

## **Recommendations and Implementation of a Hydroponics System for Gather On Trent Wellness Resort**

Includes:

Final Report

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## Acknowledgements

Gather On Trent is situated on land that has a deep history and significance long before it served as our study site. From time immemorial, the Michi Saagiig Anishnaabeg have lived in reciprocity with zaagidawijiwanaang, or the Trent River, upon which Gather On Trent is situated. Under treaty 20 of the Williams Treaties, this land was colonized and to this day, it still is. We are uninvited guests on this land and by reflecting upon that, as well as the long history of scientific studies exploiting Indigenous peoples and their land without a reciprocal relationship, we seek to ensure that our studies will serve the local community and the land. We offer our gratitude to the First Peoples for their care for, and their teachings regarding, the land and water and our relations. We seek to honour these teachings through our work and in our lives going forward.

We would also like to extend our heartfelt gratitude to Professor Shaun Watmough for his advice, support, and patience throughout our research. We would also like to thank Brittany Finigan for her work and support in coordinating our research and efforts with our host. Lastly, we thank Shamila Mackie and all those at Gather On Trent for allowing us to work on this project, as it has been an absolute pleasure.

# Abstract

This study examines the best practices for the implementation and management of a small-scale hydroponics system for the organization Gather On Trent. To fulfill the requests and requirements of our host, the system must be relatively compact, affordable, and be able to produce a wide range of marketable products. Through a literature review of both grey and academic papers, we examined the different hydroponics systems that would meet the needs of our host to determine our final recommendations. A comparative approach is taken to ensure that as the needs of the host change, the resources are there to provide updated suggestions. Factors such as cost, footprint, growth time, and water and nutrient requirements are considered to determine the best approach.

This study finds that for the needs of our host, a deep water culture (DWC) system is recommended. Due to the low cost of both money and time, the DWC hydroponics system is ideal for beginners looking to have a high crop turnover. This system would provide our host with the ability to grow most plants year-round using much less water and fertilizer.

*Keywords:* hydroponics, agriculture alternatives, local food solutions, deep water culture (DWC)

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# Introduction

Gather on Trent is an all-season wellness retreat located in Campbellford Ontario on the traditional and treaty territory of the Michi Saagiig Anishinaabeg that focuses on bringing people back to their connections with nature, themselves and the community. Gather on Trent provides several different kinds of accommodations to meet everyone's needs and wants, with several activities both in and outdoors to provide strong connections between guests and the environment surrounding them. Along with several rooms, activities like kayaking, relaxing in a hot tub or sauna, fishing and sitting around the fire, Gather on Trent has shifted towards a new focus with the hope that the organization can connect with those outside of those who stay at the retreat. This was chosen to be completed through a hydroponics system that will be implemented on the organization's property.

The objective of this project was to research and determine which hydroponic growing system would work best for the needs of Gather on Trent to provide for not only the organization but also for the community. To understand which system would be best, first, it is important to understand what a hydroponic system is, and what it can provide for the organization. A hydroponic system forgoes the use of soil when growing plants and instead uses a nutrient solution in water to support the growth of plants. While soil has been the primary method for growing plants, using a hydroponic method can reduce the amount of organic diseases in the soil.

Hydroponics is, as the name suggests, the practice of growing plants in water instead of in soil. This has a wide variety of applications and throughout the years many different system types have been developed.

Using a hydroponic system allows for year-round growth, whereas growing plants in traditional soil will only allow for growth during the warmer seasons. This report will cover the different forms of hydroponic systems that would be useful for the host and organization's needs, including the Nutrient Film Technique, Drip Irrigation, Deep Water Culture and the Kratky method. Along with information on these methods, will be the discussion of which system would best fit the needs of Gather on Trent, the costs associated with the methods, the water and nutrient requirements, pH requirements and the maintenance involved to ensure all plants are viable for production.

# Methods

## Study Site

Gather On Trent wellness resort is found in Campbellford, Ontario, at 432 Country Road 38. Located on the Trent River, the resort comprises several all-season cottages, providing ample opportunity for various activities in and around the water.



Image 1. A satellite image of the Gather on Trent property.

For the purposes of this study, we focused on the bunkhouses situated on the property, as hydroponics needs to be kept indoors in this climate for them to be able to produce year-round. In the photo above, the red line shows the property line, the green line represents the designated flower garden space, the yellow line shows the organization's building, and the blue line represents the bunkhouse where the system will grow.

## The Bunkhouse

Below are the pictures taken of the bunkhouse structure, along with the measurements of the structure, where the hydroponic system will go, for year long production. The room is 20 by 7 feet, allowing for a large variety of system sizes.



## Literature Review

Per our study objective, our research aimed to provide the best possible recommendation for a hydroponics system for the facility of Gather On Trent, one in the budget of 5-10k, and a second potential option in the budget of 10-15k. Developing a plan for what would grow best, and what maintenance would be required to sustain growth requires in-depth research into hydroponic systems in the area and what works best for those who farm utilizing this technique.

Our primary data collection method for this study is a literature review, looking at both academic and grey literature regarding hydroponics. We performed searches in the Google Scholar database using keywords related to hydroponic systems, including: crops grown in hydroponics, water monitoring and water solutions, the best plants to grow in hydroponics, and the advantages of hydroponic farming. To find grey literature and supplement our research we also used Google itself to find additional information.

The vast majority of hits were from grey literature, and interestingly enough most of the academic papers covering various topics related to hydroponics were studies based out of India and some countries in Africa (eg, Egypt). Any of the more local studies found focused on hydroponics as food solutions in the far north of Canada.

When finding specific methods of hydroponics we examined deep water culture, and as per the host's request, looked at systems that were more horizontal than vertical growing.

Ultimately, our research aims to provide the best possible recommendations for the specific location and needs of our host organization, Gather On Trent. Part of our research methods was to gather the widest variety of information possible to determine what would work best. As such, our research has outlined the following that will be utilized in our final recommendations: what plants can be grown in a hydroponics setup that also meets the needs of the host, what hydroponic technique would serve the host the best as an introduction into the field of hydroponics, and based on the two potential budgets what hardware is recommended.

## Criteria for Assessment of Hydroponics Systems

When examining the different options for hydroponics systems we assessed the common ones on a number of requirements tailored to the host's needs. Some hydroponic systems such as aeroponics were dismissed immediately due to the space required exceeding the space offered in the bunkhouses.

Firstly, we examined what plants can easily grow in the systems and the average growth time. Hydroponics typically has a faster growth period than soil-grown plants, though the exact time varies significantly depending on the system. Anywhere from 2-4 weeks to 4-6 weeks is common. Secondly, we looked at the nutrient and water requirements for each system. Lastly, considering the space and monetary budget we examined the space that each system would typically take up as well as the average cost of a pre-bought unit.

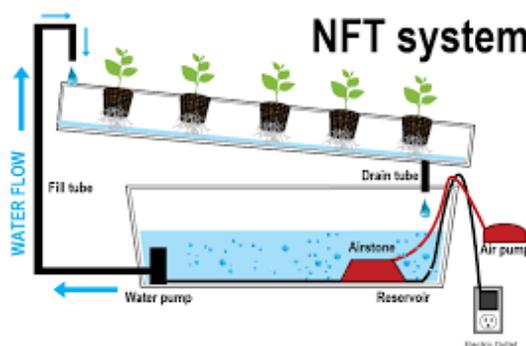
With that information, we were able to analyze a significant range of hydroponic setups.

# Results

## A Comparison of the different hydroponic systems

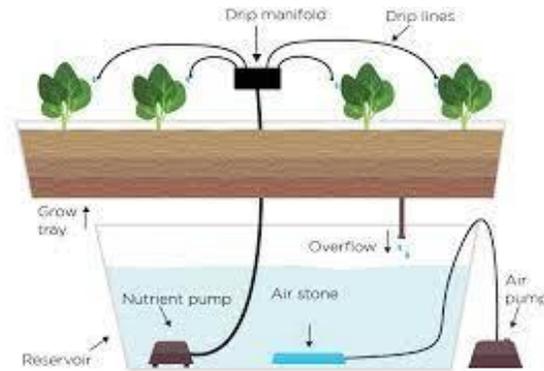
There are several different kinds of hydroponic systems that could be implemented for plant growth, however, they cannot all fit the needs of our host and their organization. Below are specific descriptions of each potential system.

1. **Nutrient Film Technique (NFT)**: NFT is a popular hydroponic growth method that uses a pump to deliver the water, containing nutrient solution, to the plants. The plants sit atop a grow tray and a drain pipe is used to recycle the unused nutrient solution. This system uses gravity, with the growth tray placed on an angle, allowing the water to flow over the roots at a continuous rate (Trees.com, 2023).



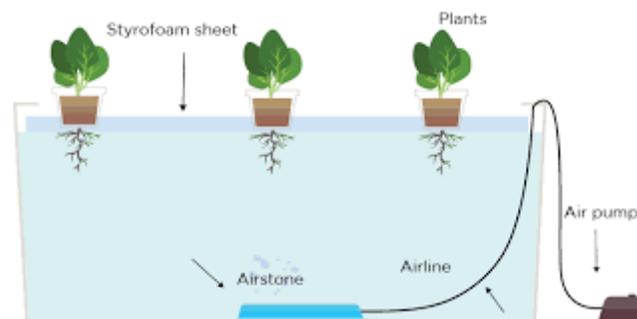
From: <https://medium.com/@HydroponicsName/nutrient-film-technique-ebd1f7e5676c>

2. **Drip Irrigation**: Drip irrigation is an active hydroponics system that involves placing tubes and using a pump to push water and nutrient solutions from a water reservoir up through the pipes and onto the plants (Trees.com, 2022).



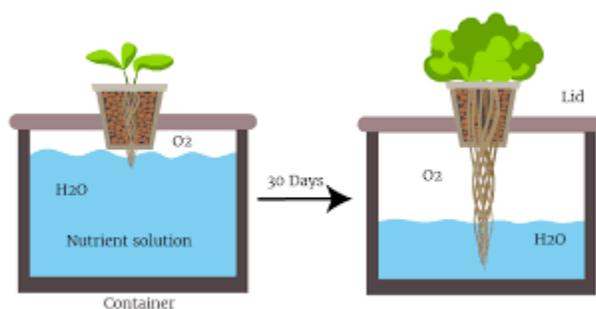
From: <https://www.trees.com/gardening-and-landscaping/hydroponic-drip-system>

3. **Deep Water Culture (DWC)**: Plants sit atop a styrofoam sheet in net pots, which is floating on a water reservoir filled with nutrient solution. Within the water, at the bottom of the tub (or structure holding water) is an airstone and airline that are connected to the air pump, on the outside. The pump and the stone work to provide oxygen to the plants/roots (Trees.com, 2022).



From: <https://www.trees.com/gardening-and-landscaping/deep-water-culture>

4. **Kratky**: Similar to DWC, plants sit atop a reservoir of water filled with nutrient solution, yet in this system, there is no air stone or air pump. Instead, in the Kratky method, the top of the plant is above the container, and the roots of the plants sit in the water, allowing them to soak up the solution. As the plant grows, the roots take up more space and absorb more water, ensuring that they have a good balance of both air and nutrient solution (McCandless, 2022).



From <https://www.trees.com/gardening-and-landscaping/the-kratky-method>

Based on the specific requirements of the host, we identified 4 potential options for a small-scale hydroponic system (Table 1).

System Type	Growth Time (a)	Nutrient Requirements (b)	Sizes (c)	Water Requirements (d)	Plants Viable for Growth (e)	Cost (f)
Nutrient Film Technique (NFT)	Between 2-4 weeks	A continuous coating of nutrient film around the roots	Plants grow in small pots, placed in shallow troughs  4-15 cm pots and 1-20m troughs	Approx. 1-3 mm of water, flowing on a downward angle, at a slower rate to maintain the nutrient film coating	The slow flow rate of the water is best for leafy vegetables like: -cabbage -bok choy -spinach	(approx.) Low end: \$800  High end: \$4,500

					-kale -oregano	
Drip Irrigation	Upwards of 3 weeks	Nutrient solution added into the water reservoir that is transported to plants through irrigation tubes	Small pots per plant set in trays, above a 10-20 gallon water reservoir to pump water up into the tubes	Water and air coexist in a void space, water is then applied through drip irrigation.  Clay pebbles anchor the plants, and help to deliver water into the roots	A wide variety of plants are viable. Including: -onions -leeks -lettuce -radish -strawberries -pumpkins	A large range with (approx): Low end: \$55-100  High end: \$3000
Deep Water Culture (DWC)	Between 2-4 weeks	Added into water and absorbed by plants, but is slow to fully disintegrate, may take a week or so before needing a replacement	1-5 gallon reservoir of water, to keep a steady supply for the plants and roots	Half a litre of water to maintain healthy plants, with more taken from reservoir if needed, Plants sit on a sheets with the roots absorbing water and solution through the bottom	A wide variety of plants are viable. Including: -lettuce -spinach -bell peppers -range of herbs -strawberries -cabbage	(approx) Low end: \$50  High end: upwards of \$2000
Kratky	Between 4-6 weeks	The nutrient solution is added into the water and then goes unchanged until the plants have finished growing, and a new plant is added	Plants grow in varying sizes of systems. These range between 1 gallon to several (20) gallons depending on number of plants	Plants sit in nutrient filled water where a passive system takes place  As the plant absorbs the water, the air space increases	The variety of plants most include leafy plants such as: -spinach -lettuce -cabbage -herbs	A large range with (approx): Low end: \$55-100  High end: \$1000

Table 1. A table describing the main features of the four different hydroponics systems, and features that are provided for optimal plant growth.

Legend:

- (a) Growth Time - The time that it takes the plant to grow from first addition to nutrient solution, until it is ready for harvest
- (b) Nutrient Requirements - The specific requirements needed for proper nutrition of plants
- (c) Sizes - The sizes of growing pots needed for plants to be healthy
- (d) Water requirements - The requirements of water needed to support the system
- (e) Plants viable for growth - Which plants are able to grow within each system
- (f) Costs - The average costs of the different sizes and qualities per system

The needs of our host and the organization fit into the lines of needing a productive system that has a fast turnover rate in plant production and species type, while also fitting into the budget of approximately ten thousand dollars. Easy use of the system was also a requirement since the organization and host are at a beginner level, so changing the water and nutrient levels would be best selected by a system that needs these changes less frequently.

## Homemade vs Store Bought Hydroponics Systems

Determining if a system should be homemade, or purchased is a large aspect of this project. Below is a table comparing and contrasting the different systems (homemade vs. store-bought).

Type	Pro's	Con's
Homemade	<ul style="list-style-type: none"> <li>- Affordable</li> <li>- Smaller scale</li> <li>- Easier to assemble</li> <li>- Easier to understand set-up (simplistic design)</li> <li>- Eco-friendly through the use of recycled materials</li> </ul>	<ul style="list-style-type: none"> <li>- Non-mechanical</li> <li>- Requires more guidance and attention</li> <li>- Possible plant growth failure</li> <li>- Cannot grow as many large plants</li> </ul>
Store Bought	<ul style="list-style-type: none"> <li>- Can hold more plants</li> <li>- Higher chance of growth success</li> <li>- Better equipment helping for a faster growth</li> <li>- Mechanical</li> <li>- Circulates nutrition solutions more efficiently</li> <li>- Self-sustaining</li> </ul>	<ul style="list-style-type: none"> <li>- Can be expensive</li> <li>- Set-up can be complicated</li> <li>- Larger systems (taking up more space in structure)</li> </ul>

Store-bought systems can hold a lot more plants and of different varieties. With a proper setup put in place, an efficient hydroponics system will dissolve, circulate and filter the nutrient solutions within the water, to ensure that the plants have the correct flow and amount of nutrition to grow properly. Hydroponic systems are created and developed for the sole purpose of growing and maintaining a set of plants. They provide a large amount of benefits that co-exist with our hosts' wants and needs. Creating a system at home with materials that are either already within someone's possession will not have the sufficient capacity needed to produce the large amount

and variety that our host intends to grow. As well, the need for this project lies in the capacity to hold a large variety of plant species, and the lack of consistent results that are produced within each set of crop harvesting, every few weeks, depending on the type (vegetable, fruit, herbs). Furthermore, a system that has the proper functions set in place will require less amounts of supervision, making it ideal for a beginner, like our host, to implement.

## Plant Selection

Different types of plants would be suitable depending on the hydroponic system. Generally, a wide variety of herbs, vegetables, and fruits are possible to grow. It is generally advised that the plants are ‘started’ from cuttings or put into the hydroponics system while young, as directly growing from seed within the hydroponic setup is not always advised (Wickison, 2023). For beginners, it is recommended to start the hydroponic system with plants that can tolerate a wide variety of pH and nutrient levels, and preferably plants with a dense root structure. Different varieties of lettuce are ideal for these requirements, due to the generally low nutrient requirements (Ohler, 2023). Below is a list of the selected plants with the best chances of viable growth.

1. Leafy greens: Plants such as lettuce, spinach, bok choy, and different types of cabbage are best chosen, yet do require more careful monitoring of nutrient levels (Wickison, 2023).
2. Herbs: Herbs such as basil, parsley, oregano, sage, rosemary, stevia, lemon balm and dill are good choices for growth in a system as they have dense root structures (Wickison, 2023) (Ohler, 2023). Mint can be grown, however, caution is recommended due to their aggressive growth, which could block out other plant roots, resulting in damage.

3. Fruits: Strawberries are ideal for beginner hydroponics, due to their compact nature (Ohler, 2023). Fruits such as tomatoes and peppers are far more difficult to grow hydroponically but can be achieved through a higher frequency of monitoring and effort (Ohler, 2023). The struggle with tomatoes and other fruits is the differing nutrient needs in the flowering and fruiting stage, combined with the top-heaviness of plants such as tomatoes which can be difficult to manage for a beginner (Skates, 2018). To manage that, it is advised that clay pebbles (or leca balls) are added to the base of the plant to provide the roots extra stability (Skates, 2018).
4. Simple Vegetables: Vegetables such as celery, broccoli and green onions are a beginner-friendly choice as well. Green onions are very easy to grow, whereas celery and broccoli could require more intense lighting and root support through clay pebbles (Ohler, 2023).
5. Microgreens: Microgreens are highly recommended in hydroponics. Root vegetables are difficult to grow hydroponically, whereas microgreens such as carrots, beets, radish, clover, alfalfa, kale and collard greens can be grown with great success (Davis, 2021). However, it is recommended that microgreens be started from seeds in the hydroponics system, as they can yield multiple harvests from just one batch of seeds (Davis, 2021). Another benefit is that they can be grown on a very small scale, and do not require a larger system like most of the other plants mentioned above.

## Hydroponics Waste Solutions

Hydroponics water waste can be a great concern, especially near a water body with a runoff risk similar to that seen at Gather On Trent. Adding vital nutrients for the plants grown in

deep water culture such as nitrogen, phosphorus, and calcium can cause major damage to an aquatic ecosystem (Gaiaca, 2020). The idea of simply dumping the wastewater is both wasteful and ecologically dangerous, so to counter that a series of steps can be taken to ensure that the nutrients can be utilized well and no harm is done to the environment.

The most resource-friendly option is to dilute the hydroponics solution and reuse it—using an equal amount of well water the solution can be diluted and used in potted plants (Gaiaca, 2020). These plants can be indoors or outdoors, as long as they have no risk of runoff.

For additional security, it is recommended that a Reverse Osmosis (RO) filtration system is obtained to deal with additional wastewater that cannot be diluted. For the uses of Gather On Trent, a 200 GPD filter is recommended (Gaiaca, 2020). Once the water has been filtered, should the pH and other parameters test acceptably, the water will be safe for disposal (Gaiaca, 2020).

# Recommendations

## System Type

### Rationale

Our recommendation for the system type selected for Gather On Trent is a deep water culture (DWC) setup. Of all the different system types, DWC is by far the easiest to use and set up (Gaikwad & Maitra, 2020). Considering the needs of our host, that would be a benefit. Not only are DWC systems easy to use and manage comparatively to other systems, they also can grow a wide variety of vegetables and fruits. When considering the requests of the host for a horizontal system and the plants requested a DWC setup would be the best fit.

The purchasing of a store-bought DWC system would lead to more consistent results and would fall well within the budget allocated. A high-end DWC system costs around \$2000, which is likely larger than the host's needs. A pre-bought system would also provide access to industry support such as warranty and customer service.

### Maintenance

There are several different factors involved with maintaining a DWC system to ensure the best plant production possible. These include monitoring the water temperature, ensuring all equipment is working properly including pumps, monitors, tubing and air stone for proper oxygenation, maintaining a healthy pH level and nutrient solution level, inspecting and cleaning

the system between large production uses, inspecting for possible pests, and ensuring adequate lighting is available for specific plant growth needs. Below are the best ranges of temperature, pH, nutrient solution and cleaning/ inspection times.

- Temperatures: Range between 18-22°C (64-72°F) (A-Grade Hydroponics, 2023)
- pH level: between 5.5 and 6.5 (Hydrotek - Hydroponics, 2021)
- Lighting: LED grow lights set on a timer for 14 hours a day to mimic a standard day-night cycle (Kilbride, 2024)
- Nutrients: (approx.) 1-2 cups of pre-mixed nutrient solution, changed with the water every 2-3 weeks (AgrowTronics, 2021)
- Cleaning/inspection: between 2-6 weeks, depending on plant growth and frequency of water change (AgrowTronics, 2021)

The wastewater produced from this system will contain levels of nutrient solution and particulates of other organic matter. These aspects could be helpful as a utilization towards another growing or composting project, such as utilizing the wastewater for a flower garden.

## Plant Selection

Gather On Trent was looking for the ability to grow marketable produce that could improve the stay of their guests as well as provide excess to the local community. To that end, small vegetables and herbs were requested. Leafy greens such as kale, spinach, and all varieties of lettuce are particularly suited to DWC due to high water needs. As discussed in our results we recommend leafy plants and other beginner-friendly selections as a starting point (eg, lettuce, strawberries, microgreens, and certain herbs) with expansions into more effortful plants once there is some experience built up with managing the system (eg, tomatoes or peppers).

Once working with more top-heavy plants it is recommended to slightly alter the DWC system. While a standard DWC system involves the suspension of the plants on a floating platform above a nutrient solution (Gaikwad & Maitra, 2020), the inclusion of a semi-hydro approach would involve plastic mesh pots like those commonly used in growing orchids as houseplants. The tomato or pepper would be placed in those pots with clay pebbles or leca balls supporting the root structure, and then the pot would be placed in the floating platform and the nutrient solution. It is just a slight alteration, as the nutrient solution and air pump would function the same, however, it would allow for growing heavier plants with ease.

As aforementioned, it is not considered best practice to start most of the plants in hydroponics from seed. There is better growth after starting them from seedling or sprout and allowing the roots to adjust to the nutrient and water solution in DWC. Microgreens are the exception, where they are able to grow multiple times from the same seed should they be cut properly.

## Cost Analysis

There are several different factors that must be considered when dealing with the overall cost of this project and a Deep Water Culture (DWC) system. Below is a list of the contributing cost factors (all numbers are an approximation).

- System set-up (all inclusive kits): \$2,500
- Nutrient Solution: \$50 - \$100/ container
- Digital pH control kit: \$200

- Air stone (if not included in kit): \$30/stone
- Reverse Osmosis Filtration System of 200 GPD: \$300
- LED Grow Lighting: \$250

**Total Cost: \$3,430**

These prices will vary depending on the particular system set-up, selection of kit, type of solution, size of bottle, and the inclusion of an airstone.

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### **Authorship Statement**

The methods and results, which were already completed, were revised as per the suggestions offered, by L.Vegh and S.Theurer respectively. L.Vegh wrote the acknowledgement and completed the abstract and S. Theurer wrote the introduction. The recommendations and reflection section was completed equally by both parties.