 12 different studies.

Investing in the AFFIRM database is also important for future research. Since the AFFIRM database is a platform that has been designed to be updated routinely, the data collected under this project will contribute to a permanent database that can be updated as future research becomes available. The ability for AFFIRM to continuously incorporate new research findings, makes it possible to build on the research findings in a systematic way that will make the research available not just to the researchers themselves but also to producers that would benefit directly from the findings.

The project also allowed for more nuanced understanding of EEF products. This project funded a literature review that brought together different types of EEF products and compared their agronomic impacts. For example, the literature on Controlled-Release Urea (CRU) appears to show a likely benefit when fertilizer is seedrow applied or fall banded. In addition, CRU tends to be beneficial in moist conditions, on irrigated land and when growing canola. The research on stabilizer products shows that fall-applied urea, even with nitrification inhibitor treatments, is unlikely to match spring applied urea in terms of yield or N retention; however, fall-applied treated urea commonly outperforms untreated fall-applied urea. Furthermore, like CRFs, stabilizer products are beneficial in moist conditions, on irrigated land and when fertilizer is seedrow applied. The mixed results of the different types of products demonstrated the importance of understanding both the agronomic and economic impacts that are important for adoption.

Variance

The importance of the large amount of new data that was collected under this project is described above. The project did not anticipate such a large amount of new data to be collected under this project and therefore did not anticipate the need for a significant amount of time to fully incorporate the new data into the AFFIRM database. As such, the data collected in this project is still being integrated into the AFFIRM platform. The delay in the full data integration has caused a delay in being able to produce a full cost benefit analysis for this report. Although the cost-benefit analysis is delayed, the project team believes that a more comprehensive and higher quality analysis can be created using AFFIRM once the database is fully integrated. The project team will also complete a set of case studies that will be shared with producers as part of the extension activities. The project team agrees that this ultimately is a more useful method of completing and presenting the cost benefit analysis, since completing it with a tool will enable it to be dynamic and updated on an ongoing basis as opposed to completed once at a fixed point in time.

5. Literature cited

Literature Review

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6. Project team (max ½ page)

The original principal investigator, Dani Degenhardt was replaced by Bonnie Drozdowski in June 2018 due to a change in personnel within the group at InnoTech Alberta. Given the difference in expertise, additional personnel were included to ensure the project deliverables could still be met. Diana Staley, an agricultural economist was asked to manage the project and a subcontractor, Viresco Solutions, with appropriate subject matter expertise was hired to complete the deliverables with direction from the project team (Len Kryzanowski, Tom Jenson, Miles Dyck).

Name	Organization	Role in Project	Contribution
Dani Degenhardt	InnoTech Alberta	Original Principal Investigator (June 2016 to May 2018)	Initial outreach to request data; preliminary literature review; interim project reporting
Marius Cutlac	InnoTech Alberta	Researcher; economic analysis (2016 to May 2018)	Preliminary market and cost benefit analysis
Diana Staley	InnoTech Alberta	Project Manager (September 2018 to April 2019)	Sub-contractor liaison; task and deliverable identification and tracking; project meetings and updates; final reporting
Bonnie Drozdowski	InnoTech Alberta	Project Lead (Took responsibility for project in June 2018; Established modified project team and participated in project meetings and decisions)	Client (AFC) liaison; contract management; document review; project advisor; final reporting
Len Kryzanowski	Alberta Agriculture and Forestry	Researcher and Project Team Advisor	Document review; strategic project direction
Symon Mezbahuddin	Alberta Agriculture and Forestry	Researcher	Data integration into AFFIRM
Tom Jenson	International Plant Nutrition Institute	Project Team Advisor	Document review; strategic project direction
Miles Dyck	University of Alberta	Project Team Advisor	Document review; data contributor
Karen Haugen-Kozyra	Viresco Solutions	Sub-contractor	Finalize literature review, identify data sources and conduct outreach to acquire data; collate data; liaison with AAF to incorporate data into AFFIRM; stakeholder engagement post scenario testing with AFFIRM
Candace Vinke			

7. Benefits to the industry (max 1 page; respond to sections *a)* and *b)* separately)

a) Describe the impact of the project results on the Alberta or western Canadian agriculture and food industry (results achieved and potential short-term, medium-term and long-term outcomes).

This project invested in the creation of an extensive literature review of EEF products specific to western Canada. To-date there is no other literature review that compiles a large number of studies on EEF products in the region and compares their results across multiple variables, products, and locations. By conducting an extensive literature review the western Canadian agriculture sector has access to the latest research on when these products should be used.

This project also invested in the collection of a large amount of EEF product data in western Canada. The data collected enabled one of the first extensive datasets to be collated on EEF data from multiple researchers in the region. In addition, the project data augmented an EEF database that is utilized within the AFFIRM decision support tool. The large amount of data collected within this project greatly enhances the ability of the western Canadian agricultural sector to utilize the AFFIRM platform to assist in their EEF fertilizer decision-making. Also, since the AFFIRM platform will continuously be modified with new data, as it becomes available, the data collected in this project will contribute to the decision support tool that will be used by western Canadian producers in both the short-term and long term.

b) Quantify the potential economic impact of the project results (*e.g.,* cost-benefit analysis, potential size of market, improvement in efficiency, etc.).

The literature review reveals that several variables are shown to be important for various EEF products to have a positive impact on western Canadian agriculture. For Controlled-Release Urea (CRU) products, the most beneficial variables include moist soil conditions, on irrigated land and when fertilizer is seedrow applied. Furthermore, canola crops tend to respond best. Stabilizer products are superior to untreated urea when fall-applied and also show a benefit under moist conditions and when fertilizer is seedrow applied (reduced seedling damage). Western Canadian producers that utilize these growing practices and crops will likely benefit most from EEF products.

Alberta producers represent nearly 70% of all irrigated farms in Canada and thus Alberta farmers may be poised to benefit the most from EEF products nation-wide. Southern Alberta, in particular, has a large number of farmers that utilize irrigation and so within the province, this is the geographic location that will likely benefit the most. Also, central Alberta, has a large amount of canola producers and thus this region may also benefit from EEF products. Nevertheless, management decisions must be made on a case by case basis using best available data for a particular farm. This is why the AFFIRM tool, once updated, will present the greatest value to farmers as it will allow them to analyze management decisions based on data specific to their farm.

8. Contribution to training of highly qualified personnel (max ½ page)

Training of highly qualified personnel was not a main project objective. The project team is more knowledgeable about EEF projects and 1 researcher obtained additional project management experience coordinating a multifaceted project with multiple collaborators and thus will be better equipped to conduct more complicated projects in the future.

9. Knowledge transfer/technology transfer/commercialisation (max 1 page)

a) Scientific publications (*e.g.*, scientific journals)
   i. No scientific publications have been submitted to date. The literature review could be synthesized into a publication, however that was out of the scope of the current project.

b) Industry-oriented publications (*e.g.*, agribusiness trade press, popular press, etc.)
   i. A preliminary guidance on EEF projects has been developed based on the literature review (see attached Appendix E). A finalized "Guidelines for Use" document that provides a summary of conditions under which EEF products will be developed that builds on the current draft literature review-based guidelines, by adding in the findings of the case study scenario analysis in AFFIRM and will be available on the AAF website [August 2019].
   ii. The full literature review will be publicly available (with AAC permission) through InnoTech's website and potentially AAF website [Upon receiving permission from AAC].
   iii. Two articles will be prepared for submission to agricultural related publications (e.g. Western Producer, Top Crop Manager, Grainews, Grainswest, IPNI Better Crops, etc.). One of the articles will be on the updated AFFIRM model and the other will be on the results of the cost-benefit analysis (including case studies) [August 2019].

c) Scientific presentations (*e.g.*, posters, talks, seminars, workshops, etc.)
   i. A Powerpoint presentation and/or poster presentation summarizing the findings of the literature review and case study scenario analysis (See Attached Appendix D) will be presented at one of the following: Alberta Soil Science Workshop, AGM Alberta Federation of Agriculture, etc.

d) Industry-oriented presentations (*e.g.*, posters, talks, seminars, workshops, etc.)
   i. A Powerpoint presentation summarizing the findings of the literature review and case study scenario analysis (See Attached Appendix D) will be presented to industry through a combination of webinar and in-person meetings. Examples of organizations that the content may be presented to include the International Plant Nutrition Institute (IPNI), Fertilizer Canada, Agrium, Koch Industries, BASF and Dow Chemical) [June and July 2019].
   ii. In addition, the project team plans to hold a presentation for producers directly.

e) Media activities (*e.g.*, radio, television, internet, etc.)
   i. None applicable

f) Any commercialisation activities or patents
   i. None applicable

Section D: Project resources

1. **Provide a detailed listing of all cash revenues to the project and expenditures of project cash funds in a separate document certified by the organisation's accountant or other senior executive officer, as per the investment agreement.** Revenues should be identified by funder, if applicable. Expenditures should be classified into the following categories: personnel; travel; capital assets; supplies; communication, dissemination and linkage (CDL); and overhead (if applicable).

   Given that the nature of the project was primarily a desktop literature and data compilation, the majority of the costs associated with the project were personnel and subcontractors. No funding was used for capital assets or supplies. Communication and dissemination costs are included in the sub-contractor expenses.

2. **Provide a justification of project expenditures and discuss any major variance (*i.e.*, ± 10%) from the budget approved by the funder(s).**

   Cash contributions from other government sources were originally budgeted as $40,000 ($25K from InnoTech Alberta and $15,000 from AAF), however, total contributions from other government sources were only $30,000 (all from InnoTech Alberta). The decision to incorporate data into AFFIRM rather than creating a new tool resulted in less need for cash contributions and additional time (in-kind) contributions from government (AAF) sources.

   The original budget had $3,000 cash funding from IPNI for travel costs associated with stakeholder consultation and dissemination of report findings. This has not been included in the total resources contributed to the project as this cash has not yet been received/spent. Communication with IPNI is required to determine if these expenses can still be covered given the timing delay.

3. **Resources:**

Total resources contributed to the project		
Source	**Amount**	**Percentage of total project cost**
Agriculture Funding Consortium	$97,000	50%
Other government sources: Cash	$30,852	16%
Other government sources: In-kind	$55,000	29%
Industry: In-kind	$10,000	5%
Total Project Cost	$192,852	**100%**

External resources (additional rows may be added if necessary)		
Government sources		
Name	Amount cash	Amount in-kind
Alberta Agriculture and Forestry	n/a	$45,000
InnoTech Alberta	$30,852	
University of Alberta	n/a	$10,000
Industry sources		
Name	Amount cash	Amount in-kind
International Plant Nutrition Institute	$3,000 (unconfirmed)	$10,000

Section E: Research Team Signatures and Authorised Representative's Approval

The Principal Investigator and an authorised representative from the Principal Investigator's organisation of employment MUST sign this form.

Research team members and an authorised representative from their organisation(s) of employment MUST also sign this form.

By signing as an authorised representative of the Principal Investigator's employing organisation and/or the research team member's(s') employing organisation(s), the undersigned hereby acknowledge submission of the information contained in this final report to the funder(s).

Principal Investigator

Principal Investigator	
Name: Diana Staley	**Title/Organisation:** Researcher/InnoTech Alberta Inc.
Signature: 	**Date:** April 17, 2019
Principal Investigator's Authorised Representative's Approval	
Name: Bonnie Drozdowski	**Title/Organisation:** Team Lead - Reclamation/InnoTech Alberta Inc.
Signature: 	**Date:** **April 17, 2019**

Research Team Members (add more tables as needed)

1. Team Member	
Name: Len Kryzanowski	**Title/Organisation:** Director/Alberta Agriculture and Forestry
Signature: 	**Date:** April 17, 2019
Team Member's Authorised Representative's Approval	
Name: For: Sean Royer Bret Kennedy – Acting Executive Director	**Title/Organisation:** Executive Director/Environmental Stewardship/ Alberta Agriculture and Forestry
Signature: 	**Date:** April 18, 2019

2. Team Member	
Name: Miles Dyck	**Title/Organisation:** University of Alberta
Signature: 	**Date: April 17, 2019**
Team Member's Authorised Representative's Approval	
Name:	**Title/Organisation:**
Signature:	**Date:**

3. Team Member	
Name: Candace Vinke	**Title/Organisation:** Viresco Solutions
Signature: 	**Date: April 17, 2019**
Team Member's Authorised Representative's Approval	
Name:	**Title/Organisation:**
Signature:	**Date:**

4. Team Member	
Name: Karen Haugen - Kozyra	**Title/Organisation:** Viresco Solutions

Signature: 	**Date: April 17, 2019**
Team Member's Authorised Representative's Approval	
Name:	**Title/Organisation:**
Signature:	**Date:**

5. Team Member	
Name: Symon Mezbahuddin	**Title/Organisation:** Geomatics and Modelling Specialist/Alberta Agriculture and Forestry
Signature: 	**Date:** April 18, 2019
Team Member's Authorised Representative's Approval	
Name: Len Kryzanowski	**Title/Organisation:** Director/Environmental Strategy and Research/Alberta Agriculture and Forestry
Signature: 	**Date:** April 18, 2019

6. Team Member	
Name: Tom Jensen	**Title/Organisation:** International Plant Nutrition Institute
Signature: **UNAVAILABLE**	**Date:**
Team Member's Authorised Representative's Approval	
Name:	**Title/Organisation:**
Signature:	**Date:**

Section F: Suggested reviewers for the final report

Provide the names and contact information of four potential reviewers for this final report. The suggested reviewers should not be current collaborators. The Agriculture Funding Consortium reserves the right to choose other reviewers. Under *Section 34* of the *Freedom of Information and Protection Act (FOIP)* reviewers must be aware that their information is being collected and used for the purpose of the external review.

Reviewer #1
Name: Eric Bremer
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Reviewer #2
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Reviewer #3
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Institution: Agriculture and Agri-Food Canada
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Reviewer #4
Name: Rich Farrell
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