Final Report

Composting Process Development

Prepared by the Agricultural Utilization Research Institute for the Fond du Lac Band of Lake Superior

(AURI No. 23070)

December 2023

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EXECUTIVE SUMMARY

The Fond du Lac Band of Lake Superior Chippewa (FDL) is well positioned to utilize food waste from the Ojibwa school and the Black Bear Casino food service facilities and restaurants and fish waste that may be available at certain times of the year. Utilizing these waste streams for compost operations and protocols will ensure that high-quality compost is available for community gardens and other application areas in the future.

The FDL Band has reported a consistent supply of 158 tons of current food waste, 1400 pounds of annual fish waste, and a future forecast of up to 1500 tons of available food waste. The current 158 tons of food waste is adequate for all community garden needs, including expanding lands at the Gitigaaning community gardens farm. The forecasted 1500 tons of additional food waste is enough to supply up to 375 acres at a 2-ton per acre application rate. Compost protocol guidelines have been prepared for the FDL Band and were presented at the Composting Roundtable held onsite at FDL on November 28, 2023. Representation at the Roundtable event included the FDL Band's composting team consisting of the FDL Environmental Outreach Coordinator, FDL School Garden Master, and Resource Management Division Minnesota Green Corps member; the FDL Agriculture Department, Public Works staff, and AURI staff with technical and business development expertise.

As part of the project objectives, three food and fish waste channels and the FDL Band's compost products were tested and analyzed by AURI Chemistry Scientist Dr. Michael Stutelberg. Analytical lab reports detailing the results were provided to FDL. Recommendations were made regarding proper composting and technical protocols based on the AURI analysis results and Midwest Valley Testing Lab soil testing results supplied by FDL.

The estimated market value of 1500 cubic yards (about half the volume of an Olympic-sized swimming pool) is approximately $20-$30 per cubic yard.

The FDL Band's officials have applied for a grant for a vessel composter that would allow seamless processing of food waste and other components in the compost. The FDL Band intends to explore mixing biochar with compost and offer potting soil as a value-added product.

Recommendations provided by AURI include the following:

- Potential Rural Cooperative Development Grant (RCDG) project tasks:
    - If awarded the EPA Solid Waste Infrastructure for Recycling (SWIFR) Grant, AURI could assist with the scale-up and operations of the vessel
    - If NOT awarded the EPA SWIFR grant, AURI could assist with identifying a TMR (total mixed ration) mixer, establishing a management protocol, and establishing an aerated static compost pile
    - Business Development Services, such as the economics of composting, including labor, time, equipment, producing versus purchasing compost and purchasing supplemental fertilizers
- Consideration of more considerable composting opportunities:
    - Biochar and potting soil
    - Use of biochar in current amendments
- Assist in identifying the most beneficial compost system for the FDL Band's needs:
    - Close-loop system – use the input in-house
    - Quasi-loop system – due to labor issues, politics, etc.

AURI recommends the FDL Band work with the University of Minnesota Extension Service on specific compost application rates for various fruit and vegetable crops.

Future project work may include compost vessel operations and start-up assistance, further economic analysis of food waste opportunities and separation of wastes, and value-added compost product and potting soil development.

PROJECT GOALS

The project goals consisted of four areas, which included: 1) compost testing and guidelines to aid with composting efficacy and interpreting composting results from their current practices; 2) identifying current and potential waste stream outputs and quantities to aid with identifying the potential composting scale required to develop a closed-loop system to eliminate landfilling of organic waste streams; 3) compost system planning services focusing on the FDL Band's current farm needs, practices, and expanded compost opportunities; and lastly, 4) aid with identifying current inventory of composting ingredients available.

GOAL 1: COMPOSTING GUIDELINES AND TESTING

Before developing a composting system, developing guidelines for proper compost start-up blending requirements is critical for success. Additional guidelines compiled by AURI and shared with the Fond du Lac Band for use when creating a compost include the following composting start-up guidelines:

1) Moisture content— 50 to 60 percent
2) Carbon to nitrogen ratio— 25:1 to 40:1
3) Oxygen— greater than 10 percent (e.g., various methods are turning, aerated static piles, etc.)
4) Temperature— a proper pile should generate its heat. Note: *55 degrees Celsius (130-140 degrees F) with five turns to reduce pathogens*
5) pH— 6.5 to 8
6) Particle size— 1/8 inches to 2 inches (can vary)
7) Soluble salts - recommended soluble salts levels are < 3.0 millimhos (mmhos) for trees and shrubs and < 2.0 mmhos for vegetables.
8) Bulk density— (700 to 1,000 pounds per cubic yard)

AURI also provided the FDL Band with a simple computer program to help calculate potential compost blends when starting a new batch. To ensure the successful production of compost, it is essential to have the nutrient profile of the ingredients being used.

Throughout the project, AURI requested the Fond du Lac Band to submit various core samples from their compost piles to identify the maturity of their compost. Compost maturity can be evaluated primarily by focusing on two key results: carbon and nitrogen. The carbon-to-nitrogen ratio (C: N) is critical for determining when composting is complete and how the material will perform when added to the soil.

- Finished compost typically ranges from 6 to 11 parts carbon to 1 part nitrogen (6-11 C: 1 N ratio).
- Materials with a < 20:1 C: N ratio means that the N is available to plants within the first year, considering that the percent availability cannot be determined at this time.
- Compost with ranges of 20-30:1 C: N ratios act as slow-release nitrogen over 2- to 5-years.
- Compost over >30:1 C: N ratio will tie up nitrogen in the soil, and you will see yellowing and/or dying plants.

The guidelines above serve as an indicator when viewing compost analytical results. Initially, compost samples were evaluated for moisture, carbon, and nitrogen by AURI's Analytical Lab located in Marshall, Minnesota, to

identify compost maturity. Copies of the AURI Lab Analysis Reports are included in Appendices C through E. Below are the results:

Carbon and Nitrogen Analysis Samples

Test	Units	Food Waste (Ingredient)	TS – 1 Year Winter	TS – 2 Year Winter	TS – 1 Year Summer	TS – 2 Year Summer
Moisture	%	62.47	46.67	71.58	64.27	28.4
Carbon	%		38.86	45.45	39.94	38.76
Nitrogen	%		1.3	3.82	3.99	4.58
C:N ratio	ratio	20.11	29.89	11.91	9.99	8.46

The above results evaluated food waste, a composting ingredient source used in FDL Band's process. Knowledge of the carbon-to-nitrogen (C:N) ratio is valuable when determining composting blends, which will be discussed later in this report. The additional four samples submitted subsequently were from active compost piles. The data shows that three of the four compost samples submitted are mature or stable based on the C:N ratios near 11:1 or less. As the project progressed, additional samples submitted were evaluated for their nutrient content.

Test	Units	Fish Compost	"June" Compost	12 Month Compost
Moisture	%	64.51	62.12	58.61
Carbon	%	48.58	28.85	32.44
Nitrogen	%	2.16	1.66	1.68
C:N ratio	ratio	22.59	17.43	19.31
Soluble Salts	mS/cm	0.40	1.37	0.56
Phosphorus (total)	%	0.24	0.09	0.10
Potassium (total)	%	0.10	0.27	0.2
Chloride	%	<0.02	0.02	<0.02

When evaluating the results, AURI developed a Benefits of Composting Handout, which was provided to the FDL composting team. A copy of the handout is included in Appendix A. Guidelines give a ruler to compare finished compost analysis results. The guidelines note that the typical finished compost characteristics include:

1) Stable— low respiration and low temperature
2) Carbon to nitrogen ratio— less than 20:1
3) pH— natural
4) Soil-like smell and appearance
5) Mature— (soluble salts, high respiration, etc., e.g., successful cucumber seed germination test)

Please refer to the following publication for more information:

Rynk, Robert. The Composting Handbook: A how-to and why manual for farm, municipal, institutional and commercial composters. Elsevier, 2022.

GOAL 2: DETERMINE THE WASTE OUTPUT AND QUALITIES OF CERTAIN BAND ENTERPRISES

Throughout the project with the FDL Band, AURI staff met with the client on various occasions to identify the potential organic waste quantities they could access. Based on gathered data, food waste collected from their school and casino generates the greatest feedstock opportunity, as it currently consists of 158 tons per year of priority waste but has the potential to grow to 1,525 tons per year. This compost ingredient was followed by fish waste, which their fish processing facility generates. An estimated 1,400 pounds of fish waste per year could be captured for composting. These two feedstocks would be the nitrogen and moisture source for compost start-up.

Along with a nitrogen source, another essential ingredient is carbon, an energy source for composting microbes. The Fond du Lac Band has wood chips available for composting. Wood chips are an ideal carbon source due to their high carbon content and high carbon-to-nitrogen ratio ranging from 150 to 400:1. When focusing on wood as a primary carbon source, focusing on product particle size is critical. Compared to larger wood chips, smaller wood particle sizes, such as sawdust or wood flakes, can significantly impact compost performance. Smaller particle sizes allow for higher levels of biologically available carbon simply due to more surface area accessible for microbes.

The FDL Band can access straw bales as a carbon source. However, the carbon-to-nitrogen ratio is lower in straw and can range from 25 to 60:1. This requires much more material than wood when starting a compost blend, resulting in fewer nitrogen sources incorporated into the mix. The last carbon source discussed with the project team was yard and garden waste. The quantities of these ingredients are currently unknown.

Lastly, when focusing on waste outputs and quantities, the transportation of ingredients needs to be considered. Food waste, along with fish waste, is exceptionally high in moisture. Limiting the distance these raw ingredients must be transported can provide significant operational savings. Fond du Lac Band's current plan is to conduct composting at Gitigaaning, which is their farm, and at the Ojibwe School Gardens. These two sites would limit the transportation needs for base ingredients and serve as the sites for intended compost use, thus limiting the need to transport finished compost long distances.

GOAL 3: PLANNING SERVICES

Identifying proper application rates and opportunities to market finished compost was the third goal of this project. AURI provided various methods for compost application, such as low-cost manure spreaders to spreader trucks, which require a much more significant investment.

Soil analysis is recommended before applying compost to the soil. Conducting soil analysis can be a tool to identify proper application rates for the compost based on the product that will be grown. AURI provided the University of Minnesota Nutrient Recommendation Guidelines for Fruit and Vegetable Crops to the team. This information allows compost application rates to be easily targeted, focusing on crop requirements and eliminating the potential for over-application. Examples of determining proper compost application were discussed with the FDL composting team.

Along with determining proper compost application rates, integrating the compost into the soil ensures that the nutrients are available to the target plant's root zone. AURI recommended a one (1)-part compost to three (3)-part soil method as a guideline for incorporating compost with soil. For example, if one inch of compost is

applied on top of the soil, it is recommended to integrate the compost into the soil at a depth of three (3) inches. Likewise, if two inches of compost are applied to the soil, it would be incorporated with six (6) inches of soil. This practice does not support no-till farming. With no-till farming, lower application rates would be required, along with diligent soil sampling to identify the nutrient migration to the root zone. Limiting the application rate will affect the desired crop to be grown and prevent any 'mulching' effect the compost may have on newly planted seeds or seedlings.

The second focus related to planning services was identifying potentially available finished compost on the FDL farm and the fertilizer potential it could provide for acres. Based on the data provided to AURI, the FDL Band currently has 158 tons of food waste available, and this would result in roughly 79 tons of finished compost based on a 50% shrink loss through composting. Using an estimated requirement of two tons per acre for garden vegetables (calculation is high based on current FDL soil samples), there would be sufficient finished compost to fertilize 40 acres. This did not include the potential of fish waste compost, which contributes 1,400 pounds per season.

Future projects using 1,500 tons of available food and fish waste with the 50% compost shrinkage estimate and an application rate of two tons per acre could produce enough finished compost to support a minimum of 375 acres. The estimated value of finished compost ranges from $20-$30 per ton. Based on the estimated 750 tons of finished compost available at $20 per ton, composting could add a minimum of $37,500 in fertilizer savings. These savings do not include the reduction in costs currently realized by the FDL Band for waste disposal or expenses associated with other current fertilizer or compost purchases.

GOAL 4: INGREDIENT SOURCING

As described in Goal 2 above, the FDL Band has feedstocks such as food waste, wood chips, straw, and fish waste available for composting. Based on our discussion at the Composting Roundtable event, further study may be required to more accurately understand any seasonality, logistical challenges, or other dynamics associated with utilizing these and other potential feedstocks. For example, the food waste from the school cafeterias will vary from summer to fall, and additional training and collection methods will be needed to minimize contaminants. However, the Band has the feedstocks on-site to supply a robust composting effort that could close the loop on turning waste into a valuable resource.

The general economics of growing composting opportunities was discussed during the Composting Roundtable discussion. The potential savings from diverting feedstocks from the landfill to composting and from purchasing less fertilizer and compost due to utilizing the Band's compost could help justify the equipment and labor costs associated with a commitment to composting. In addition, AURI also discussed the growth potential of creating a profit center that could sell commercially available compost and eventual soil blends like potting soils and greenhouse mixes.

To that end, AURI recommends continuing services to the FDL Band into 2024. If the FDL Band is awarded the EPA Solid Waste Infrastructure for Recycling (SWIFR) Grant, AURI could assist with the scale-up and operations of the composting vessel. If the FDL Band is not awarded the grant, AURI could assist with establishing more specific composting and compost management protocols. For example, equipment like a TMR mixer (as shown below) would compost blended feedstocks more precisely and could further optimize composting. AURI could also assist the FDL Band in considering whether aerated static pile composting is the best composting process. Lastly, the Band could benefit from a more in-depth economic analysis of composting, including labor, time, equipment, waste disposal savings, and compost/fertilizer purchase savings.

The TMR (total mixed ration) Mixer below is an example of a TMR Kuhn Knight 3130 available in Sauk Centre, MN. Many other mixer models are available. A used TMR Mixer can be purchased for under $20,000.

INFORMATIONAL / DISSEMINATION SESSION

A Composting Roundtable was held at Na'enimonigamig (Fond du Lac's Cannery in Cloquet, MN) on Tuesday, November 28, 2023. A copy of the presentation is included in Appendix B. Overviews of interpreting a compost analysis were reviewed. Discussion was held on the specific analysis of FDL compost and best management practices to optimize the compost components of food waste, carbon sources, and fish waste. Application methods and general guidelines for use in the community gardens were discussed. The session included opportunities for future project work and a projection of the compost volumes and value of the excess compost. FDL Band officials asked about carbon credits for the compost. This question must be researched as carbon credit markets are quite challenging. FDL Band officials are hopeful for a grant to purchase a composting vessel, increasing uniformity and overall access to compost for the FDL Band. Alternatively, should the EPA Solid Waste Infrastructure for Recycling (SWIFR) Grant not be realized, the FDL Band could consider purchasing a used TMR Mixer for composting. The photo included above is an example of one such mixer available in the region.

CONCLUSION

The band has the compost ingredients to have a highly successful closed-loop system for compost and ingredient handling, processing, and delivery to end users at the community gardens in the future. Volumes of compost will provide adequate plant nutrition for the gardens and a considerable land base beyond that. It is estimated that up to 375 acres could be land applied with compost that might be available in the future.

FUTURE RECOMMENDATIONS

As part of AURI's 2024 Rural Cooperative Development Grant program, AURI could initiate a phase 2 Compost Development Project to accomplish the following.

- Potential RCDG project objectives:
    - If awarded the EPA Solid Waste Infrastructure for Recycling (SWIFR) Grant, AURI could assist with the scale-up and operations of the vessel
    - If NOT awarded the EPA SWIFR grant, AURI could assist with identifying a TMR mixer and establish a management protocol and an aerated static compost pile
    - Business Development Services, such as the economics of composting, including labor, time, equipment, producing versus purchasing compost, and supplemental fertilizers
    - Consideration of larger composting opportunities:
        - Biochar and potting soil
        - Use of biochar in current amendments
    - Assist in identifying the most beneficial compost system for FDL Band's needs:
        - Close-loop system – use the input in-house
        - Quasi-loop system – due to labor issues, politics, etc.

AURI recommends the FDL Band work with the University of Minnesota Extension Service on specific compost application rates for various fruit and vegetable crops.

APPENDICES

- Appendix A – Benefits of Composting Handout
- Appendix B – Composting Roundtable PowerPoint Presentation
- Appendix C – AURI Lab Analysis Report No. LS2024009
- Appendix D – AURI Lab Analysis Report No. LS2024011-014
- Appendix E – AURI Lab Analysis Report No. LS2024025-127

BENEFITS OF COMPOSTING

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Why Composting?

Composting is the preferred method of managing organic wastes (e.g., food waste, yard debris, etc.). It adds valuable nutrients to the soil, helps sequester carbon and mitigates methane emissions by diverting food waste from landfills. Composting and compost can also:

> Reduce chemical fertilizers (different feedstocks can have higher nutrient value, e.g., fish waste)
> Conserve water
> Control erosion
> Save money
> Encourage biodiversity

What is Composting?

Composting is the aerobic decomposition of organic materials under controlled conditions. The key to successful composting is dedicating the time and energy to the management of the compost pile. Seven other key conditions must be met:

1) Moisture content— 50 to 60 percent
2) Carbon to nitrogen ratio— 25:1 to 40:1
3) Oxygen— greater than 10 percent (e.g., various methods are turning, aerated static piles, etc.)
4) Temperature— a proper pile should generate its own heat. *Note: 55 degrees Celsius (131 degrees F) with five turns reduces pathogens*
5) pH— 6.5 to 8
6) Particle size— 1/8 inches to 2 inches (can vary)
7) Bulk density— (700 to 1,000 pounds per cubic yard)

What is a Finished Compost and How to Use it?

Typical finished compost characteristics:

1) Stable— low respiration and low temperature
2) Carbon to nitrogen ratio— less than 20:1
3) pH— natural
4) Soil-like smell and appearance
5) Mature— (e.g., solubles salts, high respiration rate, etc.)

For garden and field use, use the 1:3 rule. Spread 1 inches to 2 inches thick and add it to the soil 3 inches to 6 inches deep. Fall applications are ideal but spring applications work too. If using compost in other ways (e.g., containers, lawns, etc.), the same general 1:3 rule applies.

Additional resources: U.S. Composting Council, University of Minnesota, Cornell Composting.

APPENDIX B

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FDL Compost Project Review & Roundtable Discussion

November 28, 2023

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AGENDA

Composting Roundtable

Na'enimonigamig (Fond du Lac's Cannery), Cloquet, MN
Tuesday, November 28, 2023
1:00 – 3:00 pm

1:00 – 1:05 pm	Welcome/Introductions (Harold)
1:05 – 1:15 pm	Project Goals (Harold)
1:15 – 1:45 pm	Overview of the Composting Process (Brad)
	➢ Interpreting A Compost Analysis – What do the numbers mean? ➢ Review of MVTL Soil Sample Analysis for Fond du Lac ➢ Not All Compost is Created Equal (e.g., fish waste compost versus others) ➢ Best Management Practices (rodents, flies, etc.)
1:45 – 2:00 pm	Application Rates for FDL—The Why and When (Alan)
2:00 – 2:15 pm	Application Methods (equipment, etc.) (Alan)
2:15 – 2:30 pm	Future Opportunities (Harold)
2:30 – 2:55 pm	Q&A Session (Harold)
2:55 – 3:00 pm	Wrap-up (Harold)

THANK YOU AND SAFE TRAVELS!

Fond du Lac Compost Goals & Objectives

UNDERSTAND CURRENT COMPOST PRODUCT AND SOILS

ASSESS QUANTITY AND QUALITY OF ORGANIC WASTE BEING GENERATED

UNDERSTAND BEST SOLUTIONS FOR COLLECTION AND PROCESSING TO PRODUCE HIGH QUALITY SOIL AMENDMENT

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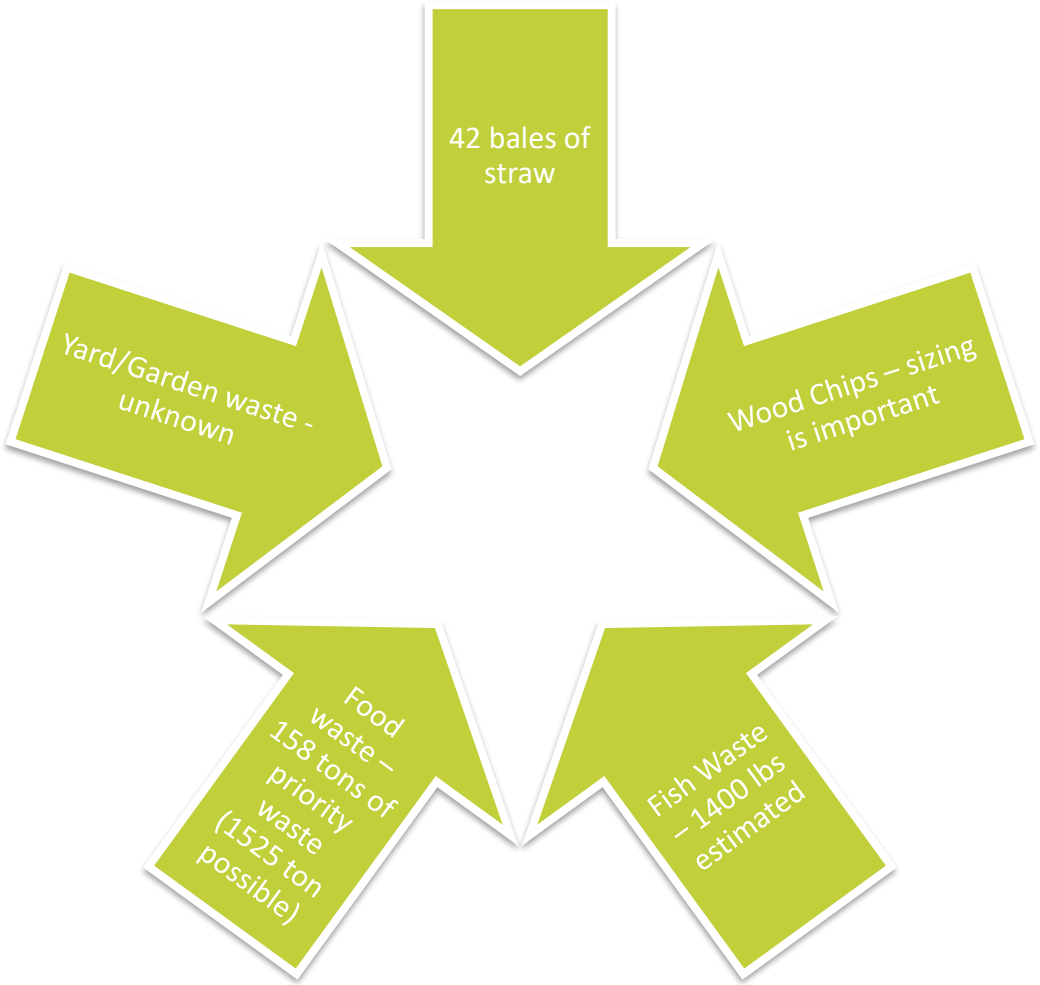
Fond du Lac Specific Needs

- Compost testing
- Determine waste output and characteristics of various compost ingredients
- Compost locations and impacts
- Ingredient sourcing (carbon, waste streams)
- Outreach of information

Type of Waste Generated at FDL (*best estimate*)



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Locations of Compost Facilities

Gitigaaning (the farm)

Ojibwe School Gardens

All products intended to be used on site.

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Interpreting A Compost Analysis

- Stability and Maturity
- Safety (i.e. are pathogens reduced)
- Nutrients and Organic Matter
- Your Results:
  - Fish and straw - average nutrients
  - Yard debris – low nutrients
  - Food waste – high nutrients – is it composted?

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Review of MVTL Soil Samples and Compost Use

- Gitigaaning (cannery) – average organic matter (OM), low nutrients
- Bimaaji'idiwin (school) – high OM, high nutrients (Phosphorous "P")

Compost Characterization and Use

- Food waste compost has the highest nutrient content
- Amend Gitigaaning but not Bimmaji'idiwin

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Best Management Practices

- Pathogen reduction
  - Need temperatures in excess of 131 degrees Fahrenheit (F)
- Pile management
  - Avoid standing water
  - Supply oxygen
  - Turn versus no turn
  - Other issues (i.e. flies, rodents, etc.)

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Compost Fertility and Soil Enhancement Potential (based on 3 % N test)

FDL has 158 tons food waste available. 50 percent shrinkage (79 tons) was used for calculations. (2 tons) is recommended for garden vegetables (except potato and sweet corn).

79 tons available / 2 tons acre food waste compost application rate = 40 acres

Fish waste (1400 lbs/season) , incorporate into whole program.

Future forecasted waste 1500 tons available. 50 percent shrink (750 tons) used for calculations. 750 tons/2 acre food waste compost application rate = 375 acres

1500 cubic yards available. Value estimate (market) $20-30 per cubic yard.

1500 x 25 = $37,500

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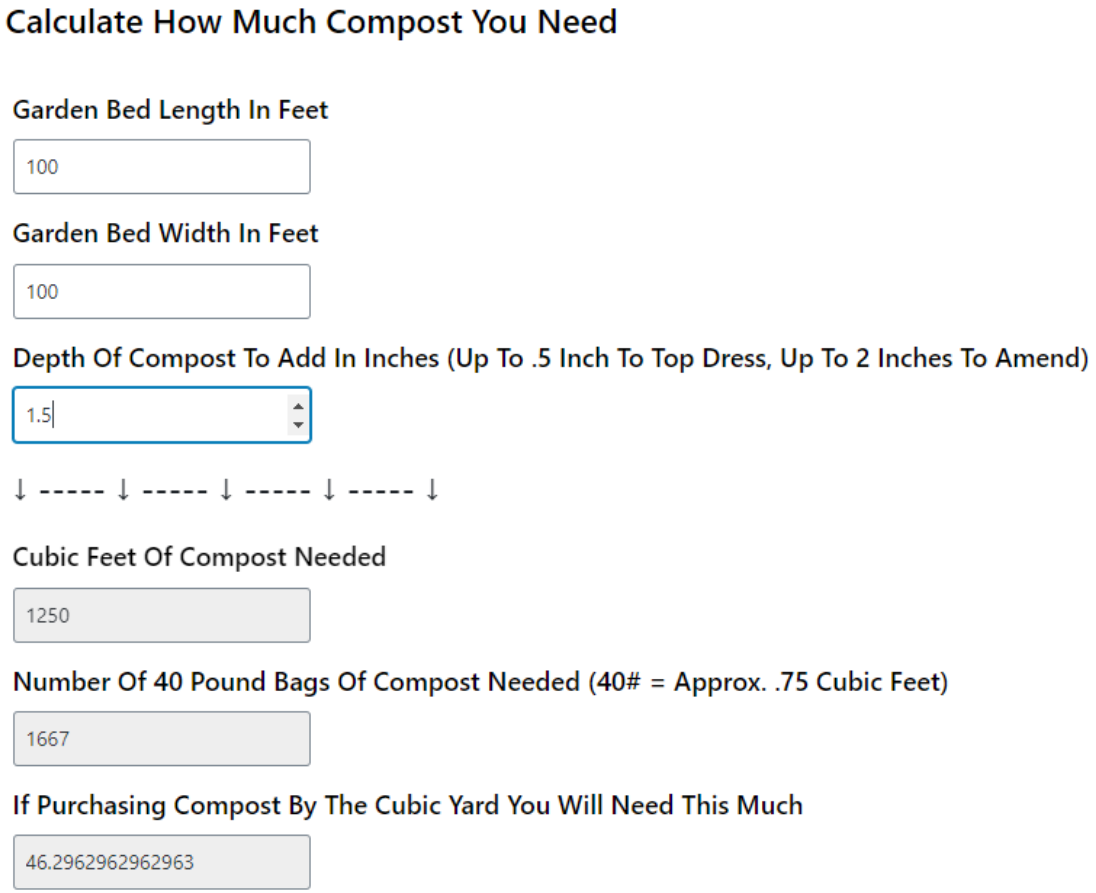
Compost Calculator – Good Tool



Source: Omni Calculator

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APPENDIX C

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Analytical Laboratory Report

Date 08/11/2023

Requestor Alan Doering

Client Fond du Lac Band of Lake Superior Chippewa
Project Name Composting Process Development
Project# 23070
Assigned Lab# LS2024009

AURI Lab#	Sample Description
LS2024009	Food Waste

Assay Results

Test	Method	Units	LS2024009
Moisture	AOCS Ba 2a-38	%	62.47
Carbon:Nitrogen	AURI	%	20.11

Reported by
Michael Stutelberg, Ph.D.

Disclaimer: The analytical laboratory at AURI is not an accredited or certified laboratory. All analytical results generated are for development use only.

APPENDIX D

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Analytical Laboratory Report

Date 08/17/2023

Requestor Alan Doering

Client Fond du Lac Band of Lake Superior Chippewa
Project Name Composting Process Development
Project# 23070
Assigned Lab# LS2024011-014

AURI Lab#	Sample Description
LS2024011	TS 1 Year Winter
LS2024012	TS 2 Year Winter
LS2024013	TS 1 Year Summer
LS2024014	TS 2 Year Summer

Assay Results

Test	Method	Units	LS2024011	LS2024012	LS2024013	LS2024014
Moisture	AOCS Ba 2a-38	%	46.67	71.58	64.27	28.40
Carbon	AURI	%	38.86	45.45	39.94	38.76
Nitrogen	AURI	%	1.30	3.82	3.99	4.58
Carbon:Nitrogen	AURI	ratio	29.89	11.91	9.99	8.46

Reported by
Michael Stutelberg, Ph.D.

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APPENDIX E

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Analytical Laboratory Report

Date 11/20/2023

Requestor Alan Doering

Client Fond du Lac Band of Lake Superior Chippewa
Project Name Composting Process Development
Project# 23070
Assigned Lab# LS2024125-127

AURI Lab#	Sample Description
LS2024125	Fish
LS2024126	June
LS2024127	12 Months

Assay Results

Test	Method	Units	LS2024125	LS2024126	LS2024127
Moisture	AOCS Ba 2a-38	%	64.51	62.12	58.61
Carbon	AURI	%	48.58	28.85	32.44
Nitrogen	AURI	%	2.16	1.66	1.68
Carbon:Nitrogen	AURI	ratio	22.59	17.43	19.31
Soluble Salts	Methods of Soil Analysis Chpt. 14, Part 3	mS/cm	0.40	1.37	0.56
Phosphorus (total)	MWL ME Proc 26	%	0.24	0.09	0.10
Potassium (total)	MWL ME Proc 26	%	0.10	0.27	0.20
Chloride	Soil Sci & Plant Analysis	%	<0.02	0.02	<0.02

Reported by
Michael Stutelberg, Ph.D.

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