

DRAFT Report of the Lewes BPW WWTF Contingency Planning Committee

Executive Summary

The Lewes BPW is exploring alternatives to address the vulnerability to sea level rise and flood damage of its current wastewater treatment facility (WWTF). The BPW identified three main options:

- Option 1: hardening the existing facility.
- Option 2: building a new facility.
- Option 3: partnering with the county to send Lewes wastewater to an expanded Sussex County WWTF on higher ground at Wolfe Neck.

Following evaluation of the long-range planning report prepared by engineering firm GHD, public comment, site visits, and discussions with Sussex County, the BPW agreed to pursue Option 3 as the primary focus of efforts to address the challenge of sea level rise to future treatment of Lewes' wastewater. The Board is holding Options 1 and 2 in abeyance should they not be able to reach an acceptable agreement with Sussex County.

The WWTF Contingency Committee ("committee") was established to evaluate alternatives and technologies should an Option 3 scenario not come to fruition. This report covers the findings of that committee.

In the time since the GHD report was prepared, several assumptions in the report have been investigated and tested. Some options must be substantially altered to be viable.

- Findings from a Phase I archeological study are expected to significantly increase costs of the County facility (Option 3).
- The technologies evaluated by the committee require less land and have lower operation and maintenance costs than the technologies assumed for Options 1 and 2 in the initial GHD report.

After extensive research and discussion, the committee concluded that the most environmentally protective, sustainable and cost-effective technologies for Option 1 or Option 2 scenarios are the AquaNereda Aerobic Granular Sludge (AGS) process equipment for secondary treatment, and Aqua-Disk Cloth Media Filters and ultraviolet disinfection equipment for tertiary treatment. Capital costs are very roughly estimated at \$20 million for Option 1, \$40 million for Option 2, based on reported costs for recently constructed WWTFs and process design estimates from Aqua-Aerobic Systems, Inc. Operational costs are expected to be substantially lower than those described in the GHD report, based on discussions with operators and engineers at existing US AGS plants.

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I. Purpose

The Board of Directors (“Board”) of the Lewes Board of Public Works (BPW) established the Wastewater Treatment Facility (WWTF) Contingency Committee (“committee”) on July 26, 2023 for the purpose of “researching, reviewing and evaluating proven operational technologies for Option 1: Hardening the Existing WWTP and Option 2: Construction of a New WWTP from the GHD Study”¹ not evaluated in the GHD Study, and providing a final report to the Board by January 31, 2024.

No funding was provided for the committee.

II. Process

The Board appointed the following persons to the committee:

Barbara Curtis: Chair and BPW Board member. M.S. Environmental Science; career in environmental management and policy for international manufacturing companies. Full-time Lewes resident.

Earl Webb: BPW Board VP. B.S. Business; GE Capital - Executive. Full-time Lewes resident.

Austin Calaman: General Manager BPW since 2021, Assistant General Manager for 5 years. B.S. Supply Chain Operations Management.

Daphne Fuentevilla: PhD, Chemical Engineering with a specialty in thermodynamics; Deputy Director of Operational Energy, US Department of the Navy. Adjunct Assistant Professor, University of Maryland in College Park teaching thermodynamics and battery manufacturing. Part-time Lewes resident and BPW customer.

Donna Colton: B.S. Civil Engineering, M.S. Water Resources, Registered Professional Engineer; working with Sussex County Soil Conservation. Full-time Lewes resident.

Mark Prouty: M.S. Environmental Engineering; Professional Engineer (ret.) with a career in water and wastewater treatment plant design and operations. BPW customer.

Sumner Crosby: B.S. Geology, M.S. Environmental and Regional Planning. Background in geographic information systems (GIS). He worked for many years at the U.S. Environmental Protection Agency, and in education at the elementary and secondary level. Full-time Lewes resident.

Bob Heffernan: BS Mechanical Engineering, MBA; president of a company that manufactured very accurate flow meters for chemical, municipal, petroleum and semiconductor, laboratory applications. Current owner of a business manufacturing products for home accessibility. Full-time Lewes resident.

Tim Ritzert: City Council ex-officio: B.S. Political Science; career includes positions in the electric utility and telecommunications industries. Full-time Lewes resident.

¹ Resolution No. 23-006 creating a committee to examine contingency options for the Lewes BPW Wastewater Treatment Plant. Adopted as amended by the Board of Directors of the Lewes Board of Public Works at its meeting on July 26, 2023.

The committee met eleven times between August 21, 2023, and January 23, 2024. Members reviewed materials available online on Sequencing Batch Reactor (“SBR”) and Nereda Aerobic Granular Sludge (“AGS”) wastewater treatment technologies. The committee reviewed materials² provided and attended webinars held by Aqua-Aerobic Systems, Inc. The webinars covered “AquaNereda Installation Performance Update” and “AquaNereda Retrofits and Upgrades”. In addition, the committee meeting on October 23rd was an in-person presentation and Q&A session by Aqua-Aerobic Systems, Inc.

Committee meeting minutes are available on the BPW website and in Appendix 3 to this report.

Other sources of information garnered by a sub-quorum of committee members and discussed at full committee meetings include a tour of the Berlin, MD SBR WWTF; discussions with University of Delaware’s School of Marine Science and Policy professors Dr. Andrew Wozniak and Dr. Bill Ullman; correspondence and discussions with Hans Medlarz, Sussex County Engineer; interviews with and answers to written questions from managers and design engineers for operations at three US AquaNereda plants (Foley, AL; Whitefish, MT; and Wolcott, KS); and correspondence with Aqua-Aerobic Systems representatives.

III. Background

A. Initial Long-Range Planning Assessment and GHD Report

In March 2022, the BPW held the first of several public meetings exploring concepts to address the vulnerability to sea level rise and flood damage of the current WWTF site. To inform the discussion, Sussex County and BPW jointly contracted with engineering firm GHD to develop and evaluate options to provide increased resilience for wastewater treatment within the BPW’s service area up to the year 2050.

The GHD analysis was an engineering study multi-criteria analysis and capital and operating cost assessment covering three main options. Option 1 hardens the existing WWTF with berms and sheet piling and includes upgrades to the current facility. Option 2 replaces the existing facility with a new facility upland. Option 3 leverages a partnership with Sussex County to pump wastewater to a new Sussex County treatment facility located at the Wolfe Neck WWTF site. Both Option 2 and Option 3 would involve decommissioning the Lewes WWTF at a preliminary cost estimated by GHD of ~ \$3.5M.

² AquaNereda Aerobic Granular Sludge Technology: Idaho Springs WWTP – Case Study. Evaluating the main and side effects of high salinity on aerobic granular sludge, M. Pronk et al; Applied Microbiology Biotechnology, Springer-Verlag Berlin Heidelberg 2013. Aerobic Granular Sludge Technology – Start-up; Aqua-Aerobic Systems, Inc. Aerobic Granular Sludge Technology – Robustness & Resiliency. Aqua Service: Programs, Parts and Cost Savings Solutions. Aqua-Aerobics Systems, Inc.: Company Profile and Capabilities. City of Whitefish 2016 Wastewater System Improvements Project; Preliminary Engineering Report. Comparison of Nereda to Other Treatment Systems Royal Haskoning website Q&As.

Options 2 and 3 also included sub-options for the discharge of the treated wastewater. Option 2 assessed discharge of treated wastewater via spray irrigation (option 2a), pumping of treated wastewater back to the existing Lewes WWTP outfall discharge point (option 2b), and development of a new ocean outfall piped through Cape Henlopen State Park (option 2c). Option 3 assessed pumping of treated wastewater back to the existing Lewes outfall pipe (option 3a) and discharge of treated wastewater to a constructed wetland (option 3b).

In order to perform the multi-criteria analysis and develop cost estimates, a design basis was established for the three options under which the quality of treated effluent would meet existing Lewes National Pollutant Discharge Elimination System (NPDES) permit limits: the current membrane bioreactor treatment process for Option 1; and activated sludge treatment with tertiary effluent filtration and UV disinfection for Options 2 and 3. The multi-criteria analysis considered permitting and schedule, community and environmental, and operation and maintenance impacts. GHD made the assumption that moving the outfall to the opposite bank of the canal would not trigger a change in permit limits.

After consideration of the GHD study multi-criteria analysis and cost estimates, testimony at public workshops, and written public comments, Lewes BPW has been pursuing Option 3.

B. Impact of Archaeological Findings

In the summer of 2023, DNREC informed Sussex County of significant findings from a Phase I archaeological study of the Wolfe Neck WWTP and spray irrigation parcel. The impact of the findings will not be fully known until further studies are completed later in 2024. This has created uncertainty for Option 3b (constructed wetlands) as well as for the County's plans to install fixed-head irrigation in managed forests. It is possible that ground disturbance in the open areas surrounding the existing Wolfe Neck treatment plant will be prohibited. Consequently, the County is evaluating a new Option 3c, an ocean outfall from the Wolfe Neck site. This outfall is different from the Option 2c outfall in location, technical risk and cost. The drilling for a 3c outfall pipe could be shorter and less costly than the 2c option and, in contrast to Option 3a, would remove all effluent from the canal.

GHD is preparing a revised report for the 3c option for Sussex County which will include a revised cost estimate. (The study is not revisiting the multi-criteria analysis included in the original engineering assessment.) The results are due in early 2024. A significant cost increase is anticipated.

C. Current Status of WWTF Long-Range Planning for Sea Level Rise and Flood Damage Resilience

Lewes BPW is pursuing Option 3 as the primary focus of long-range planning for Lewes' wastewater treatment. However, the Board is holding Options 1 and 2 in abeyance should the BPW not be able to reach an acceptable agreement with the County from both a cost and control perspective. The WWTF Contingency Committee was established to evaluate

alternatives and technologies not considered in the GHD study for Options 1 and 2. This report covers the findings of the committee.

D. Decision Timelines

Because of funding opportunities, Sussex County and the BPW targeted December 2023 to collectively reach a 'yes' or 'no' decision on Option 3. Funding considerations and uncertainties caused by the archeological study have extended the decision timelines. While the Lewes WWTF site is vulnerable, the timeline of environmental impacts from sea level rise remains undefined.

The WWTF Contingency Committee report was due on January 31, 2024. A draft was delivered to the Board on January 26, 2024. The report was finalized on January 26, 2024. It provides engineering alternatives not contemplated by the original GHD study to assist the Board in its decision-making.

An engineering feasibility study is recommended to obtain site-specific cost estimates for the new Options 1 and 2 contained herein.

Regardless of the BPW decision, it is anticipated that the current Lewes WWTF will remain in operation throughout most or all of this decade. Debt service for the plant is scheduled to be extinguished in 2027.

IV. Criteria for Evaluation of Options 1 and 2

The primary criteria for any WWTF decisions are environmental protection and cost.

Other key criteria include risk vulnerability (e.g., from storm events and sea level rise) and community acceptance. Additional considerations include permit issues, land use and acquisition, difficulty of operating the existing plant, the ability of the BPW to affect future treatment of the town's wastewater and its discharge location, the quantity and quality of the discharged effluent, and the flexibility of the selected site and technology to meet future needs including anticipated new rules (e.g., for per- and polyfluorinated alkyl substances PFAS/PFOS).

The useful life of wastewater treatment equipment is generally (with maintenance) around 30 years. However, equipment replacements and upgrades commonly extend a facility's operation well beyond 30 years, making long-term site sustainability another important consideration.

V. Technology for Wastewater Treatment at the Lewes BPW

The technology selected for wastewater treatment affects the cost, land use requirements, environmental protection/ water quality, risk profile, community acceptance and future flexibility. GHD assessed Options 1 and 2 based on continued use of the current technology for Option 1 and traditional activated sludge technology for Option 2.

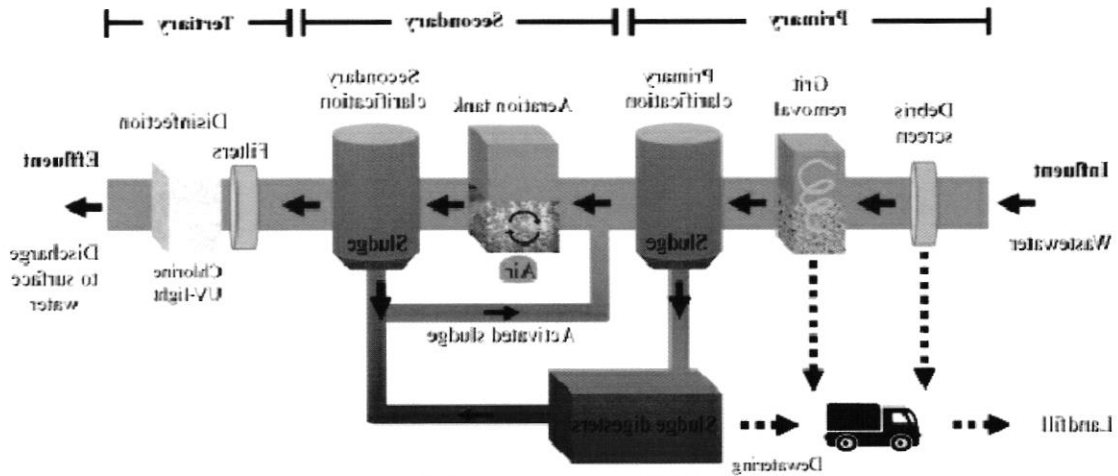
A Primer on Wastewater Treatment:

Wastewater treatment generally consists of three stages: a preliminary/primary stage, secondary treatment, and tertiary polishing. Sludge management (the materials removed in each stage) is also an important component when considering costs.

- Preliminary treatment is the physical removal of large solids and debris through processes like screening and grit removal. "Headworks" physically screen plastics and other debris to protect downstream treatment processes from potential damage or interference caused by larger particles. Primary treatment includes sedimentation of settleable solids from the incoming wastewater.
- Secondary treatment is where the bulk of treatment occurs, breaking down organic matter and removing or segregating pollutants in the wastewater. This is typically an aerobic biological process where microorganisms break down organic matter, and often includes activated sludge systems or other biological treatment methods. Biological treatment is highly effective in improving water quality in this secondary stage. Activated sludge systems rely on compressed air from large blowers to supply the needed oxygen to the microbes. However, some treatment approaches use chemical treatments or physical screening in place of or in addition to biological activity.
- Tertiary treatment processes, including filtration, disinfection, and nutrient removal, improve the quality of the effluent by removing remaining impurities. Water may be further treated for clarity and is ready for discharge at the end of this stage.

Removal of solids during the primary and secondary stages results in additional steps for sludge handling and treatment.

Figure 1: the treatment process in a typical WWTF.³



Most secondary treatment technologies are variations on the activated sludge treatment process illustrated in Figure 2(a) below. The Lewes WWTF currently operates an oxidation ditch (a type of activated sludge process) followed by a membrane bioreactor process similar to the one in Figure 2(b) below. Lewes BPW upgraded to this technology to comply with an EPA administrative order requiring compliance with discharge regulations by 2007⁴.

³ Laura Martín-Pozo, María del Carmen Gómez-Regalado, Alberto Zafra-Gómez, et al. in *Emerging Contaminants in the Environment*, edited by Hemen Sarma, Delfina C. Dominguez and Wen-Yee Lee 2022.

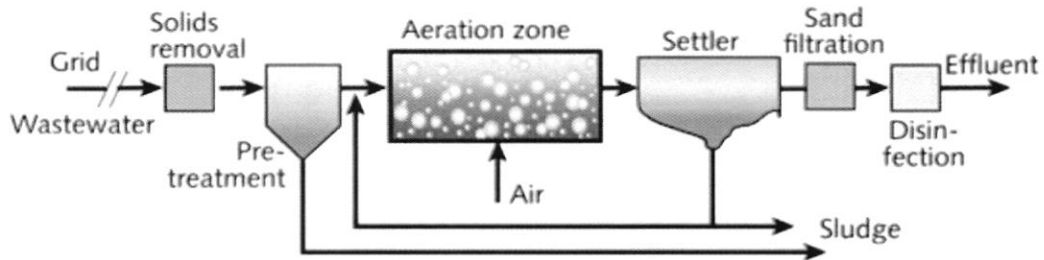
<https://www.sciencedirect.com/topics/earth-and-planetary-sciences/waste-water-treatment-plant>

⁴

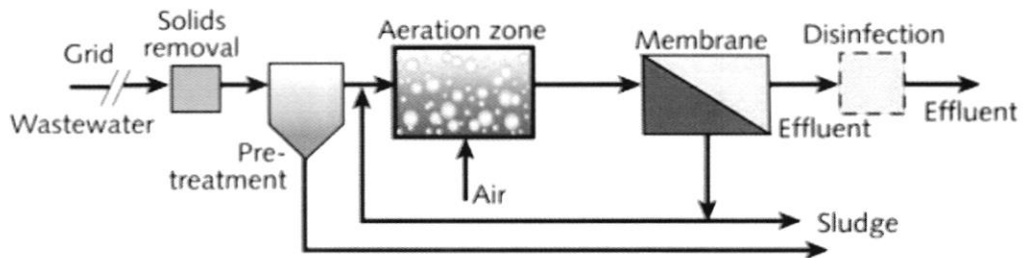
https://www.epa.gov/archive/epapages/newsroom_archive/newsreleases/ae35bec1e3fb7bd6852570d60070ff56.html

Figures 2(a) and 2(b)

(a) Activated Sludge Treatment (AST) Process



(b) Membrane Bioreactor (MBR) process



Existing Discharge Locations and NPDES Permit Limits for Treated Effluent from Lewes' and Sussex County's Wolfe Neck WWTFs

The NPDES permit for Lewes specifies discharge into the Lewes-Rehoboth canal. The facility is designed for an average flow rate of 1.50 million gallons per day (mgd), with a maximum monthly flow of 2.25 mgd, a peak hourly flow of 4.40 mgd and a maximum daily flow of 1.80 mgd.

The Lewes and Wolfe Neck NPDES effluent permit limitations are shown below, as both load and concentration numbers. Lewes for discharge to the canal; Wolfe for discharge via spray irrigation on the adjacent 306 acres.

Table 1

Parameter	Lewes Permit Limits	Wolfe Neck Permit Limits
Flow (mgd)	1.5	3.1
pH (standard units)	6-9	5.9-9
Enterococcus (average, cfu/100 mL)	10	-
Fecal Coliform (average col/100 mL)	-	200
BOD5 (average, lbs/day)	188	-
BOD5 (average, mg/L)	15	50
Total Suspended Solids (average, lbs/day)	188	-
Total Suspended Solids (average, mg/L)	15	90
Total Nitrogen (average, lbs/day)	100	
Total Nitrogen to fields (lbs/acre/day)	-	396
Total Nitrogen (average, mg/L)	8	-
Phosphorus, Total (average, lbs/day)	25	-
Phosphorus, Total (average, mg/L)	2	-
Sodium (average annual mg/L)	-	<250
Chloride (average annual mg/L)	-	<210

Note that with the exception of a bypass event in 2019, Lewes' effluent discharge has consistently been well within (i.e., lower than maximum) permit limits.

VI. Technology Considerations

The committee evaluated several wastewater treatment technologies not considered in the GHD study. Newer technologies can reduce the footprint required for a WWTF and reduce labor, operations and maintenance costs. This would affect the costs of both Options 1 and 2. The committee also considered the implications and feasibility of discharging treated effluent to the existing Lewes-Rehoboth canal outfall, i.e., to the canal but from the opposite bank, adjacent wetlands, Delaware Bay, and nearby uplands. The latter three locations were topics of discussion with professors from the UD School of Marine Science.⁵

Sequencing Batch Reactors (SBR)⁶:

The SBR process is a fill-and-draw activated sludge system: wastewater is added to a single "batch" reactor, treated to remove the undesirable components, then discharged. Equalization, aeration and clarification are all achieved in a single reactor.

Advantages: SBRs operate in cycles, allowing for flexibility in treatment phases. SBRs can offer improved nutrient removal, energy efficiency, reduced chemical usage, reduced capital cost and

⁵ Dr. William Ullman and Dr. Andrew Wozniak.

⁶ Wastewater Technology Fact Sheet; Sequencing Batch Reactors. US EPA, September 1999.

footprint because there is no need for clarifiers or lagoons, and adaptability to varying influent characteristics.

A delegation of committee members toured the Berlin, MD SBR WWTF that was constructed on the site of an existing operating plant. The delegation was impressed with its compactness, appearance, and efficiency. Although located near a stream that had previously been the discharge point for treated effluent, the governing authority chose to discharge its treated effluent via sprinkler irrigation onto forested lands miles from the site. Although the nearest residential area is about 75 yards away, odor complaints are infrequent. For context, Berlin accepts discharge of septage from private haulers.

At the committee's request, an SBR process design report was prepared by Aqua-Aerobic System, Inc. for Lewes. See Appendix 6.

Considerations: SBRs require more computerized/automated control systems than standard continuous flow activated sludge systems, and their cyclic operation results in intermittent discharge that requires effluent equalization prior to filtration.

Constructed Wetlands:

Advantages: Natural treatment systems like constructed wetlands use vegetation and microorganisms to treat - or further treat - wastewater. They offer a sustainable, low-energy solution with benefits for nutrient removal, may return of water to the aquifer, and encourage habitat creation.

The committee considered discharge of treated effluent from the current site into adjacent wetlands but rejected it when advised that the salinity mismatch would have a negative impact on the type of vegetation supported by the wetlands. Also considered was discharge into nearby uplands and forested areas via fixed-head sprinklers. Note that this latter approach is the treatment and discharge process favored by Sussex County under Option 3b at the Wolfe Neck site (prior to the "hold" caused by the archeological findings).

Considerations: Constructed wetlands have larger footprints, and their effectiveness can be influenced by climate conditions, depth to groundwater and vegetation maintenance.

Tertiary Filtration Technologies:

Advantages: Tertiary treatment options, such as disk filters or cloth media filters, enhance the removal of fine particles, improving effluent quality.

The existing Lewes WWTF provides ultrafiltration as part of the MBR process. Other secondary treatment processes considered by the committee, i.e., sequencing batch reactor (SBR) and aerobic granular sludge (AGS), would require tertiary filtration to achieve comparable water quality.

Considerations: Tertiary filtration adds to operational costs and maintenance requirements. However, both the preliminary treatment system (“headworks”) and the components of the effluent filtration system would be substantially less intricate, labor intensive and costly using cloth media filtration instead of membrane ultrafiltration.

Distributed or Decentralized Systems:

Advantages: Decentralized systems, such as modular treatment units or package plants, can offer flexibility, reduced infrastructure costs, and resilience against system failures.

The committee considered but rejected:

- splitting treatment components onto separate sites to leverage the upcoming headworks rebuild and other improvements anticipated over the next few years; and
- proposing two Lewes WWTFs – the existing WWTF altered such that it would continue to serve the beach side of town until the frequency of sunny day flooding events induced residential retreat from the beach, and a second facility serving the town side. It was the consensus of the committee that retreat from the beach may not occur and should not be a factor in decision-making.

Considerations: Maintenance and monitoring of decentralized systems would require additional manpower, coordination, and expertise.

Aerobic Granular Sludge (“AGS”): Nereda Technology

The Nereda process is a newer type of sequencing batch reactor in which durable granules composed entirely of biomass perform both nitrification and denitrification while biologically reducing phosphorus to low levels without chemical addition. The Nereda process has been used in wastewater treatment plants globally since the early 2000s and in the US since 2018, demonstrating a track record for sustainable wastewater management.

Advantages: The process eliminates the need for secondary clarifiers; it has a smaller footprint, reduced energy consumption, reduced labor needs and reduced chemical usage compared to activated sludge systems and other sequencing batch reactors.

At the committee’s request, a process design report was prepared by Aqua-Aerobic Systems, Inc. for the existing Lewes site. See Appendix 4.

Considerations: Tertiary filtration would be needed to achieve the desired effluent quality. The technology employs more complex control systems than traditional activated sludge processes. These control systems reduce everyday manpower needs for system operations but require periodic specialized maintenance.

Following extensive due diligence, the committee reached consensus that the AGS process is the preferred secondary treatment technology for both Option 1 and Option 2.

SBR was a close second option because it is a better-known technology that meets many of the criteria considered by the committee. The chart below shows data for the current treatment system, an SBR system and an AGS system.⁷ Although equipment costs for AGS are higher than for SBR, cost savings in size /construction of tanks more than make up for the equipment cost differential.

Table 2

TECHNOLOGY COMPARISON			
	CURRENT	SBR	AGS (NEREDA)
DESIGN INFLUENT FLOW (average)	1.5 MGD	2.1 MGD	2.1 MGD
HEADWORKS SCREENING	5 mm & 2 mm	6 mm (1/4")	6 mm (1/4")
SECONDARY TREATMENT TECHNOLOGY	Oxidation Ditches	Sequencing Batch Reactor	Aerobic Granular Sludge (Nereda)
EQUIPMENT COST (excluding tanks)	existing	\$1,833,630	\$2,822,460
TREATMENT TANK/BASIN GALLONS	426,000 (408,000 per GHD report)	1,206,000	420,000
HYDRAULIC RETENTION TIME	0.34 DAYS	1.09 DAYS	0.40 DAYS
SECONDARY TREATMENT POWER USE/DAY	?	2650 kWhr @ 0.112 = \$296.80	690 kWhr @ 0.112 = \$77.28
TERTIARY TREATMENT	MBR	Aqua-Disk	Aqua-Disk
SIZE expressed as GALLONS	92,000	7555*	7555*
POWER USE/DAY	?	20.7 kWhr	20.7 kWhr
EQUIPMENT COST	existing	\$482,740	\$482,740
DISINFECTION	UV	UV	UV
CHEMICALS COST/ DAY	\$967	?	\$220
TOTAL POWER USE/DAY	6538 kWhr @ 0.112 = \$732.26	6903 kWhr @ 0.112 = \$773.14	**1176 kWhr @ 0.112 = \$131.71
OPERATORS/ DAY (average)	***6	***4	***2
<p>* Aqua-Disk equipment is 11' x 8' x 12' high with a volume of 3,058 gallons - size converted to gallons to allow footprint comparison</p> <p>** Excludes headworks, UV disinfection and digestors; AGS technology is reported to reduce energy use by up to 50%</p> <p>*** Does not include maintenance staff</p> <p>Power costs: RTS, Demand, KWH and PCA were averaged to a single KWH cost using the December 2023 bill</p>			

Next is a brief comparison of Nereda/AGS, activated sludge and membrane bioreactor technologies under criteria applicable to Options 1 and 2. Activated sludge is included in this comparison because it is the technology selected for Option 2 in the GHD study. Membrane bioreactor is included because it is the technology in current use. AGS is included because it is

⁷ SBR data is from two sources: the 2017 City of Whitefish, MT predesign and equipment power summary (original plan for an SBR changed to AGS for improved cost, sustainability and footprint); and the AquaNereda SBR Process Design Report for Lewes. AGS data is also from two sources: the Aqua Nereda AGS Design Report for Lewes; and the Wolcott, KS AGS facility documents and interviews. Wolcott startup was January 2022.

the most sustainable, lowest cost, smallest footprint sequencing batch reactor /SBR process evaluated.⁸ To a limited extent the AGS evaluation applies to all SBRs.

Cost:

AGS Technology: Is cost-effective due to its compact design and reduced energy consumption. It requires lower capital and has significantly lower operational costs compared to membrane bioreactors (MBRs).

Capital cost for construction of a 2 mgd plant in Wolcott, Kansas in 2020-21 was \$35M; annual O&M budget for 2024 is \$300K, excluding sludge disposal.

Activated Sludge: Generally, have moderate capital costs but may incur higher operational expenses from their larger footprint and energy requirements. The larger footprint also affects land acquisition costs.

Capital cost estimate for Option 2b (new site, discharge to same outfall, new force main, decommission the WWTF) in the 2022 GHD report was \$91M; annual O&M was \$1M.

Membrane Bioreactors: Have higher capital costs attributed to the membrane technology. They require intensive maintenance and regular replacement, resulting in increased operational expenses.

In the GHD study, an earthen berm, sheet piling, and access ramp would need to be built around the site to continue with this technology, at substantial cost. This would not be needed to protect the AGS process. Annual O&M cost estimate for GHD Option 1 was \$2M.

Land Use:

AGS Technology: Allows for a smaller footprint, making it advantageous for sites with limited space.

The treatment complex for an AGS plant with average flow of 2 mgd in Wolcott, Kansas is 90' x 250' including headworks, AGS, sludge buffer tanks, water level correction tank, tertiary filter, rotary drum thickeners, chemical addition and miscellaneous pumping (i.e., around 0.5 acres). Adding an office building, lab, maintenance areas, storage, roads and parking, the size of a site to meet Lewes' future flow (1.75 mgd) is estimated to be 2-3 acres.

Activated Sludge: Usually requires more land due to the larger tank volumes and need for secondary clarifiers.

GHD estimated Option 2b – activated sludge treatment with effluent discharge to the canal – would require 20 acres.

Membrane Bioreactors: MBRs are compact but may necessitate additional space for membrane modules and aeration tanks, leading to a larger footprint compared to AGS.

⁸ Parkson Company, a competitor to Aqua-Aerobic Systems in the water treatment space, now offers their own patented AGS technology. See <https://www.parkson.com/products/granite-ags>