Newell Energy from Waste Feasibility Study
Technology Review

PRESENTED TO
Palliser Economic Partnership Ltd.

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EXECUTIVE SUMMARY

Tetra Tech Canada Inc. (Tetra Tech) was retained by the Palliser Economic Partnership Ltd. to undertake an Energy from Waste (EfW) feasibility study to investigate the potential of introducing a new EfW processing facility to service the Newell Region. This feasibility study, led by the Palliser Economic Partnership and the Newell Region Economic Development Initiative, will provide the Municipal Councils of the Newell Region communities with technical information intended to assist in determining the suitability of an EfW processing facility in the region.

The study (*"Report: Technology Review"*) includes a general review of technologies suitable for application in the Newell region. The review takes into consideration the waste streams and quantities identified in Phase 1 of the project, to better identify the suitability of technologies to the needs of the region. The review of technology types compares effectiveness, price and relevance for use of thermal-conversion and biological conversion technologies on MSW from the Newell Region. The report also outlines carbon credit implications, environmental approval requirements in Alberta, and makes recommendations for next steps.

The technology which is best suited to the Newell Region is identified as mass-burn, though it is noted that others may also be applicable, depending on the baseline objectives of the project. Depending on the specific goals identified for the project, other technologies may prove to be suitable.

It is recommended that the Region of Newell further define their waste stream through a detailed waste characterization study. This type of study would provide detailed BTU value of the available waste stream, as well as better defined waste characteristics.

It is also recommended that the Steering Committee further define the desired outcomes from the initiative, to allow for a targeted choice of technology that will best satisfy the criteria required for a successful project. The following next steps are recommended to identify the most suitable technology:

- Discuss within the steering committee to align the desired outcomes of an EfW project in the Newell Region. There are technology types available that are proven to have capacity to process the waste stream, but the outputs are variable, and the capital and operating costs are variable. An alignment of goals will allow a technology to be identified based on satisfying the ultimate requirements set out by the steering committee.
- Once the objectives of the EfW facility are clearly defined, an RFQ can be drafted to invite bidders to present their technological solutions, with the parameters for cost, schedule, and outputs clearly being met by proponents.
- Proposals can be reviewed by the Steering Committee, and may also be reviewed by an expert panel to confirm the details included in each proposal, and identify the best proponent.
- Details provided by proponents can be incorporated into a detailed financial evaluation of a new waste management system for the region. This evaluation would indicate the true cost of waste disposal per tonne in the proposed system, and would take into consideration, at a minimum, the cost of:
  - Ongoing landfill operations;
  - Capital costs for a new EfW facility;
  - O&M of the proposed facility, including pre-processing of material;
  - Changes to waste collection and hauling; and
  - Waste sorting as required for the EfW facility.

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ACRONYMS & ABBREVIATIONS

Acronyms/Abbreviations	Definition
ADR	Activities Designation Regulation
AEP	Alberta Environment and Parks
C&D	Construction and Demolition
EPEA	*Environmental Protection and Enhancement Act*
EfW	Energy from Waste
ICI	Industrial, Commercial, and Institutional
Tetra Tech	Tetra Tech Canada Inc.
MSW	Municipal Solid Waste
NRCB	Natural Resource Conservation Board
NRSWMA	Newell Regional Solid Waste Management Authority
NRL	Newell Regional Landfill
SAEWA	Southern Alberta Energy from Waste Alliance

LIMITATIONS OF REPORT

This report and its contents are intended for the sole use of Palliser Economic Partnership Ltd. and their agents. Tetra Tech Canada Inc. (Tetra Tech) does not accept any responsibility for the accuracy of any of the data, the analysis, or the recommendations contained or referenced in the report when the report is used or relied upon by any Party other than Palliser Economic Partnership Ltd., or for any Project other than the proposed development at the subject site. Any such unauthorized use of this report is at the sole risk of the user. Use of this document is subject to the Limitations on the Use of this Document attached in the Appendix or Contractual Terms and Conditions executed by both parties.

1.0 INTRODUCTION

Tetra Tech Canada Inc. (Tetra Tech) was retained by the Palliser Economic Partnership Ltd. to undertake an Energy from Waste (EfW) feasibility study to investigate the possibility of introducing a new EfW processing facility to service the Newell Region. This feasibility study, led by the Palliser Economic Partnership Ltd. and the Newell Region Economic Development Initiative, will provide the Municipal Councils of the Newell Region communities with technical information intended to assist in determining the suitability of an EfW processing facility in the region.

Phase I of this study included a review of all current waste streams and additional waste sources that may be available for processing within the region. This report, Phase II of the study, provides a review of suitable EfW processing technologies currently available.

The study (*"Report: Technology Review"*) includes a review of two previously identified emergent processing technologies, as well as a general review of technologies suitable for application in the Newell Region. The review takes into consideration the waste streams and quantities identified in Phase 1 of the project, to better identify the suitability of technologies to the needs of the region. The technology review of the emergent technologies examines the potential effectiveness of the technologies based on past documented projects, and also outlines carbon credit implications, marketable by-products, and makes recommendations for next steps.

2.0 SUMMARY OF WASTE CHARACTERIZATION REPORT

It is anticipated that approximately 22,000 tonnes of material is available as feedstock for an EfW facility in the Newell Region, with an energy content ranging from low to high. This waste is currently being landfilled at the Newell Regional Landfill, located west of Brooks, AB. The estimated monthly available tonnages range from 1,280 to 2,260 tonnes. Detailed waste audits would be required to better understand the composition of the Industrial, Commercial, and Institutional (ICI) and Construction and Demolition (C&D) waste streams.

Waste streams which are not currently captured by the Newell Regional Landfill (NRL) are currently being managed and disposed of by specialized private service providers, in mature markets. Other waste streams such as medical waste and rail ties may be available as feedstock, but may be in a very competitive market, and will require additional regulatory requirements to be allowed for proper disposal.

Agricultural plastic has been identified as potential feedstock, depending on the regulations developed by the Government with regards to disposal guidelines under the proposed product stewardship program, though quantities in the region may be lower than estimated, based on the types of agriculture practiced in the region.

The strongest market drivers for these waste streams are cost of disposal, combined with distance from disposal location. The low tipping rates at the NRL are understood to attract waste to the landfill that is sensitive to price, and may no longer be available if prices were to increase.

Waste materials such as specific risk materials, wastewater sludge and biosolids, manure, animal by-product, oilfield waste and contaminated soil are available in the region, but are not considered to be reliable sources of feedstock. These materials are disposed of in specialized ways, and the option for disposal in an energy from waste facility is typically not a viable option for these materials.

Staff at the JBS facility have indicated that JBS are currently hauling grease contaminated water to Lethbridge for processing, and that excess material is being stockpiled, as the Lethbridge facility is not processing the material fast enough. The JBS facility indicated that they would be interested in using a processing facility in Brooks if one was available, however, the long-term plan is for the material to be disposed of in covered lagoons owned by JBS as early as spring 2018 Once the JBS lagoons are covered, no external processing will be required.

3.0 OVERVIEW OF ENERGY FROM WASTE TECHNOLOGIES

There are two main types of energy from waste (EfW) technologies, thermo-chemical conversion technologies and bio-chemical “biological” conversion technologies. Both technologies use combinations of physical, chemical, and biological processes to convert waste materials into a usable product (e.g. biogas or syngas) that could be used as an energy source.

3.1 Thermo-Chemical Technologies

The following are several types of thermochemical conversion technology systems that are capable of processing the combustible feedstock. Thermochemical conversion technology primarily use heat and oxygen (or air) to breakdown material via thermal chemical reactions. The higher the operating temperature (large amounts of heat), the faster the thermal reaction. Similarly, when more oxygen (or air, that consist of 21% oxygen) are used, the faster the thermal reaction up to a certain level.

3.1.1 Standard Combustion

Combustion, also referred to as incineration, is defined as the burning fuel to produce power and/or heat. Combustion occurs with oxygen in slight stoichiometric excess to rapidly complete a thermal oxidation reaction. The products of combustion are heat, an ash residue, and an off gas made up of predominantly nitrogen (N_2), carbon dioxide (CO_2), and water vapor. The off gas must be treated to meet regulatory emission requirements for chemical pollutants and particulates.

Combustion is an exothermic (net heat output) process; therefore, the technology lends itself to heat recovery in many applications. Heat generation can be used in boilers or converted to power via turbines. The combustion process is highly developed commercially and is available in numerous vendor specific designs.

The most common direct combustion technology for biomass is stoker boiler technology. Various forms of stoker boilers have been employed since the 1920s. Stoker boilers employ direct fire combustion of solid fuels with excess air, producing hot flue gases, which then produce steam in the heat exchange section of the boiler. The steam is used directly for heating purposes or passed through a steam turbine generator to produce electric power. HHV basis boiler efficiencies for modern stoker boiler systems approach 71% for green biomass.

While this technology is conventional and well proven, it is not as environmentally friendly. This type of technology typically produces more fly ash and air emissions than other technologies, which may require monitoring and management.

Combustion technologies are able to process most types of municipal solid waste (MSW), but operate more efficiently with dry feedstock material with mid to high calorific value.

3.1.2 Gasification

Gasification is a partial combustion process in an oxygen-deficient atmosphere (i.e., the oxygen level is limited to convert the solid material. The resulting products are a carbon-rich ash and a “synthesis gas” (syngas) stream. The synthesis gas is composed of various gases – hydrogen, carbon dioxide, and other trace gas. Gasification processes that use pure oxygen are able to obtain higher syngas energy content (300 to 380 Btu/scf) as a result of the elimination of the nitrogen present in atmospheric air. While gasification is a more complex technology, it allows for the recovery of value products (i.e., syngas) which can be used to generate chemicals (fuels, alcohols, etc.). Catalytic conversion via the Fisher-Tropsch process and other methods can also be used to generate “drop-in” biofuels such as synthetic gasoline, natural gas (RNG) and diesel. The syngas can also be used to drive gas engines and turbines to generate electricity that could be used internally or exported onto a local electricity grid.

The benefits of gasification are considered to be increased efficiency, greater variety of end products, and fewer back-end pollution control requirements. Commercially, textbook gasification has not achieved as high a level of acceptance as traditional combustion because of its relative high complexity and high capital costs.

This technology is best suited to processing pre-shredded medium to high energy material.

This technology is more complex and more expensive than other thermo-chemical technologies, and has limited commercially viability. There is a gradational progression from hybrid gasification to gasification so most technologies considered will be in previous classification.

3.1.3 Advanced Combustion/Hybrid Gasification

In the advanced combustion or hybrid gasification process, a synthetic gas, ‘syngas’, is created from the conversion of combustibles in an oxygen starved pre-burn chamber. This syngas is then burned in a second combustion chamber. The syngas generated is more combustible than the solid carbon material (such as wood), thus improving overall combustion efficiency and generating a cleaner burn. Advanced combustion systems have high heat value (HHV) basis boiler efficiencies that approach 78% for green biomass. Despite their increased efficiency, these systems are not always financially comparable to stoker boiler systems due to the increased complexity and maintenance needs to operate these systems.

Advanced combustion is an emerging hybrid combustion/gasification methodology that results in higher combustion efficiency and less emissions as compared to traditional combustion, at a lower cost than full gasification technologies.

This technology is best suited to processing MSW and dry material.

This technology is commercially viable and is considered suitable for further evaluation for the Region of Newell.

3.1.4 Pyrolysis

Pyrolysis is defined as the thermal breakdown of higher chain organic molecules (cracking) into smaller organic components. This thermal cracking is done in the absence or reduced presence of oxygen, sometimes with the addition of a catalyst. The resulting products from the pyrolysis process are:

- **Char:** Consists of high carbon content solids. Also, any inorganics that might be contained in the waste stream and catalysts that were added and carried through the process.
- **Non-condensable Gas:** Made up of hydrogen, methane, carbon monoxide and other non-condensable gases. Can be burned similar to natural gas.
- **Liquid Fuel:** Made up of many of organic chemicals such as acetic acid, acetone, methanol, and complex oxygenated hydrocarbons.

Most organic compounds can be broken down to basic components using the pyrolysis process. As a result, many experimental and pilot plant programs have been done using pyrolysis to process products such as animal offal, used tires, agricultural field residue, and manure. The process is typically an exothermic process.

Commercially, when compared to combustion, pyrolysis is not considered as efficient as standard combustion. Commercial pyrolysis units are typically used for smaller applications as they can be used in modular installations with single boilers.

This technology is used in smaller MSW applications where ranges of capacities are needed.

3.1.5 Rotary Kiln

Rotary kiln is a technology that is used to thermally treat solid waste. As is in its name, a rotary kiln is a furnace that rotates the feedstock within a cylinder. It relies on high temperatures (around 1200 °C) to cause the decomposition of waste materials being feed into the system. The rotary kiln system typically consists of a screw auger that carries the feedstock through the kiln. In some instances, the solid waste feedstock would be shredded before entering the rotary kiln's system. The rotation enables more heat to be distributed throughout the entire feedstock thereby having better burnout. The average plant capacity is 25,000-50,000 tonnes per year.

Rotary kiln can also process some liquid and slurry-like waste, such as wastewater sludge. Rotary kiln have also been used to treat various types of hazardous wastes such as medical waste.

This technology is best suited to processing hazardous materials and can handle liquid and slurry-like waste. However, the system has a higher cost than other technologies (both capital and operating), and may require trained operators.

This technology isn't considered viable for future consideration for this project, as it's too specialized for the waste stream identified, and the high processing cost is limiting.

3.1.6 Combined Heat and Power

Each of the technologies listed can be integrated with electrical generating equipment to provide a combination of electrical power and heat.

Direct combustion is typically used in combination with a boiler to generate high pressure steam, which in turn is used to drive a steam turbine connected to an electrical generator. The steam turbine can be designed as either a backpressure turbine or a condensing turbine, depending on whether or not there is a need for steam. Steam turbines are mature technology that has been proven reliable over a century of use.

Gas turbines and reciprocating (internal combustion) engines can also be used to drive electrical generators. Gas turbines are typically used with a clean gaseous fuel, such as natural gas, but can be used with syngas. "Dirty" fuels can create issues with build-up on the turbine blades, so the syngas typically needs to be cleaned prior to injection into a turbine. Reciprocating engines can burn liquid or gaseous fuel, including biogas, and are also a mature technology with many successful installations. Removal of H_2O is also critical for the fuel to be used effectively.

Figure 1: Example of Reciprocating Engine Powered by Biogas
Source: Tetra Tech

3.2 Biological Conversion Technologies

There are two main types of biological conversion technologies – aerobic composting and anaerobic digestion. Both types utilize microbial degradation where microorganisms would breakdown the organic fraction into a valuable product (e.g. energy or compost).

3.2.1 Aerobic Composting

Aerobic composting is an effective biological process that reduces the compostable organic fraction of biomass in the presence of oxygen to nutrient rich organic compost or soil amendment. This can be done in a number of designs including windrows piles, aerated static pile, in-vessel systems, and other processes.

Composting will process organically based material only, and is not suitable for use in processing common MSW. Aerobic composting focuses on processing food scraps, leaf and yard waste, animal byproducts, manure, and biosolids.

Composting does generate large amounts of heat with the intent of pathogen deactivation within the compost pile (i.e. heat is being generated and used to reduce pathogen levels in the compost), and therefore is not considered an acceptable primary technology for this project. Composting is often used after anaerobic conversion processes to generate saleable organic rich compost, and may be applicable to the Newell Region in that capacity.

3.2.2 Anaerobic Digestion Technologies

Anaerobic digestion (AD) is an effective biological process that converts the compostable organic fraction of biomass in the absence of oxygen to biogas. The biogas is a mixture of methane (CH_4), carbon dioxide (CO_2), water, and other impurities. Biogas has a medium heat value gas suitable for use as a fuel. AD is a common conversion or waste-to-energy technology for organic fraction of MSW, agricultural waste, wastewater treatment facilities, and other operations. The generated biogas can be used by an on-site combined heat and power (CHP) system to provide both heat and electricity. Another option is to clean and upgrade the biogas and then inject into the natural gas network as renewable natural gas or as a compressed natural vehicle fuel. The art of building low-cost, reliable digesters is strictly dependent on the optimal adaptation of the design to the type of feedstock or substrate and the amount of materials being digested. The choice of which digester to use is driven by the existing or planned biomass handling system at the facility. Complete-mix, plug-flow, and covered lagoon are three common types of digesters. Each type of digester has its own specialty and constraints. All technologies can capture methane and reduce pathogens, but they differ in cost, climate suitability, and the concentration of solids in feedstock.

Covered Lagoon. This type of digester includes a lagoon with an impermeable cover. It is the simplest and lowest cost digester. The cover traps gas produced during the decomposition of the organic material (e.g., manure) and the gas collected and used. From a solid waste management perspective, this would be similar to a bioreactor landfill. Covered lagoon digesters are used for liquid manure with less than 5% solids, and generally require large lagoon volumes, preferably with depths greater than 3.5 m (12 ft.). This type of system is only compatible with temperate and warm climates and when manure must be flushed as part of the ongoing operations. An example of a covered lagoon system is shown on Figure 2.

Composting will process organically based material only, and is not suitable for use in processing common MSW. Composting focuses on food scraps, leaf and yard waste, animal byproducts, manure, and biosolids.

Figure 2: Covered Lagoon Style Digester Prior to Gas Production

Complete Mix Digestion. This configuration has been used most commonly in municipal sewage sludge digestion practices. In this system, the waste entering the digester is mixed to ideally uniformly distribute it. Digested effluent is withdrawn at a rate equal to the inflow rate to maintain the reactor content at a constant volume. It is generally suitable for liquid based feedstock (e.g., manure and pulped food waste) that has 2% to 15% solids. Therefore, this is often referred to as “wet AD.” Complete mix digesters process waste in a heated tank above or below ground. A mechanical or gas mixer keeps the solids in suspension such the bacteria can effectively decompose the feedstock. This design typically covers a smaller footprint than lagoons. A complete mix digester is suited for co-digestion with floating waste such as fats, oils, and greases and crop residues. Figure 3 is a picture of a complete mix digester under construction.

Figure 3: Complete Mix Anaerobic Digester

***Plug-flow Digesti*on.** Plug-flow digesters are operated as a longitudinal (one-directional) reactor where no intermixing occurs during the passage of the waste through the reactor. It is suitable for waste streams having a solids content of 11% to 13%. In a plug-flow digester, waste biomass enters one end of a rectangular tank and decomposes as it moves through the tank. New material added to the tank pushes older material to the opposite end. A flexible, impermeable cover on the digester traps and holds the biogas produced.

This digestion technology is not as common as those described above and below, and processes primarily organic material.

***High Solids or Dry AD*.** Dry AD technologies ("dry AD") or high solids AD is commonly used for mixed waste. Dry AD is biologically similar to wet AD. However, where wet AD uses substrates in a slurry [1% to 15% organic total solids by mass], dry AD can process solid substrates with as much as 40% to 50% total solids. This falls well within the range of available high "solid" or "stackable" substrates such as MSW, food waste, yard waste, and other organic substrates. The higher solids content equates to higher transport efficiencies in comparison to wet systems where 90% or more of the feedstock transported is simply water. Numerous proprietary technologies have been developed to commercially execute dry AD. Most notable amongst these technologies are "garage style" digesters and assisted plug flow digesters.

In "garage" style dry digesters, biomass is placed inside a sealed garage-like container with or without the use of material separation. Once the container is full, the environment is sealed, oxygen is removed, the temperature is increased to approximately 37°C (98˚F), and the substrate is "irrigated" with microbially enhanced liquids for a period of 25 to 30 days (which varies based upon substrate and technology purveyor). Liquid percolate (leachate) infiltrate the biomass and is collected thru floor drains.

The methane rich biogas is continuously collected from the container. The biogas can be used to generate heat, electricity or both as in a traditional wet AD system. After the reaction period, the remaining waste is removed (either to landfilling or composting), and a new batch is inserted. This method has few mechanical parts and thus offers the advantage of needing limited material separation prior to digestion. Therefore, if MSW were to be a feedstock, it could be added with less concern of machinery being destroyed by miscellaneous scrap metals, rocks, etc. However, this feedstock flexibility comes at the cost of gas production efficiency.

The lack of stirring during the process means that not all materials are exposed to the methanogenic microbes vital to AD reactions, and the gas production suffers as a result. Depending on the preprocessing included dry AD can achieve a portion of the efficiencies (as low as 50% to 60%) of the production rates achieved by wet AD technologies. Specifically, garage style digesters convert available total solids to biogas with roughly half the efficiency of wet AD systems. Conversely, there is more flexibility as wet and dry materials can be processed.

Figure 4: Example of Garage Style Dry Anaerobic Digestion

Source: *BioFerm Energy Systems* http://biofermenergy.com/

Assisted plug flow high solids AD systems address the issue of material conversion efficiencies. This is accomplished by moving the substrate along the length of a sealed container using “paddle arms”. The “paddle arms” serve two purposes. Firstly, they move the substrate along the length of the reactor at a pre-determined rate allowing the substrate a digester retention time of 25 to 30 days. Secondly, it mixes the substrate somewhat as it is moved such that the material is exposed to the bacteria (e.g., methanogenic bacteria) that generate biogas. This method results in a volatile solids destruction of 90% according to Eisenmann. If this efficiency is reached, it would be nearly similar to wet AD systems for conversion efficiency. However, the “paddle arms” require that material entering the digester be separated and preprocessed sufficiently prior to digestion in order to limit damage that non-digestible materials might cause to the digester. This preprocessing equipment can raise capital costs by a third, and greatly increase operational and maintenance costs as the mechanical and operation costs are higher.

This digestion technology is commercially viable, but is not considered suitable as it only processes organic material, and is not able to process MSW.

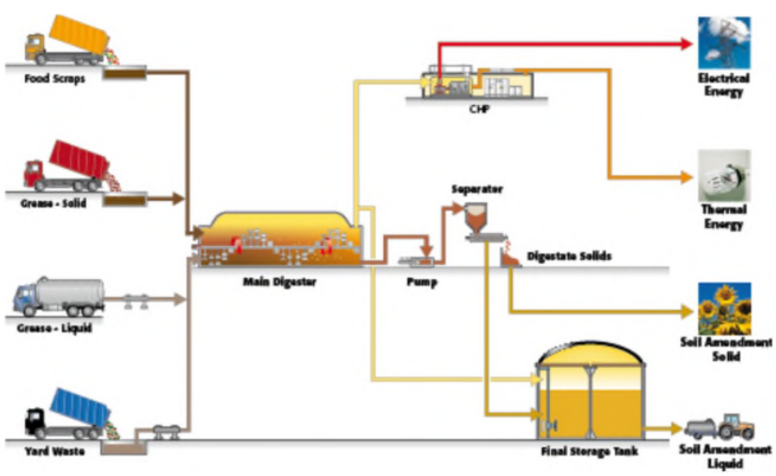

Figure 5: Example of Assisted Plug Flow Dry AD

Source: Eisenmann Corporation. http://www.eisenmann.us.com/

3.3 List of EfW Facilities across Canada

Table 3-1 summarizes the various EfW facilities in operation or under construction/development across Canada. The facilities listed in grey are not operating at this time.

Table 3-1: Canadian EfW Facilities

Technology	Facility Name	Location	Annual Waste Processed (Tonnes)	Energy Generated	Status	Date Commissioned
Mass Burn	Greater Vancouver Regional District Waste to Energy Facility	Burnaby, BC	280,000	Electricity and Steam	Operational	1988
Pyrolysis	Emerald (Previously Algonquin) Power Energy–from-Waste	Brampton, ON	182,500	Steam	Operational	1992
Mass Burn	L'incinerateur de la Ville de Quebec	Quebec City, QC	300,000	Steam	Operational	1974
Mass Burn	MRC des Iles-de–la–Madeleine	Havre-aux-Maisons, QC	4,500	None reported	Operational	1955
Mass Burn	Durham York Energy Centre	Durham Region, ON	140,000	Electricity and Steam	Construction Target	Completion Date: Late 2014
Mass Burn	Region of Peel Energy-from-Waste Facility	Peel Region, ON	300,000	Electricity	Project Cancelled	N/A
Gasification Thermo chemical	Enerkem Alberta Biofuels	Edmonton, AB	100,000	Bio-fuels, Chemicals	Unknown status	June 2014
Plasma Gasification	Plasco Trail Road Facility	Ottawa, ON	49,000	Electricity	Demonstration Facility Shut Down	N/A
Anaerobic Digestion	Toronto Dufferin Anaerobic Digestion Facility	Toronto, ON	40,000	Biogas, gas is flared	Operational	2002
Anaerobic Digestion	Toronto Disco Anaerobic Digestion Facility	Toronto, ON	90,000	Biogas, gas is flared	Operational	2013
Anaerobic Digestion	City of Surrey Biofuel Processing Facility	Surrey, BC	80,000	Biogas	Start-up Stage	Not Applicable
Pyrolysis	Enwave (Previously Veresen) Power WtE	Charlottetown, PEI	30,000	Steam	Operational	1984
Anaerobic Digestion	Stormfisher (Previously Harvest Power) London Facility	London, ON	80,000 – 100,000	Biogas	Operational	2012
TBD	New Waste-to-Energy Capacity to service Metro Vancouver	Metro Vancouver, BC	400,000	Electricity	Project on Hold, may be Cancelled	N/A

4.0 EVALUATION OF SUITABILITY

The following table summarizes the commonly used waste to energy processes, and indicates the suitability of the technology for processing the waste stream presently available in the Newell Region.

These technologies include details on scalability, though the cost effectiveness of some technologies may decrease as the scale decreases. There are economies of scale that bring technologies to a point of financial viability, and which depend on the facility and its unique circumstances.

Table 4-1: Comparison of EfW Technologies

Technology Type	Scalability	Suitability for Newell	Cost *	Environmental Impact	Typical Feedstock	Outputs
Mass Burn	Can be scaled down to a modular unit (20,000 to 300,000 tonnes per year)	Established technology and works well with existing Newell waste stream	Capital: $900 to $1200 per annual design tonne Operating: $80 to $130 per tonne	High emission outputs can be mitigated with a proper designed APC 20-30% by weight bottom ash (depending on burnout of carbon); 2-6% fly ash	Municipal solid waste, preferably dry material with high calorific value (mass burn are also designed to burn low to medium calorific waste)	▪ Heat (steam boiler) ▪ Electricity ▪ Combined heat and power ▪ Recyclable metals
Gasification	Can be scaled down to a modular unit (20,000 to 100,000 tonnes per year)	Technology is not proven at a full scale level	Capital: $900 to $1500 per annual design tonne Operating: $80 to $150 per tonne	20 -25% bottom ash; 1-5% fly ash	Municipal solid waste, high energy waste, biomass	▪ Heat ▪ Electricity ▪ Hydrogen gas ▪ Renewable natural gas ▪ Methanol ▪ Ethanol
Advanced Combustion/ Hybrid Gasification	Can be scaled down to a modular unit	Pilot Stage	Capital: $900 to $1500 per annual design tonne Operating: $80 to $150 per tonne	20 -25% bottom ash; 1-5% fly ash	Municipal solid waste	▪ Same as gasification
Pyrolysis	Can be scaled down to a modular unit (1,000 to 120,000 tonnes per year)	Technology is well proven but not as efficient as other technologies	Capital: $800 to $1000 per annual design tonne Operating: $50 to $110 per tonne	25 - 30% bottom ash; 1-5% fly ash	Municipal solid waste, preferably dry material with high calorific value (mass burn are also designed to burn low to medium calorific waste)	▪ Heat (steam boiler) ▪ Electricity ▪ Combined heat and power
Rotary Kiln	Can be scaled down to a modular unit	Technology is not suitable as	Capital: $900 to $1500 per	High emission outputs can be mitigated with a	Municipal solid waste,	▪ Heat ▪ Electricity

Technology Type	Scalability	Suitability for Newell	Cost *	Environmental Impact	Typical Feedstock	Outputs
		it is very specialized	annual design tonne Operating: $80 to $150 per tonne	proper designed APC 20-30% by weight bottom ash (depending on burnout of carbon); 2-6% fly ash	hazardous waste	▪ Hydrogen gas ▪ Renewable natural gas ▪ Methanol ▪ Ethanol
Aerobic Composting	Can be scaled down to a modular unit	Only suitable for organic waste, cannot process MSW	Relatively low, heavily depends on land cost. May be as low as $50 /tonne.	Potential for odour issues, which may be mitigated with good design.	Source separated organics	▪ Compost
Anaerobic Digestion	Can be scaled down to a modular unit	Only suitable for organic waste , cannot process MSW	Capital: $490 to $630 per annual design tonne Operating: $50 to $70 per tonne	Potential for odour issues, which may be mitigated with good design.	Source separated organics	▪ Biogas ▪ Soil amendment or compost

5.0 ENVIRONMENTAL PERMITTING

A review of the environmental permitting process has been provided as a rough indication of the expected time frame for a new approval, as well as to indicate the level of complexity required for a new environmental approval application.

5.1.1 Alberta Environment and Parks Permitting Process

Alberta Environment and Parks authorizes certain activities under the EPEA through the Activities Designation Regulation (ADR). There are three types of authorizations issued: Approvals, Registrations and Notifications.

Approvals are higher risk or more complex operations, registrations follow a prescribed set of operating conditions detailed in a code of practice. Notifications are lower risk and follow an operations plan. The more complete the application is the faster the process. AEP estimates a minimum of one year for an EPEA approval to be issued assuming all other permits are in place (municipal), the application is administratively complete, technically complete and there are no significant stakeholder concerns to address. Each of these items can significantly add to the processing time of an application.

The EPEA approval process is outlined in the Guide to Content for Industrial Approval Applications. The guide to content details what information is required by the Department.

Information on many waste management facility types can be found on the AEP website at the link:

- http://aep.alberta.ca/waste/default.aspx

This link will bring you to the page detailing the EPEA approval process including the Guide to Content for Industrial Approval Applications.

- http://aep.alberta.ca/land/land-industrial/forms-applications/epea-approval-process.aspx

Any technology employed where energy is produced will add a layer of regulatory oversight. This oversight could come from Alberta Energy, the Alberta Utilities Commission and/or the Alberta Electric System Operator depending, among other things, on the size of the power plant (in MW). It is suggested that Newell meet with the AEP regional staff who could, after reviewing the plans, better describe the electrical portion. Newell can also reach out to Alberta Energy at this link: http://www.energy.alberta.ca/About_Us/1010.asp.

6.0 DISCUSSION

The waste characterization review indicated that approximately 22,000 tonnes of material is available as feedstock for an EfW facility in the Newell Region. This is not a large waste stream compared to the major urban centers in Canada or in Europe, but there are vendors who are able to supply processing technology for the waste stream available. The cost per tonne for processing, as well as the outputs from these technologies, are variable and are required to identify which technology type is most suitable. There are numerous vendors within Canada and elsewhere who have proven equipment which is available for procurement, and should be evaluated for suitability.

Typically, EfW operations benefit from economies of scale. The cost per tonne to process material in small units tends to be much higher than the cost per tonne to process larger waste tonnages in larger units, or in a system operating a number of small units together. The waste tonnages available in the Newell Region are adequate to feed a small-scale operation, but are not expected to be large enough to benefit from these economies of scale to lower the cost per tonne for processing.

With any of the technologies reviewed, a fraction of the total waste stream will not be suitable for processing in the EfW unit, and will still require landfilling. It is expected that the regional landfill will still be required, both for unsuitable waste fractions, as well as for residuals generated by the EfW processing facility. A detailed financial evaluation of operating an EfW facility is recommended to determine the true cost per tonne of any proposed system, which includes costs for hauling, ongoing landfill operations, capital costs for a new EfW facility, O&M of the proposed facility, changes to waste collection and hauling, waste sorting as required, and pre-processing requirements for the EfW facility.

The review of commonly used energy from waste technologies indicated that the majority of the thermo-conversion technologies could be scaled for use in Newell, and each present both advantages and disadvantages. The most suitable technology type, based on our understanding at the time of reporting, is a mass burn system. This is because it will process MSW, and is well proven as a technology with operational facilities located in Canada, and elsewhere. It does produce emissions if not properly managed, which have the potential to cause environmental impacts. Other technology types may also be suitable, depending on the specific goals established for the program.

Neither of the biological conversion technologies (aerobic or anaerobic composting) are considered viable for the Region of Newell, primarily because they are best suited to processing organic waste, which makes up only a small fraction of the total waste stream available.

7.0 RECOMMENDATIONS

From the general analysis of potential EfW technology types, the selection of a suitable candidate is dependent on several factors. Though some of the following questions have been answered as part of this study, all of these questions will require answers prior to being able to move forward with a final decision on waste processing technology:

- Annual quantity of waste available to be processed;
- The consistency of the waste stream (in terms of both volume and composition);
- The nature of the waste stream available (homogeneity, BTU value, pre-processing requirements);
- The maturity of the proposed technology (has it successfully processed a similar waste stream elsewhere);
- The environmental benefits associated with the use of the technology (CO_2 reduction, reduced emissions etc.); and
- The capital and operating costs associated with the proposed processes, compared to the existing system

Waste composition questions can be better defined through a dedicated waste composition study. Questions pertaining to technology output and waste stream requirements can be provided by each individual vendor through an RFQ process.

Based on meetings with the EfW steering committee, and feedback on the Waste Characterization Report and the initial findings of the Technology Review, the most suitable processing technology would be a mass burn facility, though other thermal-chemical conversion systems may also be suitable. Based on our review of the data, as well as meetings with the steering committee, we are providing the following recommendations:

- Discussion is required within the steering committee to align the end-goals of an EfW project in the Newell Region. There are technology types that are proven to have capacity to process the waste stream available, but the outputs are variable, and the capital and operating costs are variable. An alignment of goals will allow a technology to be identified based on satisfying the ultimate requirements set out by the steering committee.
- Once the objectives of the EfW facility are clearly defined, an RFQ can be drafted to invite bidders to present their technological solutions, with the parameters for cost, schedule, and outputs clearly being met by proponents.
- Proposals can be reviewed by the Steering Committee, and may also be reviewed by an expert panel to confirm the details included in each proposal, and identify the best proponent.
- Details provided by proponents can be incorporated into a detailed financial evaluation of a new waste management system for the region. This evaluation would indicate the true cost of waste disposal per tonne in the proposed system, and would take into consideration, at a minimum, the cost of:
  - Ongoing landfill operations;
  - Capital costs for a new EfW facility;
  - O&M of the proposed facility, including pre-processing of material;
  - Changes to waste collection and hauling; and
  - Waste sorting as required for the EfW facility.

8.0 CLOSURE

We trust this report meets your present requirements. If you have any questions or comments, please contact the undersigned.

Respectfully submitted,
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APPENDIX A

TETRA TECH'S LIMITATIONS ON THE USE OF THIS DOCUMENT

LIMITATIONS ON USE OF THIS DOCUMENT

GEOENVIRONMENTAL

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Both electronic file and/or hard copy versions of TETRA TECH's Instruments of Professional Service shall not, under any circumstances, be altered by any party except TETRA TECH. TETRA TECH's Instruments of Professional Service will be used only and exactly as submitted by TETRA TECH.

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Services performed by TETRA TECH for the Professional Document have been conducted in accordance with the Contract, in a manner consistent with the level of skill ordinarily exercised by members of the profession currently practicing under similar conditions in the jurisdiction in which the services are provided. Professional judgment has been applied in developing the conclusions and/or recommendations provided in this Professional Document. No warranty or guarantee, express or implied, is made concerning the test results, comments, recommendations, or any other portion of the Professional Document.

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The Client, and any Authorized Party, acknowledges that the Professional Document is based on limited data and that the conclusions, opinions, and recommendations contained in the Professional Document are the result of the application of professional judgment to such limited data.

The Professional Document is not applicable to any other sites, nor should it be relied upon for types of development other than those to which it refers. Any variation from the site conditions present, or variation in assumed conditions which might form the basis of design or recommendations as outlined in this report, at or on the development proposed as of the date of the Professional Document requires a supplementary investigation and assessment.

TETRA TECH is neither qualified to, nor is it making, any recommendations with respect to the purchase, sale, investment or development of the property, the decisions on which are the sole responsibility of the Client.

1.7 NOTIFICATION OF AUTHORITIES

In certain instances, the discovery of hazardous substances or conditions and materials may require that regulatory agencies and other persons be informed and the client agrees that notification to such bodies or persons as required may be done by TETRA TECH in its reasonably exercised discretion.

APPENDIX B

ALBERTA'S ENVIRONMENTAL APPROVAL REQUIREMENTS

Alberta's *Environmental Protection and Enhancement Act (*EPEA) sets out conditions and requirements that dictate which activities require permits and approvals. Regulations under the EPEA also establish minimum requirements for compliance. The EPEA also outlines the process for obtaining permits and approvals.

It is unclear whether an environmental assessment is required for the proposed facility. An important consideration is whether the complexity and scale of the proposed project, technology or siting consideration would result in a potential significant environmental impact. The proposed facility receives and handles MSW, sorts and diverts marketable recyclable materials, processes organic waste (anaerobically and aerobically) and produces an alternative fuel product. Areas that would pertain to Alberta Environment approval include waste transfer stations, composting facilities and energy from waste facilities.

B1 Waste to Energy Facilities

Alberta's Energy Strategy promotes the development of renewable energy. This includes wind, solar and biomass energy, and producing RDF would be related to biomass energy. Turning waste into energy is becoming more popular since it can significantly reduce the amount of waste to landfills and could reduce carbon emissions.

Energy recovery from wastes includes technologies such as anaerobic digestion, gasification, combustion or incineration with energy recovery. Under the EPEA, the Director could require an environmental assessment in accordance with the approval process. Below is a link to the approval process.

EPEA Approval Process

If on-site generation of electricity is conducted, approvals will be required by the Alberta Utilities Commission (AUC) and Alberta Electrical System Operator (AESO) (if connecting to the Alberta Interconnected Electrical System [AIES]).

The power plant component of the project would be exempt from the AUC regulatory process if the following can be demonstrated:

- Generation is to occur, and be used, on site (i.e., no interconnection to the AIES); or
- If connecting to the AIES:
  - Is <1 MW production capacity;
  - Is demonstrated to have no direct adverse affect on any other stakeholder;
  - Is demonstrated to not have any adverse environmental impact;
  - Is operated in compliance with AUC Rule 012 for Noise Control; and
  - Is under agreement with the AESO (or other owner/operated of the transmission/distribution infrastructure).

If these conditions are not met, then the power plant component of the project would be subject to the AUC Rule 007, requiring an application for additional permitting through the AUC. In additional to these "umbrella" regulatory requirements, additional permitting, notifications and/or environmental studies may be required if there are any anticipated impacts to waterbodies (e.g., wetlands, drainages, creeks) or wildlife.

B2 Building and Construction Permits

Building and construction permits would be issued by the respective municipality. The design and specifications of the proposed facility must be prepared by a professional registered with the Association of Professional Engineers and Geoscientists of Alberta (APEGA). The facility design plan and specifications are outlined in the Standards for Composting Facilities in Alberta (dated 2007) and, as a minimum, include the following:

(i) An engineering design report that provides a description of following:
   a. Proposed feedstocks;
   b. Composting/processing methods;
   c. Design capacity, including:
      - Processing area capacity;
      - Storage area capacity; and
      - Curing area capacity.
   d. Environmental control measures included in the design; and
   e. Monitoring systems.

(ii) Engineering maps and plans that include the following:
   a. Soils investigation report;
   b. Topographic site plans showing the overall site development and setbacks;
   c. Cross-sections showing based grades and elevations;
   d. Description and interpretation of groundwater elevations, flow, patterns and composition;
   e. Details of components of the composting facility;
   f. Design for liner for receiving areas, feedstock storage, active composting areas, curing areas, and process water retention ponds;
   g. Working surface specifications that has a positive slope and capable of withstanding wear through normal operations;
   h. Run-on control system designed to prevent flow of water onto developed areas of the composting facility for events up to at least the peak discharge from a 1 in 25 year – 24 hour duration storm event;
   i. Run-off control system designed to collect and control the volume of process water run-off for a 1 in 25 year – 24 hour duration storm event; and
   j. Groundwater monitoring system, unless authorized in writing by the Director.

B3 Operational Requirements

B3-1 Operations Plan

The proposed facility should include an operations plan that includes the following:

a. List of feedstock accepted at the composting facility;
b. Feedstock acceptance policies and procedures;
c. Prohibited waste handling procedures;
d. Site security and public access control procedures;
e. Working surface maintenance program;

f. Liner maintenance program;
g. Composting/organics processing plan, including:
   (i) a description of composting technology used;
   (ii) procedures for maintaining aerobic conditions;
   (iii) a pathogens reduction plan;
   (iv) a composting temperature monitoring program;
   (v) quality assurance and quality control program;
   (vi) procedures for curing compost to meet maturity requirements;
   (vii) procedures for storage and management of final product; and
   (viii) procedures for preventing pathogen re-growth in final product;
h. Odour management program;
i. Process water management procedures;
j. Environmental monitoring program;
k. Compost quality monitoring plan;
l. Procedures for handling and disposal of residual materials;
m. Site safety and emergency response plan;
n. Contingency plan for reasonably foreseeable events;
o. Nuisance management plan; and
p. Reporting procedures.

B3-2 Odour Management Program

Odour management is a critical part of any organics processing facility. To address provincial requirements, the odour management program should as a minimum include all the following components:

a. Description of odour control technology;
b. Identification of areas in the facility where odours can be generated;
c. Best management practices (infrastructure and operational) to mitigate odours;
d. Odour detection methods;
e. Procedure to track and document public complaints regarding odours from the composting facility;
f. Procedure to respond to public complaints regarding odours originating from the composting facility; and
g. Odour contingency response plan to minimize or remedy offensive odours.

B3-3 Groundwater Monitoring Program

Unless authorized in writing by the Director, the groundwater monitoring program shall include, at a minimum, the following:

a. Program to establish background groundwater quality prior to the start of composting operations;

b. Detailed program for groundwater sample collection and analysis, that includes, at a minimum, the following:

   (i) Retrieval of representative samples from each groundwater monitoring well at least once per year;

   (ii) Laboratory analysis of the samples for parameters as set out in Table 1; and

   (iii) Monitoring the depth to water at each monitoring well at time of sampling.

APPENDIX C

CARBON CREDIT OVERVIEW

Numerous countries have engaged in initiatives and programs to reduce GHG emissions to a specified limit, such as the limits included in the Kyoto Protocol, Copenhagen Accord, and Paris Agreement. Each country uses a variety of programs and mechanisms to promote GHG reduction, increase carbon sequestration activities, and overall move towards less GHG intensive practices and processes.

In Canada's approach to action on climate change, a wide variety of approaches are used to reduce GHG emissions. In 2016 the federal government signed onto the Paris Agreement, a non-binding commitment to keep global temperatures down through limiting GHG emissions. In 2017, a Pan-Canadian Framework on Green Growth and Climate Change released by the federal government set an overall vision for harmonized efforts across provinces and territories to develop and implement their own programs to reduce GHG emissions and assist in achieving the national target, while each facility reports its GHG emissions to Environment Canada.

As a result of these commitments, there are federal and provincial funding opportunities to incentivize GHG emission reduction including research grants and capital infrastructure investment. Common provincial programs include: GHG limits and bans, carbon tax, and cap-and-trade systems.

- **Emission limits and bans** – Limits are typically mandates that restrict GHG emissions to a specified amount per year, while bans prohibit certain activity that generate large amounts of GHG emissions. For example, Ontario has a ban and eliminated the use of coal-fired plants that generates electricity.
- **Carbon tax** – A financial fee (e.g. tax, tariff, or environmental fee) is imposed for certain GHG activity/process and/or for using a certain product. For example, British Colombia has a carbon tax on the purchase and use of fuels such as gasoline, diesel, and natural gas.
- **Cap-and-trade** (also known as carbon trading; emission trading) – This involves creating a carbon market where entities are able to buy and sell carbon credits generated by users who are producing less than their industry threshold for GHG emissions. Organizations that exceed a specified GHG emission threshold (cap) would purchase credits from another organization that is selling credits (trade). For example, the Alberta Offset System is an Alberta-specific carbon trading market under the Specified Gas Emitters Regulation.

C1 Overview of Carbon Markets in Canada

The Canadian carbon market uses carbon credits, also known as offset credits. These credits are treated like commodities that can be sold and traded between parties. A carbon credit is a reduction in greenhouse gas emissions (commonly expressed in a metric tonne of carbon dioxide equivalent, tonne CO_2e) that would not occur under typical, standard, or conventional conditions. In other words, the GHG reduction is a result of GHG reduction efforts which are considered to be operating outside of industry norms. For example, processing the organic fraction of MSW through anaerobic digestion instead of landfilling may qualify and generate carbon credits. These carbon credits could then be sold into a carbon market as a source of revenue. Note that this only applies in regions where organics processing is not yet considered the industry norm; for example, new organics facilities are not eligible for carbon credits in Nova Scotia since the organics ban has been in place for two decades, and the organics processing infrastructure is already well served.

There are numerous carbon markets worldwide which vary by geographical boundaries – international, national, regional/local. Some internationally known carbon markets are the Joint Implementation and Clean Development Mechanism, as well as other US markets such as the California Action Reserve. Each market has its own set of eligible criteria, conditions/limitations, and quantification processes.

In Canada, there are two primary carbon markets:

1) Alberta Offset System

The Alberta Offset System is Alberta-specific, where trading is only between Alberta-based facilities (i.e. no organization outside of Alberta may purchase and sell carbon credits under the Alberta Offset System).

2) Western Climate Initiative

The Western Climate Initiative is comprised of multiple Canadian provinces (British Columbia, Manitoba, Ontario, and Quebec) and US states (currently only California active).

C2 Alberta Offset System

The Alberta Offset System, initiated by Alberta Environment and Parks, is specific to facilities in Alberta, i.e. trading is between two facilities in Alberta. The price of a carbon credit in 2017 is $20/tonne and is expected to increase in 2018 to $30 / tonne. The credit duration period is typically 8 years with a possible extension for 5 years, making an eligible project's revenue potential limited to 13 years.

To obtain carbon credits, the project must adhere to all eligibility criteria described in Section 3.1 of the Offset Project Guidance document. The organization claiming carbon credits would be required to develop a project plan and complete a project report. Once these are completed, a third-party verifier approves all the information and the carbon credits can be sold into the market.

A project plan is a document describing how the organization estimates their GHG reductions (e.g., which quantification protocol(s) are followed), how all data sets are obtained and managed (e.g. amount of feedstock processed), and what quality assurance and quality control processes/instruments are implemented. A project report summarizes all the information listed (e.g. data sets) and the estimated GHG reduction.

C3 Cap and Trade under the Western Climate Initiative

The Western Climate Initiative (WCI) is a non-profit body with no legislative authority to enact requirements to industry members for participation. It is the responsibility of partner organizations to incentivize, implement and maintain the recommendations of the WCI in their own geographical districts. The WCI provides only administrative and technical services; importantly, it provides the Compliance Instrument Tracking System Service (CITSS) for participating members to manage and track carbon assets on the market.

APPENDIX D

BACKGROUND INFORMATION ON FEEDSTOCK PRE-PROCESSING

Feedstock may need to be pre-processed and stored over various lengths of time depending on the technology scenario selected. These issues include feedstock homogenization, space management, and moisture management.

- **Feedstock Homogenization**. In order to ensure a clean and even burn, refuse derived fuel (RDF) boilers are designed to operate optimally within a somewhat narrow range of feedstock energy values. More advanced thermalchemical systems also require feedstock consistency. Because MSW is a combination of several types of feedstocks, and because these feedstocks can vary in thermal energy content, shredding and/or densifying raw MSW fuel helps to maintain a consistent energy content and flow.
- **Space Management**. The combustible portion of MSW feedstocks consists primarily of wood wastes, cardboard, plastics, textiles and paper products. When loosely stored, the shape and structure of these biomass sources will inherently generate a low density storage. Practically speaking, this means that if the biomass is left unprocessed, long term storage could require a significant footprint. Space management is a required consideration for a commercial operation.

D1 Shredding

Feedstock homogenization and storage space management often includes mechanical material shredding. Shredding is recommended for both RDF and bulk waste conversion systems. Shredders are widely used, robust pieces of machinery which can be provided by a number of different vendors. Photo below depict typical shredder options. Shredding advantages include:

- Improved handling material qualities;
- Improved homogenization capabilities;
- Improved fuel density; and
- Readies material for further processing.

Photo D1: MSW Shredder
(Source: UNTHA)

Photo D2: Wood Shredder
(Source: UNTHA)

D2 Pelletization and Briquetting

After the shredding phase, one way to further improve the storing and handling characteristics and process efficiencies of the MSW is through densification. This is particularly important when producing RDF that requires shipping. This is accomplished through one of two processes; pelletization or briquetting.

In pelletization, shredded MSW would be fed into a hammer mill reducing it to sawdust sized particles. This material would then be mixed with a binding agent (such as waste oil), and passed through a mechanical extrusion pelletizer. Briquetting also mechanically compacts shredded MSW, though without the additional step of hammer milling. Despite the different processes, both methods accomplish similar goals. These include:

- **Densification** – Storage space can be reduced by up to 50% over material that is only shredded.
- **Transportability** – The increased energy density of the pelletized/briquetted feedstock improves transport efficiencies several orders of magnitude. Because of this pellets/briquettes could be imported to supplement shortfalls, or increase anticipated system size.
- **Homogenization** - Wood, cardboard, paper, and (maybe) binder waste oil can be combined into a single fuel source with a consistent density, heat or Btu value, and thus consistent combustion properties.

Photo D3: Biomass Pellets

(Source: www.cleantechloops.com)

Photo D4: MSW Briquettes

(Source www.bhsenergy.com)

TETRA TECH

APPENDIX E

WASTE CHARACTERIZATION MEMO

TETRA TECH

TECHNICAL MEMO

ISSUED FOR USE

To:	Palliser Economic Partnership Ltd.	**Date:**	October 20, 2017
		Memo No.:	1
From:	Tetra Tech Canada Inc.	**File:**	704-SWM.SWOP03694-01
Subject:	Newell Energy from Waste Feasibility Study Technical Memorandum 1: Waste Stream Characterization		

1.0 INTRODUCTION

Tetra Tech Canada Inc. (Tetra Tech) was retained by the Palliser Economic Partnership to undertake an Energy from Waste (EfW) feasibility study to investigate the feasibility of introducing a new EfW processing facility to service the Newell Region. This feasibility study, led by the Palliser Economic Partnership and the Newell Region Economic Development Initiative, will provide the Municipal Councils of the Newell Region communities with technical information intended to assist in determining the suitability of an EfW processing facility in the region.

The study includes a review of all current waste streams and additional waste sources that may be available for processing, and a review of EfW processing technologies currently available. This Technical Memorandum summarizes the findings of the Waste Characterization Study. The objective of this Technical Memorandum (*"Technical Memorandum 1: Waste Characterization"*) is to establish baseline waste volumes and composition for all waste streams that could potentially be processed by an EfW facility in the Newell Region, and to determine the availability of these waste streams.

2.0 METHODOLOGY

Tetra Tech reviewed landfill tonnage data reports provided by the Newell Regional Landfill (NRL), and historical Southern Alberta Energy from Waste Alliance (SAEWA) reports to establish baseline waste composition and waste volumes that are being generated in the Newell region.

Tetra Tech also interviewed local waste generators, including JBS Food Canada Inc. (JBS), haulers, and local farmers. This supported the collection of waste generation and disposal data, and confirmed the data received from the NRL was representative of how waste was disposed of throughout the region.

This review includes residential waste, construction and demolition (C&D) waste, and industrial, commercial, and institutional, (ICI) waste streams. Additional waste sources investigated include rail ties, specific risk materials, biosolids, manure, medical waste, agricultural waste, contaminated soil, and oilfield waste. Quantities of available material have been provided where relevant.

Pre-treatment requirements for EfW processing have been identified for certain materials, and additional pre-treatment requirements will be identified for specific processing technologies during the Technology Evaluation phase of the project.

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3.0 WASTE STREAMS

The majority of waste generated in the Newell region is disposed of at the NRL. Waste material that does not go to the landfill is taken to an alternative location due to regulatory requirements (e.g., oilfield waste, medical waste, used oil), or else disposed of at the point of generation (e.g., manure), where it can be disposed of at no cost, and without incurring transportation costs. The waste that is disposed of at the NRL is classified as either Municipal Solid Waste (MSW) or Industrial Waste.

3.1 Newell Regional Landfill

The Newell Region's solid waste is serviced by the NRL, which is operated by the Newell Regional Solid Waste Management Authority (NRSWMA), located 10 km NW of Brooks, Alberta. The NRSWMA operates five transfer stations as well as a landfill.

Table 1 summarizes the quantity of materials accepted at the NRL site between 2010 to 2016. These materials are classified in two main categories, MSW and industrial waste. MSW is waste material that is generated by the residential, commercial, and construction sectors, while the industrial waste accepted at the NRL is primarily contaminated soil and drilling mud (Juska, R., personal communication, 2017).

As shown in Table 1, the total quantity of material entering the NRL site varies from year to year. The average annual total quantity of material accepted is 177,410 tonnes per year, with a relative standard deviation of 27%. The relative standard deviation indicates a moderate variability between years. Of the total waste tonnage accepted, 83% of material was industrial waste (147,032 tonnes/year), and 13% MSW (30,377 tonnes/year).

3.1.1 Industrial Tonnage

The industrial waste accepted at the NRL is characterized as primarily contaminated soil and drilling mud. This material is not considered suitable as feedstock for an EfW facility, so will not be considered for the remainder of this material evaluation.

3.1.2 Municipal Solid Waste Tonnage and Composition

The quantity of MSW accepted monthly between 2010 and 2016 is illustrated in Figure 3-1. The 2016 values were adjusted to resemble a typical month, i.e., VISCO and Lakeside ground clearing materials were not accounted for in 2016 as these materials were generated by a one-time event (Juska, R., personal communication, 2017). As shown in Table 2, the average annual quantity of MSW accepted at the landfill was approximately 28,000 tonnes per year, with a relative standard deviation of 7%. The 7% relative deviation suggest variability between years was low, i.e., the MSW waste stream is considered stable.

Figure 3-1 summarizes the average monthly quantity of MSW accepted and its standard deviation. The average monthly weight accepted was approximately 2,300 tonnes. While the annual variability was low, the monthly variability of MSW accepted was high; October had the highest deviation and January being the lowest deviation. The monthly quantities accepted at the landfill ranged from 1,295 to 4,840 tonnes. This wide range and variability may impact the loading (amount of material processed during a specified time) of an EfW facility, and would need to be taken into account during the facility design.

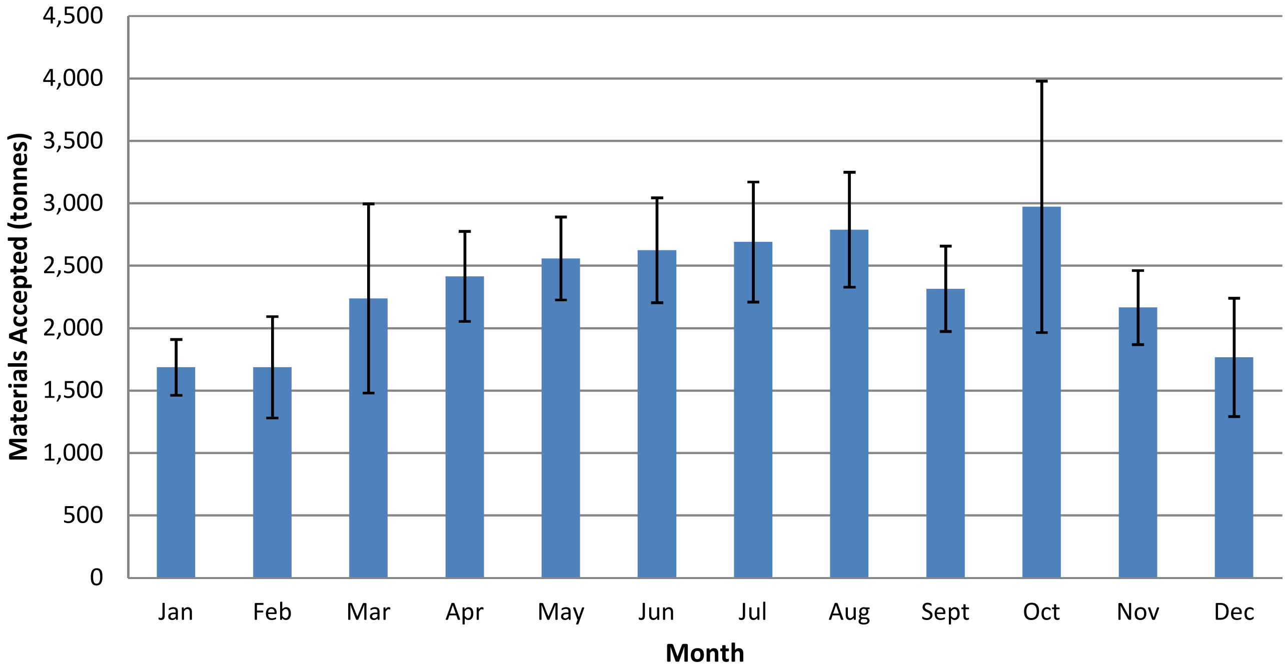

Figure 3-1: Average Monthly MSW Accepted (tonnes)

The MSW stream accepted at the landfill is variable in composition. The NRSWMA tracks and categorizes the materials into 11 different categories – some are based on generator type and others are material specific. The categories are:

- **Residential** – Waste accepted from county residents (single family and multi-family homes) in towns and hamlets
- **Institutional, Commercial, and Industrial** – Waste accepted from institutions, commercial and business waste, and light industrial activity. Examples include schools, office buildings, shopping malls, and office waste (but not industrial process waste)
- **Construction and Demolition** – Waste accepted from construction, renovation, and demolition activities
- **Tires** – Tire material from various sources
- **White Goods** – Major household appliances such as fridges, washers, dryers, and stoves
- **Wood (commercial)** – Wood waste derived from commercial activity, including pallets and construction waste. Wood may be clean, pressure treated, painted or other
- **Concrete and Asphalt** – Concrete and asphalt material derived from various construction and demolition activities
- **Chemical Containers** – Containers which previously contained chemical agents. Containers may be plastic, steel or other
- **Ground Clear (wood)** – Material derived from ground clearing activities, typically tree stumps or branches
- **Special Waste** – Contaminated soil
- **Animal By-Products** – Brine screenings and animal parts generated by JBS Food in Brooks

As shown in Figure 3-2, the majority of MSW is derived from the residential (43%), ICI industrial (22%), and C&D (12%) sectors. Comparing the last three years (see Figure 3-3), the composition of the MSW stream has not changed significantly, with the exception of a one-time event which generated 'Ground Clearing' waste in 2016.

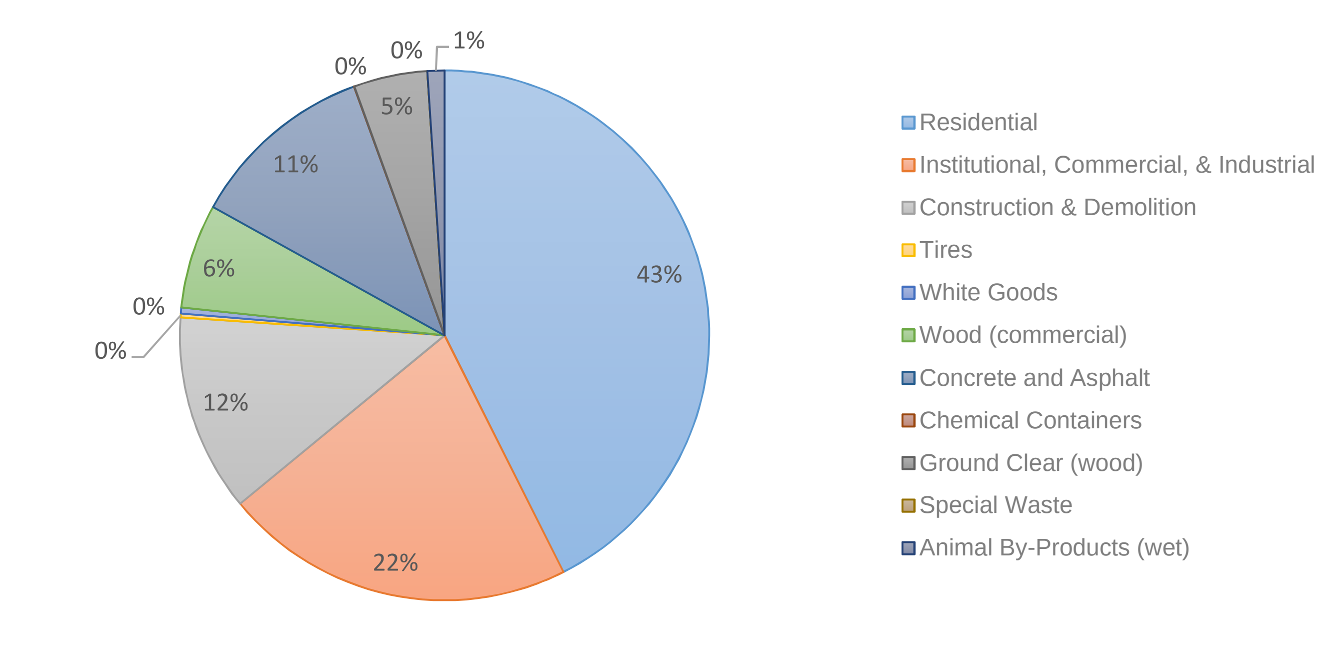

Figure 3-2: Composition of MSW (average of 2014, 2015, and 2016 data)

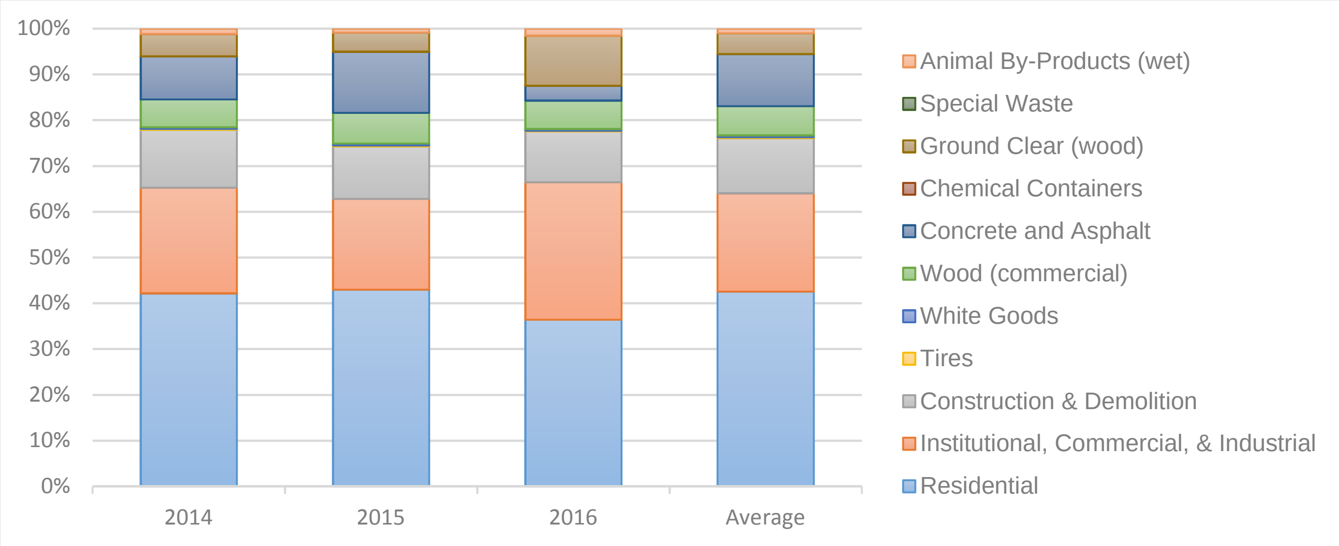

Figure 3-3: Annual MSW Composition Comparison (2014 – 2016)

3.2 Additional Waste Sources

Additional waste streams that are currently not being disposed of at the NRL were also assessed. Table 3-1 summarizes the alternate waste streams that could be used as feedstock, and their availability for processing by the Newell Region. A full description of each material type is included in Appendix A.

Table 3-1: Additional Waste Feedstock Availability in Newell Region

Material	Generator	Quantities Available		Competitor	Technology		Comments
		Estimated Available in Newell Region (tonne per year, tpy)	Total Available in Alberta (tonne per year, tpy)		Preferred Technology	Typical Pre-Treatment	
Railway Ties	Canadian Pacific Railway	113,272 tpy	▪ Generation Rate: 180,000 tpy across Canada (57,000 tpy in Alberta) ▪ Stockpiled: 585,000 tpy across Canada	▪ LafargeHolcim Exshaw Plant (currently in facility in permitting stage) ▪ Enerkem Gasification system (Edmonton) ▪ Cielo Biodiesel (High River)	Incineration	Shredding to appropriate size (e.g. 2 inches)	While there are large amounts of railway ties available and stockpiled in Western Canada, additional details regarding the contractual arrangements with contractors retained by the railways for track maintenance would be necessary. Furthermore, there are other competitive markets in Western Canada interested in using railway ties as an energy source and these markets are further along the permitting process.
Specific Risk Materials	JBS Food Canada Inc.	Not Quantified	27,500	▪ West Coast Reduction	Incineration	N/A	Specific Risk Materials are regulated by the Canada Food Inspection Agency, who are required to approve disposal methods for all SR material.
Wastewater Sludge and Biosolids	Wastewater treatment facilities	<1000 tonnes	100,000+ tpy	▪ City of Calgary Compost Facility ▪ Lethbridge Compost Facility (future) ▪ Medicine Hat Compost Facility	Anaerobic Digestion and/or Composting	Dewatering and/or drying	Large population centers with wastewater treatment plants have existing programs and may not be interested in an EfW facility in the Newell Region. For example, the City of Calgary and City of Medicine have their own composting facility. Also, the City

Material	Generator	Quantities Available		Competitor	Technology		Comments
		Estimated Available in Newell Region (tonne per year, tpy)	Total Available in Alberta (tonne per year, tpy)		Preferred Technology	Typical Pre-Treatment	
							of Lethbridge is looking at implementing a curbside organics collection program by 2021 with the intent of composting biosolids.
Manure	Local farmers and JBS Food Canada Inc.	Estimated 180 million tonnes across Canada in 2006. Local tonnages are not quantified.	Over 2,754 farms in Southern Alberta, close to the Newell area.	▪ Material is typically disposed of at the location of origin (the farm) at no cost to farmers.	Anaerobic Digester	Drying	Manure is typically land spread at a low cost to producers, with no transport cost required. There is no incentive for farmers to transport manure for disposal elsewhere.
Animal By-Products	JBS Food Canada Inc.	Approx. 50 tonnes/yr		▪ Currently disposed of at NRL	None.	Drying	Brine screenings, not suitable for AD or incineration.
Medical Waste	Stericycle (service provider), produced by Alberta Health Services facilities and others.	Estimated 400 tonne/yr	Estimated 8,000 tonne/yr	▪ SwanHills Waste Treatment Facility or Autoclaving Facilities	Incineration, Autoclave		Approximately 85% of medical waste is autoclaved, and the remaining 15% requires specialized treatment, which includes extensive Chain of Custody tracking, and specialized incineration units. This waste stream may be available, though market is mature and very competitive.

Material	Generator	Quantities Available		Competitor	Technology		Comments
		Estimated Available in Newell Region (tonne per year, tpy)	Total Available in Alberta (tonne per year, tpy)		Preferred Technology	Typical Pre-Treatment	
Agricultural Plastics	Local farms	Up to 420 to 891 tonnes.	6,600 to 14,000 tonnes in Alberta	▪ Small landfills (<10,000 tonnes), or burning at the farm	Incineration or recycling.	None	Management of agricultural plastics in Alberta has been identified by the regulatory authority as an important issue. Alberta is currently planning to implement Ag Waste Stewardship Program, which may allow an EfW facility to become a disposal option. Recycling is currently the preferred option for disposal of bags, twine has been recycled previously in Alberta, but can now be shipped to Minnesota for processing. (Juska, R., personal communication, 2017).
Oilfield Waste and Contaminated Soils	Oil and gas producers, remediation contractors, drilling companies.	2,500	>100,000 t/yr	▪ Tervita, Secure Energy, Newalta, Gibsons, and others	None, not suitable for incineration.	N/A	Oilfield waste composition is highly variable, wet, typically with a low BTU value. The oilfield waste market is very competitive in Alberta, and current disposal companies have been known to drop prices as low as $5 per tonne to maintain market share.

4.0 ANTICIPATED FEEDSTOCK TONNAGES

The materials that have been identified as reliable sources of feedstock material are all included in what is currently the MSW stream accepted by the NRL, as well as agricultural plastics. Table 4-1 summarizes the MSW streams that may be used as feedstock, including estimated annual tonnages available in the region. A graphical illustration of monthly anticipated feedstock tonnages is included as Figure 4-1. This chart shows an estimate of the combustible portion of the MSW which is currently accepted at the NRL, including standard deviation. The tonnages were determined based on historical average monthly quantities accepted at the NRL.

The total anticipated available feedstock is approximately 22,000 tonnes per year. As previously discussed, MSW materials currently collected from the NRL would be the primary feedstock sources because other waste sources (such as wastewater sludge and biosolids, agricultural plastics, and manure) may not be readily available in the Newell Region. Approximately 76% of the MSW materials are deemed suitable for use as feedstock.

Table 4-1: Anticipated Feedstock Details

Material Type	Estimated Annual Quantities (tonnes)	Energy Content	Typical Pre-processing Requirements	Comment
Residential	11,869	Medium	Drying (if material is wet)	Most residential waste materials are suitable, but the energy value is moderate due to large amounts of organic materials (e.g. food waste) present.
Institutional, Commercial, & Industrial	4,787	Low - High	Sorting to remove non-combustible materials	Assume 20% of total material would not be suitable for combustion. Typically, large amounts of plastics exist. A detailed waste composition study would be required to determine actual quantities.
Construction & Demolition	1,679	Low - High	Sorting to remove non-combustible materials, some shredding may be required.	A good portion of construction and demolition material is non-combustible such as concrete and aggregate (assumed 60% non-combustible). However, plastics and wood are combustible. A detailed waste composition study would be required to determine actual quantities.
Tires	N/A	High	Not applicable	High energy value, but not suitable as an EfW feedstock as tires are listed as a designated material under a product stewardship program in Alberta.
White Goods	N/A	Low	Not applicable	Not suitable as an EfW feedstock because of hazardous material content. Low energy value.
Wood (commercial)	1,780	Medium	Shredding	Good energy source, readily available.
Concrete and Asphalt	N/A	Very low	Not applicable	Not suitable as an EfW feedstock due to its low energy value.

Material Type	Estimated Annual Quantities (tonnes)	Energy Content	Typical Pre-processing Requirements	Comment
Chemical Containers	0	Medium	Not applicable	Recycling program in place, none recorded as disposed of at NRL.
Agricultural Plastics	600	Medium	Shredding	Currently under review for a product stewardship program, which may allow incineration as a disposal option.
Ground Clearing(wood)	1,004	Medium	Size reduction (e.g. shredding)	Good energy source (assume 80% is suitable and is primarily wood and the other 20% is non-combustible).
Special Waste	N/A	Variable	Not applicable	Defined as contaminated soils, not suitable for combustion. Included in the Industrial Waste Category.
Animal By-Products (wet)	290	Very Low	Not applicable	Not suitable as an EfW feedstock, material is very wet (slurry), and has very low energy value.
Total	**22,000**			

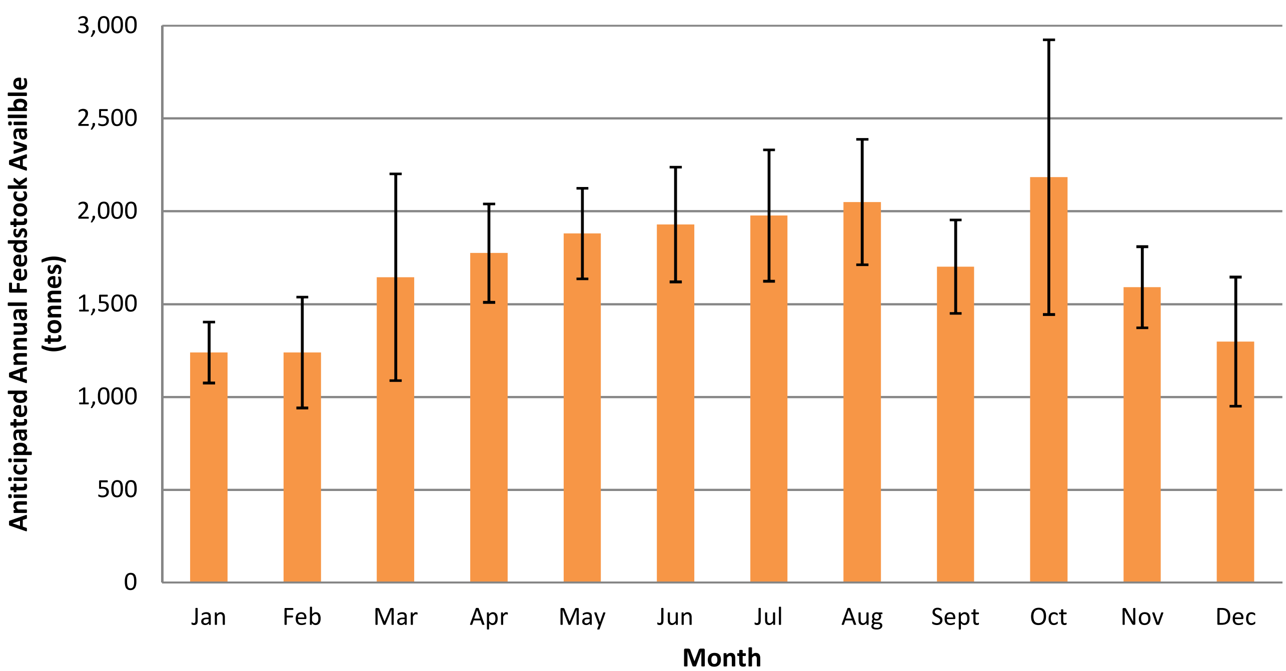

Figure 4-1: Aniticipated Monthly Feedstock avaible for a EfW Facility in Newell Region

The highest waste generation months are typically also the warmest months. Some feedstock storage may be required to provide adequate fuel during the winter months.

5.0 JBS FOOD CANADA INC. WASTE

Tetra Tech interviewed JBS, as they are considered to be a major contributor of waste to the region, to determine what future waste generation trends can be expected from their facility and feed lots.

The waste streams which are produced by JBS and managed by private waste contractors are:

- Chemical containers, which are recycled with a private recycling company.
- Paunch, which is land spread by a contractor.
- Specific Risk Materials, which are sent off-site for specialized processing as disposal.
- Recyclables, clean cardboard and e-waste is recycled.

JBS manages liquid waste in lagoons on-site, or deep well injects material which required special handling. Manure from feedlots is composted on-site, and land spread.

The majority of JBS solid waste consists of soft plastic, contaminated cardboard, office waste, and pallets. This material is all hauled to the NRL, where no tipping fee is currently charged. JBS also hauls brine screenings to the NRL for disposal. The landfill currently does not differentiate between load types when tracking tonnages, making it difficult to estimate annual tonnage of combustible material sources from JBS. The NRL currently receives approximately 161 tonnes per year of mixed waste from JBS, and 553 tonnes of mixed waste from the Lakeside Feedlot.

A Co-Gen facility has already been designed and permitted to collect gas from JBS lagoons, and generate electricity and steam. This facility is planned to be operational by early 2018.

6.0 SUMMARY

In summary, it is anticipated that approximately 22,000 tonnes of material is available as feedstock for an EfW in the Newell Region, with an energy content ranging from low to high. The estimated monthly available tonnages range from 1,280 to 2,260 tonnes. Detailed waste audits would be required to better understand the composition of the ICI and C&D waste streams.

Waste streams which are not currently captured by the NRL are currently being managed and disposed of by specialized private service providers, in mature markets. Waste streams such as medical waste and rail ties may be available as feedstock, but in a very competitive market, and with additional regulatory requirements to be satisfied for proper disposal.

Agricultural plastic has been identified as potential feedstock, depending on the regulations developed by the Government with regards to disposal guidelines under the proposed product stewardship program, though quantities in the region may be lower than estimated, based on the types of agriculture practised in the region.

The strongest market drivers for these waste streams are cost of disposal, combined with distance from disposal location. The low tipping rates at the NRL are understood to attract waste to the landfill that is sensitive to price, and may no longer be available if prices were to increase.

Additional waste sources such as specific risk materials, wastewater sludge and biosolids, manure, animal by-product, and oilfield waste and contaminated soil exist, but are not considered to be reliable sources of feedstock.

7.0 LIMITATIONS OF REPORT

This report and its contents are intended for the sole use of Palliser Economic Partnership Ltd. and their agents. Tetra Tech Canada Inc. (Tetra Tech) does not accept any responsibility for the accuracy of any of the data, the analysis, or the recommendations contained or referenced in the report when the report is used or relied upon by any Party other than Palliser Economic Partnership Ltd., or for any Project other than the proposed development at the subject site. Any such unauthorized use of this report is at the sole risk of the user. Use of this document is subject to the Limitations on the Use of this Document attached in the Appendix or Contractual Terms and Conditions executed by both parties.

8.0 CLOSURE

We trust this technical memo meets your present requirements. If you have any questions or comments, please contact the undersigned.

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Attachments: Tables (2)
Appendix A – Additional Waste Sources
Appendix B – Tetra Tech's Limitations on Use of this Document

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TABLES

Table 1: Materials Collected - Newell Region Landfill from 2010-2016

Year	Total Materials Collected (tonnes)	MSW (tonnes)	Industrial Waste (tonnes)
2010	219,436	29,660	189,776
2011	153,762	30,282	123,480
2012	174,102	27,269	146,833
2013	236,238	26,264	209,975
2014	209,788	29,070	180,718
2015	145,495	27,285	118,211
2016	103,046	42,812	60,234
Average	**177,410**	**30,377**	**147,032**

Table 2: MSW Collected (in tonnes) in the Newell Region Landfill from 2010 to 2016

Month	2010	2011	2012	2013	2014	2015	2016	Average
Jan	1,466	1,878	1,466	1,526	1,755	1,656	2,052	1,686
Feb	2,237	2,220	1,297	1,462	1,499	1,295	1,793	1,686
Mar	3,106	1,875	1,906	1,483	1,923	1,855	3,357	2,215
Apr	2,217	1,839	2,474	3,016	2,396	2,344	2,614	2,414
May	2,610	2,370	2,397	2,740	2,944	2,857	1,987	2,558
Jun	2,808	2,634	2,433	2,511	2,604	3,383	1,993	2,624
Jul	2,684	3,419	2,440	2,957	2,662	2,816	1,850	2,690
Aug	2,705	3,660	2,597	2,915	2,847	2,667	2,131	2,789
Sept	2,253	3,023	2,059	2,124	2,480	2,107	2,159	2,315
Oct	3,431	3,296	4,840	2,532	2,646	2,345	1,713	2,972
Nov	2,228	2,417	2,039	1,687	2,602	2,178	2,004	2,165
Dec	1,914	1,651	1,321	1,311	2,712	1,782	1,669	1,766
Total	**29,660**	**30,282**	**27,269**	**26,264**	**29,070**	**27,285**	**25,322**	**27,879**
Monthly Average	**2,472**	**2,524**	**2,272**	**2,189**	**2,422**	**2,274**	**2,110**	**2,323**

APPENDIX A

ADDITIONAL WASTE SOURCES

A.1 Railway Ties

Alberta's railway network is approximately 7,000 km (16% of the overall Canadian track) (Alberta Canada 2017). The network uses railway ties (treated lumber with creosote), while some use concrete and steel.

Railway ties are commonly replaced every 20 to 25 years, and have limited disposal options. Class I and Class II landfills in Alberta are permitted to accept treated wood such as railways ties, but disposal is only permitted by a landfill prior to entering the site or provincial authorization (AEP 2012). Many Class II landfills do not accept railway ties and those that do may charge a higher tipping fee.

Photo 1: Railcar filled with railway ties

The two major railway companies: Canadian National and Canadian Pacific (CP) in Western Canada have stated that they would support and utilize an alternative disposal facility in Western Canada.

The large majority of rail infrastructure and operations within the Newell Region is owned by CP rail (see Figure A-1). CP railway ties are commonly pressure treated wood with creosote. Railway ties treated with pentachlorophenol are not used by CP. In 2015 and 2016, CP replaced more than 2 million unusable railway ties (180,000 tonnes) and 99% of all unusable railway ties were sent to energy recovery facilities (Canadian Pacific, 2016). HDR and AECOM (2012) reported that there are approximately 6.5 million railway ties (585,000 tonnes) stockpiled and that 10% of these are treated and disposed of annually.

Photo 2: Railway Ties

Railway companies have been seeking alternative disposal methods for railway ties in Alberta because there have limited options in Western Canada. For example, On-Track Railway Operations Ltd. (On-Track) is an Alberta-based company that provides railway maintenance services as well as being responsible for disposing of the railway ties. On-Track has sold approximately 60,000 tonnes of hogged/chipped railway ties to the City of Edmonton to use in their solid waste facility. In the future, On-Track may require more disposal options for railway ties, and would have the option to use Newell Region's EfW facility if it were developed. In addition to railway ties, On-Track is responsible for disposing of telephone poles which could be another feedstock for the proposed EfW facility.

Additional details regarding the contractual arrangements with contractors retained by the railways for track maintenance would be necessary to adequately assess the use of railway ties as a potential feedstock. Issues relating to control of the disposal or reuse of the ties as well as environmental liability for use of the ties if they are sold for recycling or reuse could significantly affect access and use of the ties as a potential feedstock. Furthermore, there are other competitive markets in Western Canada interested in using railway ties as an energy source and are further along the permitting process.

Figure A-1: Railway Network in Alberta (Source: Alberta Canada, 2017).

A.2 Specific Risk Materials

Specified risk materials (SRM) are regulated through the Canadian Food inspection Agency (CFIA). It is defined as "certain cattle tissues capable of transmitting BSE [bovine spongiform encephalopathy] or mad cow disease" (CFIA 2017). *"SRM are defined as:*

- *the skull, brain, trigeminal ganglia (nerves attached to the brain), eyes, tonsils, spinal cord and dorsal root ganglia (nerves attached to the spinal cord) of cattle aged 30 months or older; and*
- *the distal ileum (portion of the small intestine) of cattle of all ages."* (CFIA 2017).

SRM are banned from all animal feeds, pet foods, and fertilizers, meaning that SRM cannot be composted. Disposal of these materials must be approved of by the CFIA, and final landfilling must be in a secure landfill.

A.3 Wastewater Sludge and Biosolids

Wastewater sludge and biosolids are a potential feedstock for an EfW facility. Typically, dried biosolids have an energy content similar or higher than that of lignite. Sludge, on the other hand, have higher energy content than biosolids because biosolids have undergone a digestion/stabilization process thereby reducing the carbon content. However, sludge has a relatively high moisture content (e.g. 1-5% solids content) and therefore requires a dewatering and/or drying pre-processing step before being used in an EfW process. The dewatering and/or drying step can be energy intensive and subsequently costly.

Photo 3: Compost using nutrient-rich biosolids

Biosolids from large wastewater treatment plants can be a reliable feedstock for an EfW facility due to the continuous large quantities of sludge and/or biosolids generated and the need for downstream treatment. However, all of the large communities near the Newell Region have existing biosolids management programs and are likely not interested in disposing of these materials at an EfW facility in the Newell Region. For example, the City of Calgary composts their biosolids to produce a high quality compost in their new composting facility. Similarly, the City of Medicine Hat composts their biosolids (Advanced Enviro 2012). While the City of Lethbridge is pursuing a curbside organics collection program by 2021 (City of Lethbridge 2015), with the intent of producing composting food scraps and biosolids. Numerous treatment and disposal options for biosolids are available closer to the points of generation.

A.4 Manure

The agricultural industry produces waste that could potentially be used for an EfW facility, including manure. Manure is not typically available as feedstock because land application (its preferred treatment disposal option) is a well-established low-cost practice. Land application on agricultural land will likely remain the most cost effective disposal option for producers.

A.5 Animal By-products

Animal by-products produced by the JBS facility consist primarily of brine screenings from the plant. (Juska, R., technical review comments, 2017). This material is wet, and not suitable for incineration in an EfW facility. Specific risk materials are discussed separately.

Photo 4: Cattle Industry
(Source: Biomass Magazine)

A.6 Medical Waste

Medical waste generated from hospitals such as biomedical and pathological wastes are regulated and managed separately and differently than other waste materials. Medical waste are required to be autoclaved or incinerated. Research such as audits have shown that non-pathological wastes generated at hospitals consist of a large proportion of plastic materials. Since plastic materials tend to have a higher energy content compared to other materials, medical waste is an attractive feedstock for an EfW facility. One limiting factor is collecting and hauling of medical waste as some hospital buildings may not have a sufficient amount of materials to be transported efficiently and effectively by themselves. Thus, having an agreement with a major hauling company such as Stericycle that specialize in medical waste collection would be beneficial.

A.7 Agricultural Plastics

Photo 5: Agricultural Plastics

The Government of Alberta has identified agricultural plastics as a waste management issue. A product stewardship program is currently being considered for agricultural plastics in Alberta. CleanFARMS is a not for profit stewardship organization which focuses on agricultural waste. The 2011 Census of Agriculture reported there is a total of 43,234 farms in Alberta, including 10 acre to 3,520 acre farms (Statistics Canada, 2012). Agricultural plastic products include: wrapping plastics, plastic films, PVC pipes and valves, and vinyl siding. About 6,600 to 14,000 tonnes of agricultural plastics are expected to be generated each year in Alberta (Table 3). Most of agricultural plastics producers were found “burning them, sending them to a landfill, sending them for recycling, [and] burning them on-farm… ” (Government of Alberta 2016). Agricultural plastics could be used as a feedstock in an EfW facility due to its relatively high energy potential (30,000 kJ/kg), but will not be available if a stewardship program is implemented with a focus on recycling.

Agricultural plastics are commonly disposed of through recycling, on-site at farms (e.g. burning), or at local landfills (<10,000 tonnes per year) in small communities. This makes quantifying agricultural plastics as a feedstock difficult. The quantities agricultural plastic is relatively low with the Newell Region. For example, between Newell County No.4 (717 farms), Wheatland County (782 farms), Vulcan County (603 farms), and Taber (652 farms), there are 2,754 farms that may generate between 420 tonnes to 891 tonnes of agricultural plastics (assuming the same generation rates per farm across Alberta, Figure A-2).

Table 3: Estimated Total Annual Generation of Plastic Film Waste (Source: Alberta Agricultural Waste Characterization Study, 2013)

	Estimated Total Annual Generation (tonnes)
Plastic Film Waste	
Bale Wrap	550 to 1400
Grain Bags	700 to 1800
Greenhouse Film	60 to 160
Silage Plastic	1500 to 2300
Total Ag Film Waste	**3260 to 6360**
PP Twine	2000 to 6000
Net Wrap	450 to 700
Polypropylene Totes	275 to 300
Pesticide Containers	620
Sanitation Containers	4
Total Plastic Ag Waste	**6600 to 14,000**

TETRA TECH

A.8 Oilfield Waste and Contaminated Soils

Oilfield waste consists mostly of conventional drill cuttings, which includes solid and liquid wastes. The majority of these wastes are produced during the drilling and completion stages in the form of drilling solids, drilling fluids, oils, general industrial wastes including plastics, wood, and oil filters, and incidental domestic wastes.

Oilfield activity in Alberta, especially outside of the Athabasca and Cold Lake Oil Sands regions which are located over 550 km from the Newell region, has decreased since 2013. The opportunities to use oilfield waste as a feedstock are currently not very attractive due to intense competition from existing waste management providers.

Solid wastes are classified as hazardous (Class I) or non-hazardous (Class II) based on their level of contamination.

Class I oilfield materials are transported to one of two Class I landfills in Alberta located near the towns of Ryley and Drayton Valley, respectively. Class II materials are less contaminated (and therefore have less heating value potential) and are most often transported to nearby landfills constructed specifically for oilfield wastes. Based on the Alberta Energy Regulator (AER) Approved Oilfield Waste Management Facilities, there are approximately seven oilfield waste management facilities within 200km of the Newell region.

South Saskatchewan*	No. of Farms**	C.D.
Bighorn No. 8	44	15
Calgary	55	6
Cardston County	497	3
Cypress County	827	1
Foothills No. 31	1,224	6
Forty Mile County No. 8	524	1
Lethbridge County	933	2
Newell County No. 4	717	2
Pincher Creek No. 9	448	3
Ranchland No. 66	78	14
Rocky View County	1,271	6
Taber	652	2
Vulcan County	603	5
Warner County No. 5	488	2
Wheatland County	782	5
Willow Creek No. 26	772	3

Figure A-2: Number of Farms in Southern Alberta
Source: (2011 Census of Agriculture for Alberta)

Oilfield waste landfills charges typically have very low tipping fee (approximately $20 per tonne to a maximum of about $70 per tonne) and are difficult to compete with due to their proximity to waste generation and the long-standing relationships they already have with oilfield waste producers. Oilfield waste landfills can easily change their tipping fees to encourage waste disposal at their facilities making it hard for other industries to compete with their pricing.

Solid oilfield wastes are managed effectively in the Alberta by strategically located landfills and oilfield waste service providers

Liquid oilfield residuals follow a different flow path than their solid counterparts, although the companies that own and operate oilfield waste landfills are often midstream liquid waste processors as well. Liquid oilfield wastes have a well-established midstream market which produce marketable end products –mostly by extracting the valuable remaining hydrocarbons.

APPENDIX B

TETRA TECH'S LIMITATIONS ON USE OF THIS DOCUMENT

LIMITATIONS ON USE OF THIS DOCUMENT

GEOENVIRONMENTAL

1.1 USE OF DOCUMENT AND OWNERSHIP

This document pertains to a specific site, a specific development, and a specific scope of work. The document may include plans, drawings, profiles and other supporting documents that collectively constitute the document (the "Professional Document").

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Where TETRA TECH submits electronic file and/or hard copy versions of the Professional Document or any drawings or other project-related documents and deliverables (collectively termed TETRA TECH's "Instruments of Professional Service"), only the signed and/or sealed versions shall be considered final. The original signed and/or sealed electronic file and/or hard copy version archived by TETRA TECH shall be deemed to be the original. TETRA TECH will archive a protected digital copy of the original signed and/or sealed version for a period of 10 years.

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1.4 DISCLOSURE OF INFORMATION BY CLIENT

The Client acknowledges that it has fully cooperated with TETRA TECH with respect to the provision of all available information on the past, present, and proposed conditions on the site, including historical information respecting the use of the site. The Client further acknowledges that in order for TETRA TECH to properly provide the services contracted for in the Contract, TETRA TECH has relied upon the Client with respect to both the full disclosure and accuracy of any such information.

1.5 INFORMATION PROVIDED TO TETRA TECH BY OTHERS

During the performance of the work and the preparation of this Professional Document, TETRA TECH may have relied on information provided by persons other than the Client.

While TETRA TECH endeavours to verify the accuracy of such information, TETRA TECH accepts no responsibility for the accuracy or the reliability of such information even where inaccurate or unreliable information impacts any recommendations, design or other deliverables and causes the Client or an Authorized Party loss or damage.

1.6 GENERAL LIMITATIONS OF DOCUMENT

This Professional Document is based solely on the conditions presented and the data available to TETRA TECH at the time the data were collected in the field or gathered from available databases.

The Client, and any Authorized Party, acknowledges that the Professional Document is based on limited data and that the conclusions, opinions, and recommendations contained in the Professional Document are the result of the application of professional judgment to such limited data.

The Professional Document is not applicable to any other sites, nor should it be relied upon for types of development other than those to which it refers. Any variation from the site conditions present, or variation in assumed conditions which might form the basis of design or recommendations as outlined in this report, at or on the development proposed as of the date of the Professional Document requires a supplementary investigation and assessment.

TETRA TECH is neither qualified to, nor is it making, any recommendations with respect to the purchase, sale, investment or development of the property, the decisions on which are the sole responsibility of the Client.

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In certain instances, the discovery of hazardous substances or conditions and materials may require that regulatory agencies and other persons be informed and the client agrees that notification to such bodies or persons as required may be done by TETRA TECH in its reasonably exercised discretion.