Memorandum

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TO: Zack Hansen and Judy Hunter
Ramsey/Washington Counties Resource Recovery Board
Joint Staff Committee

CC: Kate Bartelt, Ramsey County
Curt Hartog, Foth Companies (Foth)

FR: Warren Shuros, Foth Companies
Susan Young, Foth

RE: Two Additional Technology Options Requested

This memorandum provides a summary of two additional technology options for comparison to the five technology options considered in the previous *Preliminary Resource Recovery Feasibility Report* and *Technology Comparative Analysis* (Foth 2014 reports) prepared by Foth (presented January 30, 2014). The two additional options are modifications to options addressed in our report and include:

- Modifying Newport to include Mixed Waste Processing (MWP) to separate organics to be processed at a facility such as the proposed Sanimax Anerobic Digestion (AD) Facility, along with production of refuse-derived fuel (RDF) for gasification. (Newport with MWP/AD/Gasification option)
- Modifying Newport to include Mixed Waste Processing (MWP) to separate organics to be processed at a facility such as the proposed Sanimax AD Facility, along with production of refuse-derived fuel (RDF) for combustion at the existing Xcel Combustion facilities. (Newport with MWP/AD/Xcel Combustion option)

This memo provides a summary of these options, primarily focusing on the differences from the options presented in the Foth 2014 reports. The differences are explained and the various costs are addressed such that the approaches are consistent with the previous analysis.

Process Overview

Both additional options assume location and continued use of the Newport facility. Both also include a MWP system as a "front-end" process to remove organics.

For this analysis, the organics included are yard waste (those yard wastes left in the MSW stream, not source-separated), food waste, diapers, and other organics – not wood. The MWP system for this option is different from the previous report as it only targets the organics and does not target recyclable fibers and containers. Therefore, non-recyclable papers are not removed from the waste stream.

The MWP system includes the following steps:

- A primary reducer to start reducing the size of items to 12" or less, open bags, etc.
- A pre-sort to manually remove bulky items.
- A disc screen to separate items above and below 6". The material greater than 6" proceeds to the existing RDF processing system.
- The under 6" materials proceed to a second disc screen to separate items plus and minus 2". This results in two streams. One stream is material less than 2" in any one direction and a second stream of material that is from 2" to 6" in any one direction.
- Both streams (minus 2" and 2" to 6") pass under a magnet to remove ferrous items.
- The stream containing the 2" to 6" items passes through an optical sorter to remove plastics and metals.
- The 2" to 6" stream rejoins the 2" minus stream as "organic rich fines" which is sent to AD.

Anything that passes through the MWP system not recovered as organics continues on to the existing RDF processing system. The material is made into RDF and the RDF is sent to a gasification system. The RDF to gasification process was discussed in the Foth 2014 report.

The MWP system for organics recovery has two processing lines. Each line is rated at 120,000 tons per year (tpy). Two lines could handle ~ 240,000 tpy total. A single line is projected to require 15,000 square feet. Two MWP lines are assumed to require 25,000 square feet since there would be common space used by both lines. The required space is less than the 38,750 square feet for the MWP system that targeted fiber and container recyclables in the Foth 2014 report. MWP for organics recovery also requires less manual sorting. MWP for organics recovery requires 7 sorters per line. MWP for targeting fiber rich and containers required 18 sorters as stated in the Foth 2014 report.

The targeted organic materials are estimated in the waste composition data to comprise 22.3% of the entire waste stream. The MWP system was estimated to recover approximately 60% of the targeted materials. Therefore, processing 240,000 tpy and recovering 60% of the organics, yields 32,112 tons of organics recovered (240,000 tpy x 22.3% organics x 60% recovery = 32,112 tpy of organics).

The same tonnage of process residue from MWP was assumed for this analysis as was provided in the Foth 2014 report. The process residues were estimated to be 53,200 tpy. Therefore, starting with 400,000 tpy; removing 32,112 tons of organics and 53,200 tons of residues yields; 314,688 tons of material that would be made into RDF and sent to gasification.

Gasification yields are based on dry tons of RDF processed. Foth assumed the average moisture content of the RDF is 20%. Foth understands that the moisture content of RDF can vary throughout the year, but a good "rule of thumb" is MSW contains 20% moisture. The gasification process can yield 90 to 100 gallons of ethanol from 1 ton of dry RDF. Given the RDF system for this option would accept 314,688 tpy of waste material to produce the RDF; and the waste material contains 20% moisture; the dry tons of RDF sent to the gasification process would be 251,750 dry tons of RDF per year. This would then be converted to ethanol at a rate of 90 to 100 gallons of ethanol per dry ton of RDF. Ethanol production estimates and revenues from the RDF to gasification process are presented in Table 3.

Preliminary Economics for Newport with MWP/AD/Gasification

The capital costs for the RDF and gasification system is unchanged from the Foth 2014 report. The preliminary estimated capital costs for the MWP system is reduced from $20M to $25M presented in the Foth 2014 report to $15M to $20M for this option. This is a result of fewer equipment components needed for organics recovery and the size of a building expansion is reduced in this option. Table 1 provides a summary of the total estimated capital costs with the debt service calculation adapted from the Foth 2014 report.

Table 1
Preliminary Estimated Annual Debt Service Costs

Capital Costs - Gasification	$150,000,000	$150,000,000	$200,000,000	$200,000,000
Capital Costs – MWP/Organics	$15,000,000	$15,000,000	$20,000,000	$20,000,000
Capital Costs – RDF	$0	$0	$26,400,000	$26,400,000
Total Capital Costs	$165,000,000	$165,000,000	$246,400,000	$246,400,000
Term (Years)	20	25	20	25
Net Interest Rate	4.40%	4.76%	4.40%	4.76%
Annual Debt Service[1]	$14,950,000	$13,565,000	$22,325,000	$20,255,000
Tons Per Year	400,000	400,000	400,000	400,000
$ Per Ton	$37.38	$33.91	$55.81	$50.64

[1] Debt service pro-rated by Foth from previous cost estimates provided by Springsted Incorporated

The rounded cost per ton for the annual debt service ranges from a low of $34 to of $56.

The operating and maintenance (O&M) costs for the RDF and gasification processes are unchanged from the Foth 2014 report. The O&M costs for MWP have been reduced in this analysis since the number of manual sorting positions is reduced from 18 people to 7 people as discussed previously. The preliminary estimate for O&M costs for MWP is $2.1M to $2.4M as shown in Table 2.

There is an additional line for the O&M costs shown in Table 2 due to the AD tip fees. Since this option separates the organic portion from municipal solid waste (MSW) stream, there will be a tipping fee at Sanimax (or other future AD facility) to accept the organic materials. The reported potential tip fee from Sanimax for source-separated organics (SSO) was $25 to $35 per

ton. Due to the potential contaminants remaining in the organics due to the MWP system and the unknown nature of the organics composition, the tipping fee for the AD facility was estimated to be from $40 to $60 per ton. Based on 32,114 tons per year, the range of tipping fee costs are $1,284,480 to $1,926,720 per year. Table 2 provides a summary of the preliminary estimated O&M costs.

Table 2
Summary Table of O&M Costs for Newport with MWP/AD/Gasification

O&M Costs - Gasification	$20,000,000	$30,000,000
O&M Costs – MWP/Organics	$2,100,000	$2,400,000
O&M Costs - RDF	$12,500,000	$13,000,000
Tip Fees for AD	$1,285,000	$1,925,000
Annual O&M Costs	**$35,885,000**	**$47,325,000**
Tons Per Year	400,000	400,000
$ Per Ton	$89.71	$118.31

The rounded cost per ton for annual O&M ranges from $90 per ton to $118 per ton.

The only revenues for this option originate from the production of ethanol in the gasification system. The same calculations were used to estimate revenues as the Foth 2014 report, except that the amount of RDF available has changed due to the change in the MWP system only sorting organic materials. Table 3 provides the preliminary estimate of revenues from the gasification system.

Table 3
Estimated Annual Revenue Table for Ethanol Production

Ethanol Production Rate (gallons/dry ton of RDF)	90	100	90	100
Dry Tons Processed	251,750	251,750	251,750	251,750
Total Ethanol Produced	22,657,500	25,175,000	22,657,500	25,175,000
Range of Wholesale Ethanol Prices ($/ gallon)	$2.10	$2.10	$2.25	$2.25
Estimated Range of Revenue	$47,580,750	$52,867,500	$50,979,375	$56,643,750
Revenue Per Gate Ton (400,000)	$118.95	$132.17	$127.45	$141.61

The rounded revenues per ton range from $119 to $142.

Using the high and low ranges of the estimated cost per ton for annual debt service, operating costs, and revenues, a range in the net annual costs per ton operating at 400,000 tpy is shown in Table 4. Net annual costs are the estimated per ton tip fee that would be charged for each ton received at Newport to cover all estimated costs. The net annual costs consider the revenue generated from the sale of ethanol and the costs for capital and O&M as presented previously. Given the variability of the many factors associated with the processes analyzed the net annual costs per ton estimates have a wide range.

Table 4
Newport with MWP/AD/Gasification
Preliminary Estimated Net Cost per Ton

Low Debt Service	$33.91	High Debt Service	$55.81
Low O&M	$89.70	High O&M	$118.30
High Revenue	$141.61	Low Revenue	$118.95
Low Total	($18.00)	High Total	$55.16

The rounded net annual cost ranges from $(18) to a high of $55 with an average of $19 per ton. As noted in the previous report, the net annual costs are very dependent on ethanol markets and the final debt and O&M costs which range significantly. Further analysis is needed to provide better estimates, but the potential appears to be positive. The gasification technology used to produce ethanol from RDF is still in the development stage.

"Diverted tons" is defined as the number of tons that are diverted by the process from landfilling. The calculation for the diverted tons for this option is 400,000 tpy (received at Newport) minus 53,200 tons of process residue (which would be sent to landfill) minus 39,000 tons of gasification system residue (which would be sent to a landfill) equals 307,800 tons diverted from landfills.

Using an estimated 400,000 tpy received at Newport and the average annual net cost per ton of $19 provides an estimated total annual net annual cost of $7.6M. The cost per diverted ton is calculated by dividing the $7.6M annual costs by the 307,800 tons diverted from the landfill which yields a cost per diverted ton of $25.

Preliminary Economics for Newport with MWP/AD/Xcel Combustion

This option analyzes a system where waste is received at Newport, sent through a MWP system to recover organics, the residuals are converted to RDF and the RDF is sent to the Xcel plant for combustion. This option is similar to the previous option except the RDF is sent to Xcel for combustion versus sent to gasification for ethanol production as was analyzed previously. Since the only major change in this process versus the previous process is the end market for the RDF, many of the capital and O&M costs remain unchanged.

The capital costs for the RDF system is unchanged from the Foth 2014 report and the preliminary estimated capital costs for the MWP system is the same as in the previous option analyzed in this memo.

Table 5 provides a summary of the total estimated capital costs with the debt service calculation. The preliminary estimates of debt service for this option are significantly less than the first option analyzed due to the elimination of the gasification system.

Table 5
Preliminary Estimated Annual Debt Service Costs

Capital Costs – MWP/Organics	$15,000,000	$15,000,000	$20,000,000	$20,000,000
Capital Costs – RDF	$0	$0	$26,400,000	$26,400,000
Total Capital Costs	$15,000,000	$15,000,000	$46,400,000	$46,400,000
Term (Years)	20	25	20	25
Net Interest Rate	4.40%	4.76%	4.40%	4.76%
Annual Debt Service[1]	$1,360,000	$1,233,000	$4,204,000	$3,814,000
Tons Per Year	400,000	400,000	400,000	400,000
$ Per Ton	$3.40	$3.08	$10.51	$9.54

[1] Debt service pro-rated by Foth from previous cost estimates provided by Springsted Incorporated

The rounded cost per ton for the annual debt service ranges from $3 to $11.

The operating cost for the RDF system is as provided in the Foth 2014 report. The operating costs for MWP are the same as the previous option analyzed in this memo.

The annual O&M costs for the RDF system that includes the shipping of RDF to the Xcel plants (Red Wing and Wilmarth) was provided in the Foth 2014 report as the tipping fee charged at Newport of $84 per ton (the actual O&M costs for the Newport facility are unknown and the tipping fee charged at Newport was used to represent the O&M cost). With the assumed 400,000 tpy and the $84 tip fee, the total estimated annual O&M cost is $33,600,000. There is a significant difference between the O&M costs for the first option analyzed and this option. The increase in O&M costs for RDF production are a result of hauling the RDF to the Xcel plants, the burn fee charged by Xcel and various other costs that are not likely to be incurred in the first option analyzed previously.

There is an additional line in Table 6 for the O&M costs due to the AD component. The AD component costs provided in Table 6 are the same costs provided in Table 2 in the previous option. Table 6 provides a summary of the preliminary estimated O&M costs for the Newport with MWP/AD/Xcel Combustion option.

Table 6
Summary Table of O&M Costs for Newport with MWP/AD/Xcel Combustion

O&M Costs – MWP/Organics	$2,100,000	$2,400,000
Tip Fee Costs – RDF to Xcel	$33,600,000	$33,600,000
Tip Fees for AD	$1,285,000	$1,925,000
Annual O&M Costs	**$36,985,000**	**$37,925,000**
Tons Per Year	400,000	400,000
$ Per Ton	$92.46	$94.81

The rounded cost per for the annual O&M costs ranges from $92 per ton to $95 per ton.

Unlike the revenues generated from ethanol sales in the previous option, there are no revenues from the sale of materials or energy in this option that are available under the current system.

Using the high and low ranges of the estimated cost per ton for annual debt service, O&M costs, and revenues, a range in the net annual costs per ton operating at 400,000 tpy is shown in Table 7. As stated previously, the net annual costs are the estimated per ton tip fee that would be charged for each ton received at Newport to cover all estimated costs.

Table 7
Newport/MWP/AD/Xcel Combustion
Preliminary Estimated Net Cost per Ton

Low Debt Service	$3.08	High Debt Service	$10.51
Low O&M	$92.46	High O&M	$94.81
High Revenue	$0	Low Revenue	$0
Low Total	$95.54	High Total	$105.32

The rounded net annual cost per ton ranges from $96 to $105 for an average cost per ton of $100 per ton.

“Diverted tons” is defined as the number of tons that are diverted by the process from landfilling. The calculation for the diverted tons is 400,000 tpy received at Newport, minus 53,200 tpy of process residue (sent to the landfill) minus approximately 80,000 tpy of RDF combustion system residue (sent to a landfill) equals 266,800 tpy diverted. Using an estimated 400,000 tpy and the average net annual cost per of $100 per ton provides an estimated total net annual cost of $40M. The cost per diverted ton is calculated by dividing the $40M net annual costs by the 266,800 tons diverted from the landfill which yields a cost per diverted ton of $150.