Update to November 2021 Pilot Study Report:

Straightway & Hyannisport

Evaluation of Single Plant Option

Town of Barnstable Department of Public Works

MAY 2023

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TECHNICAL MEMORANDUM

TO: Griffin Beaudoin, PE; Mike Tieu, PE & Hans Keijser – Town of Barnstable

FROM: Alexander B. Bishop, PE
Kirsten Ryan, PG
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DATE: May 16, 2023

SUBJECT: UPDATE to NOVEMBER 2021 PILOT STUDY REPORT: Straightway and Hyannisport Drinking Water Filtration and Treatment Facilities – Evaluation of a Single Plant Option

EXECUTIVE SUMMARY

This Technical Memorandum serves as an update to the Kleinfelder November 2021 "*Pilot Study Report: Straightway and Hyannisport Facilities, Hyannis Water System"* (Pilot Study Report). The Pilot Study Report presented a conceptual design for two separate facilities at the Hyannis Water System (HWS) Straightway-Hyannisport site, which were proposed to maximize redundancy. Given the high cost and extended timeframe associated with constructing two separate plants at the site, Kleinfelder was subsequently asked to prepare this evaluation of a single-plant option for comparison with the two-plant scenario.

The Pilot Study Report confirmed the selected process technologies for removing PFAS (granular activated carbon), 1,4-dioxane (UV-AOP) and iron and manganese (greensand filtration) and was approved by MassDEP in February 2022. A single, larger treatment facility changes the treatment basis of design previously prepared, and so this Technical Memorandum provides an updated basis of design as well as an opinion of probable construction cost. Additional consideration for phasing, re-use, and winterization of the existing granular activated carbon system is also presented. These options and approaches will be solidified during the preliminary design phase.

This Memorandum also presents an updated assessment of system-wide firm yield and alternatives analysis. The analysis compares the single-plant and two-plant options on the basis of initial and buildout costs, system capacity and firm yield, timeframe, and cost per gallon of firm yield. **The single-plant option restores the most system capacity, in the shortest amount of time, for the lowest cost. The single-plant is also more favorable for almost every metric both in the near term, and for future buildout.**

The information in this memorandum is organized as follows:

- **Section 1:** Background – Purpose and cross referencing to key information and updates to the Nov 2021 Pilot Study Report.

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- **Section 2:** Design Criteria – For a single-plant, provides flow and process equipment sizing for the selected treatment processes (greensand filtration, granular activated carbon, and UV-AOP).
- **Section 3:** Updated Costs – Provides estimated costs for single-plant and describes updates to the two-plant costs for equitable comparison.
- **Section 4:** Summary Comparison of Single and Two-Plant Options
- **Appendix A:** Single Plant Options - Process & Flow Diagrams and Equipment Layouts
- **Appendix B:** Updated Capital Costs for Two-Plant Option from 2021 report
- **Appendix C:** Demand Projections, System Supply and Firm Yield Analysis

1 BACKGROUND

The purpose of this technical memorandum is to provide an update to the November 2021 "*Pilot Study Report: Straightway and Hyannisport Facilities, Hyannis Water System"* (Pilot Study Report). The update presents a conceptual single-plant alternative that will treat all four wells at the site (Straightway Wells 1 & 2, Hyannisport Well, and Simmons Pond Well) for comparison with the two-plant alternative presented in the 2021 Pilot Study Report. This evaluation uses the same approach and methodology to apply the results of the Pilot Study to update the flow, sizing and design criteria, capital costs, and operation and maintenance costs of a single plant. A system wide demand analysis was also conducted to evaluate and compare the two vs single-plant scenarios.

The following criteria, goals and assumptions are summarized:

- Raw Water Contaminants of Concern – The pilot study collected and established baseline levels of iron, manganese, 1,4-Dioxane (1,4-D) and per and polyfluoroalkyl substances (PFAS). Results are detailed in Section 3 of the Pilot Study Report and are not revisited herein.
  On March 14, 2023, the United States Environmental Protection Agency (EPA) announced a proposed new drinking water regulation for six PFAS compounds. EPA has stated its intention to finalize the rule by the end of 2023, and states would have three years to implement the rule. The regulation would establish enforceable Maximum Contaminant Levels (MCLs) of 4 parts per trillion (ppt) for PFOA and PFOS as individual contaminants, and for four others (PFNA, PFHxS, PFBS and HFPO-DA) as a mixture, limited to 1 ppt. The EPA also issued new non-enforceable MCL Goals (MCLGs) of zero for PFOA and PFOS, which requires the EPA to set MCLs as close as feasible to the MCLG. The MCLs of 4 ppt for PFOA and PFOS are set at the practical quantitation level (PQL), or the lowest concentration that can be reliably achieved by laboratories. **This new proposed regulation does not change the design concept for Straightway.** The piloting results for finished water indicated that all of the proposed regulatory limits would still be met.
- Treatment Goals – These define the necessary removal level of each contaminant of concern and are detailed in Section 3 of the Pilot Study Report (not revisited herein).
- Treatment Technologies – Process details are explained in associated sections of the Pilot Study report, the single-plant alternative presented here utilizes the same processes:
  - Manganese Greensand Filtration (Greensand) for iron and manganese removal

  - Advanced Oxidation Process with ultraviolet light and hydrogen peroxide (UV-AOP) for destruction of 1,4-D
  - Granular Activated Carbon (GAC) for adsorption of PFAS
  -
- Process Flow Diagram and Equipment Layouts – Using the updated design criteria, updated process flow diagrams and equipment layouts are provided in Appendix A.
- Cost Estimates – The larger equipment required to meet the system flows from all four wells required new vendor quotes and was updated. The two plant alternative estimates were also updated to provide a more accurate comparison (Appendix B).
- Operation and Maintenance Costs – The same assumptions used in the Pilot Study were used to develop chemistry, electrical, and other costs for the first year of operation.
- Redundancy Goals – A priority for HWS is to restore as much system capacity as quickly as possible.

2 DESIGN CRITERIA – SINGLE PLANT OPTION

2.1 SUPPLY AND DESIGN FLOWS

Table 2-1 compiles updated well design and performance data. The Hyannis Water System is interested in improving the performance of the Hyannisport and Simmons Pond Wells to achieve production closer to their Approved Daily Pumping rates. As the Pilot Study Report discussed, the Hyannisport and Simmons Pond Wells are recommended for replacement. In order to restore yield as soon as possible, the replacement wells should be designed on a parallel track with the new treatment facility or facilities. More detailed information regarding the well replacement recommendations is presented in Section 9 of the Pilot Study report. The target design flow of 4.03 MGD (2,800 gpm) and design yield for each individual well was used for treatment system sizing calculations.

Table 2-1: Well Yields and Design Flow

		Hyannis Port	Simmons Pond	Straightway No. 1	Straightway No. 2	Totals
Depth	ft	75	74	62	187	---
Diameter	in	24	18	16	24	---
Approved Daily Pumping Rate	MGD	0.720	1.01	0.720	1.584	4.03
	gpm	500	701	500	1,100	2,801
Actual Yield[1]	gpm	423	500	277	437	1,637
	MGD	0.61	0.72	0.40	0.63	2.36
Active Well Production[1]	gpm	200	298	298	0	796
	MGD	0.29	0.43	0.43	--	1.15
Design Yield	MGD	0.72	1.01	0.72	1.58	**4.03**

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[1] As reported by HWS, 2022

2.2 GREENSAND FILTRATION

Greensand filtration is proposed for the removal of iron and manganese. Pretreatment of raw water will be via pre-oxidation with sodium hypochlorite and pH adjustment with sodium hydroxide. Pretreatment chemical dosages and the target pH from the Pilot Study Report were adapted for a single facility as shown in Table 2-2.

Table 2-2: Pretreatment Chemical Dosage, Single Plant

Chemical	Target
Target NaOCl Dose	0.9-3.7 mg/L
Target pH	7.4 s.u.
NaOH Dose	25%

Results from the Pilot Study Report suggest that the lower than typical loading rates between ≈4 and 6 gpm/ft^2 are preferred to achieve treatment goals. A single facility would require five (5) 12-foot diameter filters arranged in parallel and online during normal operations. During backwash operations four filters shall be online and one in backwash/standby. Loading rates under normal operations with all five filters in operation shall be 4.95 gpm/ft^2; and a maximum of 6.19 gpm/ft^2 under backwashing operation. Design criteria for the greensand filters for a single plant facility are detailed in Table 2-3.

Table 2-3: Greensand Pressure Filtration Design Criteria – Single Plant

Parameter	Design Criteria
Design Flow Rate	2,800 gpm
Flow rate per filter (four online, one in backwash)	700 gpm/filter
Filter Vessel Diameter	12 ft
Normal Filter Surface Loading Rate with 5 filters operating	4.95 gpm/ft^2
Maximum Filter Surface Loading Rate with 4 filters operating	6.19 gpm/ft^2
Total Number of Pressure Filters	5
Filter Configuration	Parallel: 4 online, 1 backwash
Total Filter Surface Area	565 ft^2
Media Type and Depths:	
Anthracite	12 inches
Greensand – Inversand GreensandPlus™	24 inches
Gravel	12 inches

Backwash of the Greensand filters will be required periodically to removed precipitated solids from the filters. Typically, it is standard practice to backwash Greensand filters when a 10-psi differential pressure across the filters is observed. The updated backwashing design criteria is specified in Table 2-4.

Table 2-4: Backwash Design Criteria for Greensand Filters, Single Plant

Parameter	Design Criteria
Design Backwash Cycle Frequency	>10 psi headloss
Backwash frequency*	50 hours
Backwash Process Durations Per Contactor	15 minutes
Backwash Cycle Duration (All Five Contactors)	75 minutes
Backwash Rate per Contactor[1]	1,360 gpm
Backwash Loading Rate per Contactor[1]	12 gpm/ft^2
Backwash Volume per Filter	20,400 gallons
Total Backwash Volume (All Five Contactors)	102,000 gallons

* as determined from the Blueleaf Report based upon worst case conditions for STWY 2 well only. Actual backwash frequency may be less as the wells are blended

[1] Backwash filter loading rate recommended by vendor Hungerford and Terry. Alternatives to include air scour will be evaluated in the preliminary design.

A target backwash holding tank volume of 130,000 gallons, located under the treatment plant building will accommodate the volume of all filters plus a 25% contingency volume. This volume is also capable of handling a higher backwash loading rate of up to 15 gpm/ft^2. HWS's goal is to recycle backwash supernatant. However, during piloting, supernatant recycling of backwash water (recycle water) was tested and results indicated that the Straightway wells recycle water negatively impacted filter performance and thus water quality, whereas the Hyannisport and Simmons Ponds recycle water yielded favorable results (no impact). The results merit further evaluation during the detailed design phase to meet HWS' goal to ideally incorporate recycle in a single plant solution. Other additional design considerations for backwash supply, air scour, and holding, will also be developed as part of the detailed design phase. Descriptions of these considerations are noted in Section 9 of the Pilot Study Report.

2.3 UV-AOP

UV-AOP is proposed for the destruction of 1,4-D. The treatment process will include injecting hydrogen peroxide upstream of the reactors. Three (3) Trojan Flex 100 – four bank reactors arranged in parallel, with each capable of treating 50% of the design flow to allow maintenance of one reactor while the other two can treat 100% of the design flow. Design criteria for the UV-AOP system can be seen below in Table 2-5.

Table 2-5: UV-AOP Design Criteria, Single Plant

Parameter	Design Criteria
Design Flow Rate	2,800 gpm
Reactor	Trojan Flex 100
Reactor Quantity/arrangement	3 Trains, Four Banks Each
Lamp Power	500 watts
Lamps per Bank	32
Banks per Train	4
Total Number of Lamps	384
Ballast Power	High (100%)
H_2O_2 Dose	12.8 - 16.9 mg/L
H_2O_2 Storage Tanks	3,000 gallons

[1] H_2O_2 dose should be optimized during operation with preference to minimize H_2O_2 concentration

2.4 GAC CONTACTORS

Granular Activated Carbon (GAC) is proposed for the removal of PFAS. As was discussed in the Pilot Report, the Town has already invested significantly in GAC contactors at other treatment sites, and with two seasonally used trains (four x 10-foot diameter contactors) at the site currently. Therefore, during preliminary design, consideration should be given to prioritize the reuse of the existing equipment where possible and to utilize similar sized contactors. For a single-plant solution, the use of 10-ft diameter contactors was considered, however the number of trains required (6, for 12 total units) was considered to be too costly due to the amount of space required to house them. One of two options presented below will need to be chosen during the preliminary design and will be as follows:

1. Design of a single treatment facility & building to treat all wells that utilizes new 12-foot diameter GAC contactors. The existing seasonal filters would be utilized until the new facility is brought online, and would be reused by relocating them to a future plant upgrade at the Mary Dunn site.
2. Winterization of the existing seasonal GAC contactors with a prefabricated insulated metal building constructed over them (Phase 1) and then adding a new building with additional 10-foot diameter GAC contactors (to match the existing contactor sizes).

In both options, the total flow of 2,800 gpm will be split between the trains with a goal to provide the required 10 minutes of empty bed contact time for PFAS removal, and a total of 20 minutes per train. The lag contactor therefore provides 100% redundancy in the process. The design criteria for the GAC filters of each Option is provided in Table 2-6.

GAC requires backwashing upon initial loading and periodic backwashing if solids loading creates a >10-psi differential pressure. Backwashing GAC requires a lower surface loading rate compared to other heavier medias like greensand. The lighter F400 type GAC media requires a backwashing surface loading rate of 9 gpm/ft^2. With the greensand filtration upstream of the GAC, it is possible that the contactors may only need backwashing once per year and during carbon change outs. GAC Backwash Design criteria is presented below in Table 2-7. Spent GAC backwash water will be discharged to a future onsite holding tank and then the supernatant recycled to the extent feasible or pumped to the unlined lagoon for onsite infiltration.

Table 2-6: GAC Design Criteria

Parameter	Option 1	Option 2
Design Flow Rate (gpm)	2,800	
Flowrate per Contactor (gpm)	934	466
Filter Surface Loading Rate - (per contactor, gpm/ft^2)	8.25	5.94
Contactor Diameter (ft)	12	10
Number of GAC contactors	6 (6 new)	12 (8 new; 4 existing)
Number of Trains (2 Contactors per train)	3	6
Train Contactor Configuration	Lead/Lag	
Empty Bed Contact Time (minutes per train)	21	21
Empty Bed Contact Time (minutes per contactor)	11	11
Media Type	Calgon F400 type	
Total Media Volume (ft^3)	8,000	
Total Media Weight (40,000 lbs/per contactor)	240,000 lbs.	

Table 2-7: GAC Backwash Design Criteria

Parameter	Option 1	Option 2
Design Backwash Cycle Frequency	>10 psi headloss	
Backwash Process Durations Per Contactors (minutes)	15	
Backwash Cycle Duration - minutes (All Contactors)	90	180
Backwash Rate per Contactor (gpm)	1,017	710
Backwash Loading Rate per Contactor (gpm/ft^2)	9	
Total Backwash Volume – gallons (All Contactors)	90,000	128,000

2.5 4-LOG DISINFECTION

As mentioned in Section 9 of the Pilot Study Report, finished water from the new treatment facility will require sufficient contact time (CT) for 4-log inactivation of viruses for Groundwater Rule compliance. In the two-plant alternative a contactor tank or pipe loop was proposed to be built adjacent to the Hyannisport facility. For the purposes of this memorandum, to provide a more conservative cost estimate, a new concrete contactor tank similar in size to the existing tank (400,000 gallons) is proposed near the existing tank. The proposed tank would be arranged in parallel to the existing tank and provide a similar detention time to meet CT requirements with the added flows. Further evaluation of a contact tank or pipe loop will be conducted in the design phase as options to reduce costs.

3 UPDATED COSTS

This section provides revised Opinion of Probable Capital Costs (OPCC) and anticipated operational and maintenance (O&M) costs for the first year of operation. An OPCC for the proposed single treatment facility was developed using the piloting results and design criteria presented herein. The cost estimates were prepared in accordance with the guidelines of the Association for the Advancement of Cost Engineering (AACE) International for the Class 5 Estimate. Given the conceptual level of the evaluation, the engineer's OPCC include contingencies.

It should be noted that material costs have risen steeply in recent years and the construction market has been highly volatile and remains so for the foreseeable future. Availability of labor and materials also contributes to the rise and volatility of the construction project costs. For this reason, we have presented a range of costs using both 25% and 35% contingencies. NOTE: These costs were prepared in October 2022 and should be used for comparative evaluation only and are subject to change.

3.1 CAPITAL COSTS - SINGLE PLANT

The OPCC for the proposed facility (Option 1) is presented in Table 3-1. Updated costs and revisions made from the 2021 Pilot Study Report are detailed as follows:

- Greensand – The higher flow rate of a single-plant (2,800 gpm) required an additional filter and therefore an updated quote from the vendor (Hungerford and Terry). The required backwash holding tank volume is estimated to be 130,000 gallons. Both the backwash holding tank sizing and pricing were updated in the cost estimate.
- UV-AOP – To accommodate the higher flow rates of a single-plant, the manufacturer of the UV-AOP unit (Trojan Technologies) provided an updated budgetary quote that included preliminary O&M costs.
- GAC - To accommodate the higher flow rates of a single-plant, the GAC units were upsized to the Calgon Model 12-40 units which are 12 feet in diameter and hold 40,000 pounds (lbs) of carbon each. The two-plant alternative was based upon 10-foot diameter contactors that hold 20,000 lbs each. The HWS requires the interim GAC units remain operational during the new plant construction. Calgon provided a new quote for the larger equipment.
- Disinfection – A new 400,000-gallon baffled storage tank is included for disinfection to meet CT requirements and the cost was based on vendor quote for a concrete tank.
- Booster Pump Station and Entry point – A new booster station or upgrades to the existing 1,500 gpm booster station will be required to match the throughput and design flow of the plant.

- Well Replacement – Costs to conduct a replacement well investigation and permitting and installation of replacement wells (with new vertical turbine pumps and pumping stations) of both the Hyannisport and Simmons Pond wells. These were unchanged from the Pilot Report.
- Building – The cost was updated to re-size the building to accommodate the new added treatment equipment.

The OPCC for the proposed facility (Option 2 - Phased) is presented in Table 3-2. Many assumptions presented in Option 1 are similar, with key differences presented as follows and reflected in the cost estimate:

- GAC – Re-use the existing GAC contactor units in place by adding an insulated building fabricated around them. Next construct a new treatment building with the four new additional trains with 10-foot diameter contactors (and the other process equipment).
- Disinfection – A new 400,000-gallon baffled storage tank is included for disinfection to meet CT requirements and the cost was based on vendor quote. Preliminary design value engineering will also consider a pipe loop.
- Building – The cost was updated to re-size the proposed building and an additional building for the existing units.

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3.2 Two Plant Option

The two-plant option is presented in Section 9 of the Pilot Report and consists of a Straightway Treatment Facility serving Straightway Wells 1 and 2 with a flowrate of 1,500 gpm, and a Hyannisport Treatment Facility serving the Simmons Pond and Hyannisport Wells with a flowrate of 1,200 gpm. In order to facilitate an equitable comparison, updated vendor quotes for the major equipment (i.e. Greensand filters, UV-AOP reactors, and GAC contactors) were also applied to the two plant alternative costs tables from Pilot Study Report. This is primarily to account for increased costs of raw materials, labor, and supply chain issues seen since the original vendor quotes were obtained in 2020 and 2021. Significant cost increases were observed in the Greensand and GAC units in particular. In addition, vendors stated lead times of approximately 40 weeks.

The treatment facilities featured the following elements, and the updated cost estimate is provided in Appendix B:

Table 3-1: Summary of Two Plant Alternative from Piloting Report

	Straightway Treatment Facility	Hyannisport Treatment Facility
Flow	1,500 gpm	1,200 gpm
Greensand	Four (4) 12' dia filters w/ pretreatment for pH and pre-oxidation Backwash storage and lagoons	Four (4) 10.5' dia filters w/ pretreatment for pH and pre-oxidation Backwash Storage & Recycle
UV-AOP	Three (3) Trojan Flex 100 Reactors with H_2O_2	Three (3) Trojan Flex 100 Reactors with H_2O_2
GAC	Three (3) GAC contactor treatment trains (six total contactors)	Three (3) GAC contactor treatment trains (six total contactors)
4-Log Disinfection	Existing Baffled storage Tank	New Contactor Pipe loop or Baffled tank
Booster Pump Station	Existing Booster Station	New 1,200 gpm Booster Station
Wells		Replacement Wells (Hyannisport & Simmons Pond)
Building	Metal w/holding tank under foundation	Metal w/holding tank under foundation

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Table 3-2: Straightway-Hyannisport 4MGD (2,800 gpm) Facility Opinion of Probable Capital Cost (Option 1 – 12' dia. GAC Contactors)

Item/Description	Quantity	Unit/Basis	Unit Budgetary Cost	Item Budgetary Cost
Hyannisport & Simmons Pond Replacement Wells				
Replacement Wells - Exploratory / Approval Phase	2	LS	$ 125,000	$ 250,000
Installation (new wells, pumps, motors, station) – includes engineering and 20% contingency	**2**	**LS**	$ 1,090,000	$ 2,180,000
Well Replacement Subtotal				**$ 2,430,000**
Straightway and Hyannisport Water Treatment Facility				
Major Equipment & Systems				
Greensand filters (Hungerford Terry quote)	1	LS	$ 1,630,000	$ 1,630,000
Granular Activated Carbon (three trains, 12' dia, Calgon quote)	3	LS	$ 650,000	$ 1,950,000
UV-AOP (Trojan quote)	1	LS	$ 2,545,000	$ 2,545,000
4-log inactivation Storage Tank (400k gal)	1	LF	$ 1,250,000	$ 1,250,000
Process piping #1: Raw water to greensand filter	200	LF	$ 250	$ 50,000
Process piping #2: Greensand to AOP to GAC to storage	150	LF	$ 250	$ 38,000
Process piping #4: New entry point to Straightway	500	LF	$ 250	$ 125,000
Sludge & Supernatant pumps	4	LS	$ 15,000	$ 60,000
Booster Pump station	1	LS	$ 300,000	$ 300,000
Chemical feed systems	3	LS	$ 50,000	$ 150,000
Valves, fittings and accessories - 15%	1	LS	$ -	$ 1,215,000
Subtotal				*$ 9,313,000*
Installation	25%			$ 2,329,000
Major Equipment & Systems Subtotal				***11,642,000***
Unit Price & Other Items				
Concrete Base Slab	595	CY	$ 650	$ 387,000
Concrete Side Walls	94	CY	$ 950	$ 89,000
Excavation, Backfill, compaction, grading, seeding	1012	CY	$ 45	$ 46,000
Unit Price & Other Item Subtotal				***522,000***
Buildings				
Pre-Engineered Metal Building (106 x 86) (w/ Mech, HVAC)	9116	SF	$ 250	$ 2,279,000
Buildings Subtotal				***$ 2,279,000***
Bulk Work Percentage and Other Items				
Site civil	10%			$ 1,445,000
Electrical	18%			$ 2,600,000
Instrumentation & Controls	10%			$ 1,445,000
Yard Piping	5%			$ 730,000
Bulk Work Subtotal				***6,220,000***
Subtotal STRAIGHTWAY AND HYANNISPORT WTF Direct Costs				**$ 20,663,000**
GC Overhead and Profit	20%			$ 4,133,000
Contingency	25%			$ 5,166,000
STRAIGHTWAY AND HYANNISPORT WTF - TOTAL BUDGETARY CONSTRUCTION COST				**$ 29,962,000**
Design, Permitting and Construction Administration	15%			$ 4,495,000
TOTAL STRAIGHTWAY AND HYANNISPORT WTF BUDGETARY CAPITAL COST (25% contingency)				**$ 34,457,000**
TOTAL STRAIGHTWAY AND HYANNISPORT WTF BUDGETARY CAPITAL COST (35% contingency)				**$ 36,833,000**
TOTAL STRAIGHTWAY AND HYANNISPORT BUDGETARY CAPITAL COST- WELLS & WTP (25% contingency)				**$ 36,887,000**
TOTAL STRAIGHTWAY AND HYANNISPORT BUDGETARY CAPITAL COST- WELLS & WTP (35% contingency)				**$ 39,263,000**

Note: prepared Oct 2022. For comparison purposes only and subject to change.

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Table 3-3: Straightway-Hyannisport 4MGD (2,800 gpm) Facility Opinion of Probable Capital Cost (Option 2 – Winterizing of Existing 10' dia. GAC Contactors plus additional)

Item/Description	Quantity	Unit/Basis	Unit Budgetary Cost	Item Budgetary Cost
Hyannisport & Simmons Pond Replacement Wells				
Replacement Wells - Exploratory / Approval Phase	2	LS	$ 125,000	$ 250,000
Installation (new wells, pumps, motors, station) – includes engineering and 20% contingency	**2**	**LS**	$ 1,090,000	$ 2,180,000
Well Replacement Subtotal				**$ 2,430,000**
Straightway and Hyannisport Water Treatment Facility				
Major Equipment & Systems				
Greensand filters (Hungerford Terry quote)	1	LS	$ 1,630,000	$ 1,630,000
Granular Activated Carbon (four new trains, 10' dia, Calgon quote)	4	LS	$ 400,000	$ 1,600,000
UV-AOP (Trojan quote)	1	LS	$ 2,545,000	$ 2,545,000
4-log inactivation Storage Tank (400k gal)	1	LF	$ 1,250,000	$ 1,250,000
Process piping #1: Raw water to greensand filter	200	LF	$ 250	$ 50,000
Process piping #2: Greensand to AOP to GAC to storage	150	LF	$ 250	$ 38,000
Process piping #4: New entry point to Straightway	500	LF	$ 250	$ 125,000
Sludge & Supernatant pumps	4	LS	$ 15,000	$ 60,000
Booster Pump Station	1	LS	$ 300,000	$ 300,000
Chemical feed systems	3	LS	$ 50,000	$ 150,000
Valves, fittings and accessories - 15%	1	LS	$ -	$ 1,163,000
Subtotal				*$ 8,911,000*
Installation	25%			$ 2,228,000
Major Equipment & Systems Subtotal				***11,139,000***
Unit Price & Other Items				
Concrete Base Slab	595	CY	$ 650	$ 387,000
Concrete Side Walls	94	CY	$ 950	$ 89,000
Excavation, Backfill, compaction, grading, seeding	1012	CY	$ 45	$ 46,000
Unit Price & Other Item Subtotal				***522,000***
Buildings				
Pre-Engineered Metal Building (106 x 86) (w/ Mech, HVAC)	9645	SF	$ 250	$ 2,411,250
Buildings Subtotal				***$ 2,411,250***
Bulk Work Percentage and Other Items				
Site civil	10%			$ 1,408,000
Electrical	18%			$ 2,534,000
Instrumentation & Controls	10%			$ 1,408,000
Yard Piping	5%			$ 710,000
Bulk Work Subtotal				***6,060,000***
Subtotal STRAIGHTWAY AND HYANNISPORT WTF Direct Costs				**$ 20,132,000**
GC Overhead and Profit	20%			$ 4,026,000
Contingency	25%			$ 5,033,000
STRAIGHTWAY AND HYANNISPORT WTF - TOTAL BUDGETARY CONSTRUCTION COST				**$ 29,191,000**
Design, Permitting and Construction Administration	15%			$ 4,379,000
TOTAL STRAIGHTWAY AND HYANNISPORT WTF BUDGETARY CAPITAL COST (25% contingency)				**$ 33,570,000**
TOTAL STRAIGHTWAY AND HYANNISPORT WTF BUDGETARY CAPITAL COST (35% contingency)				**$ 35,885,000**
TOTAL STRAIGHTWAY AND HYANNISPORT BUDGETARY CAPITAL COST- WELLS & WTP (25% contingency)				**$ 36,000,000**
TOTAL STRAIGHTWAY AND HYANNISPORT BUDGETARY CAPITAL COST- WELLS & WTP (35% contingency)				**$ 38,315,000**

Note: prepared Oct 2022. For comparison purposes only and subject to change.

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3.3 OPERATIONS AND MAINTENANCE COSTS – SINGLE PLANT

Operations and Maintenance (O&M) costs estimates for the first year of service were updated from the Pilot Study Report using data from the piloting study and design criteria updates. The estimates are detailed along with assumptions used in the estimate below. The O&M costs are presented in Table 3-4.

Power: A $0.165/kWh price was used for all power usage of major equipment such as pumps and HVAC equipment (cost provided by HWS and used same methodology/costs as in the Pilot Study Report).

Chemicals: The Piloting study developed an average daily flow rate based upon the design yield for each facility divided by a factor of 1.5. Summation of these give a new average daily flow for a single facility equal to 2.69 MGD. This was used to calculate chemical usage at the plant.

- NaOCl *(12.5%)* - Assumes a chemical cost of $1.70/gallon. Calculations account for pre-oxidation and disinfection. The wells with an average dose of 2.3 mg/L of active ingredient, at average flow will require 50 lbs/day (active ingredient).
- NaOH (25%) – Assumes a chemical cost of $1.56/gallon. The wells with an average dose of 37.5 mg/L of active ingredient, at average flow will require flow approximately 3,264 lbs/day (of 25% solution).
- H_2O_2 – Assumes a chemical cost for 50% H_2O_2 estimated to be $0.55/lbs. The wells with a maximum dose of 10 mg/L at average flow will use approximately 337 lbs/day (of 50% solution).
- Orthophosphate – Assumes a chemical cost of $13.47/gallon. The treatment facility will target a dosage of 1.5 mg/L. Assuming an average flow rate the treatment facility is estimated to use 32 lbs/day.

UV-AOP: Typical energy usage and lamp replacement costs were provided by the UV-AOP reactor piloting vendor Trojan. Trojan estimates a typical lamp life of 15,000 hours. O&M costs were calculated in the same manner as that in the Pilot Study Report.

GAC: Carbon replacement was estimated using the same methodology and pricing employed in the Pilot Study report (contract pricing provided by HWS). The volume of carbon was updated to reflect the additional pounds needed and assumes replacing five contactors with reactivated carbon and one contactor with virgin carbon to make up any lost during replacement or reactivation.

Residuals removal: Residuals disposal will be primarily for the Fe/Mn settled sludge that will collect in the holding tanks beneath the treatment facility. Removal cost assumes that the holding tank will need to be pumped out on an annual basis.

Table 3-4: Straightway-Hyannisport Single Plant (4MGD) Estimated First Year Operations and Maintenance Cost

Item	Estimated Annual Cost
Electrical[1]	$250,000
Chemicals	
NaOCL	$30,000
NaOH	$180,000
Orthophosphate	$20,000
UV-AOP	
Electricity[1]	$150,000
Lamps	$30,000
H_2O_2	$70,000
GAC Replacement	$200,000
Residuals Removal	$30,000
Total	$960,000

[1]Electrical costs include costs for operating pumps, HVAC, and other major equipment except the UV-AOP generator which is accounted for separately. Labor not included.

4 DISCUSSION AND COMPARISON OF ALTERNATIVES

As was presented in detail in the supply-demand analysis in Appendix C, the HWS needs to restore lost capacity as soon as is feasible. Demand trend updates indicate that earlier projections for 2020 were overly conservative, however, historical MDD has varied significantly, and is difficult to predict year to year. The MDD for 2022 is a new 10-year high; a 14% increase from 2021. HWS supply limitations are driven primarily by water treatment needs, and secondarily by well limitations. Interconnections with other suppliers which could formerly be relied upon are now unavailable as these systems also have sources offline pending installation of PFAS treatment. Newly proposed federal regulations would require treatment for any source with detectable PFAS.

Table 4-1 below summarizes key decision factors for the comparison of the Straightway single and two-plant scenarios. **The single larger plant restores the most system capacity, in the shortest amount of time, for the lowest cost**. Building the single 4MGD plant will give a system capacity of 7.92 MGD which exceeds even the conservative projection 2040 MDD of 6.63. **The single-plant is also more favorable for almost every metric both in the near term, and for future buildout.**

Table 4-1: Summary of Decision Factors and Alternative Comparison, Straightway Site

Decision Factors	Single Plant	Two Plants
Initial Capital Cost*	$36-39M	$50-53M
Estimated Year Online	2026	2029
System Capacity (Phase 1)	7.92	7.78
System Firm Yield (Phase 1)	3.89	5.62
System Firm Yield (Phase 2)	10.79	10.65
$M Per MGD Firm Yield	9.3	9.5
Construction Considerations	Less complex	More complex
Operational Flexibility	Less flexibility	More flexibility
Maintenance Considerations	Less complex	More complex
Other considerations or benefits	Invests less capital in a watershed where future quality is uncertain	

Notes: Most Favorable of the two options shaded in green. See Appendix C for details.
*(OPCC, 2021$; escalated 3.5% annually to midpoint of construction). Costs appropriate for comparison purposes and subject to change.

As discussed in Appendix C, the firm yield metric very conservatively assumes the largest treatment plant offline. However, recent conversations with MassDEP, SERO indicate that a single plant solution would be acceptable. The plants have backup power, and so this scenario could result from a severe lightning strike or fire but is not a high probability event. In addition, redundancy in a new plant includes redundant internal treatment trains, instrumentation, and bypasses of variable frequency drives which will be further detailed in the design phase. These significant infrastructure investment decisions are complex and require a balance of meeting both immediate/near-term needs and long-term goals as cost-effectively as possible. The degree to which the solution(s) satisfy or exceed projected demands (moderate vs conservative calculations) is not an engineering problem, but a policy decision that the Town will need to make. One other long-term consideration is the uncertainty of future watershed impacts and regulations. The Straightway and Hyannisport sites are downstream of the wastewater facility and surrounded by septic systems, while the Mary Dunn and Airport wells are impacted by existing more targeted releases. This indicates that investments for the longer term may be better directed to Mary Dunn area or the New Source being evaluated in the less developed watershed.

APPENDICES

APPENDIX A – SINGLE-PLANT PROCESS AND FLOW DIAGRAM AND EQUIPMENT LAYOUT
APPENDIX B – UPDATED TWO-PLANT CAPITAL COSTS FROM PILOT STUDY REPORT
APPENDIX C – DEMAND PROJECTIONS AND FIRM YIELD ANALYSIS

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APPENDIX A:

SINGLE-PLANT PROCESS AND FLOW DIAGRAM AND EQUIPMENT LAYOUT

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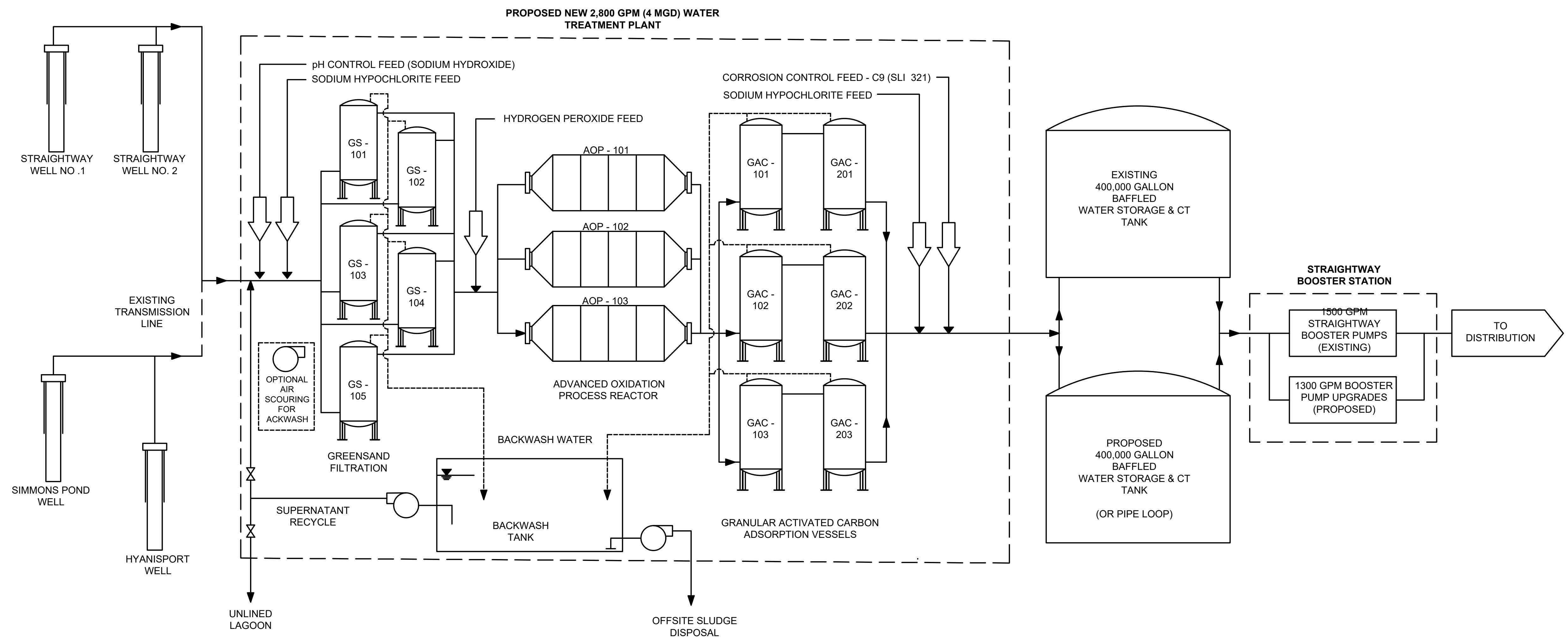

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STRAIGHTWAY AND HYANNISPORT
ALTERNATIVE ANALYSIS
OPTION 1 - SINGLE PLANT ALTERNATIVE

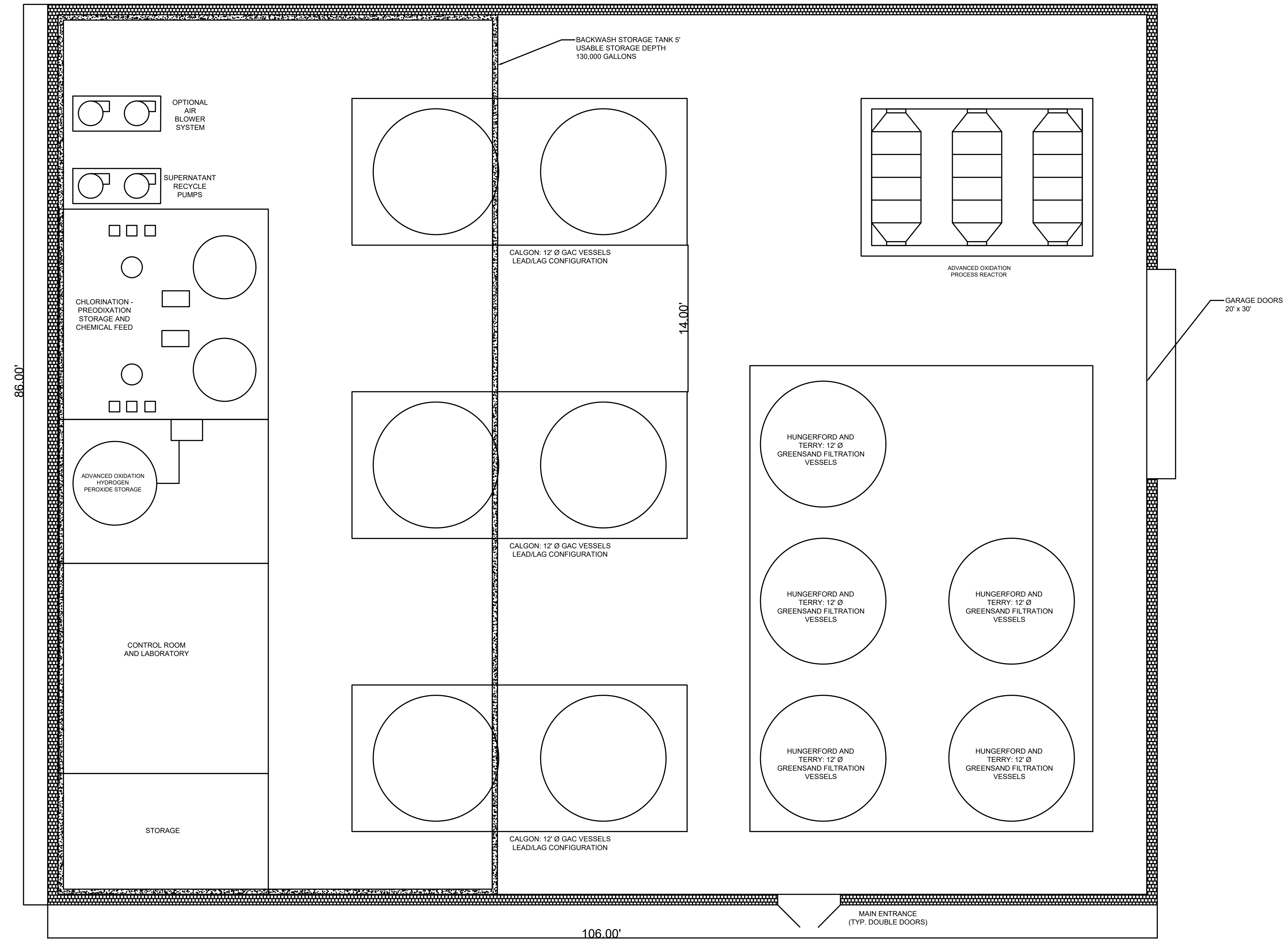
HYANNIS WATER SYSTEM
BARNSTABLE DPW - WATER DIVISION
47 OLD YARMOUTH ROAD
HYANNIS, MA 02601

PROCESS FLOW DIAGRAM

PROJECT NO.	20202245.001A
ISSUE DATE	04/11/2023
CURRENT REVISION	1.0
DESIGNED BY	ABB
DRAWN BY	ABB
CHECKED BY	KR
APPROVED BY	KR

FIGURE 1

SHEET 1 of 5



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STRAIGHTWAY AND HYANNISPORT ALTERNATIVE ANALYSIS
OPTION 1 - SINGLE PLANT ALTERNATIVE

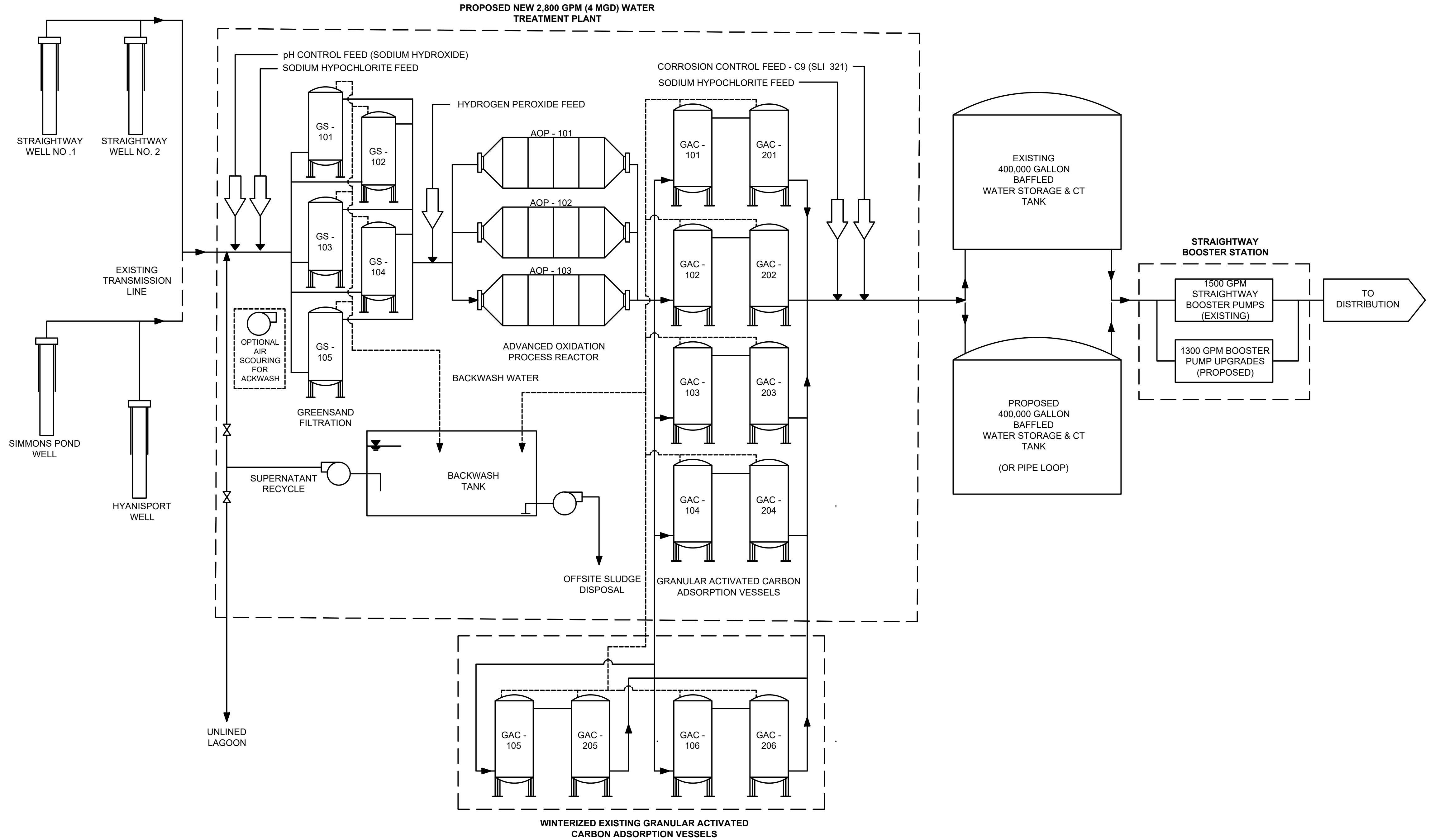
HYANNSI WATER SYSTEM
BARSTABLE DPW - WATER DIVISION
47 OLD YARMOUTH ROAD
HYANNIS, MA 02601

EQUIPMENT LAYOUT

PROJECT NO.	20202245.001A
ISSUE DATE	04/11/2023
CURRENT REVISION	1.0
DESIGNED BY	ABB
DRAWN BY	ABB
CHECKED BY	KR
APPROVED BY	KR

FIGURE 2

SHEET 2 of 5



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STRAIGHTWAY AND HYANNISPORT
ALTERNATIVE ANALYSIS
OPTION 2 - WINTERIZATION OF EXISTING GAC

HYANNIS WATER SYSTEM
BARNSTABLE DPW - WATER DIVISION
47 OLD YARMOUTH ROAD
HYANNIS, MA 02601

PROCESS FLOW DIAGRAM

PROJECT NO.	20202245.001A
ISSUE DATE	04/11/2023
CURRENT REVISION	1.0
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DRAWN BY	ABB
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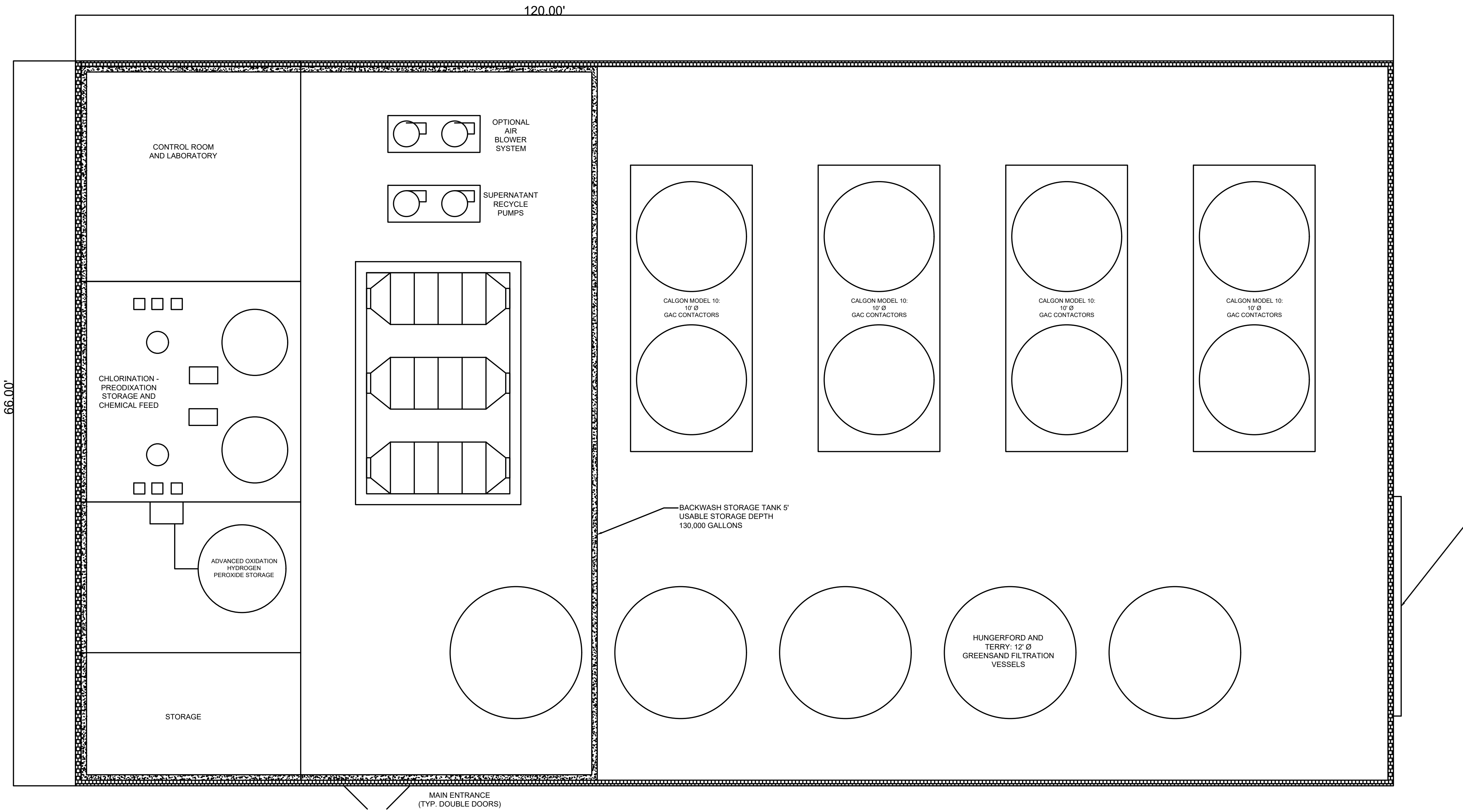
APPROVED BY	KR

FIGURE 3



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STRAIGHTWAY AND HYANNISPORT
ALTERNATIVE ANALYSIS
OPTION 2 - WINTERIZATION OF EXISTING GAC

HYANNSI WATER SYSTEM
BARSTABLE DPW - WATER DIVISION
47 OLD YARMOUTH ROAD
HYANNIS, MA 02601

EQUIPMENT LAYOUT

PROJECT NO.	20202245.001A
ISSUE DATE	04/11/2023
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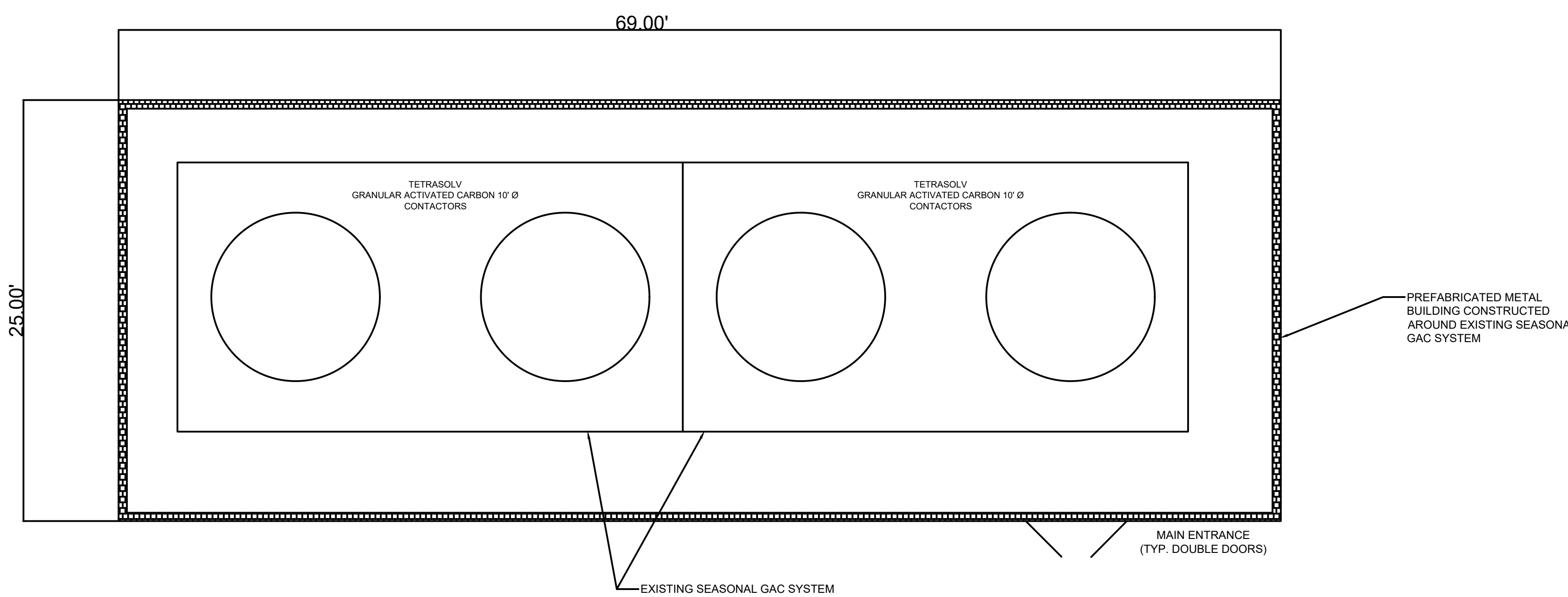
FIGURE 4

SHEET 4 of 5



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STRAIGHTWAY AND HYANNISPORT
ALTERNATIVE ANALYSIS
OPTION 2 - WINTERIZATION OF EXISTING GAC

HYANNSI WATER SYSTEM
BARSTABLE DPW - WATER DIVISION
47 OLD YARMOUTH ROAD
HYANNIS, MA 02601

EQUIPMENT LAYOUT (WINTERIZED EXISTING GAC SYSTEM)

PROJECT NO.	20202245.001A
ISSUE DATE	04/11/2023
CURRENT REVISION	1.0
DESIGNED BY	ABB
DRAWN BY	ABB
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APPROVED BY	KR

FIGURE
5

SHEET 5 of 5

APPENDIX B:

UPDATED CAPITAL COSTS FROM PILOT STUDY REPORT,
2-PLANT OPTION

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Opinion of Probable Capital Costs for Straightway Plant 2.16 MGD (1,500 gpm) [Updated]

Item/Description	Quantity	Unit/Basis	Unit Budgetary Cost	Item Budgetary Cost
Major Equipment & Systems				
Greensand filters (Hungerford Terry quote)	1	LS	$ 1,304,000	$ 1,304,000
Granular Activated Carbon (3 new trains, 10' dia, Calgon quote)	3	LS	$ 400,000	$ 1,200,000
UV-AOP (Trojan quote)	1	LS	$ 2,173,000	$ 2,173,000
Process piping #1: Raw water to greensand filter	100	LF	$ 250	$ 25,000
Process piping #2: Greensand to AOP to GAC to storage	150	LF	$ 250	$ 38,000
Sludge & Supernatant pumps	4	LS	$ 15,000	$ 60,000
Chemical feed systems	3	LS	$ 50,000	$ 150,000
Valves, fittings and accessories - 15%	1	LS	$ -	$ 743,000
Subtotal				*$ 5,693,000*
Installation	25%			$ 1,424,000
Major Equipment & Systems Subtotal				***$ 7,117,000***
Unit Price & Other Items				
Concrete Base Slab - Backwash Tank; Building	503	CY	$ 650	$ 328,000
Concrete Side Walls - Backwash Tank	84	CY	$ 950	$ 81,000
Excavation, Backfill, compaction, grading, seeding	906	CY	$ 45	$ 41,000
Unit Price & Other Item Subtotal				***$ 450,000***
Buildings				
Pre-Engineered Metal Building (102 x 80) (w/ Mech, HVAC)	8160	SF	$ 250	$ 2,040,000
Buildings Subtotal				***$ 2,040,000***
Bulk Work Percentage and Other Items				
Site civil	10%			$ 961,000
Electrical	18%			$ 1,730,000
Instrumentation & Controls	5%			$ 481,000
Yard Piping	2%			$ 200,000
Bulk Work Subtotal				***$ 3,372,000***
Subtotal STWY WTF Direct Costs				**$ 12,979,000**
GC Overhead and Profit	20%			$ 2,596,000
Contingency	25%			$ 3,245,000
TOTAL STWY WTF BUDGETARY CONSTRUCTION COST				**$ 18,820,000**
Design, Permitting and Construction Administration	15%			$ 2,823,000
TOTAL STWY WTF BUDGETARY CAPITAL COST (w/ 25% contingency)				**$21,643,000**
TOTAL STWY WTF BUDGETARY CAPITAL COST (w/ 35% contingency)				**$23,136,000**

Note – The original Pilot Study Report Costs for the Straightway Facility were $19.8M (25% contingency) and $21.2M (35% contingency).

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Opinion of Probable Capital Costs for Hyannisport Plant 1.73MGD (1,200 gpm) [Updated]

Item/Description	Quantity	Unit/Basis	Unit Budgetary Cost	Item Budgetary Cost
Hyannisport & Simmons Pond Replacement Wells				
Replacement Wells - Exploratory / Approval Phase	2	LS	$ 125,000	$ 250,000
Installation (new wells, pumps, motors, station) – includes engineering and 20% contingency	**2**	**LS**	$ 1,090,000	$ 2,180,000
Well Replacement Subtotal				**$ 2,430,000**
Hyannisport Water Treatment Facility				
Major Equipment & Systems				
Greensand filters (Hungerford Terry quote)	1	LS	$ 1,269,227	$ 1,270,000
Granular Activated Carbon (3 new trains, 10' dia, Calgon quote)	3	LS	$ 400,000	$ 1,200,000
UV-AOP (Trojan quote)	1	LS	$ 1,500,000	$ 1,500,000
4-log inactivation contactor (create pipe loop by adding 2500 ft of 12" DI to existing 8" HYPT-STWY transmission)	2500	LF	$ 225	$ 563,000
Process piping #1: Raw water to greensand filter	200	LF	$ 250	$ 50,000
Process piping #2: Greensand to AOP to GAC to storage	150	LF	$ 250	$ 38,000
Process piping #4: New entry point to Straightway	500	LF	$ 250	$ 125,000
Sludge & Supernatant pumps	4	LS	$ 15,000	$ 60,000
Booster Pump Station	1	LS	$ 300,000	$ 300,000
Chemical feed systems	3	LS	$ 50,000	$ 150,000
Valves, fittings and accessories - 15%	1	LS	$ -	$ 789,000
Subtotal				*$ 6,045,000*
Installation	25%			$ 1,512,000
			Major Equipment & Systems Subtotal	***7,557,000***
Unit Price & Other Items				
Concrete Base Slab	468	CY	$ 650	$ 304,000
Concrete Side Walls	80	CY	$ 950	$ 76,000
Excavation, Backfill, compaction, grading, seeding	906	CY	$ 45	$ 41,000
			Unit Price & Other Item Subtotal	***421,000***
Buildings				
Pre-Engineered Metal Building (102 x 80) (w/ Mech, HVAC)	8160	SF	$ 250	$ 2,040,000
			Buildings Subtotal	***$ 2,040,000***
Bulk Work Percentage and Other Items				
Site civil	10%			$ 1,002,000
Electrical	18%			$ 1,804,000
Instrumentation & Controls	10%			$ 1,002,000
Yard Piping	5%			$ 510,000
			Bulk Work Subtotal	***4,318,000***
Subtotal HYPT WTF Direct Costs				**$ 14,336,000**
GC Overhead and Profit	20%			$ 2,867,000
Contingency	25%			$ 3,584,000
HYPT WTF - TOTAL BUDGETARY CONSTRUCTION COST				**$ 20,787,000**
Design, Permitting and Construction Administration	15%			$ 3,119,000
			TOTAL HYPT WTF BUDGETARY CAPITAL COST (25% contingency)	**$ 23,906,000**
			TOTAL HYPT WTF BUDGETARY CAPITAL COST (35% contingency)	**$ 25,555,000**
TOTAL HYANNISPORT BUDGETARY CAPITAL COST- WELLS & WTP (25% contingency)				**$ 26,336,000**
TOTAL HYANNISPORT BUDGETARY CAPITAL COST- WELLS & WTP (35% contingency)				**$ 27,985,000**

Note – The original Pilot Study Report Costs for the Hyannisport facility were $21.5M (25% contingency) and $23M (35% contingency) and including the well replacement

APPENDIX C

DEMAND PROJECTIONS AND FIRM YIELD ANALYSIS

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APPENDIX C: DEMAND PROJECTIONS AND FIRM YIELD ANALYSIS

Hyannis Water System (HWS) system-wide demand trends were updated and reviewed in relation to supply limitations and required and desired redundancy and resiliency goals. A system-wide firm yield analysis was prepared. Alternative system buildout scenarios for the single-plant and two-plant options are compared on the basis of initial and buildout costs, firm yield, timeframe, and cost per gallon of firm yield.

C.1 Demand Projection Updates

The Hyannis Water System (HWS) currently operates eleven active wells to provide water to a seasonally variable population. Historical system demands were gathered compiled from HWS pumping records provided to Kleinfelder (2017-2022) and reported in the "*Weston and Sampson 2019 New Source Alternatives Evaluation Report"* (2010 – 2016). Table C-1 presents the average day demand (ADD), maximum day demand (MDD), and peaking factor (MDD divided by ADD) data. Also provided are maximum values and 3-year and 10-year historic averages.

Table C-1: Historical System-Wide Demand

Year	Average Daily Demand (MGD)	Maximum Daily Demand (MGD)	Peaking Factor (MDD/ADD)	Data Source
2010	2.39	5.09	2.13	Weston and Sampson 2019 New Source Alternatives Evaluation Report
2011	2.21	4.55	2.06	
2012	2.32	4.62	1.99	
2013	2.18	4.89	2.24	
2014	2.32	4.59	1.98	
2015	2.41	~~5.49~~[1]	~~2.28~~[1]	
2016	2.43	4.66	1.92	
2017	2.18	3.79	1.74	Hyannis Water System Pumping Records
2018	2.31	4.61	2.00	
2019	2.23	4.40	1.97	
2020	2.25	4.59	2.04	
2021	2.36	4.66	1.97	
2022	**2.57**	**5.32**	2.07	
3-YR AVG	2.28	4.86	2.03	
10-YR AVG	2.29	4.61	1.99	
Maximum	2.56	5.32	2.24	

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[1] The 2015 result was reported by the HWS to be a recording error and is therefore not considered as the Maximum Daily Demand and is not included in statistical calculations.

As Figure C-1 illustrates below, historical MDD has varied significantly, and is difficult to predict year to year. The MDD for 2022 was a new 10-year high; a 14% increase from 2021. HWS demand projections based on population projections were presented in the 2019 Weston & Sampson New Source Alternatives report. Based on comparison with observed demand, these projections are very conservative. This can be seen in Figure C-1, which shows historical MDD, the 2019 WSE projections, along with Kleinfelder's 2022 adjustment to the 2019 projections based on recent trends. The projections are described in more detail in Table C-2.

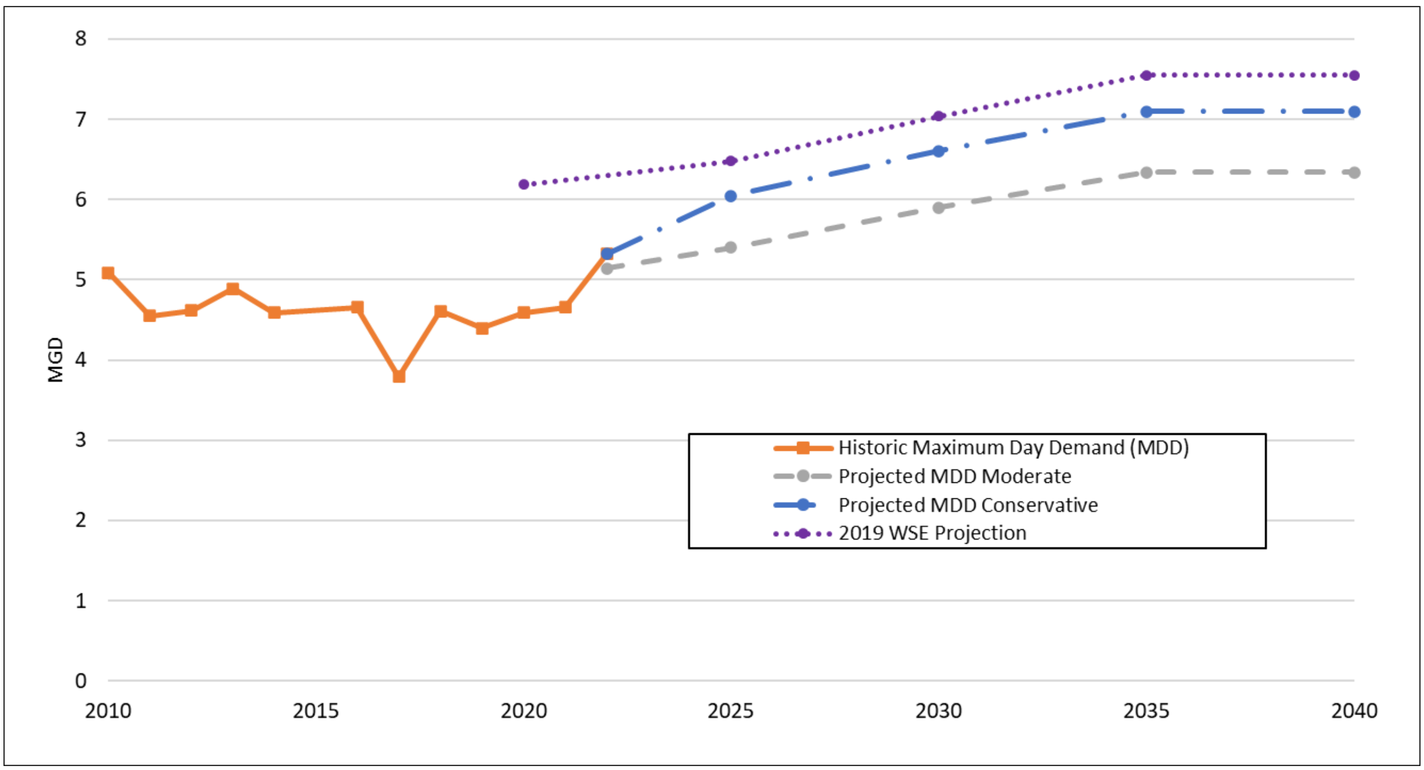

Figure C-1: Historic Maximum Day Demand, 2019 Projection, and Adjusted Projections

Table C-2 presents the 2019 and 2022 adjusted projections which are graphed in Figure C-1. The 2019 Weston & Sampson report projected ADD and then calculated MDD using a worst-case peaking factor (ratio of ADD to MDD) of 2.28, which was the maximum observed (but was later reported as based on an error in the ADD). Kleinfelder adjusted the 2019 WSE Projection by using the same WSE trendline (population projections were not revisited) and adjusting it downward to begin with the observed 2022 MDD. We present both a moderate and conservative projection. The moderate scenario is based on a peaking factor of 2, which is supported by both the 3-year and 10-year average peaking factor. The conservative scenario uses the largest validated peaking factor of 2.24, recorded in 2013.

Table C-2: Projected System Maximum Daily Demands – Historic and Adjusted Projections

2019 Weston & Sampson Projection (2.28 Peaking Factor)		2023 Adjusted Projection (Kleinfelder)[1]		
			Moderate[2] Scenario 2.00 PF	Conservative[3] Scenario 2.24 PF
2020	6.19	2022	5.14	5.32
2025	6.48	2025	5.40	6.05
2030	7.04	2030	5.90	6.61
2035	7.55	2035	6.34	7.10
2040	7.55	2040	6.34	7.10

[1] Updated Projection was based on the water needs forecast trendline from the 2019 Weston & Sampson report but adjusted downward to start with the 2022 Actual MDD

[2] Moderate Scenario based on 2.00 peaking factor, representative of 3-yr and 10-yr average

[3] Conservative Scenario based on 2.24 peaking factor (10-yr max)

C.2 System Supply and Limitations

An inventory of all treatment facilities, their current treatment output (5.04 MGD) and issues causing significant limitations are presented in Table C-3. Table C-3 presents the factors which currently limit production which include wells in need of redevelopment and/or wells with suboptimal water quality which are used only as needed during summer high demand. The HWS's largest single well (Straightway #2, 1.58 MGD) is offline due to water quality limitations. A second well, Mary Dunn 4, is undergoing replacement and is offline.

HWS has interconnections with the adjacent Yarmouth and Centerville-Osterville-Marstons Mills (COMM) water systems. In the past, Yarmouth has provided water to the Hyannis Water System as HWS developed interim and permanent PFAS facilities. However, as recently as Spring 2022, Yarmouth has had to shut down three of its own wells, (with others at risk) due to PFAS levels exceeding the MassDEP PFAS6 MCL. Therefore, Yarmouth is no longer in a position to provide water during high demand season in the near term and may not be for years. COMM also has sources impacted by PFAS contamination and has installed their own treatment facilities. COMM's new PFAS treatment processes may limit their capacity to provide water in non-emergency circumstances. EPA's newly proposed regulations will exacerbate this trend.

HWS was able to meet 2022 summer demand by pumping their remaining sources essentially 24-hours a day, utilizing seasonal GAC systems for PFAS removal (often backwashing frequently due to high iron and/or manganese), and prioritizing well and treatment system maintenance during the winter months. **This table illustrates that the primary limitation on supply is treatment, and a secondary limitation is well production.**

Table C-3: Hyannis Water System's Treatment Facility and Well Production (MGD)

Treatment Facility	Permit Approved Pumping Rate[1]	Current Well Yield for Max Day[2]	Current Booster Station Capacity	Current WTP Finished Water Production[3]	Factors which currently limit production
Maher	3.00	2.23	2.16	2.16	None significantly
Mary Dunn-Airport	4.60	2.73	2.73	1.73	• Airport well: High Fe & PFAS (seasonal removal only) • MD4 offline. Replacement under construction. • Wells in need of redevelopment;
Straightway-Hyannisport	4.02	2.36	2.16	1.15	• STWY-1 offline (PFAS, Mn & 1-4 dioxane exceedance) • Seasonal PFAS removal only • SP & HYPT wells in need of replacement.
Totals	11.62	7.77	7.05	**5.04**	

[1] Sum of source WMA Permit limits.

[2] Current potential yield is summation of individual source max production (provided by HWS Feb 2022). When replaced, well MD4 will add approx. 0.72 MGD to the well yield.

[3] Approximate annual total pumping reported for 2020-21 (adjusted to account for piloting pumpage loss).

Interconnections not included in the above analysis due to PFAS limitations.

C.3 Redundancy and MassDEP Requirements

The Massachusetts Drinking Water regulations requirement in relation to groundwater system redundancy is cited below:

> *"310 CMR 22.21(3): Requirements for all New and Existing Groundwater Sources (a) Sources for Community Systems. Any person who obtains Department approval for a community public water system that relies entirely upon groundwater sources shall provide additional wells, wellfield, or springs and pumping equipment, or the equivalent, capable of producing the same volumes and quality of water as the*

> *system's primary well, wellfield, or spring at all times, or shall provide the storage capacity equivalent to the demand of at least two average days if approved by the Department, unless an interconnection with another public water system has been provided which can adequately provide the quantity and quality of water needed."*

In our experience with similar projects, the term 'source' has been interpreted by other MassDEP regions to refer to an individual well or pump station and not to an entire treatment facility which treats multiple wells. In the past, the MassDEP Southeast Region, however, has indicated that "source" should be interpreted as "treatment facility". Because each HWS facility has backup power and redundant treatment trains, pumps, and wells, this scenario has a low likelihood of occurrence and would require an event such as a severe lightning strike or serious fire. The conservative redundancy interpretation has led to a focus on evaluating multiple, smaller plants (2021 Kleinfelder Pilot Study Report, and 2020 Tata & Howard Mary Dunn Alternatives Study). However, this comes at a significantly increased cost for constructing multiple facilities. As a result of concerns over cost and time to implement, the option for a single-plant deserves further consideration. In addition, in a recent conversation with Kleinfelder, MassDEP SERO indicated they have no objection to a single plant solution at the Straightway site (personal communication, Jim McLaughlin, April 2023).

C.4 Firm Yield Analysis and Alternatives Comparison

Table C-4 provides a tool for HWS to examine different alternatives to construct treatment for restoring system yield. Scenarios are shown as starting in Phase 1 with either a single plant (1-STWY, top half of table) or two-plants (2-STWY, bottom half of table). Alternatives for Phase 2 are added to build out each alternative. For each alternative scenario, the columns provide:

- System capacity and firm yield
- Supply shortfall or surplus for various maximum daily demand metrics
- Estimated time to complete construction
- Phase 1 rough capital cost
- Buildout capital cost (sum of phase 1 and phase 2)
- Cost ($M) per MGD of firm yield

Table C-4 below defines firm yield (FY) conservatively (per prior MassDEP SERO interpretation) as the total system finished water production with the largest treatment facility offline. Scenarios of current MDD and 2040 Projected MDD (both conservative and moderate) are used to calculate if there will be production surpluses or shortfalls under the FY. Mary Dunn – Airport facility scenarios consider either a single-plant (Mary Dunn-AP) or a two-plant option (Mary Dunn North, Mary Dunn South as defined in the Tata & Howard 2020 Report).

A conditional formatting color scale is used for visualizing relative favorability of alternatives. It shows the most favorable alternatives in green and least favorable in red for timeline, capital costs, and $M/MGD.

Phase 1: Comparing the 1-STWY to the 2-STWY Phase 1 options shows that the **1-STWY single larger plant restores the most system capacity, in the shortest amount of time, for the lowest cost**. Building the single 4MGD plant will give a system capacity of 7.92 MGD which exceeds even the conservative projection 2040 MDD of 7.1. The only metric by which the single-plant option is less favorable is the firm yield. However, either 1-STWY or 2-STWY requires a second plant in Phase 2 for firm yield to satisfy demand projections.

Phase 2: Comparing each of the Phase 2 alternatives shows that adding a second single large plant at Mary Dunn-Airport is the fastest and least expensive buildout alternative with the largest system capacity (10.79 MGD). This table can be modified in the future to include the New Source which is undergoing exploration. This source could be developed as an alternative to a large Mary Dunn plant, or an alternative to a second Mary Dunn plant.

In summary, this table shows that selecting the single-plant option at Straightway is favorable against most metrics both in the near term, and for future buildout.

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Table C-4: System Firm Yield and Buildout Analysis of Hyannis Water System Treatment Alternatives

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		Facilities / Scenarios (new facilities shaded blue)	A: WTP Capacity (MGD)	B: System Capacity (MGD)	C: Firm Yield (MGD)	D: Max Day Demands (MDD) – 10-Yr Average 4.61	D: Historic Max 5.32	D: 2040 Moderate Projection 6.34	D: 2040 Conservative Projection 7.1	Estimated Time Horizon	$M Rough Capital Cost* (Phase 1)	Est. Buildout Capital Cost* (Ph1 +Ph2)	$M per MGD of Firm Yield	Notes
ALTERNATIVES		**Existing Conditions:**				E: Supply Shortfall (-) or Surplus				Comparison of Alternatives				
		Maher	**2.16**	5.04	2.88	-1.73	-2.44	-3.46	-4.22					
		Mary Dunn-AP	1.73											
		Straightway/Hypt	1.15											
1 STWY	Phase 1	**Existing Maher, MaryDunn-AP + New 4MGD Single Straightway Plant:**												
		Maher	2.16	7.92	3.89	-0.72	-1.43	-2.45	-3.21	---	36		9.3	Lowest Phase 1 Capital cost and cost per MG for greatest yield in shortest time. Still need another plant for resiliency
		Mary Dunn-AP	1.73							---				
		Straightway (Single Plant)	**4.03**							2026				
	Phase2	**Existing Maher + 1 Straightway 4MGD + 1 Mary Dunn-AP 4.6 MGD:**												
		Maher	2.16	10.79	6.19	1.58	0.87	-0.15	-0.91	---		65	10.4	Lowest buildout cost, cost per MG, and shortest buildout timeframe.
		Straightway (Single Plant)	4.03							2026				
		Mary Dunn-AP	**4.6**							2029				
	Ph2 Alternative	**Existing Maher + 1 Straightway 4MGD + Mary Dunn 2 New Plants;**												
		Maher	2.16	10.79	6.76	2.15	1.44	0.42	-0.34	---		80	11.9	Second lowest buildout cost and cost per MG
		Straightway	**4.03**							2026				
		Mary Dunn North	2.44							2029				
		Mary Dunn South	2.16							2032				
2 STWY	Phase 1	**Existing Maher & Mary Dunn-AP + 2 New Straightway and Hyannisport Plants:**												
		Maher	2.16	7.78	5.62	1.01	0.30	-0.72	-1.48	---	47		9.5	Highest Ph. 1 Capital cost and longer time frame. Still need another plant for resiliency.
		Mary Dunn-AP	1.73							---				
		Straightway	**2.16**							2026				
		Hyannisport	1.73							2029				
	Phase 2	**Existing Maher + 2 new Straightway and Hyannisport Plants + Mary Dunn 2 New Plants:**												
		Maher	2.16	10.65	8.21	3.60	2.89	1.87	1.11	---		102	12.4	Highest Capital cost; second highest cost per MG. Excess Supply; longest timeframe.
		Straightway	2.16							2026				
		Hyannisport	1.73							2029				
		Mary Dunn North	**2.44**							2032				
		Mary Dunn South	2.16							2035				
	Phase 2 Alternative	**Existing Maher + 2 new Straightway/Hyannisport Plants + 1 MaryDunn-AP 4.6 MGD:**												
		Maher	2.16	10.65	6.05	1.44	0.73	-0.29	-1.05	---		85	14.0	Highest cost per MG, second highest buildout cost. Second longest timeframe. Still need another plant for resiliency
		Straightway	2.16							2026				
		Hyannisport	1.73							2029				
		Mary Dunn-AP	**4.60**							2032				

LEGEND

- existing facilities
- added facilities

Relative Alternative Rankings

Most Favorable	1
	2
	3
Least Favorable	4

NOTES:

A: Individual WTP Facility Capacity
B: System Capacity = Sum of Individual Facilities in column A for a given system scenario
C: Firm Yield is calculated for each scenario by subtracting the largest single WTP (bold) from the System Capacity.
D: Max Day Demand (historic and projections) from Tables C1 and C2
E: Supply Shortfall or Surplus = C - D

*Rough Capital Cost Estimates for comparison use include replacement wells, 25% contingency; and 3.5% escalation to year of construction.
Mary Dunn North = Mary Dunn No. 2, 3, and 4 Replacement wells; Mary Dunn South = Mary Dunn No. 1 and Airport Wells.

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