

Objectives

- Design a drought resilient water supply for private well owners in Argyle, Nova Scotia by incorporating climate change projections from present-2100
- Provide recommendations for future work

Background and Problem Definition

- Since 2016, many parts of southwestern NS have experienced recurring periods of drought during the summer months
- Many residents lack sufficient water for daily tasks
- In 2020, ~ \$50,000 was spent on emergency water allocation

Argyle, Nova Scotia

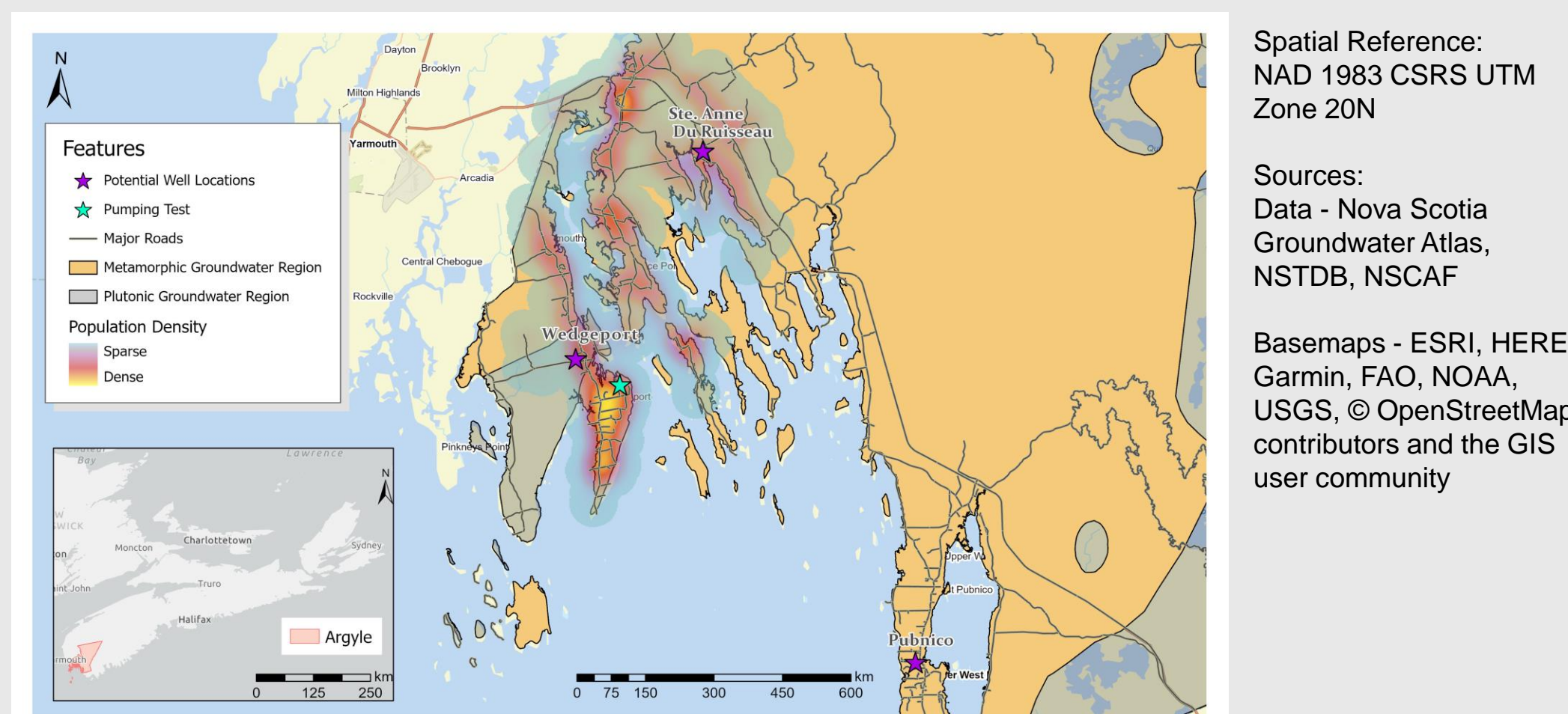
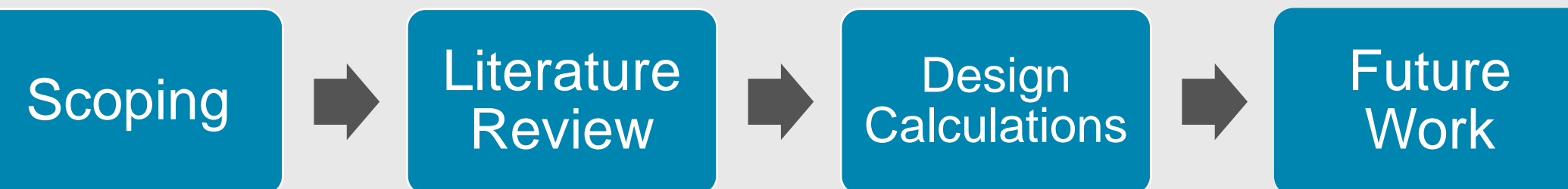


Figure 1. Map of Argyle, NS showing potential well locations, bedrock groundwater regions and population density

- Located in Yarmouth County
- 7900 residents
- Most homeowners currently rely on private wells
- Highest percentages of shallow or dug wells in the province – estimated at around 30% +
- Most dwellings are located on or very near the coast

Design Process

An overview of the key design components is presented below.



Analysis relied heavily on existing literature and datasets.

Constraints and Considerations

- Access to and quality of data (historical and projected climate data, location-specific hydrogeological data, property data)
- Ability of proposed water supply source to meet water quality and quantity demands
- Compliance (maximum freshwater withdrawals, well construction regulations)
- Spatial distribution of population
- Peak projected demand and duration
- Usage (potable vs. non-potable, community vs. individual use, seasonal vs. year-round)
- Land ownership

Data Compilation and Site Analysis

Hydrogeological (Groundwater Atlas, 2021)

- Transmissivity
- Storativity
- Static water level
- Well depth
- Elevation
- Bedrock groundwater region

Historical Climate (Environment Canada, 2021)

- Monthly precipitation and climate normals
- Climate Projections (Climate Data Canada, 2021)
- Statistically downscaled climate data (total precipitation, max/min temperature) for RCPs 2.6, 4.5 and 8.6

Demand was determined through information provided by the Municipality of Argyle. In 2020, peak demand for Argyle residents was estimated at about 77 users per day, requiring 1000L per home.

Table 1. Weighted decision matrix for analysis of proposed well locations (highest value = most desirable)

Criteria	Weight	Wedgport		Ste. Anne du Ruisseau		Pubnico	
		Value (out of 10)	Total	Value (out of 10)	Total	Value (out of 10)	Total
Hydrogeological Properties	10	7	70	5	50	5	50
Demand	8	8	64	8	64	5	40
Land Ownership	4	10	40	10	40	5	20
Water Quality	6	7	42	5	30	4	24
Totals	28	33	216	25	184	21	134

Climate Change Analysis

- Identified trends in historical climate data

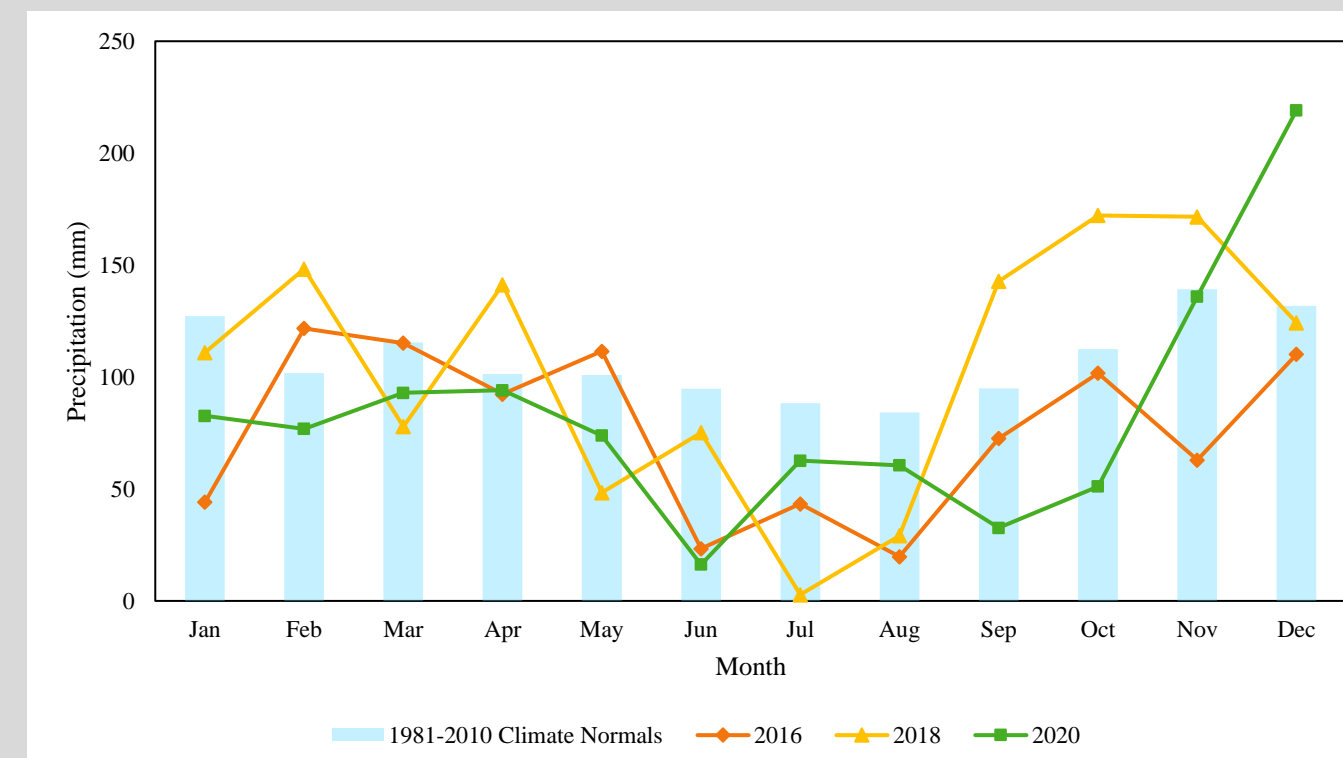


Figure 2. Comparison of total monthly precipitation vs. 30-year monthly precipitation climate normals for Yarmouth A. Climate ID: 8206495 (Environment Canada, 2021)

- Used climate scenarios to forecast drought severity

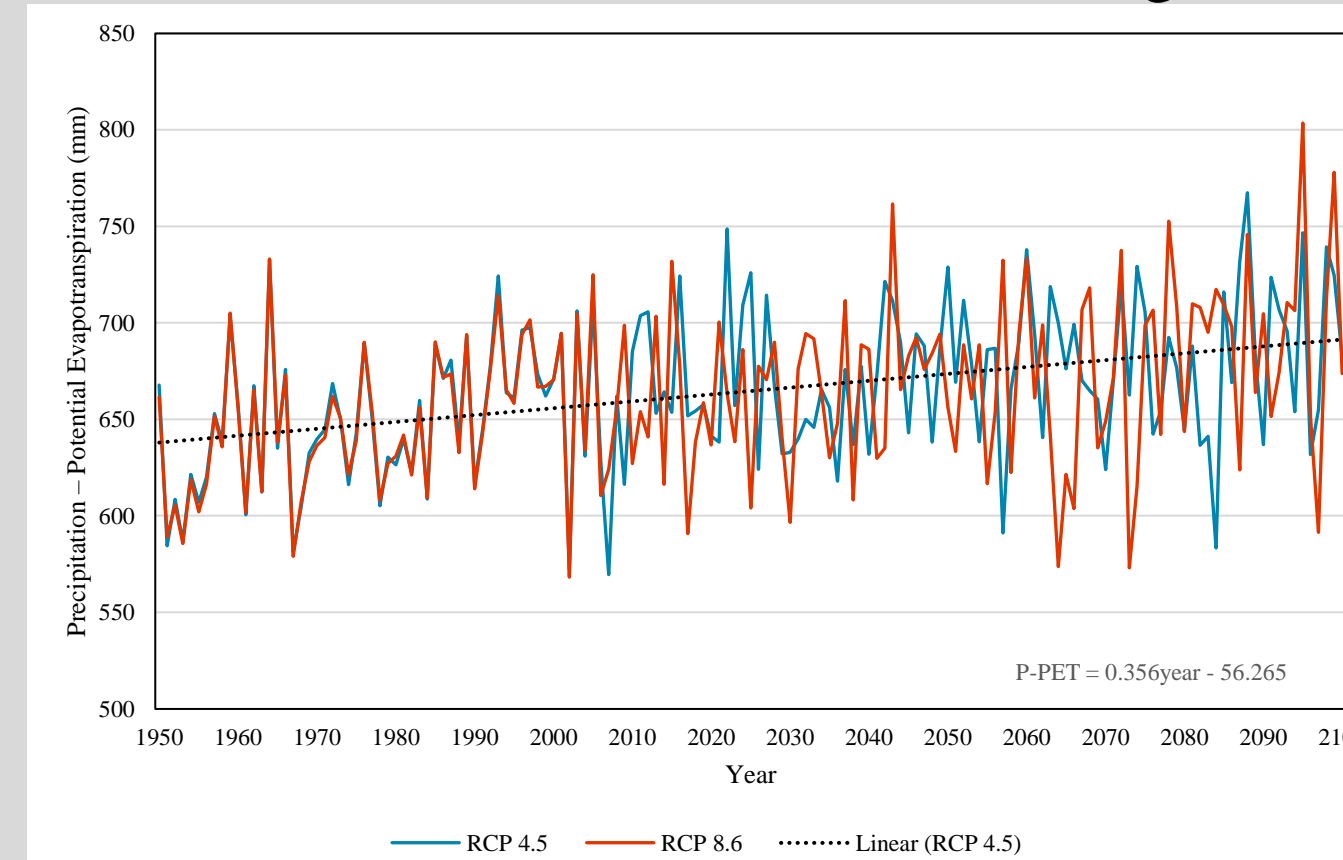


Figure 3. Simplified Standardized Precipitation Evapotranspiration Index for Wedgport, NS using Modified Hargreaves PET method for Q2 data (Climate Data Canada, 2021)

Table 2. Summary Statistics for Annual Q2 P-PET for 3 RCPs

Representative Concentration Pathway (RCP)	Standard Deviation (mm)	Minimum (mm)	Maximum (mm)
2.6	41	565	771
4.5	40	570	767
8.6	44	568	804

Well Design

- Two proposed wells of radius 150 mm would be located ~50 meters to the east and west of the fire hall
- Under ideal conditions, this would supply 36,800 L/d for 2 months before drawdown exceeds 13.9 m under Cooper-Jacob assumptions
- Well efficiency losses would significantly reduce this result

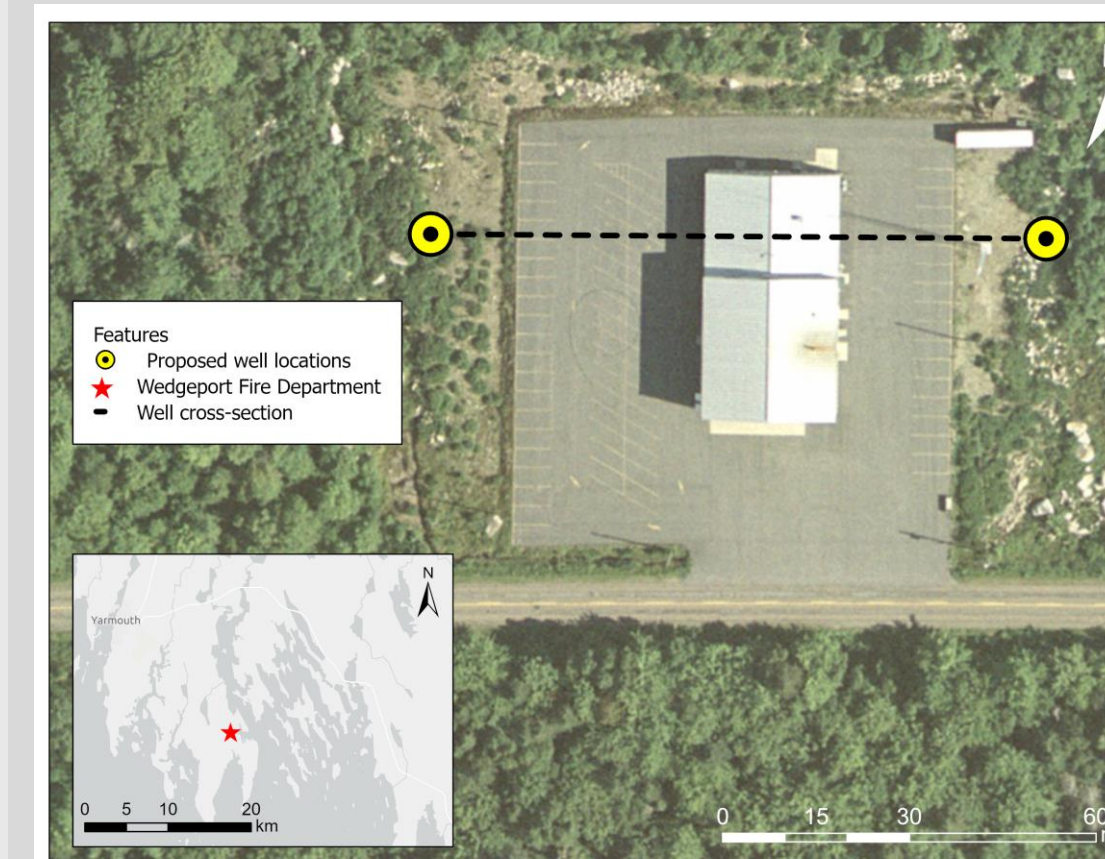


Figure 4. Plan view of Wedgport Fire Department with proposed well locations

Spatial Reference: NAD 1983 CSRS UTM Zone 20N

Sources: 10K Orthophotos – Service Nova Scotia and Internal Services (2019)

Basemaps - ESRI, HERE, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors and the GIS user community

- As seen in Figure 5, this would perturb the potentiometric surface

- Well logs near the Wedgport Fire Station indicate a static water level of 13.9 masl
- This was taken to be the maximum allowable drawdown without potential for seawater intrusion

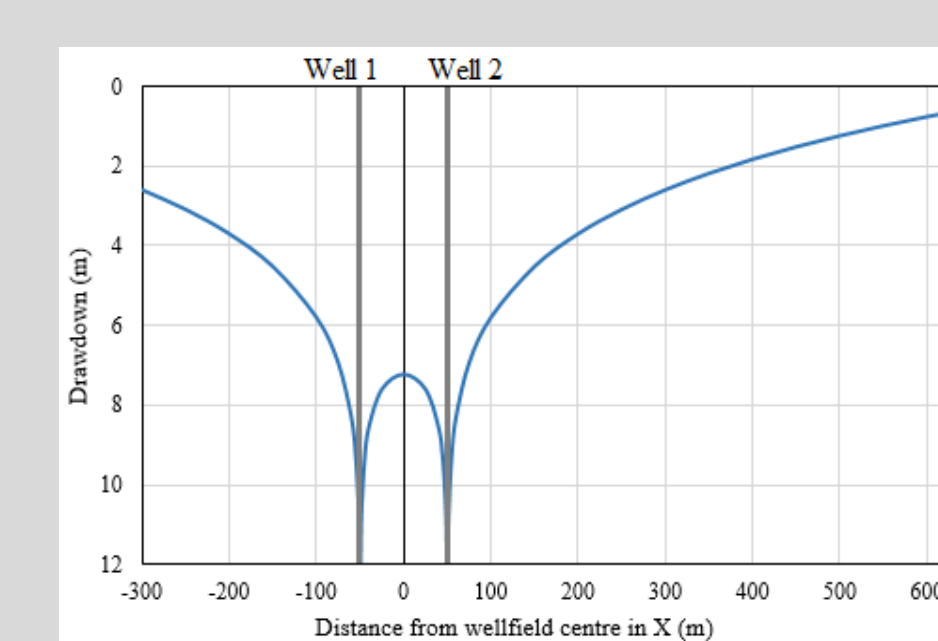


Figure 5. Graph of drawdown versus distance along the line directly connecting both wells at t = 61 days

Storage and Distribution

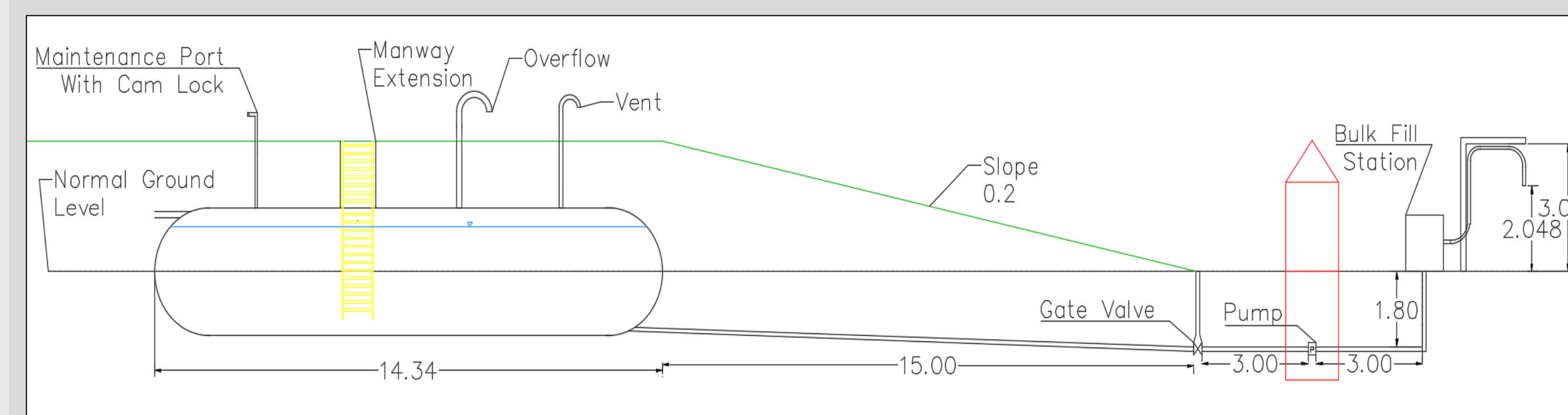


Figure 6. AutoCAD drawing of water storage and bulk fill station

- 100,000L of water storage
- Fiberglass underground storage reservoir
- NSF Standard 61 Certified
- Four-inch PVC water main
- Bulk fill station with backflow preventor rated to -34°C
- Q= 600L/min

Water Treatment

The installation of one (1) UV water treatment unit is recommended to provide a baseline level of protection against bacteria. This water treatment unit will:

- Be placed at the end of the distribution system (i.e., directly before the bulk water fill station, past the storage tank)
- Ensure extracted groundwater is made safe to a non-potable standard

Once wells are installed, regular water quality testing is recommended to determine any further treatment that may be required. The installation of further water treatment units to raise the extracted groundwater to a potable standard may also be implemented, but this design step will be up to the discretion of the Municipality.

Cost Analysis

An estimated cost breakdown is provided below. Note that the costs of installation, maintenance, and labour are not included.

Table 3. Estimated costs for the proposed community well. Cost estimate acknowledgements include DJ's Well Drilling Ltd., Nova Scotia Environment, Emco Corporation, BIRKSCO, Fresh Water Systems, and Xerxes by Shawcor.

Design Component	Cost (\$)
Wellfield design (i.e., well drilling, well casing)	15,000.00 – 25,000.00
Storage & distribution (i.e., storage tank, piping)	62,000.00
Bulk fill station	55,000.00
Water treatment & pumping units	12,000.00 – 45,000.00
Groundwater withdrawal permit	331.75

Conclusions

- Groundwater was determined to be the most suitable solution for resiliency to climate change; however, none of the locations proposed by the Municipality are able to meet the expected demand for Argyle residents due to their hydrogeological properties
- In the short term, the Municipality should drill a community well to meet the current demand during water shortages
- In the long-term, further development of residential drilled wells will be important to adapt to the changing climate

Recommendations

- Further exploration of suitability of alternative locations (Tusket and Plymouth), based on hydrogeological properties followed by site specific pumping tests for promising locations
- Development of wellfield protection zones to ensure the safety of Argyle residents

References

- Climate Data Canada. (2021). *Monthly Projected Climate Data*. [Lower Wedgport, NS 1950-2100]. Retrieved from: <https://climatedata.ca/>
- Environment Canada (2021). *Historical Climate Data*. [Yarmouth A 2016-2020, climate ID: 8206495]. Retrieved from: https://climate.weather.gc.ca/climate_data
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- Nova Scotia Department of Municipal Affairs. (2018). *Municipal Report: Municipality of the District of Argyle*. Retrieved from: <https://beta.novascotia.ca/sites/default/files/documents/1-1735/municipality-district-argyle-municipal-profile-and-financial-condition-indicators-results-2018-en.pdf/>

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