SCHEDULE E

Pilot Project Completion Report

GMF number		GMF 15164
Date of the Report		April 5th, 2019
Name of the lead applicant (municipality or other partner)		**Symbiotic EnviroTek Inc.**
Name, title, full address, phone, fax, e-mail of lead technical contact for this Pilot Project		Art Deane, President and CEO 8210, 11500 - 35th Street SE Calgary, AB T2Z 3W4 Business Phone: 403-453-0233 Fax: 403-453-0235 Cell: 403-870-6836 adeane@symenv.com
Wheatland County	Alan Parkin, CAO	Alan.Parkin@wheatlandcounty.ca
NRC-CNRC	Dr. Boris Tartakovsky	Boris.Tartakovsky@cnrc-nrc.gc.ca
	Dr. Patrick McGinn	Patrick.McGinn@nrc-cnrc.gc.ca
NRC-IRAP	Bob Golding, ITA	Recently retired
	Jeremiah Lindstrom, new ITA	Jeremiah.Lindstrom@nrc-cnrc.gc.ca
JMP Engineering	Jeremy Sluyters, Manager	jeremy.sluyters@gmail.com
Ross Scinergy Inc.	Dr. Neil Ross, President	neilrossphd@gmail.com
BRT Engineering	Brian Smit, President	brian.smit@brtconsulting.ca
Westhoff	Dennis Westhoff, President	DWesthoff@westhoff.ab.ca
EHC	Elizabeth Huculak, Principal	Elizabeth.ehc@shaw.ca
Rosebud Hamlet	LaVerne Erickson, Resident	lavernerosebud@gmail.com

1. Introduction

Symbiotic EnviroTek Inc. (Symbiotic) in collaboration with Wheatland County, executed the pilot project to validate Symbiotic's Algae Cultivation System (ACS) as an innovative wastewater treatment technology. The pilot was also supported by National Research Council of Canada (NRC), Alberta Environment and Parks (AEP), JMP Engineering, Westhoff Engineering Resources Inc, BRT Engineering, Ross Scinergy and E. Huculak Consulting Services. Community support from Rosebud Hamlet residents was also key to the success of the pilot.

In this report, wastewater drawn from the Rosebud central septic collection tanks, or the storage containers holding the septic wastewater trucked-in from Gleichen, that's being pumped into the ACS will be referred to as "raw influent" or "influent" or "incoming wastewater". All water following treatment by the ACS will be referred to as "effluent" or "treated water" or "discharge water".

2. The Pilot Project

a) Alberta Environment and Parks requires the ACS to be approved as a wastewater treatment technology.

The Designated Activities Regulation allows for the application for approval as a private facility, however, as Symbiotic's algae wastewater treatment system is considered a novel or innovative technology and was deemed by AEP to require a pilot to prove its robustness, efficacy and efficiency. The Province requires that the technology meet compliance with the effluent quality standards, as defined by the Standards and Guidelines for Municipal Waterworks, Wastewater, and Storm Drainage Systems (2013) (parts 3 and 4). The pilot also considered the Water Quality Based Effluent Limits (WQBEL) requirements for water discharge as specified under the Environmental Quality Guidelines for Alberta Surface Waters, updated March 2018.

AEP further stipulated a series of 33 parameters that were evaluated as criteria for determining the pilot success.

Goal(s) of the Pilot Project:
To obtain approval from Alberta Environment and Parks for use of the ACS as viable wastewater treatment solution by:

i. Demonstrating the efficacy of Symbiotic's ACS as a wastewater treatment solution for municipal wastewater.
ii. Proving out the consistent technical viability through a series of demonstration scale trials ($2m^3$) prior to implementation at commercial scale.
iii. Demonstrating the process and operating protocols that will ensure consistency and safety of the treated water discharged from the system to the environment, and alignment to the WQBEL.
iv. Providing biomass characterization, to prove its safety and suitability for development as a feedstock for manufacture of bio-based products.

The pilot system design was based on $1/50^{th}$ scale, $2m^3$ version of the commercial system as well as the characterization of the incoming wastewater.

The pilot study was designed to run in 2 phases –lab scale (3 iterations of 4-day growth cycles) and pilot scale –30 iterations of 4-day growth cycles using Symbiotic's $2m^3$ photobioreactor (PBR). Raw influent from the Rosebud septic collection system was used in all phases. Independent laboratory analysis of the raw influent was undertaken 4 times over the course of the pilot, and full water chemistry analysis of the treated water were also undertaken for each iteration. Water quality values for cBOD, TSS, TP, TN, total and faecal coliform, metals and other micro nutrients were determined after each algal growth cycle (see Final Rosebud Pilot Project Report, sections 6 and 7 for additional details).

b) Did the pilot project include a methodology or approach for verifying or testing the performance of the technology or solution? Please respond Yes or No.

Yes [X] No [ ]

If you answered yes to Question #3, which methodology did you use in this pilot project for testing the performance of the technology or solution?

- o Environmental Technology Verification Program
- o Engineering Consultant
- o Other (please specify):

Pilot Study Method
Symbiotic used a combination of real time, kinetic observations of key operational parameters, including comparison of the raw influent and treated water laboratory assays of macro and micro nutrients.

The Pilot study method was approved by Alberta Environment and Parks as an acceptable method for verifying of the ACS as a municipal wastewater treatment solution.

3. Pilot Project Results:

a) Recommendations:
The results of the pilot were outstanding, especially for communities with population <20,000, and although the treated water discharge to the environment surpassed the Standards for such small communities, analysis of the Rosebud community water source (sourced from a well) showed it contains levels of sodium and fluoride (which are non-degradable elements) and cyanide that are higher than the CCME recommended limits. Pre-treatment of the source water is therefore recommended, given that this would also benefit the community and enhance the potential for the treated water reuse.

There were a few additional steps identified in order to help achieve 100% depletion of nitrogen and phosphorous. Because the algae grow quickly, increasing rapidly in cell density, this potentially could impede light penetration into media, limiting photosynthesis and algae growth. It is recommended that the follow-up steps include undertaking a lab scale study to test the impact of reducing the cell density midway through the 4-day growth cycle, with the aim to maintain adequate and even light penetration throughout the media, deep into the depths of the photobioreactor. The school of thought is that this should allow the remaining algae cells to more efficiently absorb and metabolize the remaining nitrogen and phosphorous. Reducing cell density can be easily achieved by harvesting off approximately 25-75% of the actively growing algae media, separating out the cell/mass and immediately returning the partially treated water back to the PBR, to complete the growth cycle.

A second lab scale study is also recommended to test adjusting the C, N and P nutrients levels, to establish an optimal growth media formulation, to benchmark the starting nutrient ratio for each growth cycle. Favorable results would effectively establish the starting levels of the organic and inorganic nutrients that is forecasted to be depleted, while generating the targeted biomass yield, within the 4-day growth cycle.

During the pilot study, it became apparent that a system for kinetic modelling of wastewater streams, based on their incoming wastewater chemistry analysis data, would be highly beneficial to the process. Work to develop such system has been initiated. The modeling system will provide real time frontend information for balancing the critical nutrient parameters at the start of each growth cycle. It will also forecast biomass yield and depletion of all necessary nutrients within the prescribed growth period.

b) Technical Feasibility:

The pilot study undeniably confirmed that the technical design of Symbiotic's Algae Cultivation technology is highly feasible for septic wastewater treatment. No technical difficulties were experienced during the pilot. The system performed exceptionally well throughout weather extremes ranging from 40°C to -40°C. It also adapted very well to seasonal changes, as well as different influent wastewater streams. The automated monitoring and control systems proved very helpful over the course of the pilot, but post pilot correlation of the collected data reveals that the process would benefit from expanding the monitoring capability to capture data from at least four additional parameters and improving the data collection quality. Implementing this recommendation would further enable real time response to changes in the growth conditions that may occur during the growth cycle (more information is available in Section 7.5.2 of the final pilot project report). Depending on outcomes from the lab studies recommended above, minor modification may need to be made to the growth process, but should not require modification to the main operating system.

c) Financial Feasibility:

Symbiotic's ASC remains a very financially feasible wastewater treatment alternative for small rural communities. The potential for revenue from biomass and treated water sale which are applied to offsetting operating costs, creates the opportunity for changes to the business model for wastewater utilities. From a treated discharge water perspective, a simple capital costs comparison shows that the System offers a competitively priced process that more effectively mitigates environmental risk.
(More information is available in Section 7.5.4 of the Final Pilot Project Report).

d) Environmental Results:

Project Parameter	Units	Baseline Performance before project	Anticipated Performance after project Completion	Actual Pilot Results		
Primary						
Wastewater Treated to Regulatory Standards	m^3	9,640	9,640			
Other						
cBOD	mg/l	159	7.1	1.0		
TSS	mg/l	29	5.2	.1		
Total Nitrogen	mg/l	72.5	0	34		
Total Phosphorous	mg/l	7.8	1	4.16		
CO_2 sequestered	t/yr		403	93*		
E.coli	CFU/100 ml	470,000	100	<1.0		
Fecal Coliform	CFU/100 ml	630,000	100	0.08		
Total Coliform	CFU/100 ml	730,000	500	0.47		
Compliance to CCME guidelines	Yes/No		yes	Mean values of the following exceeded standards due to source water levels		
				mg/l	CCME	Pilot
				F	.12	.38
				SAR**	9.0	13.99

* Average yield of 148 Million cells/l for an estimated 1.2 g/l was less than the anticipated 5g/l. CO_2 consumption (CO_2 sequestered) is projected to be 1.85g CO_2 per gram of biomass yield.
** SAR of below 9 is required for use of the treated water for irrigation.

e) Environmental Results Description: As noted in the detailed report (Section 7.5.3), the wastewater treatment results for the main measures of cBOD, TSS, E.coli and Coliforms were exceptional. The Nitrogen and Phosphorous did not achieve targets, due in part to the influence of the Septic Additive concoction that the Rosebud Residents were using to enhance decomposition of solids in their at-home septic tanks. Also as noted earlier, the Rosebud community water source showed higher levels of sodium, contributing to higher than acceptable SAR levels, which renders the treated water unsuitable for irrigation.

Post pilot analysis of the data showed that the starting levels of ammonia were higher than the algae can absorb within the 4-day growth cycle, and even though nitrogen levels were reduced, the reduction fell short of the targeted AEP discharge limits for un-ionized ammonia, which is set at 0.019 mg/l. The pilot results averaged 0.279 mg/l.

Midway through the pilot, when it was discovered that the Septic Additive was negatively influencing the nitrogen and phosphorous results, the Run cycles with the Rosebud influent was suspended. The pilot was subsequently expanded to accommodate growth trials using a different septic wastewater stream, recognizing that some growth trials needed to be undertaken to evaluate septic wastewater that was free of any Septic Additive. Septic wastewater was trucked from a similar rural community in Wheatland County to the Rosebud pilot site. The detailed final report provides comparison between the two different wastewater streams. The results were significantly better, with un-ionized ammonia averaging 0.027 and several other observations near 0 mg/l.

WQBEL analysis of the Rosebud river stream flow, established that the ammonia limit for safe discharge into that receiving water body should not exceed 10mg/l. The pilot average results for ammonia were 40.6 mg/l.

f) Social and Economic Outcomes:

Figure 1 – Economic benefits

A	B	C
Economic benefit	**As described in your GMF application**	**Anticipated economic benefits of the pilot project at full scale based on pilot experience.** If the result is different than what was expected in the application form, please indicate **why**.
Increased return on investment	Revenue from algal biomass, water sales and GHG credits.	If deemed necessary, diluting the incoming wastewater in order to effectively deplete N and P, may require an increase in the size of the commercial facility. The larger facility will yield more biomass leading to increase revenue. The reuse of the discharge water will reduce available water for sale. On the other hand, the partial harvest should also increase the biomass yield, but eliminate the requirement

		to increase the facility size.
Deferred or avoided capital expenditures	Leverages private capital investment for 70% costs of the facility.	Capital expense is likely to be 10-15% higher to allow for dilution yet Symbiotic's ACS would still be more cost effective than alternative technologies.
Decrease in facility operating or maintenance costs	Operating and maintenance costs are borne by the new private operating company.	No change
Extended lifespan for facility	The existing Rosebud septic field has past its service life. The addition of Symbiotic's ACS will extend the usefulness of the collection system and the central tanks.	No change
Increased municipal revenue streams (e.g. property tax, user fees, etc.)	As a partner, the County is able to benefit in the operational surpluses (30%).	No change
Lower taxes	The community would have been faced with tax surcharge required to fund a lagoon. Not only will taxes not need to increase, but profit share from biomass sales can be applied to funding community enhancements (parks, etc.)	No change
Stimulus for local economy (use of local business, capacity for local business development)	Where possible, local contractors will be used for site preparation. As this technology is novel and a first of its kind, its operation is expected to attract visitors that will support local tourism.	No change
Increased employment options or job retention	Jobs will be created in Symbiotic's operation that would not be created with a lagoon.	No change
Increased transit ridership		
Attraction of new businesses	Jobs will be created in Rosebud for planned operations that will extend beyond just wastewater treatment, with the addition of the food grade cultivation component. The clear water discharge is planned to be used to attract a greenhouse or a micro brewery. The waste from these spin off operations will further augment the ACB.	No change
Other (please specify)		

Figure 2- Social benefits

A	B	C
Social benefits	**As described in your GMF application**	**Anticipated social benefits of the pilot project at full scale implementation based on pilot experience** If the result is different than what was expected in the application form, please indicate **why.**
Improvements to public health		
Improvements to public safety		
Improvements to community quality of life		
Increased opportunities for community engagement	The community has used this issue as a catalyst to come together in collective planning.	No change
Increased public education or awareness	The community has already been engaged in understanding the importance of effective wastewater treatment and in the innovative business model possibilities through a series of community consultations.	The signage and tour of the pilot facility were effective in educating the community and visitors. Other communities are anxiously awaiting final results and are looking to leverage this technology.
Community revitalization	The funds generated are intended to contribute to the community recreation and parks development.	The final revenue will determine how much additional net revenue is available for community enhance-ment.
New housing and infrastructure	New development has been constrained by the existing wastewater treatment system that is at capacity and now failing. The Symbiotic ACB will have a 40% excess capacity for growth.	No change. The amount of growth capacity will be determined once the rate of dilution is firmed through additional lab trials.
New or enhanced public space or public facilities	The community plans to invest returns on new parks and walking paths. Site of the current facility impedes the natural vistas.	No change
Improved access to recreation and physical activities		
Reduced urban sprawl		
Increased civic pride, ownership and participation	The community is already engaged in the project as part of planning, financial investment and advocacy with the County.	The signage and tour of the pilot facility were effective in educating the community and visitors. Other communities are anxiously awaiting final results and are looking to

		leverage this technology.
Improved quality and efficiency of service provision to residents		
Reduced opportunities for crime		
Other (please specify)		

4. Lead Applicant's Next Steps

a) What next steps does your municipality plan to take based on the findings and recommendations of the Pilot Project?
Wheatland County is awaiting approval for the ACS technology from Alberta Environment and Parks. Upon AEP approval, Symbiotic's understanding is that Wheatland County plans to purchase a commercial scale system from Symbiotic, and also plans to contract Symbiotic to operate and maintain the system to provide wastewater treatment for the community of Rosebud.

5. Lessons Learned

In answering the questions in this section, please consider all aspects of the Pilot Project —from the initial planning through each of the essential task until the Final Report of the Pilot Project was prepared.

a) What would you recommend to other municipalities interested in doing a similar Pilot Project?
A pilot of this nature is fairly expensive. Undertaking a pilot involving a new innovative technology in rural areas that are a long distance away from modern business conveniences adds cost and poses unusual challenges such as limited availability to trades and labour resources. That said, having a willing partner such as Wheatland County and the strong support from Rosebud community was essential to overcoming some of the issues that were encountered.

What would you do differently if you were to do this again?
We definitely would try to find a willing partner with the available wastewater stream that is within 30 minutes of essential business conveniences.

We would also canvas the community to gain good knowledge of what is going into their septic system. As well as conduct a more comprehensive and more frequent analysis of the incoming wastewater stream to fully understand its chemical make-up and changes that may occur that could limit or impede the ability of the algae to remediate wastewater.

Although difficult to find, we would try to find a person to add to our team, that has both traditional wastewater treatment knowledge and algae growth expertise, that is able to be onsite every day, and is dedicated to compiling and interpreting the lab analysis data as they are received. Such person would be able to then provide on-the-spot, knowledge based scientific answers to occurrences, that they would be in position to observe as it is happening during every growth cycle.

We would also try to devise the means for obtaining incoming wastewater and treated water analysis results quicker than what was available during the pilot study.

And finally, we would undertake a more rigorous budgeting exercise that realistically and accurately forecast the project costs, then factor in a contingency that anticipates the unexpected.

b) What barriers/challenges (if any) did you encounter in doing this Pilot Project?
The regulatory approvals process posed the most significant barrier. Delays in getting AEP approval to start the pilot, caused other down-line permitting approvals and scheduling difficulties.

The unanticipated impact of the Septic Additive, as well as the lapse of time in obtaining the lab analysis result were also identifiable challenges.

How did you overcome them?
We worked with Wheatland County and the community of Rosebud to secure their support, then leveraged that support to lobby key government to help expedite the approvals process.

To shorten the lapse of time between each growth cycle and speedup receiving the essential lab analysis results more quickly, without incurring additional costs, we had to work out an arrangement with a laboratory service provider to obtain interim partial analysis data while we await the final results.

6. Knowledge Sharing

a) Is there a website where more information about the Pilot Project can be found?
If so, please provide the URL.

Approval by Alberta Environment is required before it would be practical to explore another community opportunity. Pilot results have been restricted to stakeholders at this time.

Pilot results suitable for sharing will be available on the website by June 15th 2019.

In addition to the Pilot Project results, has your Pilot Project led to other activities that could be of interest to another municipality (for example, another pilot project, sharing of the results of this pilot project with other municipalities formally or informally, changes to existing policies and/or practices etc.)?

The pilot project has not led to activities, but it has led to inquiries from two different companies that are currently setting up to grow Cannabis in two different municipalities (one in Wheatland County and one in Lamont County). These inquiries were regarding the possibility of using Symbiotic's ACS to treat the discharged water from the Cannabis growth operation, with the view to recirculating water.

If so, please list these outcomes and include copies of the relevant documents (or website links).
Symbiotic plans to share any information that may arise in the future as a result of the pilot, that may be beneficial to other municipalities.

The preparation of this pilot project was carried out with assistance from the Green Municipal Fund, a Fund financed by the Government of Canada and administered by the Federation of Canadian Municipalities. Notwithstanding this support, the views expressed are the personal views of the authors, and the Federation of Canadian Municipalities and the Government of Canada accept no responsibility for them."