1. INTRODUCTION

This Memo is part of a series of assignments commissioned by the Regional District of Okanagan Similkameen (RDOS) from SLR, in connection with the development and implementation planning of a strategy for the management and diversion from landfill of the organic fraction of municipal solid waste (MSW). Organic wastes includes the biodegradable materials in the waste stream, typically food waste, leaf and yard waste (green waste), wood, compostable paper, biosolids, agricultural waste and slaughterhouse waste.

1.1. Objectives

Phase 1 of RDOS' current Organics Management project involved an assessment of the feasibility of developing or expanding organics processing facilities on nine publically-owned sites in the RD. For this the RDOS commissioned Tetra Tech EBA to undertake a number of related studies, including an assessment of the potential to develop or expand organics processing operations at the sites, as well as preparing associated preliminary cost estimates.

Tetra Tech's December 2014 report entitled *Organic Management Consultant, Task 1 – Site Assessment*, was peer reviewed by SLR in May 2016, and SLR's review was documented in a memorandum dated May 31, 2016. Subsequent to receipt of this memorandum, the RDOS requested that SLR review Tetra Tech's Task 2 report entitled *Organic Management Consultant Task 2 – Feasibility Assessment,* dated August 2015. Specifically, the RDOS requested that SLR's review focus on determining if the cost estimates presented were 'reasonable', since the Tetra Tech estimates would be used to support public consultation and by-law development activities, and in developing associated budgets. This memorandum presents SLR's review of Tetra Tech's Task 2 report, and our review comments follow.

2. BACKGROUND

The Tetra Tech Task 2 report (Report) presents costing information for development or expansion of organics processing activities according to the following 13 scenarios:

Individual Sites

- Campbell Mountain Landfill;
- Summerland Landfill
- Okanagan Falls Landfill;
- Oliver Landfill;
- Osoyoos Landfill;
- Princeton Landfill;
- Princeton Hayfield; and,
- Keremeos Transfer Station.

Regional Sites

- Campbell Mountain Regional;
- Summerland Regional;
- Summerland RDCO Biosolids;
- Oliver Regional, and
- Osoyoos Regional with Biosolids.

The Report evaluates and provides costing for four technology options that were proposed as suitable for organics processing at each site selected:

I. aerated static pile (ASP);
II. membrane covered aerated static pile (MCASP);
III. in-vessel composting (IVC); and,
IV. anaerobic digestion (AD).

The design capacity used by Tetra Tech was calculated centred on the peak month percentage of municipal solid waste (MSW) handled at each facility, which we consider is a suitably pragmatic basis. A summary of the tonnages and waste compositions was presented in *Table 2, p4* of the Report. The range of tonnages to be treated at the eight locations varied widely, as did the waste composition, ranging from 0%-50% food/compostable paper waste, 50%-93% green and wood waste and 0%-23% biosolids/manure.

Each of the technologies selected is capable of treating the wastes highlighted but the key selection issues revolve around the suitability of the outputs for the intended end-use and requisite regulatory requirements.

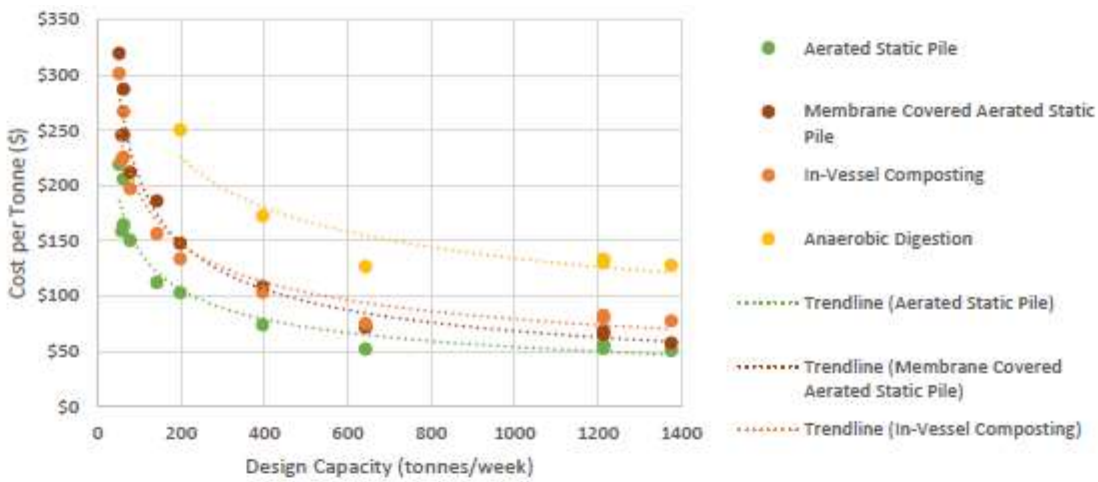
Both composting and anaerobic digestion (AD) produce an output that can be applied to land as a beneficial amendment material with a nutrient value. The added benefit of AD is that it also produces an energy source, a methane rich gas (biogas), that can be used in a boiler to generate heat, in a gas engine/turbine to generate electricity, or upgraded to biomethane, a 'fossil free' natural gas replacement with the digestate then composted as with the other techniques.

Having established the technical validity of each technology, practical aspects relate to the cost of the technology for the scale of operations proposed. Both IVC and AD are more appropriate for treating large quantities of waste.

The Report provides a comprehensive assessment of the estimated cost of each technology at each location, summarised in *Tables 3 and 5, p9/10* of the Report, expressed as the total capital cost and cost/tonne waste treated respectively. A full cost analysis was not conducted for the windrow composting scenarios but instead the average industry cost/tonne range for a windrow facility with food waste composting was included for comparison.

A plot of the data was presented in *Figure 1, p11* (reproduced as **Figure 1** below) of the Report that shows the cost/tonne decreasing with increasing size of facility, generally following a decreasing exponential trend, such that the larger the facility the higher are the cost savings due to the 'economies of scale' factor. On this basis the conclusion is that rather than single, site based facilities, it is worthwhile considering regional scale organics processing facilities that can combine feedstocks from multiple sites. There is a natural limit to the benefits of the 'economy of scale' factor and the data presented suggests that once a facility reaches c.650tpw the cost/tonne benefit reduces significantly. For technologies that use pre-fabricated, modular units, the capital cost for larger facilities can actually increase.

Figure 1: Capital Cost Scale Factor (Tetra Tech)



3. COMMENTS RELATING TO PROCESSING TECHNOLOGIES

3.1. GENERAL

SLR's experience is that the cost of waste processing technologies (e.g. purchase of waste processing equipment, such as in vessel composting systems) is generally similar in North America, the UK and Europe, accounting for appropriate exchange rates. Sources of difference in overall project costs will be associated primarily with the overall state of the construction industry in a given locale, labour rates for construction work and the cost of other equipment manufactured items. In addition, engineering costs associated with site specific ground conditions can and will vary and add significantly to the overall project cost. In general the number of organics processing projects implemented in the UK and Europe significantly exceeds the number of projects in North America, especially for IVC and AD systems. For this portion of the review we therefore draw primarily on our database of UK and European experience.

SLR concurs with the general findings presented in the Report, as the output follows the findings of comparable studies in the UK and Europe. Similar work has been undertaken by SLR estimating the costs of different technologies operating at different scales of throughput.

In comparing costs an exchange rate of £1= CAN$1.84 was been used. For ease of comparison, selected data for the range of design capacities in *Figure A* in the Report is presented in **Table 1** below.

Table 1: Capital Cost Data* (CAN$/tpa)

TPA	TPW	ASP	MCASP**	IVC	DRY AD
10,400	200	75	140	150	250
20,800	400	70	100	100	170
41,600	800	50	65	80	150
62,400	1200	50	65	80	150

* rounded values
** membrane covered ASP

The use of aerated static piles, with or without a membrane, is limited in Europe and applied only to the composting of non-food wastes, due to issues of the regulatory requirements of the Animal By-Product (ABP) Regulations for food waste composting and production of odours. Under the ABP Regulations 'unhoused' composting of waste containing food is not allowed and 'housed' composting i.e. in a building, requires processing for eight days at a minimum 60^0C during which the windrow must be turned at least three times at no less than two day intervals.

Dry AD processes have similarly had limited uptake in both the UK and Europe, with wet AD being predominant. The lack of application/takeup is due primarily to incentives to produce energy from biogas, as dry AD produces less biogas than wet AD, together with operability issues associated with dry AD that require a 'constant' feedstock mix throughout the year, which can be problematic when dealing with the increased proportion of green wastes during Spring/Summer.

3.2. CAPEX

The following section compares the CAPEX costs for equivalent European facilities. All costs quoted should be taken as $^{+}/_{-}$10-15%

3.2.1. ASP/MCASP

Indicative CAPEX cost data for similar facilities treating only 'green' wastes are generally of the same order of cost. The facility involves simple construction and limited equipment/process controls and any cost differences will relate to labour/material costs and relevant building and environmental regulations.

Similar comments apply to the MCASP facilities i.e. a comparable order of cost and impacts of labour/materials/regulations etc.

In most of Europe, if the waste contains food it cannot be composted in open windrows but must be 'housed' (i.e. inside a building). If the food waste includes meat or meat products, then a second identical composting stage is needed. On that basis for the same annual throughput a facility treating food waste containing meat/meat products is about twice the physical area and the additional cost of a building, leading overall to more than twice the capital cost for a green waste plant only.

3.2.2. IVC

On the basis of treating green waste only, capital costs for an IVC plant in Europe are generally of a similar order of cost.

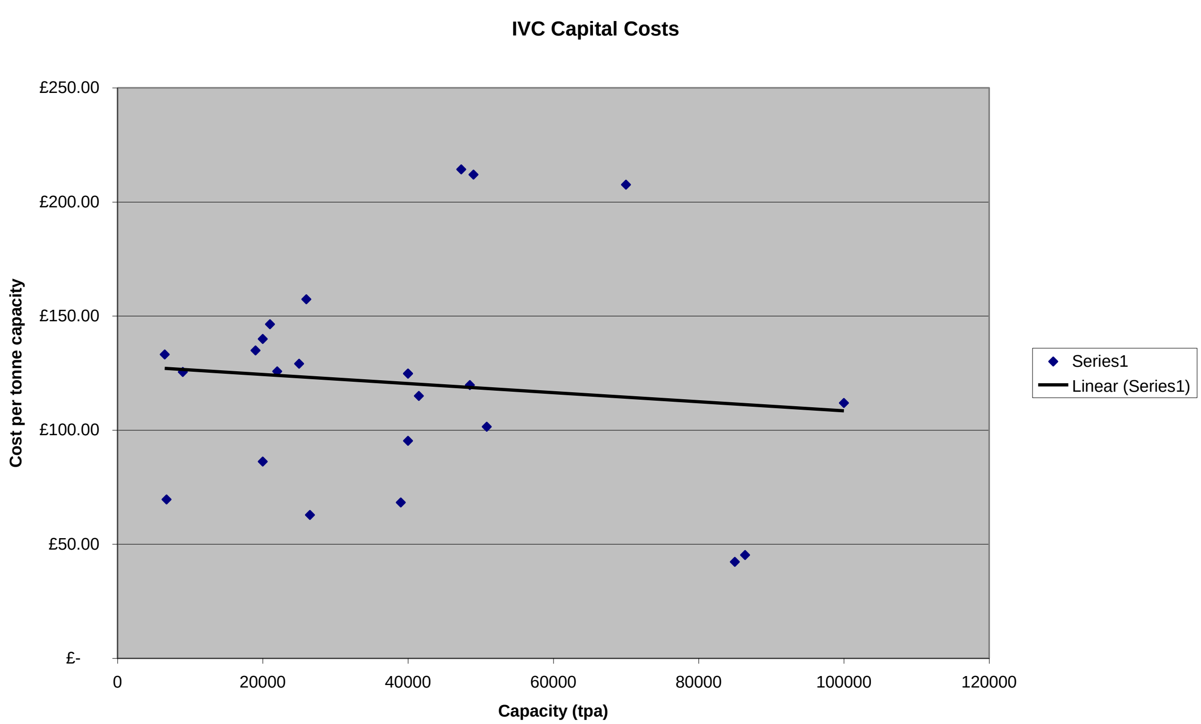
IVC is only used in the UK for treating mixed food and green wastes, for those Municipalities that do not implement source-segregated food waste collections, but use co-collection of food and green wastes.

CAPEX costs for IVC facilities in Europe treating wastes containing food come under the ABP Regulations and are required to compost the waste at the required minimum temperature of 60^0C for a minimum of two days. Composting plants treating catering waste containing meat and meat products must also include an additional barrier by performing a second composting stage, using the same time/temperature treatment i.e. second treatment at minimum 60^0C for a minimum of two days.

The two stages of processing required effectively doubles the plant area and can more than double the capital cost, as while the IVC units do not need to be enclosed in a building, a building is required to accommodate the waste unloading and pre-treatment operations i.e. shredding etc., before placement in the IVC units.

Figure 2 shows the results of a survey of the capital costs of IVC facilities in Europe of varying treatment capacities treating food and green wastes. IVC is rarely used in Europe to treat green wastes only.

Figure 2: European Capital Costs for IVC Plants [SLR]



The costs for a 20ktpa plant are in the range $165-$280/tpa, of which the lower cost aligns with the TetraTec cost data but the median European cost is c.$200/tpa, roughly double the TetraTech estimate at c.$100/tpa.

At the 40ktpa capacity the cost range is $130-$240/tpa with the median value c.$200/tpa, compared to c.$80/tpa in the TetraTech Report, more than double the cost.

The doubling of the capital cost ties in with the comments made above regarding treating mixed green waste and food wastes and the additional composting stage required.

3.2.3. Dry AD

As above with IVC, dry AD is mainly used in Europe for treating mixed food and green wastes, for those Municipalities that do not implement source segregated food waste collections but use co-collection of food and green wastes. If source segregated food wastes are collected, treatment of the food waste is undertaken using wet AD.

Costs in the UK/EU for treating waste containing food using dry AD technology are signficantly higher than the costs cited in the Report. Plant sizes in the UK are a typically in the order 20ktpa-40ktpa, with the $/tpa c. $800/tpa, over five times the unit cost cited in the Report i.e. $130-$170/tpa. It is unclear as to why there is such a large difference for what appears to be a similar type of plant in the Report and in a building (e.g. *Photo 3.3, p6)*, unless the photo is for illustrative purposes only, as it also includes a fully enclosed building that would be required in European usage.

In terms of the cost breakdown, for both dry and wet AD plants in European plants the split is roughly 50-55% process, 30-35% civil infrastructure and 10-20% miscellaneous costs. In contrast the Tetra Tech dry AD cost breakdown at the 46-53ktpa scale is of the order 75% process, 6% civils and 19% miscellaneous.

It is possible that some of Tetra Tech's indicative civil infrastructure costs are included under the scope of supply of the process technology provider in a european context, where they are usually undertaken separately.

3.3. OPEX

The annual OPEX costs listed in *Table 4,* in the TetraTech Report, are presented in **Table 2**.

Table 2: Operating Cost Data (CAN$/te)

TPA	TPW	ASP	MCASP**	IVC	DRY AD
14,000	270	37.5	53	47.5	68.5
46,000	885	25-28	33-35.6	34.5-37	49.7-52.4
53,000	1020	26.5	36.6	35.5	50

When comparing OPEX costs it is not always stated as to whether the costs are for labour, consumables and maintenance only, or include depreciation, which can lead to a significant difference in the reported OPEX costs. It is noted in the Report that the annual OPEX does not include depreciation but does include a 20% contingency.

Based on regional scale facilities i.e. +40ktpa the UK OPEX costs for ASP/MCASP plants are of a similar order as that cited in the Report.

OPEX costs for a European IVC plant at the 46-53ktpa scale, including 20% contingency, are around $32.4/te, similar to the estimated costs.

OPEX costs for a 46ktpa, dry AD plant in Europe, including 20% contingency, are around $34/te, compared to around $52/te annual cost. The increased cost is attributed to the 'double' composting required in the UK for plants treating mixed food and green wastes.

4. COMMENTS RELATING TO CIVIL INFRASTRUCTURE

For each scenario examined, site infrastructure cost estimate information is grouped according to the following categories:

- General Grading and Preparation;
- Scale house;
- Leachate and surface water management;
- Receiving building;
- Screening, curing, and storage; and,
- Equipment (mobile).

As an overarching comment, the Report does not provide supporting information for the majority of the infrastructure costs reported to allow verification of whether or not the costs are reasonable. For example, costs for each scenario are presented as lump sums for each of the cost categories noted, but assumptions for the specific construction activities or related quantities used to build up the lump sums are not provided. However, the unit rates used to build up the estimates are presented in *Appendix C* of the Report. Our review of the civil infrastructure costs is therefore limited to general commentary on the lump sums, as well as commentary on the unit rates.

We provide the following general comments:

- Site grading and preparation costs will be highly dependent on conditions at each site, and would likely include operations such as excavation, placement of fill, compaction, proof-rolling, placement of granulars, etc. Information is not provided on quantities or specific operations, and as such we cannot comment on these estimates.
- Scale houses, where required, are costed at $50,000. This appears reasonable if it is reflective of a small pre-fabricated or purpose built building. By comparison, over the past 4 years SLR has completed the design and construction oversight of over 10 rural transfer stations in northern BC, and actual costs for attendant buildings for these sites has been on the order of $40,000 to $50,000. Building designs in this cost range

included modified shipping containers, or small buildings that include a one room office space, a washroom and an electrical closet.

- Receiving buildings vary from dome-shaped fabric buildings set atop of concrete lock blocks, or partially enclosed structures with bunkers. Building cost estimates vary from a low of $195K for the Osooyos Landfill scenario, to a high of $987K for the Summerland RDCO Biosolids scenario. Building costs will vary extensively base on size and details, information on specific building size is not provided in the Report. However, based on our understanding of the general size and type being contemplated, the costs presented do not appear to be unreasonable.

- Estimates for screening, curing, and storage requirements will be highly dependent on conditions at each site. Since little specific information is not provided on quantities or specific construction operations, we cannot comment on these estimates.

The construction unit rates used to build up the estimates are presented in *Appendix C* of the Report and are summarize in **Table 3**, along with a commentary on the rates.

Table 3: Construction Unit Rates

Item	Unit	Unit Rate	Comment
Mob/demob	each	$220,000	No supporting information provided. By comparison, SLR often builds up cost estimates for civil construction projects by first costing all specific construction activities using quantities and unit rates. An allowance for 'general' or 'balance of project' costs (which includes mob/demob, bonding, insurance, etc.) is then added, calculated as a percentage of the construction activity costs. For civil projects in relatively populated areas in the southern parts of the province, we will often add 10 to 15% as general costs.
Land clearing	m2	$10.00	Dependent on nature of vegetation being cleared. Reasonable rate if considering mix of dozer and skidder work.
Grading	m2	$3.00	Dependent on amount of earthmoving being undertaken, but reasonable if reflective of dozer work.
Access road construction	m	$333.00	Dependent on the width, pavement design, and existing ground conditions (e.g. upgrading/rehab of an existing road vs. new road on unbroken ground).

Common excavation for storm water pond	m3	$11.00	Reasonable rate if considering excavator/truck operation.
Geomembrane liner	m2	$8.72	Dependent on type and thickness of geomembrane. Possibly low when considering supply and installation. Cost would not likely include protective geotextiles or other related elements.
Clay liner for storm water pond	m3	$15.00	Reasonable rate for placement and compaction of a clay liner if reflective of zero purchase cost and a local source of soil (e.g. 500 m haul distance or less)
Clay liner for screening and storage areas	m3	$14.74	See above comment.
Surface water ditches	m	$46.00	Dependent on ditch cross section. In consideration of common excavation rate of $11, rate is reasonable if cross-sectional area is approx. 4 m2 or less. Rate is likely low if intended to include erosion protection such as rip rap.
Berms	m	$33.00	Dependent on berm cross section and material used.
Supply and place concrete	m3	$600.00	Reasonable.
Supply and place aggregate	m3	$60.00	Reasonable but will depend on proximity of aggregate source to site.
Load, haul and place soil	m3	$10.00	Reasonable.

Equipment rates are estimated as $200k each for a wheel loader, grinder, screener, and $25k for an airlift separator. Costs for equipment will depend heavily on factors such as size, capacity, and age, although the estimates do not appear unreasonable. For example, marketbook.ca listings reviewed on June 22, 2014 for wheel loaders reflect asking prices of $100k for a Komatsu WA380 with 14,000 hours, and $233k for a Komatsu WA320 with under 2000 hours.

Labour rates are estimated as ranging from approximately $25/hr for a labourer up to approximately $40/hour for a machine operator. We consider these rates to be reasonable.

5. CONCLUSIONS

Based on our review of the Tetra Tech Task 2 Report we provide the following conclusions:

1. The Report approaches assessing the feasibility of potential treatment options in a clear, methodical manner based on the specifics of the individual site location.

2. The assumptions used appear appropriate from a technical perspective and applicable in terms of meeting the requirements of the RDOS.

3. While the technologies chosen are suitable for the range of wastes to be treated, in much of Europe ASP and MCASP are not suitable for mixed food and green wastes, due to regulatory requirements. European capital and operating costs for treating only green wastes are of the same order of cost as those in the Report.

4. IVC and dry AD are generally only used in Europe for treating mixed food and green wastes, for those Municipalities that do not implement source segregated food waste collections but use co-collection of food and green wastes.

5. For mixed food and green wastes, regulatory requirements stipulate that the composting stage is undertaken twice, leading to an approximate doubling of the capital cost and an increase in the operating costs.

6. Making an allowance for these operational differences accounts for most of the variances in IVC plant costs (i.e. doubling the size of plant and increased operating costs), but not for the differences in the dry AD costs. These are more likely to derive from the lower costs of supply of standard plant items in N. America.

7. The civil infrastructure costs presented in the Report could not, in general, be reviewed effectively because of lack of supporting information. Where costing specifics are identified the costing is deemed to be generally reasonable.