Resilient Groundwater Supply for Rural Homeowners & Small Communities in Nova Scotia

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Scope of Work

The purpose of this project is to implement a resilient emergency groundwater supply system for regions in rural Nova Scotia during a drought event. In 2016 and 2018, the southwest region of Nova Scotia experienced drought conditions, which resulted in water scarcity. This project will outline the design process and development of the system, with the intent of the design being translated to other regions within the province.

Selected Location

Decision Variable	Assigned Weight
Total population	3
Population density	4
Percent using private dug wells	5
Climate data availability	3
Pumping test data availability	4

Ranking Matrix

County	Total Population	Population Density	Private Dug Wells	Climate Data	Pumping Test Data
Digby	3	3	3	3	3
Lunenburg	5	5	2	3	3
Queens	2	2	1	3	3
Shelburne	2	3	5	3	3
Yarmouth	4	4	4	5	5

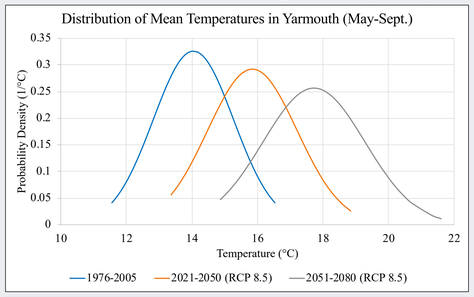
*Selected criteria based on pertinent well design factors with scores of: 1(low priority) to 5 (high priority)

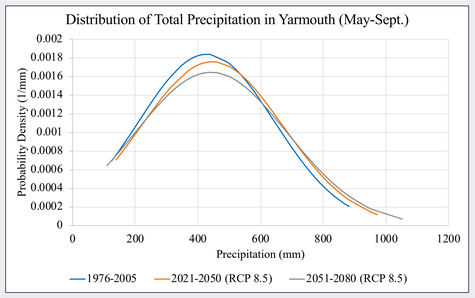
Preferred Location Selection

County	Digby	Lunenburg	Queens	Shelburne	Yarmouth
Total	57	66	40	64	**83**

Climate Projections

- Analyzed downscaled climate projections to quantify impacts on drought frequency
- Point source data was collected from the Canadian Centre for Climate Services for Yarmouth (43.83° N, 66.09° W)
- Data formulated from 24 equally weighted global GCMs from CMIP5





- Shifts in the 2016 & 2018 climate observations over time are shown below (mean is 50%)

Projections	2016 & 2018 (15.6°C)
Historical (1976-2005)	89.8%
2021-2050 (RCP 4.5)	47.3%
2021-2050 (RCP 8.5)	42.9%
2051-2080 (RCP 4.5)	26.4%
2051-2080 (RCP 8.5)	8.6%

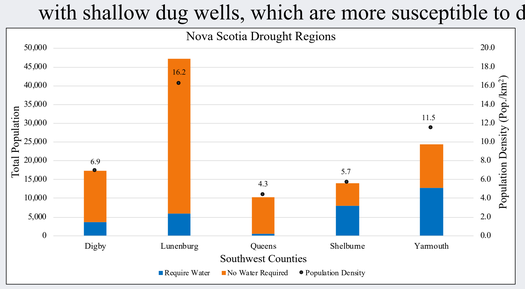
- RCP 4.5 and RCP 8.5 mean temperature projections show significant increases over time, while precipitation events will persist similarly in the future

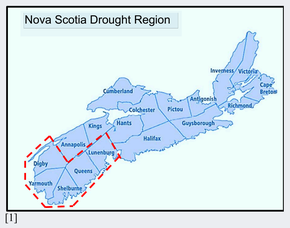
Projections	2016 (270.8 mm)	2018 (298.4 mm)
Historical (1976-2005)	23.5%	27.6%
2021-2050 (RCP 4.5)	22.1%	25.7%
2021-2050 (RCP 8.5)	22.1%	25.9%
2051-2080 (RCP 4.5)	23.2%	26.8%
2051-2080 (RCP 8.5)	24.0%	27.7%

- Over time, data indicate a reduction in precipitation minus evapotranspiration, which can increase drought frequency

Population Distribution

- Nova Scotia's southwestern region has a high concentration of rural homeowners with shallow dug wells, which are more susceptible to drought





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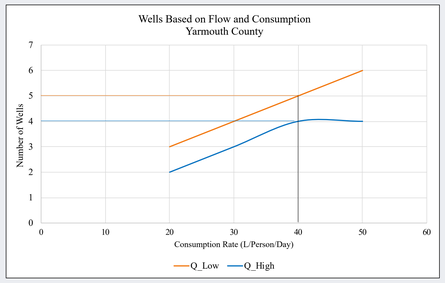
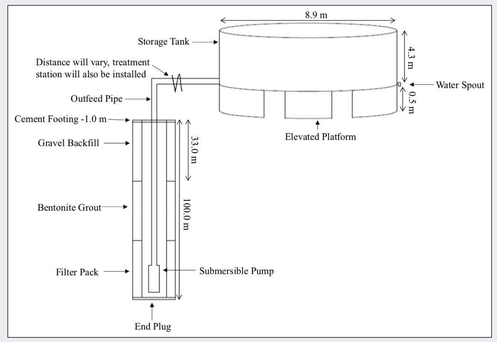
Consumption Analysis

- Determination for the number of wells was based on consumption rate, expected yield and the population in need of an emergency water supply
- To make a well plan for Yarmouth and the other four regions, well log pumping test data was collected from the Nova Scotia database
- Approximate well yields were calculated using the Cooper-Jacob method
- A consumption rate of 40 L/person/day was used to calculate the number of wells required
- Q_{low} and Q_{high} are based on a range of typical fractured bedrock compressibility values and subsequent storitivities

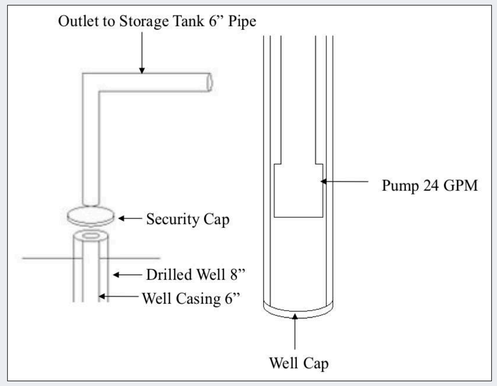
$Q_{measured}$ (m^3/d)	Q_{low} (m^3/d)	Q_{high} (m^3/d)
131	126	165



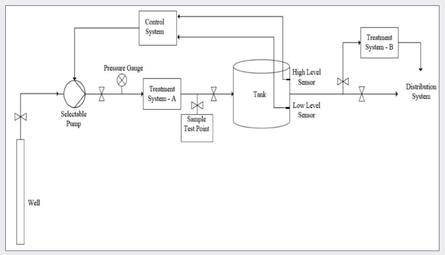
Well Design



- This well has been designed to be altered to fit the region where the system is being implemented
- This drilled well will be 8" in diameter, 300' deep and is expected to be able to provide an output of water equal to 24 GPM
- The well will have safety measures in place to prevent tampering and cross contamination
- When the well is not in use (winter months), the well will be covered and locked with a security cap



Hardware and Materials	Dimensions
Drilled well	8" (20 cm) Diameter
Casing	6" (15 cm) Diameter
Well depth	300' (100 m)
Cement end plug and footing	0.02 m^3
Gravel backfill	0.468 m^3
Bentonite grout	0.468 m^3
Filter pack	0.468 m^3
Submersible pump	24 GPM pumping capacity



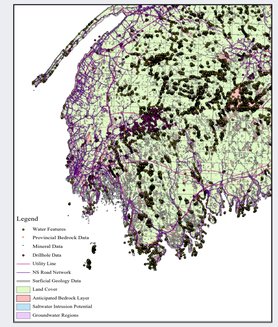
Cost Analysis

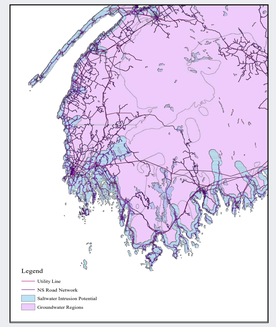
- Using available data and professional recommendations, a beneficial cost analysis was performed based on approximately 510,000 L/day for 12,747 people

Expense	Associated Cost
Old Cost of Water Delivery	$6,000 per truckload
Projected Cost for Yarmouth for Delivery	$162,000 per day
Estimated Cost Range of Each Well	$75,000 - $90,000
Total Estimated Cost Range for Yarmouth	$300,000 - $360,000

Hydrogeological Analysis

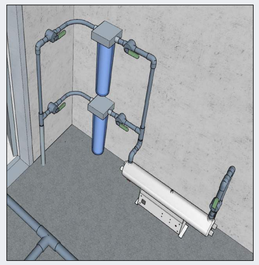
- The hydrogeologic data indicated that the bedrock likely to be found in Yarmouth County will be igneous or metamorphic
- Within these bedrock layers, the water to be extracted will be found in various fractures in the bedrock
- To determine locations of water bearing fractures, test wells must be drilled
- ArcGIS has been utilized to determine constraining factors in well selection
- It is important to consider regions susceptible to saltwater intrusion, areas with high concentrations of dug wells, and areas with known contaminants or underground utility lines
- Road access was considered to optimize user convenience





Treatment, Testing & Maintenance

- Maintenance and Safety: Testing occurrence, off season, physical barriers, filter (KW4520G-5M) and UV (CQE-UV-00105) identifiers
- Provincial registration
  - Offer contract
- Bacteria test:
  - Semi-annually
- Chemical test:
  - Bi-annually
- When not in use:
  - The power will be off
  - The valves will be closed
  - All water will be removed from the tank



Operation Process:
1. Filtration
2. Disinfection
3. Storage
4. Disinfection
5. Distribution

Conclusion & Recommendations

- This system will benefit the residents of rural Nova Scotia by providing a safe and reliable source of drinking water, allowing 40L/person/day
- This project will consist of strategically located groundwater wells across each county to satisfy population density, while minimizing travel time and overall cost
- It is recommended that prior to the implementation of this project thorough site investigations, including test wells, are conducted at each proposed location

Acknowledgements

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