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 materials[2] 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.

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[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.

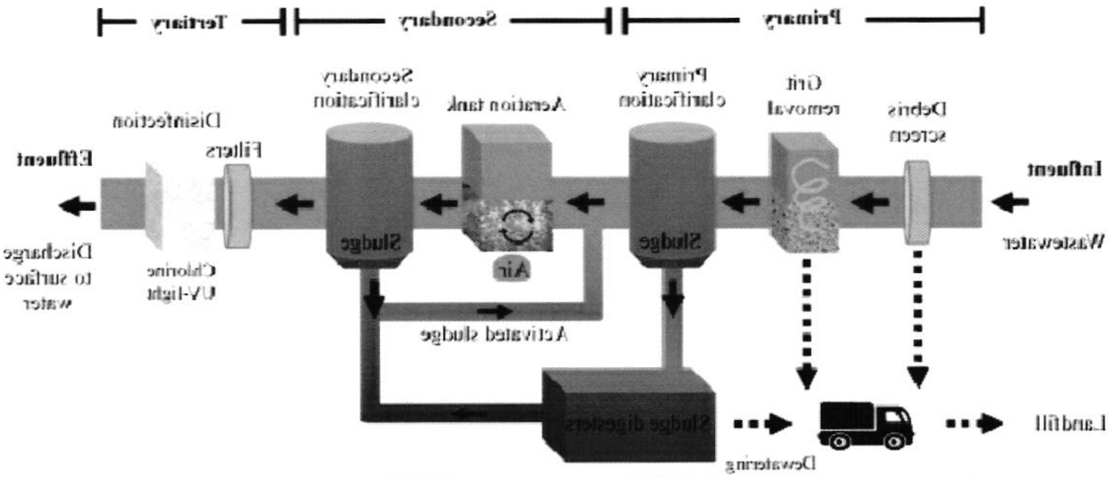
- Preliminary treatment is the physical removal of large solids and debris through processes like screening and grit removal. "Headworks" physically screen plastics and other debris to protect downstream treatment processes from potential damage or interference caused by larger particles. Primary treatment 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]

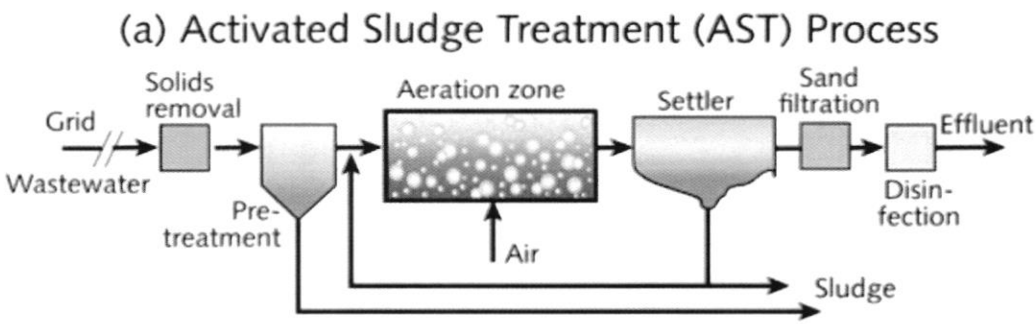


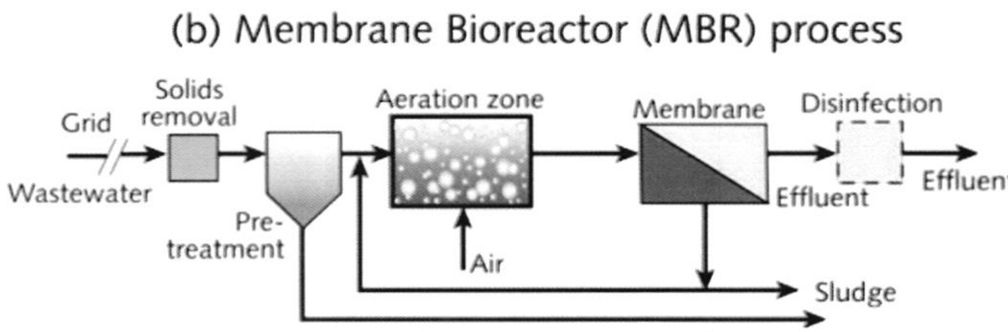
Most secondary treatment technologies are variations on the activated sludge treatment process illustrated in Figure 2(a) below. The Lewes WWTF currently operates an oxidation ditch (a type of activated sludge process) followed by a membrane bioreactor process similar to the one in Figure 2(b) below. Lewes BPW upgraded to this technology to comply with an EPA administrative order requiring compliance with discharge regulations by 2007[4].

[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)





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]

<u>Sequencing Batch Reactors (SBR)[6]:</u>

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 TREAMENT	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

* 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
** Excludes headworks, UV disinfection and digestors; AGS technology is reported to reduce energy use by up to 50%
*** Does not include maintenance staff
Power costs: RTS, Demand, KWH and PCA were averaged to a single KWH cost using the December 2023 bill

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.

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[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

Water Use:
AGS Technology: Generally, exhibits efficient water use, with minimal requirements for backwashing or dilution.

Activated Sludge: May need more water for backwashing and sludge wasting, impacting overall water efficiency.

Membrane Bioreactors: MBRs are water-intensive due to the frequent need for membrane cleaning, leading to increased water consumption.

Reliability:
AGS Technology: Is known for its operational reliability, attributed to the robust nature of aerobic granules that are less affected by shock loads and other disturbances.

Activated Sludge: Can be sensitive to shock loads and variations in influent characteristics, potentially affecting reliability.

Membrane Bioreactors: Experience reliability challenges due to fouling issues, demanding frequent maintenance and membrane replacements.

Environmental Impact:
AGS Technology: Considered environmentally friendly with lower energy and reduced chemical requirements (50-80% lower), contributing to a smaller carbon footprint.

Activated Sludge: Requires more energy and chemicals, affecting its environmental sustainability.

Membrane Bioreactors: Have a higher environmental impact due to the energy-intensive membrane aeration and cleaning processes, although the quality of the effluent produced is excellent.

Ability to Meet Water Quality Standards:
AGS Technology: Effective in meeting stringent water quality standards, due to its nutrient removal capabilities and consistent treatment performance. Tertiary filtration can be added to enhance effluent quality.

Activated Sludge: Can achieve desired water quality standards, but sensitivity to fluctuations may require additional operational adjustments. Tertiary filtration was anticipated in the GHD study for Option 2b.

Membrane Bioreactors: Excel in producing high-quality effluent, meeting strict water quality standards with efficient solids removal through membrane filtration.

In summary, AGS technology stands out as the cost-effective, space-efficient, and environmentally friendly option, offering reliable performance with the ability to meet stringent water quality standards. Activated sludge and membrane bioreactors, while effective in their own right, are labor-intensive and pose challenges in terms of land and/or energy use, water consumption, and environmental impact.

VII. Option 1

After evaluating Option 1 – hardening the existing site to reduce vulnerability to sea level rise and storm event flooding – the committee concluded:

- Because of its small footprint, infrastructure for the AGS system could be constructed on site without adversely affecting the functioning and safety of existing operations. There is more than enough open space in the drying beds area (no longer in use). Alternatively, the system could be sited east of the oxidation ditches or west of the EQ tank.
- Elevating structures is recommended as more cost-effective and less unsightly than installing a sea wall around the perimeter: tanks for AGS technology are 20-24' high. After installing partially below grade, tank heights would likely be at least 18' above grade, higher than the 12' elevation the BPW Mitigation Committee recommends for critical equipment.
- Platforms could be constructed on top of the new tanks to house blowers and other equipment.
- Excavated soils from installation of the AGS tanks (~ 3,000 cubic yards) could be used to elevate the area for office and other buildings if that is more cost-effective than elevating buildings on pilings.
- A sludge dewatering press could be installed if the County is no longer willing or able to take sludge directly from the digester. Cost of a belt filter press is estimated at around $500K. If a new building is needed (e.g., if a filter press won't fit in the building currently housing the MBRs or elsewhere on the site), that would add to the cost.
- UV disinfection and discharge piping could possibly remain where they are.
- Tertiary filtration (Aqua-Disks) should fit either inside the MBR building or near the AGS basins.
- The oxidation ditch could be repurposed as a shunt tank for unacceptable influent flow (e.g., significant saltwater intrusion) by slightly raising the height of the walls to withstand flood conditions.
- The digester building could be dry floodproofed and pumps/blowers/controls elevated.
- Headworks operations / equipment might be staged on upper floors within the existing building, above the base flood elevation. Alternatively, a new headworks could be built onto the AquaNereda equipment and tanks. Space requirements for the headworks would be smaller; screening would be 6 mm instead of 5 mm and no 2 mm screen would be needed. An engineering study would determine the best location.

- Access via American Legion Road should be possible during low tide for many years of flooding events. If/when not possible, options include:
    - Temporarily shutting down the plant during city-wide evacuation (as many WWTF emergency plans envisage)
    - Temporarily accessing via ATV or boat
    - Accessing via Freeman Highway and the hiking trail off Freeman leading to the site. The trail could be widened for vehicular access during flooding (hikers and bikers would be evacuated so would not be at risk). A higher elevation ramp from the highway could be constructed at a future date if needed.
- Costs for system and site improvements are anticipated to be significantly lower ($20M ±) under Option 1 versus Option 2. Some equipment and structures can be repurposed. Demolition costs would be minimal.
- No environmental impact study would be required if discharge is via the same outfall.[9]
- Engineers are capable of designing flood-resistant sites and structures, all but eliminating vulnerability from sea level rise and storm inundation.
- Because the WWTF is already part of the community, there is a greater likelihood of community acceptance for this option.

We recommend Lewes BPW retain an engineering firm familiar with AGS technology to develop a preliminary layout and cost estimate.

VIII. Option 2

The GHD study virtually eliminated the lowest cost Option 2 (2b - greenfield site near Lewes with discharge to the canal), primarily because there is no 20+ acre suitable undeveloped site within the city. Infrastructure costs (piping and pumping stations to transport wastewater to and from a distant site), delays for easement acquisition, difficulties and delays coordinating with DelDOT, cost and outcome of environmental impact studies and permit negotiations for a new outfall location, and other difficulties combined to make this an infeasible option.

However, advantages of Option 2b include the ability to control the quantity and quality of our effluent, and a reduction in vulnerability to sea level rise and storm surges by building at a higher elevation site. Open is the question of community acceptance of an alternate site.

The GHD estimated capital cost was $91M for Option 2b. In contrast, new (2018-2021) AGS WWTFs of comparable size have seen capital costs in the range of $35M. Instead of GHD's estimated annual O&M costs of $1M for Option 2b, AGS WWTFs are experiencing annual O&M costs in the $300K range.

GHD estimated the cost for a 20-acre site near Lewes at $1M, although no site was identified.

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[9] As stated earlier, the committee considered but rejected discharge into the adjacent wetlands. Discharge to uplands was not ruled out (and is desirable), but costs and feasibility were not considered by the committee.

Finding a technology that would provide effluent quality equivalent to that currently achieved but in a significantly reduced footprint – 2-3 acres – was a game changer. The committee identified three sites within the city:

Map 1: Possible sites for WWTF

Site labeled "A"

Current site and adjacent wetlands – all within the floodplain; described under Option 1.

Map 2: Lewes flood hazard areas (light blue)

text

Delaware Flood Planning Tool

Point Text

Effective Flood Hazard Areas
- A
- AE
- AE, Floodway
- AO
- VE
- X, 0.2 Pct. Annual Chance Flood Hazard
- Base Flood Elevation
- LiMWA
- Cross Sections
- Transect
- LOMA
- LOMR

Preliminary Flood Hazard
- A
- AE
- AE, Floodway
- X, 0.2 Pct. Annual Chance Flood Hazard

Contours
- Index
- Depression
- Hidden
- Interval

DNREC Building Line
- No Build Line

0 1,250 2,500 5,000 ft

State of Delaware, Department of Natural Resources and Environmental Control

January 10, 2024

Map 3: Lewes Zoning Map with city boundaries and zoning for Areas A, B, C and D

Site Labeled "B"

Land adjacent to Freeman Highway owned by DNREC and within city limits. Delaware Flood Map insert Map 2 above shows the portion of site B – significantly more than 3 acres – outside the 500-year floodplain (i.e., areas showing vegetation colors instead of blue shading). Possibly swap land with DNREC for the decommissioned existing WWTF site, or lease 3± acres in an agreement similar to the lease Sussex County holds for the Wolfe Neck land. Further investigation would be required to find the highest elevation area. Some buildup of land elevation may be beneficial to reduce future flood vulnerability, given the uncertain science of sea level rise and climate change predictions. Note that the Wolcott Kansas WWTF was constructed in a floodplain at a cost of $35M including earthwork to stabilize the site and elevate it by 17 feet.

Advantages

a. no nearby homes and partially forested area, increasing the likelihood of community acceptance
b. short run for additional piping from the current collection and discharge system, and limited need for additional pump stations
c. possible continued use of current discharge pipe, eliminating need for environmental impact study ("EIS")
d. land acquisition cost not an issue

e. closer to Cape Henlopen Park who has expressed interest in connecting to the BPW WWTF
f. possible use of surrounding area to discharge some or all of the treated effluent via fixed head sprinklers, recharging the groundwater table, reducing land subsidence, and inhibiting saltwater intrusion.

Disadvantages

a. may require raising the site elevation for maximum risk reduction, increasing cost and visibility
b. site currently zoned "open space"; code change or variance needed
c. requires DNREC acceptance / approval
d. land swap would require City approval
e. demolition costs for the current site were estimated by GHD to be in the $3.5M range – applicable to all options except Option 1.

Site labeled "C"

Schley Avenue BPW/City Property: There is sufficient land to build a new AGS WWTF and associated buildings. Development of the Army Reserve site might allow relocation of current operations and equipment from the Schley Ave property.

Advantages

a. Area is already developed commercial property, albeit as a non-conforming use
b. No fill required; good elevation
c. Few homes nearby, raising probability of community acceptance
d. No land purchase expense: land is jointly owned by the City and BPW.

Disadvantages

a. Would require zoning code change or variance
b. Likely public opposition by close neighbors. Architectural creativity and odor control measures could soften resistance
c. EIS would be required for discharge to the canal, although likely an abbreviated version since the change from current outfall would be minimal, i.e., discharge would simply be moved to the opposite bank
d. Piping length, pump stations and easement acquisitions will add to cost, although easements would primarily be along the hiking trail
e. Demolition of the current WWTF site adds to overall cost (~ $3.5M).

Site labeled "D"

Vacant parcel (3+ acres) bordering the canal and between the hiking trail and Freeman Highway: This parcel is of sufficient size to contain the AGS system and other WWTF processes and buildings. It might also provide office space for other BPW needs.

Advantages

a. Good elevation

b. Vacant land, therefore minimal pre-construction site work needed
c. Buffered by Freeman Highway bridge and trail lands
d. Directly across canal from current site, minimizing cost and easement acquisition for additional piping and pump stations

Disadvantages
a. Zoned residential: would require zoning change
b. Likely public opposition by neighbors. Architectural creativity and odor control measures could soften resistance
c. Abbreviated EIS would be required for relocating canal outfall to the opposite bank
d. Property acquisition cost not known
e. Demolition of the current WWTF site adds to overall cost (~ $3.5M)

The committee deemed these three sites to be the most favored locations to construct a new Lewes WWTF. The sites were identified based on size/location. No studies or engineering were conducted to evaluate the viability of the individual sites. No real estate professionals were consulted. There may be other parcels more appropriate, including but not limited to the two below.

1. A potential site considered but rejected is the Rapid Infiltration Bed ("RIB") area within Cape Henlopen Park. Elevation is excellent, space is sufficient, site is already in use for wastewater treatment, there are no homes nearby, and DNREC/Cape Henlopen has expressed an interest in being served by the Lewes WWTF (concerns have been noted regarding the sufficiency of treatment provided by the RIBs). Options for discharge from this site include fixed head irrigation, piping to the canal, or discharge via an ocean outfall.

2. A vacant parcel of sufficient size west of the canal.

IX. Discussion and Conclusions

The November 28, 2022 *Lewes WWTF Long Range Planning Study; Conceptual Evaluation Report* prepared for Lewes BPW and Sussex County by consulting engineering firm GHD evaluated three major options for Lewes to respond to sea level rise: Option 1 – harden the existing plant; Option 2 – build a new plant on higher ground; and Option 3 – send all Lewes wastewater to the to-be-expanded Sussex County treatment plant at Wolfe Neck. Were it not for Lewes residents' discomfort with County development decisions and concerns with long-term cost, environmental protection, impact on the canal and other issues, Option 3 would have clearly been the best choice. As the significantly lowest cost option, the BPW deemed it in the best interest of its ratepayers to explore terms of an agreement under Option 3 while holding Options 1 and 2 in abeyance. Attractive from an environmental standpoint were the Option 3 plans to return much of the treated wastewater to the ground via constructed wetlands and to change from seasonal spray irrigation to fixed-head sprinkler irrigation in an area to be converted from agricultural to forest on the County's leased Wolfe Neck property. This would help recharge the water table, decrease land subsidence, and decrease saltwater intrusion.

As the County began to move forward with studies for the Wolfe Neck expansion, an archeological investigation found significant historical artifacts, precluding disturbance to the site pending further studies - and perhaps permanently. Discharge via an ocean outfall became the preferred option for the Wolfe Creek expansion, at a cost to be determined by the County's engineering contractor, GHD.

The WWTF Contingency Planning Committee ("committee") was formed to investigate whether treatment technologies other than those proposed in the original GHD study might make Options 1 and/or 2 more reasonable. This report is a result of those investigations.

Some important considerations:

- should Lewes decide to choose Option 3, there is no going back
- with discharge to wetlands removed from Option 3 the environmental benefits of the County's proposed expansion were also removed. It is old technology
- ocean discharge of treated wastewater is not the best environmental option: permit limitations are less stringent; fresh water introduced into a saline environment changes water chemistry, with implications for marine life; reuse of treated water and/or recharge of the water table is precluded; and land subsidence is accelerated
- cost increases associated with ocean discharge will change the economics of the County's offer and continuing development in the county will change the capital and operating costs over time
- the recently-announced retirement of Sussex County's well-respected engineering manager raises the level of unknowns in future County decision-making, and
- although sea level rise is creating vulnerability to storm-event flooding, Lewes has time to plan wisely before making a decision.

After considerable research and due diligence, the committee concluded that Lewes can choose to continue to manage its wastewater within the city in a safe, sustainable and cost-efficient manner using aerobic granular sludge technology. However, if Option 3 is ultimately selected, we recommend that the BPW Board urge Sussex County to expand the Wolfe Neck facility using this newer, more sustainable, lower energy technology.

The tables below compare the AquaNereda Aerobic Granular Sludge treatment technology to Options 1 and 2 data from the original GHD study:

Table 3: OPTION 1 - Harden Existing Site

	GHD	AQUA-AEROBIC SYSTEMS, INC.
TECHNOLOGY	Oxidation ditch, MBR expansions	Aerobic Granular Sludge (AquaNereda) + Aqua-Disk filters
PROJECT CAPITAL COST	$18M	Estimated to be similar: Aqua-Aerobic equipment cost is ~$3M. Engineering study needed to estimate other capital costs, e.g., costs for concrete tanks, building elevation, piping, other site work and equipment modifications
O&M COSTS	$2M/year	$500K/year ($300K annual reported expenses for 2-year-old Wolcott, KS plant)
LAND	Existing site + expansion into wetlands	Existing site
HARDENING METHOD	Dike around property, larger EQ tank, elevated roadway	Elevate buildings; depth of new tanks 20-24' (partially belowground); elevate pumps, blowers, electrical and other equipment; floodproof digester building
CONTINGENCY	Emergency plan + increase size of EQ basin 600% for storage	Emergency plan: evacuate residents; shut down pump stations. Shunt saltwater to ox ditch, bleed into system as appropriate
ACCESS	Elevated road over dike*	Widen hiking trail to allow access from Freeman Highway*
LABOR	6 FTE	2 FTE (+ manager per DNREC rules)
DISCHARGE	Canal	Canal
ENERGY USE	6500 kWhr/day	Estimated 50% lower
CHEMICALS USE	$1K/ day	$0.2K/day
* Anticipate low tide access during storm events, use of ATVs or boats if needed. American Legion Road will flood.		

Table 4: OPTION 2b - Relocation /New WWTF & Utilization of Existing WWT Outfall

	**GHD	**AQUA-AEROBIC SYSTEMS, INC.
TECHNOLOGY	Activated sludge + tertiary filtration	Aerobic Granular Sludge (AquaNereda) + Aqua-Disk filters
PROJECT CAPITAL COST	$91M	Estimated at $35-40M (based on $35M capital cost for Wolcott, KS 2 mgd WWTF 2021 in floodplain)
O&M COSTS	$1M+ /year	$300 - 500K/year (reported $300K expenses for 2-year-old Wolcott, KS plant)
LAND	20 acres	2-3 acres
LABOR	6 FTE	2 FTE (+ manager, per DNREC rules)
DISCHARGE	Canal	Canal + possible fixed-head irrigation to uplands (this would add to labor FTEs)

** GHD's numbers are based on data from 2022. Some of that information will need to be updated.

** The AGS construction numbers are from similar sized plants operated by others.

Discussions with three AquaNereda municipal WWTF General Managers in the US and the engineering firm HDR who designed the Wolcott, KS plant were key to understanding and resolving questions about the technology. All indicated without reservation that if they had to choose over again, they would select AquaNereda. They extended invitations to tour their sites and see for ourselves. The Wolcott team toured operating sites in the US, UK and Ireland before making their choice.

Aqua-Aerobic Systems extended an expenses-paid invitation to BPW Board members to visit their Rockford, IL demonstration facility (in operation since 2018) and meet with staff at their research facility and headquarters there. It's worth noting that after monitoring the operation of the AquaNereda demonstration facility for five years, the Four Rivers Sewer Authority in Rockford, IL recently contracted to build a 10 MGD AquaNereda plant. Startup is anticipated in 2025.

There are currently 80 operating Nereda plants in 22 countries globally, with 100 under contract. Nereda technology was originally developed by the Dutch: Royal Haskoning DHV owns the technology and licenses it around the world. Aqua-Aerobic Systems is the US licensee, with 15 projects under contract: seven operational and two in start-up mode.

Advantages over traditional wastewater treatment include

- Small footprint, up to a factor 4 smaller
- Sustainable: significant energy savings; no/minimal chemicals; no plastic support media
- Excellent effluent quality including biological nutrient removal
- Cost effective with low CAPEX and OPEX

- Easy to operate; automated and resilient.

Please note that nearly all costs provided in this report are rough estimates: the committee had neither the time nor the funding to retain engineering support. The GHD numbers were also Having monitored the operation of the AquaNereda demonstration facility for five years, the Four Rivers Sewer Authority in Rockford, IL recently contracted to build a 10 MGD AquaNereda plant. Startup is anticipated in 2025.
reported as rough estimates and are now two years old. We recommend the Board retain an engineering consultant to provide a better estimate of costs and to evaluate site considerations for Options 1 and 2.

Community acceptance would need to be gauged, and permit issues would need to be explored, should the Board determine a deeper exploration of Options 1 and/or 2 are advisable.

The committee stands ready to serve if the Board so desires.

Appendices

Appendix 1: Resolution 23-006

Resolution No. 23-006

A RESOLUTION OF THE BOARD OF DIRECTORS OF THE BOARD OF PUBLIC WORKS OF THE CITY OF LEWES REGARDING THE CREATION OF A COMMITTEE TO EXAMINE CONTINGENCY OPTIONS FOR THE LEWES BPW WASTEWATER TREATMENT PLANT

WHEREAS, Section 4.1, *among other provisions*, of the Charter for the Board of Public Works of the City of Lewes (the "Lewes BPW"), being Chapter 10, Volume 77, Laws of Delaware, as amended (the "Lewes BPW Charter"), grants the Lewes BPW authority, responsibility, supervision, and control over current or future utility systems established within the Lewes BPW Service Area; and

WHEREAS, Section 4.5 of the Lewes BPW Charter authorizes Lewes BPW to do all things necessary for the location, erection, construction, equipment, maintenance, and operation of its utility systems as established by the BPW and to provide for the care and maintenance of the same;

WHEREAS, the Lewes BPW Bylaws authorize the Board of Directors of the Lewes BPW (the "Board") to, by Resolution, create certain committees to review and offer recommendations of issues for Board consideration; and

WHEREAS, the Board deems it in the best interest of the ratepayers to establish a Committee to review and further evaluate Options 1 and 2, as described in the draft November 28, 2022 GHD Lewes WWTP Long Range Planning Study ("GHD Study"), and make recommendations to the Board of Directors concerning the same.

NOW THEREFORE, BE IT RESOLVED BY THE BOARD OF DIRECTORS OF THE LEWES BOARD OF PUBLIC WORKS, IN SESSION MET THIS 26TH DAY OF JULY, 2023, THAT:

Section 1. The Board hereby establishes a Committee as set forth herein, to review and provide recommendations to the Board concerning contingency plans for Options 1 and 2 from the GHD Study. The Board shall retain all decision-making authority.

Section 2. The Committee shall be comprised of at least seven (7) members, but no more than ten (10) members, four of whom shall include two Members of the Board, one of whom will also serve as Chair of the Committee, the General Manager of the Lewes BPW or his designee, and a member of the Mayor and City Council ex officio. The remaining members shall not be members of the Board during their service on the Committee. The Committee members shall be chosen by the Board.

Section 3. The Chair's duties shall include ensuring proper function and organization of the Committee, creating an agenda prior to any meetings, and presenting the Board with the Committee's final report and recommendations. The Board shall have the power to remove any member of the Committee at any time for any reason, in which case the Board shall vote on a replacement nominee, provided by the Chair, to replace the removed member.

Section 4. The Committee shall keep minutes of each meeting, which must include an attendance record, a copy of the agenda, and a report of topics and recommendations. The Chair shall file the minutes with the Board no later than twenty-one (21) days after each meeting. The Committee may hold meetings in person or virtually, meaning video conference or any other teleconference communications technology as allowed under Delaware's Freedom of Information Act. The Committee may invite non-members to meetings as deemed necessary by the Chair. All meetings shall comply with Delaware's Freedom of Information Act under 29 Del. C. Section 10001 et. al.

Section 5. The Committee's purview shall include consideration of the following:

1) Research, review, and evaluate costs, benefits, and feasibility of proven and operational alternative technologies for Option 1: Hardening the Existing WWTP and Option 2: Construction of a New WWTP from the GHD Study;

2) Any other tasks, responsibilities, or duties specifically requested by the Board.

Section 6. The Committee shall issue its final report to the Board no later than January 31, 2024, after which date the Committee shall be dissolved, unless extended by the Board.

Section 7. This Resolution shall take effect immediately upon its adoption by the Board of Directors of the Lewes Board of Public Works.

Adopted as Amended by the Board of Directors
Of the Lewes Board of Public Works

____

I, D. Preston Lee, Secretary of the Board of Public Works of the City of Lewes, do hereby certify that the foregoing is a true and correct copy of the Resolution as adopted by action of the Board of Directors of the Lewes BPW at its meeting on July 26, 2023, at which meeting a quorum was present and voting throughout and the same is still in full force and effect.

____
Secretary

00071062.DOCX.4

Appendix 2: GHD Lewes Long-Range Planning Study; Conceptual Evaluation Report

Lewes WWTF Long Range Planning Study

Conceptual Evaluation Report

Lewes Board of Public Works and Sussex County

December 2, 2022

→ The Power of Commitment

Project name	Lewes BPW Long Range Planning Study						
Document title	Lewes WWTF Long Range Planning Study | Conceptual Evaluation Report						
Project number	12582813						
File name	12582813-REP-Lewes WWTF Long Range Planning Study Report_Rev E.docx						
Status Code	Revision	Author	Reviewer		Approved for issue		
			Name	Signature	Name	Signature	Date
S4	0	T. Biagioli	H. J. Sturdevant	*Record on File	H. J. Sturdevant	*Record on File	10/31/22
S4	1	T. Biagioli	H. J. Sturdevant	*Record on File	H. J. Sturdevant	*Record on File	11/11/22
S4	2	T. Biagioli	H. J. Sturdevant	*Record on File	H. J. Sturdevant	*Record on File	11/28/22
S4	3	T. Biagioli	H. J. Sturdevant	*Record on File	H. J. Sturdevant	*Record on File	12/02/22

GHD

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Executive Summary

The Lewes Board of Public Works (BPW) owns and operates the Lewes BPW Wastewater Treatment Facility (WWTF). Due to the low elevation of the existing facility, the BPW would like to evaluate options to mitigate impacts of sea level rise and flood/storm events as well as evaluate options to relocate the facility.

Sussex County owns and operates wastewater infrastructure in the areas surrounding Lewes and has an existing agreement in place with the BPW to transfer wastewater flows from the County's collection network to the Lewes WWTF when demand is lower in Lewes during the winter months. Sussex County has committed a significant portion of its ARPA funding and is interested in expanding the current cooperation with the Lewes BPW, as set forth in Agreement for Wastewater Services, via diversification of the County's wastewater treatment and disposal options.

This report sets out the concept development for upgrade options that will provide increased resilience for wastewater treatment within the BPW's service area, including options for further collaboration with Sussex County.

GHD evaluated a total of six (6) options to increase the resilience of BPW's wastewater treatment to storm events and sea level rise. The following options were evaluated:

Table 1 Summary of Options Evaluated

Option Reference	Option Title	Notes
1	Existing WWTF Hardening	Determine existing site improvements necessary to mitigate treatment impacts from sea level rise, subsidence, storm events including flooding, power loss etc., including: – Perimeter Dike around facility with stormwater/dewatering pumping station. – Raising and or flood proofing the biosolids unit processes. – On-site fuel storage for extended storm events/emergencies.
2 – a	Relocation & Spray Irrigation and/or RIBS	Determine if a suitable site can be found to construct a new WWTF using Rapid Infiltration Beds (RIBS) or spray irrigation for effluent disposal and decommission the existing WWTF.
2 – b	Relocation & Utilization of Existing WWTP Outfall	Construct a new WWTF but maintain the existing permitted outfall, new force main, and decommission the WWTF.
2 – c	Relocation & New Ocean Outfall	Construct a new WWTF with new ocean outfall and decommission the existing WWTF.
3 – a	Partnership with Sussex County & Utilization of Existing WWTP Outfall	Network upgrades to transfer wastewater from the Lewes collection network to a new WWTP in Sussex County, and transfer treated flows back to the existing permitted, outfall in Lewes.
3 – b	Partnership with Sussex County & Constructed Wetland	Given a suitable site, provide network upgrades required to transfer wastewater from the Lewes collection network to a new WWTF in Sussex County and decommission the existing WWTF.

A multi-criteria analysis (MCA) was performed to evaluate the concept options based on a series of non-cost criteria, grouped into three categories: Permitting & Schedule, Community & Environmental Impacts and Operation & Maintenance.

The MCA scoring is summarized in Figure 1.

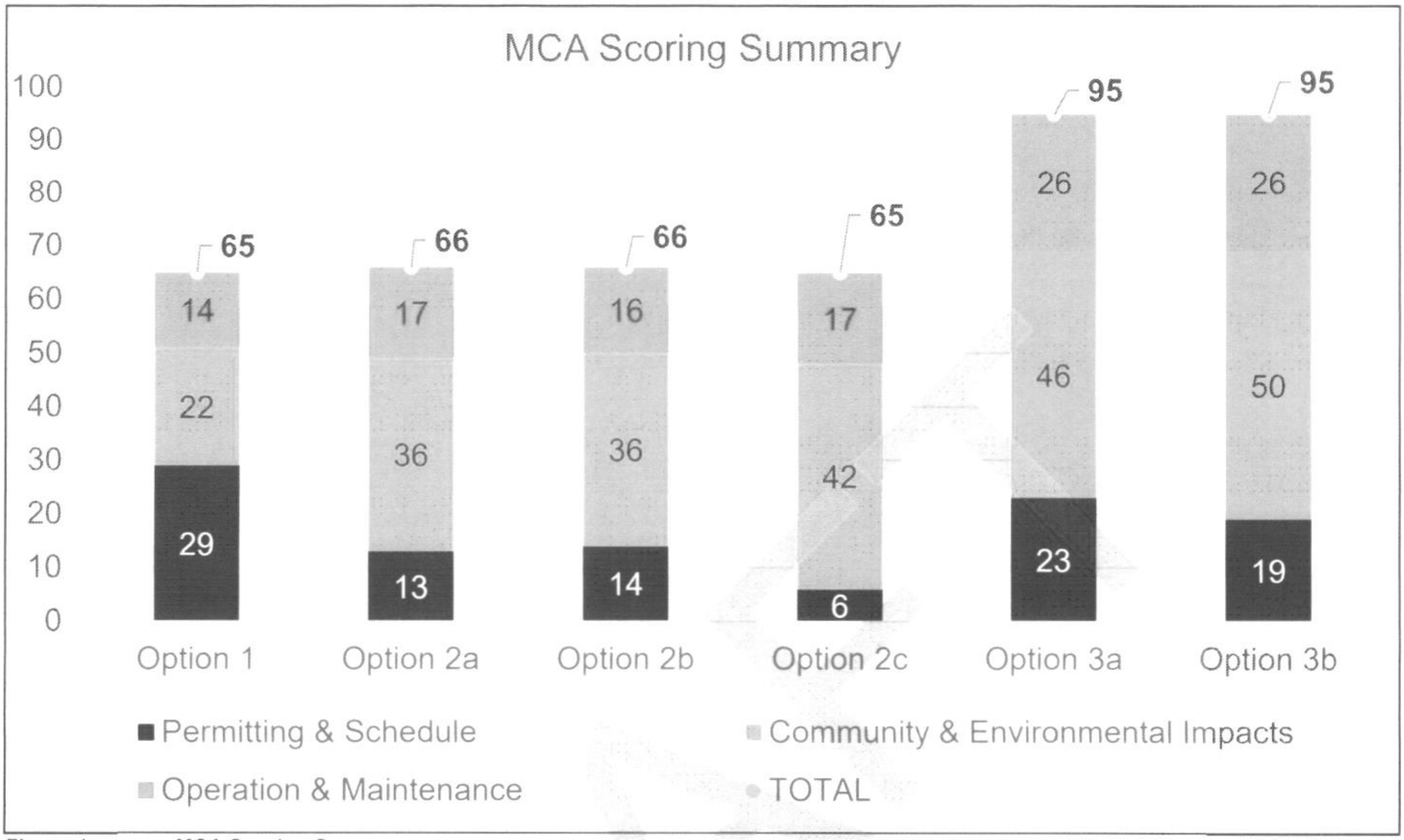

Figure 1 MCA Scoring Summary

Note: a higher MCA score indicates that an Option is more favorable.

The Project Lifecycle Costs incurred by Lewes BPW for the long range planning study concepts are summarized in Table 2.

Table 2 Project Lifecycle Cost Estimates

	Option 1	Option 2a	Option 2b	Option 2c	Option 3a	Option 3b
Preliminary Capital Cost Estimate	$22,800,000	$155,600,000	$114,000,000	$186,500,000	$19,600,000	$19,600,000
2050 NPV O&M Cost Estimate	$75,500,000	$40,000,000	$40,000,000	$40,500,000	$36,000,000	$36,000,000
Project Lifecycle Cost	**$98,300,000**	**$195,600,000**	**$154,000,000**	**$227,000,000**	**$55,600,000**	**$55,600,000**
MCA Score	65	66	66	65	95	95
Cost per MCA Scoring Point	$1,510,000	$2,960,000	$2,330,000	$3,490,000	$590,000	$590,000

All costs are presented in 2022 US Dollars.

Option 3a and Option 3b have the lowest estimated Project Lifecycle Costs for Lewes BPW, as well as the joint-highest MCA scores. Therefore, these options also have the lowest cost per MCA scoring point, which indicates that they provide the best value for Lewes BPW.

Option 3a scores higher for the Permitting & Schedule category, primary due to the relative uncertainty associated with acquiring permitting approvals for the constructed wetland discharge arrangement under Option 3b. Option 3b scores higher for the Community & Environmental Impacts category as there is no requirement to pump treated effluent back to the existing outfall location in Lewes.

Option 2c has the highest estimated Project Lifecyle Costs for Lewes BPW, primarily due to the requirement to purchase land and the complexities associated with a new ocean outfall.

The Option 1 and Option 2 concepts have very similar overall MCA scores; Option 1 scores lower for Community & Environmental Impacts due to the residual risk of flood damage at the coastal location, leading to failure at the treatment plant. The Option 2 concepts score lower for Permitting & Schedule due to the requirement to acquire land and install significant lengths of transfer force mains in public roads. Option 2c scores particularly low in this category due to the permitting complexities associated with constructing a new ocean outfall. However, Option 2c scores relatively well in the Community & Environmental Impacts category as treated effluent would no longer be discharged to the Canal or surrounding bays.

The next steps to advance the Lewes WWTF Long Range Planning Study and address the underlying issues are as follows:

1. BPW will include the Long Range Planning Study on the agenda for an upcoming Board meeting and at that time the BPW Board will discuss the findings of this report.
2. Sussex County will present the findings of this report to the County Council.
3. BPW will arrange a Special Meeting to present the findings to the public, engage with the community stakeholders and provide an opportunity for stakeholders to comment on the findings before a preferred option is identified by the BPW Board.
4. BPW will include the Long Range Planning Study on the agenda for a further Board meeting and at that time the Board will make its final decision on a preferred option for further design development.
5. The preferred option will advance for further development, including (but not limited to): field investigations, modeling, conceptual design and permitting design stages.

The following specific tasks should be undertaken as part of future design development, as a means of validating the preferred option:

- Hydraulic Modeling and Analysis for the Lewes and Rehoboth Canal.
- Greenhouse Gas Emissions Analysis of the selected option.

This report is subject to, and must be read in conjunction with, the limitations set out in Section 1 and the assumptions and qualifications contained throughout the Report.

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1. Introduction

1.1 Purpose of this report

The Lewes Board of Public Works (BPW) owns and operates the Lewes BPW Wastewater Treatment Facility (WWTF), which is also known as the Howard Seymour Water Reclamation Facility and is located in Lewes, DE. The WWTF was originally constructed in 1950 and major refurbishments were completed in 2008, which included the installation of a membrane filtration process in the secondary treatment train. Due to the low elevation of the existing facility, the BPW would like to evaluate options to mitigate impacts of sea level rise and flood/storm events as well as evaluate options to relocate the facility.

Sussex County owns and operates wastewater infrastructure in the areas surrounding Lewes and has an existing agreement in place with the BPW to transfer a proportion of the wastewater flows from the County's collection network to the Lewes WWTF when demand is lower in Lewes during the winter months. Flow that is not transferred to Lewes is treated at one of the County's four regional wastewater facilities: South Coastal, Inland Bays, Wolfe Neck, and Piney Neck.

The County is experiencing growth and is open to further collaboration with BPW in order to increase their wastewater treatment and disposal capacity.

This report sets out the concept development for upgrade options that will provide increased resilience for wastewater treatment within the BPW's service area, including options for further collaboration with Sussex County.

1.2 Scope

The following tasks were completed for the WWTF Long Range Planning Study:

GHD evaluated a total of six (6) options to increase the resilience of BPW's wastewater treatment facilities to storm events and sea level rise. The following options were evaluated:

Table 3 Summary of Options Evaluated

Option Reference	Option Title	Notes
1	Existing WWTF Hardening	Determine existing site improvements necessary to mitigate treatment impacts from sea level rise, subsidence, storm events including flooding, power loss etc., including: – Perimeter Dike around facility with stormwater/dewatering pumping station. – Raising and or flood proofing the biosolids unit processes. – On-site fuel storage for extended storm events/emergencies.
2 – a	Relocation & Spray Irrigation and/or RIBS	Determine if a suitable site can be found to construct a new WWTF using Rapid Infiltration Beds (RIBS) or spray irrigation for effluent disposal and decommission the existing WWTF.
2 – b	Relocation & Utilization of Existing WWTP Outfall	Construct a new WWTF but maintain the existing permitted outfall, new force main, and decommission the WWTF.
2 – c	Relocation & New Ocean Outfall	Construct a new WWTF with new ocean outfall and decommission the existing WWTF.
3 – a	Partnership with Sussex County & Utilization of	Network upgrades to transfer wastewater from the Lewes collection network to a new WWTP in Sussex County currently zoned for wastewater treatment, and transfer treated flows back to the existing permitted, outfall in Lewes.

Option Reference	Option Title	Notes
	Existing WWTP Outfall	
3 – b	Partnership with Sussex County & Constructed Wetland	Given a suitable site, provide network upgrades required to transfer wastewater from the Lewes collection network to a new WWTF in Sussex County currently zoned for wastewater treatment and decommission the existing WWTF.

The aim is to provide a like-for-like comparison of the total financial implications of each option to BPW. The cost estimates will only account for costs incurred by BPW directly, i.e., will exclude any costs incurred by Sussex County or other stakeholders.

For each of the options outlined above, GHD performed the following analyses:

1. Preliminary hydraulic analysis to size major equipment:
   a. Developed facility treatment capacity and effluent performance goals.
   b. Performed high level calculations, based on agreed average and peak flow rates, sufficient to determine the size of collection and/or transfer pipelines and pumping requirements.
2. Project Lifecycle Cost analysis:
   a. Assuming an overall project lifecycle of 25 years, developed Preliminary Capital Cost Estimates and 25-year Net Present Value (NPV) Operation & Maintenance Cost Estimates for each option.
3. Multi-Criterial Analysis (MCA) was performed to rate and assign overall scores to each option based on the non-cost attributes:
   a. The final MCA criteria included:
      i. Permitting Complexity
      ii. Delivery Schedule
      iii. Property & Easement Acquisition
      iv. Interagency & Regulatory Coordination
      v. Stakeholder Impacts – Construction Stage
      vi. Stakeholder Impacts – Long Term
      vii. Water Quality Impacts for Inland Bays
      viii. Overall Environmental Risk
      ix. Energy & Chemical Use
      x. Land Use within City of Lewes
      xi. Impact to WWTF Operations During Construction
      xii. Operational Complexity
      xiii. Future Flexibility
4. The final MCA scoring and Project Lifecycle Costs were used to assess the Best Value (BV) option for BPW, and will form the basis of GHD's recommendations.

1.3 Limitations

This report: has been prepared by GHD for Lewes Board of Public Works and Sussex County and may only be used and relied on by Lewes Board of Public Works and Sussex County for the purpose agreed between GHD and Lewes Board of Public Works and Sussex County as set out in section 1.1 of this report.

GHD otherwise disclaims responsibility to any person other than Lewes Board of Public Works and Sussex County arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report (refer section 1.4 of this report). GHD disclaims liability arising from any of the assumptions being incorrect.

Accessibility of documents

If this report is required to be accessible in any other format, this can be provided by GHD upon request and at an additional cost if necessary.

1.4 Information

The following background information has been utilized by GHD as part of the concept development work:

- Design Drawings
  - Lewes Board of Public Works (1960); Proposed Improvements to Sanitary Sewerage System
  - GMB, LLC (2021); Howard Seymour Water Reclamation Plant Headworks Rehabilitation
- As-built Drawings
  - GMB, LLC (2007); Pump Station No. 4 Force Main Upgrade
  - GMB, LLC (2009); WWTF Upgrade and Expansion
  - GMB, LLC (2019); Lewes Board of Public Works and Sussex County Flow Diversion Project, Phase 1
- Elevation Certificates
  - Atlantic Surveying & Mapping, LLC (2021); *City of Lewes Wastewater Treatment Plant*
- Reports
  - Inframark, LLC (2021); Monthly Operations Report: January 2021 to September 2021
  - SUEZ Water Technologies & Solutions (2020); Lewes, DE Outage Report
  - GMB, LLC (2021); Lewes BPW Asset Management Report
  - Dolphin Electric, LLC (2021); Lewes BPW Electrical Survey
  - Mumford-Bjorkman Associates, Inc. (2020); Lewes WWTF EQ Tank Condition Assessment
  - National Oceanic and Atmosphere Administration (2022); Global and Regional Sea Level Rise Scenarios for the United States
  - Lewes Board of Public Works (2020); Root Cause Report for WWTF Failure Event
- Operational Data
  - Daily Average Flow Rates at LS-4 and LS-8; 2019, 2020 and 2021
- Permits
  - NPDES Permit for Lewes WWTF; Expiration Date October 31, 2023
- Geographic Information System (GIS) Databases
  - Lewes BPW Sewer Master Plans
  - Lewes BPW Water Master Plans
  - Lewes BPW Electric Master Plans
  - City of Lewes Zoning Map (2020)
  - Sussex County GIS Map Viewer
  - First Map, Delaware

- Delaware Geological Survey
- US Geological Survey
- FEMA Floodplain Mapping

Note: no survey, utility locating, geotechnical investigations, or other field investigations were undertaken as part of the project scope.

2. Existing Lewes BPW WWTF

2.1.1 Process Overview

A schematic summary of the existing Lewes WWTF collection network and critical lift stations (LS) is provided in Figure 2.

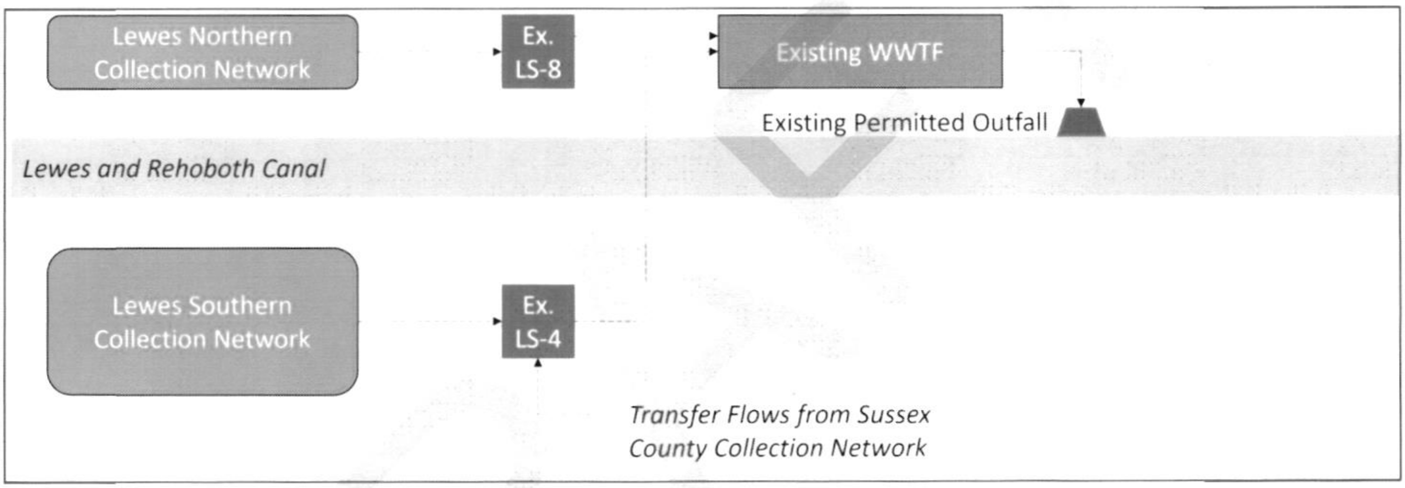

Figure 2 Existing WWTF Flow Schematic

The northern collection network includes all connections north of the Lewes and Rehoboth Canal and includes the beachside residential and commercial properties that see significantly higher demand in the summer months. All flows from the northern collection network are conveyed to the WWTF via LS-8.

Flows from the southern collection network are conveyed to the WWTF via LS-4, which also receives transfer flows from the Sussex County wastewater collection network.

The Lewes BPW WWTF was originally constructed in 1950 and major refurbishments were completed in 2008, which included the installation of a membrane bioreactor (MBR) process in the secondary treatment phase.

The key components of the wastewater treatment process are summarized in the annotated schematic diagram in Figure 3.

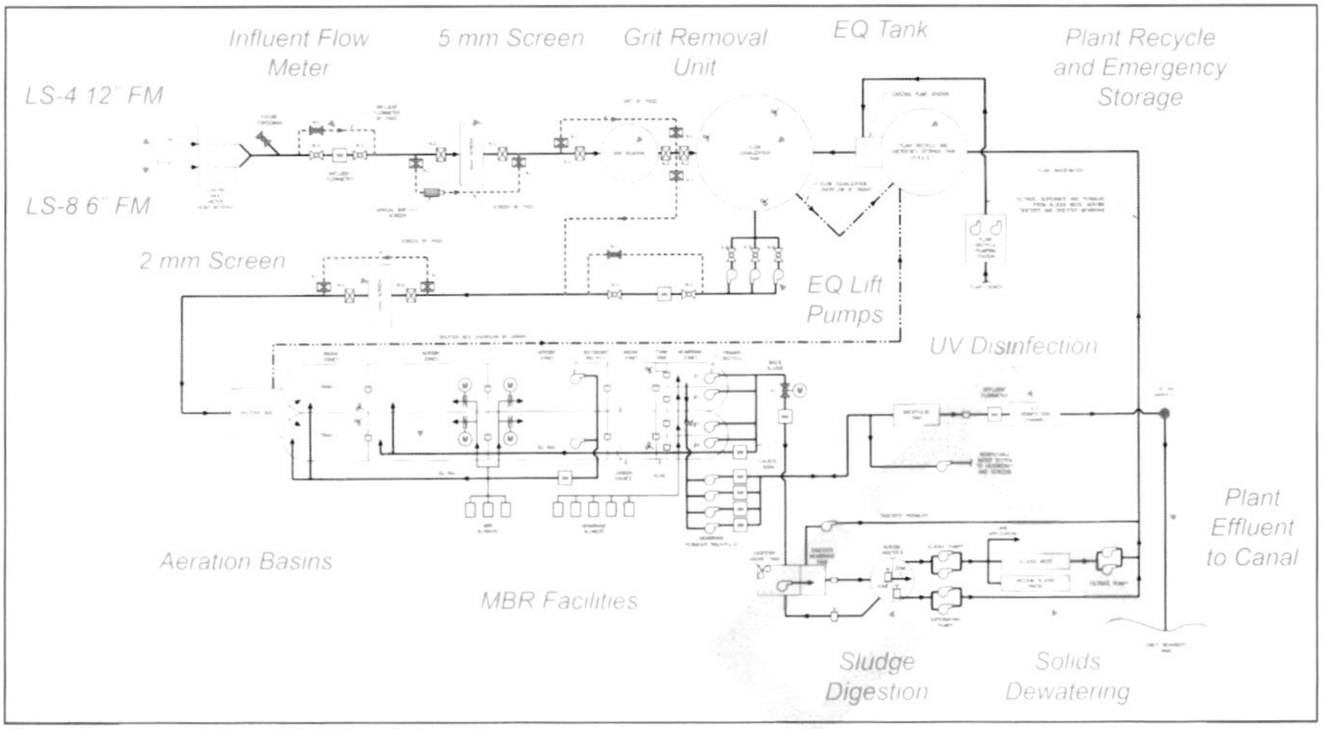

Figure 3 Existing WWTF Flow Schematic

The permitted plant outfall discharges to the Lewes and Rehoboth Canal approximately 1,000 feet from the WWTF. According to the current National Pollutant Discharge Elimination System (NPDES) permit (effective November 1, 2018), the facility is rated for 1.5 mgd.

Stabilized, dewatered sludge is disposed of at landfill.

2.1.2 Catchment Flows and Loads

The design criteria flow rates that were used for the 2008 facility upgrade are summarized in Table 4.

Table 4 Lewes WWTF Design Criteria, 2008 Upgrades

WWTF Design Criteria[1]	Current Design Flow Rate (mgd)
Design Flow – Average Day	**1.50**
Max Day Flow	1.80
Max. Week Flow	1.95
Max. Month Flow	2.25
Peak Hour Flow	4.40

Note:
1. Design Data per GMB Contract Ref 1998002.D1, "WWTF Upgrade and Expansion", Drawing G-2 – Design Data & Abbreviations.

The "Average Day" flow corresponds to the rated capacity indicated in the NPDES permit. It is not known how the peaking factors used to calculate the other design criteria flow rates were developed.

GHD reviewed daily average influent flow rate data for the WWTF from January 2019 to September 2021. A summary of the daily average flow rates in each calendar year is provided in Table 5.

Table 5 Daily Average Flow Rate Data, 2019 to 2021, Lewes WWTF

WWTF Daily Average Flow[2]	2019	2020	2021[1]
Minimum (mgd)	0.39	0.25	0.47
Average (mgd)	**0.80**	**0.86**	**0.85**
Maximum (mgd)	1.33	1.60	1.33

Notes:
1. January thru September 2021 only.
2. "Daily Average Flow" has been taken as the daily average flow rate recorded at the WWTF effluent flow meter, i.e., the total flow through the treatment facility, including recycles.

On review of the available flow data, the WWTF does not typically treat the "Average Day" design flow that was used to size the facility during the most recent upgrade project. BPW indicated that the projected daily average flow rate from the Lewes collection network, assuming that all feasible lots are developed, is 1.75 mgd.

BPW currently accepts raw wastewater flows from Sussex County during winter months, when flows in the Lewes collection network are consistently lower, under the existing Agreement for Wastewater Service Transfer. As these additional flows are only receiving during off-peak periods, they are not included in the estimated Average Day design flow noted above.

BPW has also been involved in preliminary discussions with Cape Henlopen State Park to transfer additional flows to the Lewes collection network in the order of 49,000 gpd during winter, increasing to 120,000 gpd during summer. These additional flows were not included in the Average Day design flow provided to GHD for concept development.

Furthermore, BPW has advised that the existing gravity sewers that connect the State Park to the Lewes collection network can only accommodate an additional 25,000 gpd, and therefore considerable network upgrades would be required in order to convey additional flows of up to 120,000 gpd from the State Park. Given that the Average Day design flow was estimated based on full build-out of the Lewes BPW service area, assuming all available parcels are fully developed per current zoning (considered a highly conservate approach), no additional allowance will be made in the Average Day design flow for future flows transferred from Cape Henlopen State Park to the Lewes collection network for this study.

An extract from the existing NPDES permit for Lewes WWTF, outlining the effluent limitations, is provided in Figure 4.

Parameter	Effluent Limitations						Monitoring Requirements[2]	
	Load			Concentration			Measurement Frequency	Sample Type
	Daily Average	Daily Maximum	Units	Daily Average	Daily Maximum	Units		
Flow[3]			MGD	---	---	---	Continuous	Record/ Totalize
Dissolved Oxygen	Monitoring Only					mg/L	Continuous	Membrane Probe Immersion/ Record
pH	The pH shall be between 6.0 S.U. and 9.0 S.U. at all times.					S.U.	Once Daily	Grab
Enterococcus[4]	---	---	---	10	104	Col/ 100 mL	Once Weekly	Grab
BOD_5	188	288	lbs/day	15.0	23.0	mg/L	Once Weekly	Composite
BOD_5 (Influent)[5]	---	---	lbs/day			mg/L	Once Monthly	Composite
Total Suspended Solids (TSS)	188	288	lbs/day	15.0	23.0	mg/L	Once Weekly	Composite
TSS (Influent)[5]	---	---	lbs/day			mg/L	Once Monthly	Composite
Total Nitrogen (as N)	100		lbs/day	8		mg/L	Once Monthly	Composite
	See Part III. A., Special Condition No. 9							
Total Phosphorus (as P)	25		lbs/day	2		mg/L	Once Monthly	Composite
	See Part III. A., Special Condition No. 9							
Biomonitoring	See Part III. A., Special Condition No. 4 of this permit.							Composite
The discharge shall be free from floating solids, sludge deposits, debris, oil and scum								

Figure 4 NPDES Permit Extract, Lewes WWTF

The Monthly Operation & Maintenance reports produced by BPW's appointed contractor, Inframark, LLC, were summarized to show nutrient trends over the operational period. Treated effluent nutrient data observed between January 2021 and September 2021 is provided in Table 6.

Table 6 Effluent Nutrient Data, January 2021 to September 2021

Parameter	Minimum	Average	Maximum	Permit Limit
pH	7.1	7.3	7.5	6 - 9
Total Nitrogen (mg/L)	3.5	5.6	7.7	8 (daily av.)
Total Phosphorous (mg/L)	0.05	0.59	1.66	2 (daily av.)
Enterococcus (cfu/100 mL)	0.50	0.89	2.0	10 (daily av.); 104 (daily max)
Total Suspended Solids (mg/L)	0.25	0.33	0.40	15 (daily av.); 23 (daily max)
BOD (mg/L)	1.2	1.2	1.3	15 (daily av.); 23 (daily max)
Average Daily Flow (mgd)	0.39	0.89	1.69	-

The data indicates that the WWTF did not exceed any of the permit limits during the observed period.

The estimated average effluent waste loads for Total Nitrogen (TN) and Total Phosphorus (TP) during this time period are summarized in Figure 5.

Figure 5 *Estimated Average Effluent Waste Loads, TN and TP*

The average daily flow during this period was 0.89 mgd. The data indicates that the average total pounds per day of TN and TP discharged by the BPW was less than half of the permitted waste load allocated for the observed data period.

2.1.3 Existing Treatment Capacity

The supplier of the MBR arrangement, SUEZ Water Technologies and Solutions (SUEZ), provided GHD with process modeling calculations to estimate the capacity of the WWTF assuming effluent is discharged at the permit limits. This data is provided as Appendix A. Review of that data and other facility data provided by BPW indicated that the limiting factors on the treatment capacity of the existing facilities are:

- Hydraulic
  - The hydraulic capacity of the WWTF is limited by the MBR facilities, which currently have a stated capacity of 1.62 mgd with all three existing cassettes in place (space is allocated for a future fourth unit).
- Maximum Month Biological Treatment Capacity
  - SUEZ estimated that the max. month biological treatment capacity at the permit limits is 1.80 mgd.
- Maintaining Current Effluent Nutrient Performance
  - For comparison purposes, assuming the WWTF continues to discharge treated effluent with an average Total N concentration of 5.4 mg/L (noting that this may not be feasible using the same tanks/ equipment with significantly higher flow), the plant would reach the permitted Waste Load Allocation at an average daily flow of 2.14 mgd.
  - Refer to Figure 6 for a summary of performance comparison data.

Figure 6 *Comparison of Existing Effluent Waste Load Performance Compared with Permit Limits, Total N*

2.1.4 Site Flood Risk

2.1.4.1 Definitions

The following terminology has been used to outline the site flood risk for existing and future facilities:

- Base Flood Elevation
  - The elevation of surface water resulting from a flood that has a 1% chance of equaling or exceeding that level in any given year (FEMA; March 2020).
  - Also referred to as the "100-yr Flood Elevation".
- Eustatic Sea Level Rise (SLR)
  - An observed increase in the average Global Sea Level Trend and is caused by two primary factors: melting land ice and thermal expansion of the Earth's oceans (Lindsey and Dahlman; 2021).
- Coastal Subsidence
  - The gradual sinking of landmass, which can occur due to Glacial Isostatic Adjustment (the ongoing movement of land once burdened by ice-age glaciers, GIA), sediment compaction (both from natural and anthropogenic processes), and oceanographic changes (Miller et al.; 2013).
- 2050 Basis of Design Flood Elevation
  - The current Base Flood Elevation plus the projected Eustatic Sea Level Rise and Coastal Subsidence estimated to the year 2050.
- Recommended Freeboard
  - The recommended vertical offset from the Flood Elevation to building thresholds, equipment elevations and other critical components for treatment capacity.
  - Freeboard is not added to, or included in, the Flood Elevation; it is used to compare building and equipment elevations with projected water surface elevations.
- Calculated Freeboard
  - The calculated vertical offset from the Flood Elevation to building thresholds, equipment elevations and other critical components for treatment capacity.
  - The Calculated Freeboard is compared with the Recommended Freeboard to assess the flood risk at a particular location.

2.1.4.2 Regulatory Guidance Review

According to the Ten State Standards (Wastewater Committee of the Great Lakes – Upper Mississippi River; Recommended Standards for Wastewater Facilities, 2014 Edition), which is widely used in Delaware, wastewater treatment plant structures, electrical, and mechanical equipment shall be protected from physical damage by a one hundred (100) year flood. Treatment plants should remain fully operational and accessible during a twenty-five (25) year flood. This requirement applies to new construction and to existing facilities undergoing major modification.

The American Society of Civil Engineers (ASCE) 24-14 Flood Resistance Design and Construction is a referenced standard in the 2015 International Building Code® (IBC) and the 2015 International Residential Code® (IRC). ASCE 24-14 classifies buildings and structures associated with water and wastewater treatment facilities to be Flood Design Class 3 structures which should be set 2 feet or more above the Base Flood Elevation (BFE, i.e., 100-year flood elevation).

Executive Order 13690 (EO 13690), establishing a Federal Flood Risk Management Standard and a Process for Further Soliciting and Considering Stakeholder Input, signed in 2015, states that federally funded projects are required to provide 3 feet of freeboard above the BFE for critical actions such as wastewater treatment facilities.

Based on the published industry standards and previous precedents, GHD considers the following to be the best design practice for Recommended Freeboard:

- All critical wastewater treatment equipment such as mechanical, electrical, or control systems protected at least 3 feet above the 100-year flood elevation.
- All other infrastructure, such as structural slab elevations for buildings or top of wall for open tanks, set at least 2 feet above the 100-year flood elevation.

It should be noted that the current FEMA flood maps do not account for future climate change. Climate change and sea level rise will also impact future flooding and a greater level of flood protection may be warranted in some cases.

Additional analysis related to projected sea level rise and coastal subsidence is outlined in Section 2.1.5, below.

2.1.4.3 Preliminary Flood Risk Assessment

An extract from the FEMA National Flood Hazard Layer FIRMette mapping for the City of Lewes, showing the 100-year flood elevation for different zones, is provided in Figure 7. The flood map data was last refreshed in October 2020.

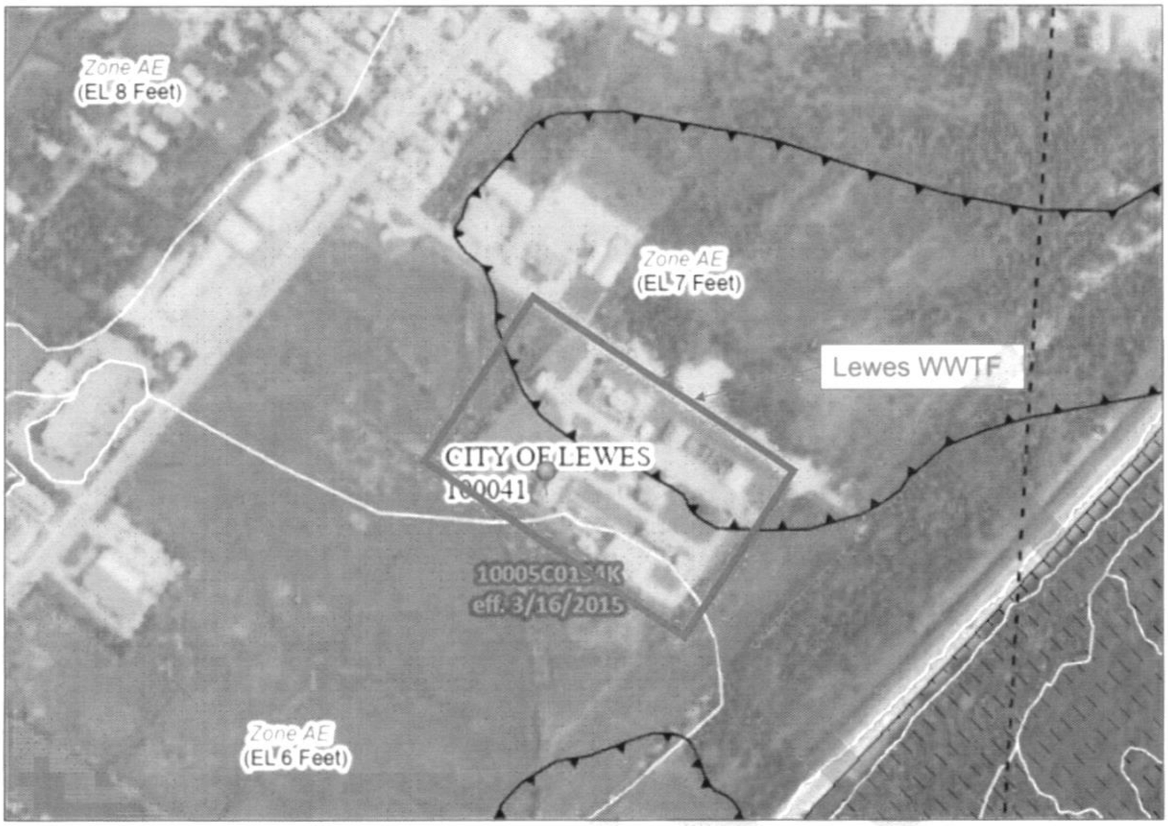

Figure 7 Extract from FEMA Flood Maps, Lewes WWTF

The FEMA mapping indicates that the 100-year flood elevation is 7 ft for most of the WWTF site, with a small section in the southeast at 6 ft. A sitewide 100-year flood elevation of 7 ft has been assumed for the high-level flood risk assessment outlined below.

GHD reviewed the finished surface elevations of existing facilities relative to the published 100-year flood elevation in order to assess the existing flood risk at each location. The findings are summarized in Table 7.

Table 7 Existing Facilities Flood Risk Assessment Summary

WWTF Area	100-yr Flood Elevation (ft)[1]	Existing Grade (ft)[2]	Threshold Elevation (ft)[3]	Calculated Freeboard to 100-yr Flood Elevation (ft)[4]
Site Access (American Legion Road)	7	3.78	3.78	-3.22
Headworks Building: Lower Level, Structural Slab	7	5.5	9.50	2.50
WWTF Office & Administration Building	7	6.31	9.55	2.55
Aeration Basins, Top of Wall	7	5.5	10.32	3.32
Process Building: Structural Slab	7	6.0	7.50	0.50
Process Building: MBR Tanks, Top of Wall	7	N/A	10.13	3.13
Digester Blower Building, Structural Slab	7	6	7.13	0.13

WWTF Area	100-yr Flood Elevation (ft)[1]	Existing Grade (ft)[2]	Threshold Elevation (ft)[3]	Calculated Freeboard to 100-yr Flood Elevation (ft)[4]
Sludge Drying Beds	7	6.60	6.60	-0.40

Notes:
1. FEMA National Flood Hazard Layer FIRMette, cell ref: 10005C0194K.
2. Existing grade elevations per GMB Contract Ref 1998002.D1, "WWTF Upgrade and Expansion", Drawing C-4 – Site Plan.
3. Threshold elevation is the lowest elevation at which water ingress may occur for a given building or structure.
4. Freeboard is the difference between the 100-year flood elevation and the threshold elevation.

As noted above, the current FEMA flood maps do not account for future climate change. Additional analysis related to projected sea level rise and coastal subsidence is outlined in Section 2.1.5, below.

The assessment found that all the major process building thresholds are above the current published 100-year flood elevation. The only facilities below flood elevation are the sludge drying beds, which do not contain any critical equipment (although flooding may lead to sludge being dispersed to the surrounding environment, which would be a major issue).

The Aeration Basins and MBR Tanks have threshold elevations that provide in excess of 3 ft of freeboard during a 100-year flood scenario, and therefore are aligned with the guidelines outlined in Section 2.1.4.1.

The lower level slab elevation of the Headworks Building has freeboard greater than 2 ft above the 100-year elevation. Provided that all critical equipment at that level (MCC, Pump Motors etc) are located at least 6 in. above the structural slab elevation, then the building is in line with the guidelines outlined in Section 2.1.4.1.

The WWTF Office & Administration Building is 2.55 ft above the 100-year flood elevation; the building does not contain any critical equipment and therefore meets the guidelines outlined in Section 2.1.4.1.

The structural slab elevation at the Process Building and Digester Blower Building are above the 100-year flood elevation but do not provide the recommended freeboard. In the process building, the following equipment is located in areas that do not meet the guidelines outlined in Section 2.1.4.1:

- Sodium Hypochlorite Feed Systems
- Sodium Hydroxide Feed Systems
- Sodium Acetate Feed Systems
- Citric Acid Feed Systems

The Digester Blowers and associated electrical equipment are located in areas with very little freeboard above the 100-year flood elevation.

Access to the site (via American Legion Road) would be severely restricted during a 100-yr flooding scenario, with surface water approximately 3ft above the existing road elevation. Plant site road elevations are generally 12 to 18 inches higher than the public access road but would still be hazardous for Plant Operations & Maintenance staff during a flooding scenario.

Under the Ten State Standards (Wastewater Committee of the Great Lakes – Upper Mississippi River; Recommended Standards for Wastewater Facilities, 2014 Edition), treatment plants should remain fully operational and accessible during the 25-year flood.

While it is not officially published, the 25-year flood elevation has been estimated based on NOAA tide gauge data (Center for Operational Oceanographic Products and Services – Annual Exceedance Probability Curves 8557380 Lewes, DE). At the Lewes monitoring station as of 2018, the water level with a 4% annual exceedance probability is 3.9 ft above the Mean Higher High Water Level, which is itself 2.3 ft above the base elevation. Therefore, a 25-year flood elevation has been approximated as 6.2 ft.

During a 25-year flooding scenario, access to the site would be significantly impacted as American Legion Road would be approximately 2.4 ft below the surface water elevation.

Site roads would also be potentially hazardous. Unlike the 100-year flood scenario, the surface water elevation would be lower than that of the sludge drying beds, although the resulting 0.4 ft of freeboard would be less than the recommended 2.0 ft.

2.1.5 Projected Sea Level Rise and Coastal Subsidence

2.1.5.1 Background

Eustatic Sea Level Rise (SLR) refers to an observed increase in the average Global Sea Level Trend and is caused by two primary factors: melting land ice and thermal expansion of the Earth's oceans. As global temperatures rise (Lindsey and Dahlman 2021), terrestrial ice caps begin to melt and runoff into the ocean, contributing to SLR. Thermal expansion is the increase in the volume of water (in this case, sea water) as the temperature of the water increases.

Subsidence, or the gradual sinking of landmass, can occur due to Glacial Isostatic Adjustment (GIA), sediment compaction (both from natural and anthropogenic processes), and oceanographic changes (Miller et al. 2013). GIA is the ongoing movement of land that was once covered by ice-age glaciers (NOAA 2021). During the last ice age, glaciers covered large portions of North America, which caused landmass under the ice sheets to sink, and landmass on the borders of those glaciers to rise. As the glaciers receded and the ice age ended, landmass that was previously under the ice sheets are rising, while landmass that was on the borders of the glaciers is subsiding. The extent to which GIA affects subsidence rates is determined by the location (relative to the historical ice sheet) and whether the local geology is based in a bedrock location (lower effects) or a coastal plain sediment location (higher effects) (Karegar et al. 2016). Beyond GIA, groundwater withdrawal also plays a critical role in local land subsidence (Miller et al. 2013). High rates of groundwater withdrawal result in reduced pore fluid pressure, which leads to compaction of the aquifer and land subsidence (Karegar et al. 2016).

Relative SLR is the combination of eustatic SLR and local subsidence and result in the rise in water elevation relative to land (Rovere et al. 2016). Relative SLR can be measured through the use of satellite altimetry and tidal gauge data, as well as utilizing historical geological data. Local factors affecting SLR also include changes in the ocean's currents (Karegar et al. 2017; Lee et al. 2017) and shoreline retreat (Delaware Department of Natural Resources and Environmental Control [DNREC] 2012). Relative SLR causes compounding effects of storm events (nor'easters, hurricanes, etc.) and an increase in flood damage severity and frequency (Miller et al. 2013).

2.1.5.2 Observed Eustatic Sea Level Rise Rates

Over the past 2,000 years, the average eustatic SLR was slow (0 to 0.002 inches per year [in/yr]) until the late 1800s (Miller et al. 2013). Between 1880 and 2006, the average eustatic SLR accelerated slightly to 0.006 in/yr, and satellite altimetry indicated further acceleration of eustatic SLR to 0.010 in/yr between 1993 and 2013 (Miller et al. 2013). As global temperatures are expected to continue to rise and cause the melting of land ice and increase the thermal expansion of the oceans, the rates of SLR will continue to accelerate in the future (Lindsey and Dahlman 2021; Miller et al. 2013).

2.1.5.3 Subsidence in Delaware

Subsidence also plays a major role in determining the severity of the effects of SLR. The state of Delaware is a coastal plain that lies within the latitudes (approximately 38.5 to 40° North) most affected by the GIA of the former Laurentide Ice Sheet, which contributes up to half of the relative SLR observed in the state (Karegar et al. 2017; DNREC 2012; Watson 2020). Subsidence rates in the state of Delaware are approximately 0.08 in/yr (Karegar et al. 2016).

As mentioned above, high rates of groundwater withdrawal can cause aquifer compaction and land subsidence (Karegar et al. 2016). This was observed in the southern Chesapeake Bay region where heavy groundwater use between 1970 and 2010 caused the groundwater level to decline, and the subsidence rate increased to double that which was due to GIA (Karegar et al. 2016). When groundwater management practices were implemented from 2010 to 2015, the groundwater levels rose again, and the subsidence rate slowed to the GIA rate. Although Lewes, Delaware's groundwater extraction rates are currently stable (2005-2015), continued groundwater management practices can be effective at reducing aquifer compaction and the associated subsidence (Miller et al. 2013; Karegar et al. 2016).

2.1.5.4 Relative Sea Level Rise in Delaware

Along the Atlantic coast, the mid-Atlantic coastal plains are a hot spot for accelerated relative SLR rates due to the compounding effects of subsidence (Miller et al. 2013; Karegar et al. 2016). Additional contributing factors to relative SLR in the mid-Atlantic region include the weakening of the Gulf Stream and other ocean currents along the Atlantic coast (Lee et al. 2017) and shoreline retreat, which was estimated to recede at 15 to 30 feet per year between 1969 and 2007 in the Bombay Hook area of Delaware Bay (DNREC 2012).

The *SLR Vulnerability Assessment for the State of Delaware* conducted by the DNREC in 2012, noted that the local mean sea level (MSL), as indicated by tide gages in Lewes, Delaware, increased at a rate of 0.13 inches per year between 1919 and 2011 (twice the global rate), due to the additive effects of subsidence in the region. The sea level in Delaware Bay rose a total of 7.9 inches over the twentieth century, and as a result, Hurricane Sandy (2012) flooded approximately 27 square miles more than it would have in 1880 due to the effects of SLR (Miller et al. 2013).

Further, as relative SLR causes coastal erosion and the loss of tidal wetlands – a critical natural flood protection for the state – flood frequency and depths may increase in flood-prone areas, as well as create new flooding areas (DNREC 2012).

2.1.5.5 Forecasting Relative Sea Level Rise

In the *SLR Vulnerability Assessment for the State of Delaware* conducted by DNREC in 2012, the eustatic sea level was projected to rise by up to 1.57 feet (high level projection; range 0.59 to 1.57 feet) by the year 2050. Should SLR rates remain constant, rather than increase as other models suggest, the eustatic sea level is projected to rise by 0.43 feet by the year 2050. NOAA's *Global and Regional Sea Level Rise Scenarios for the United States* (2017) projects the eustatic sea level to rise 2.13 feet (high level projection; range 0.59 to 2.13 feet) by the year 2050.

The mid-Atlantic coastal plains have been identified as a hot spot for accelerated SLR rates due to the compounding effects of subsidence, and projections of eustatic SLR (such as DNREC's 2012 and NOAA's 2017 projections) may be biased low for what the relative SLR may be along the mid-Atlantic coast and the state of Delaware (Miller et al. 2013; Karegar et al. 2016). Miller et al. (2013) projected the relative sea level to rise by up to 2.33 feet (high level projection; range 1.08 to 2.33 feet) on the mid-Atlantic coast by the year 2050.

Factoring in the rate of local subsidence (approximately 0.08 in/yr), relative SLR is projected to rise by up to 2.39 feet (range 0.85 to 2.39 feet) by 2050 based on NOAA's 2017 projections. Forecasting to the year 2100, a eustatic SLR of 2.29 to 4.59 feet (or 2.88 to 5.18 feet of relative SLR, considering local subsidence) is expected with 90-percent probability (Miller et al. 2013). Figure 8 presents the relative SLR projected by 2050 and 2100 and the relative contribution of eustatic sea level rise and subsidence.

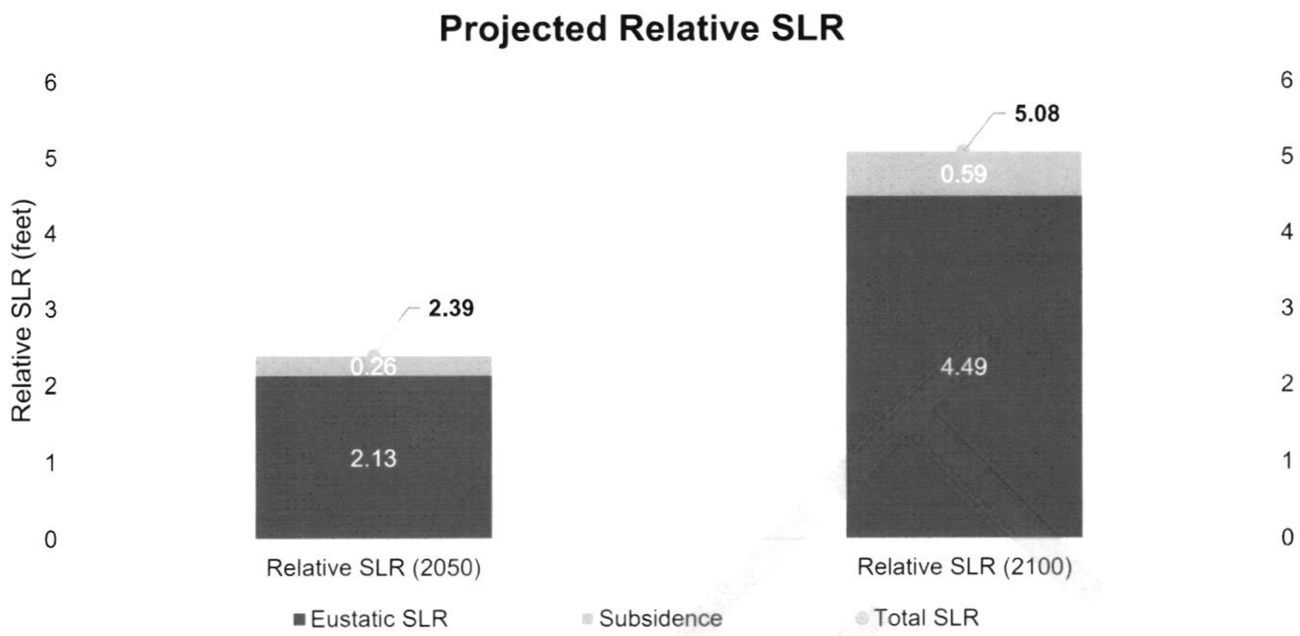

Figure 8 Relative Sea Level Rise by 2050 and 2100

2.1.5.6 Local Impacts of Relative Sea Level Rise

Utilizing the Delaware Geological Survey's *Coastal Inundation in Delaware* interactive mapping tool, different levels of coastal inundation can be mapped to determine local effects to a specific area. In the area surrounding the Lewes BPW Wastewater Treatment Facility (Site), the mean highest high water (MHHW) has been observed in small channels of the marsh areas to the southwest of the Site. Under a coastal inundation scenario of 1.0 feet (a conservative value of relative SLR by 2050 based on the projections presented in Section 2.0), nearly the entire marsh area to the southwest of the Site will be submerged, with small areas of land to the northwest and southeast of the Site remaining above water. Under a coastal inundation scenario of 2.0 feet, the entire facility will be waterlocked due to water covering large portions of the access road (American Legion Road), as well as portions of East Savannah Road. Under a coastal inundation level of 4.0 feet, as projected by 2100, approximately 60-percent of the Site would be submerged, as well as large portions of American Legion Road and East Savannah Road.

According to the *SLR Vulnerability Assessment for the State of Delaware* (2012), DNREC ranks wastewater facilities as a "moderate concern" for risk to SLR. The initial effects of SLR to wastewater facilities are from intermittent flooding from increasing spring tides (new and full moon tides), resulting in potential flood damage and facility access issues, with effects becoming more chronic as SLR continues to progress (Deyle, Baily & Matheny 2007; Karegar et al. 2017). DNREC (2012) estimates 13 to 37 percent of the wastewater facilities in Sussex County will be exposed to SLR in the future.

The effects of SLR will also exacerbate flooding due to storm events such as hurricanes and nor'easters by increasing storm surge (DNRC 2012; Miller et al. 2013). Studies estimate that a 1.47-foot increase in sea level (intermediate projection of SLR by 2050) would cause a moderate "10-year" storm to have the equivalent flood level of a "100-year" storm event by today's standards (Miller et al. 2013; Karegar et al. 2017).

2.1.5.7 Conclusions

For the purposes of concept development, the projected Relative SLR indicated in Figure 8 (above) will be added to the published FEMA 100-year Site Flood Elevation to estimate a suitable value for the 2050 Design Flood Elevation.

Refer to Section 3.1.1 (below) for further details.

2.1.5.8 References for Project Sea Level Rise and Coast Subsidence Review

The following studies and reports were used to develop the various scenarios described in the previous paragraphs.

Delaware Department of Natural Resources and Environmental Control (DNREC). 2012. *Preparing for Tomorrow's High Tide: Sea Level Rise Vulnerability Assessment for the State of Delaware*. Prepared for the Delaware Sea Level Rise Advisory Committee by the DNREC.

Miller, K.G., R.E. Kopp, B.P. Horton, J.V. Browning, and A.C. Kemp. 2013. A geological perspective on sea-level rise and its impacts along the U.S. mid-Atlantic coast. *Earth's Future, 1*, 3-18, doi:10.1002/2013EF000135.

Karegar, M.A., T.H. Dixon, and S.E. Engelhart. 2016. Subsidence along the Atlantic Coast of North America: Insights from GPS and late Holocene relative sea level data. *Geophys. Res. Lett., 43*, 3126-3133, doi:10.1002/2016GL068015.

Lee, S.B., M. Li, and F. Zhang. 2017. Impact of sea level rise on tidal range in Chesapeake and Delaware Bays. *J. Geophys. Res. Oceans, 122*, 3917-3938, doi:10.1002/2016JC012597.

Lindsey, R., and L. Dahlman. 2021. Climate change: global temperature. NOAA Climate.gov website, https://www.climate.gov/news-features/understanding-climate/climate-change-global-temperature, 03/15/21.

Karegar, M.A., T.H. Dixon, R. Malservisi, J. Kusche, and S.E. Engelhart. 2017. Nuisance flooding and relative sea-level rise: the importance of present-day land motion. *Scientific Reports, 7: 11197*, doi:10.1038/s41598-017-11544-y.

Rovere, A., P. Stocchi, and M. Vacchi. 2016. Eustatic and relative sea level changes. *Current Climate Change Report, 2*, 221-231, doi:10.1007/s40641-016-0045-7.

Watson, P.J. 2020. Status of mean sea level rise around the USA. *GeoHazards 2021, 2*, 80-100. https://doi.org/10.3390/geohazards2020005.

National Oceanic and Atmospheric Administration (NOAA). What is glacial isostatic adjustment? National Ocean Service website, https://oceanservice.noaa.gov/facts/glacial-adjustment.html, 08/11/21.

NOAA. 2017. Global and regional sea level rise scenarios for the United States. NOAA Technical Report NOS CO-OPS 083.

3. Long Range Upgrade Options: Concept Development

3.1 Basis of Design Criteria

The proposed Basis of Design Criteria were used for long-range planning purposes and were developed to provide consistency between the potential upgrade options and to ensure that new facilities meet BPW and Sussex County's performance requirements up to the long-range planning horizon of year 2050.

3.1.1 Flood Risk

The Basis of Design Criteria for flood risk are summarized in Table 8.

Table 8 Basis of Design Criteria, Flood Risk

Parameter	Value
2015 FEMA 100-yr Site Flood EL, ft	7
Projected 2050 Eustatic Sea Level Rise, ft	2.13
Projected 2050 Coastal Subsidence, ft	0.26
Estimated 2050 100-yr Design Flood Elevation, ft	9.39
Freeboard to structural slabs and building thresholds, ft	2
Freeboard to critical equipment, ft	3

3.1.2 Influent Flow Rates

The Basis of Design Criteria for future flow rates have been calculated based on projected increases in average daily flows and using the same catchment peaking factors as the 2008 Lewes WWTF design criteria.

The Basis of Design Criteria for the BPW collection network flow rates are summarized in Table 9.

Table 9 Basis of Design Criteria, BPW Collection Network Flow Rates

Parameter	2008	2050
Average Day, mgd	1.50	1.75
Max Day, mgd	2.25	2.63
Max Week, mgd	1.95	2.28
Max Month, mgd	1.80	2.10
Peak Hour, mgd	4.40	5.13
Equalized Flow[1], mgd	2.60	3.03

Note:
1. Equalized Flow is the difference between Peak Hour flow and Max Month flow.

For the Option 3 scenarios a combined facility was evaluated to treat flows from both the BPW and Sussex County collection networks. Sussex County has advised that the projected 2050 average day flow for Sussex County should be 1.75 mgd. Combining this with the projected 2050 average day flow for BPW (also 1.75 mgd), and using the same peaking factors as indicated in Table 10, the following Basis of Design Criteria flow rates have been estimated for the combined BPW and Sussex County collection networks:

Table 10 Basis of Design Criteria, Combined BPW and Sussex County Collection Network

Parameter	2050
Average Day, mgd	3.50
Max Day, mgd	5.25
Max Week, mgd	4.55
Max Month, mgd	4.20
Peak Hour, mgd	10.27
Equalized Flow[1], mgd	6.06

Note:
1. Equalized Flow is the difference between Peak Hour flow and Max Month flow.

3.1.3 Treated Effluent Water Quality

The Basis of Design Criteria for treated effluent water quality is as follows:

- The future WWTF will meet all of the conditions of the existing NPDES permit
  - Refer to Figure 4 for details.

On that basis, given that the Average Daily Flow is projected to increase for all Options, the critical effluent limitation will be the Waste Load Allocation (WLA) for TN and TP.

In order to maintain the WLAs within the existing permit limits at the 2050 Basis of Design flow rates, the new WWTFs will need to maintain TN and TP concentrations below the stated permit limits. The maximum acceptable average concentrations of TN and TP at 2050 Basis of Design Flows are summarized in Figure 9 (Option 1 and Option 2 concepts) and Figure 10 (Option 3 concepts).

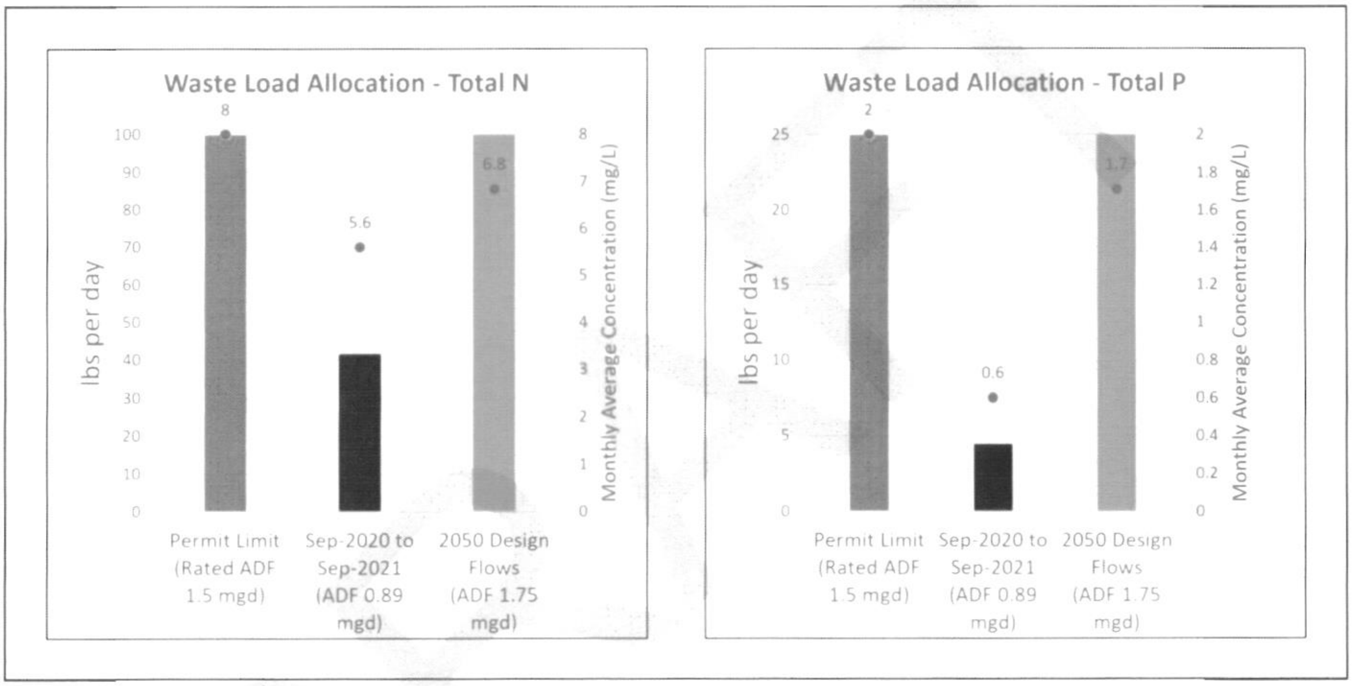

Figure 9 ***Waste Load Allocation, 2050 Average Day Flow 1.75 mgd (Option 1 and Option 2)***

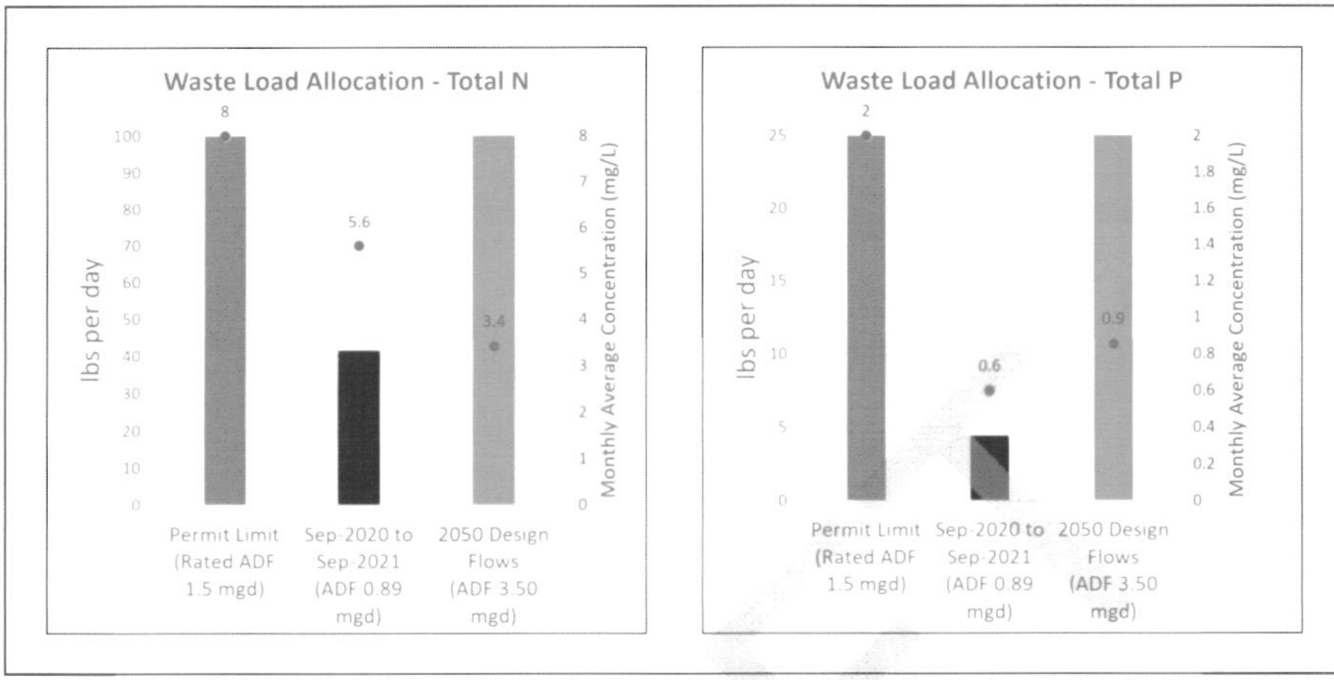

Figure 10 Waste Load Allocation, 2050 Average Day Flow 3.50 mgd (Option 3)

The nutrient concentration values indicated in the figures above correspond to the average concentration of TN and TP (mg/L) that would result in the WLA values shown, at a particular ADF.

As noted in Section 2.1.2, the existing Lewes WWTF currently discharges Total N and Total P average waste loads to the Canal that are less than half of the permitted Waste Load Allocation. For Option 1, it is assumed that the existing MBR process will be maintained for the 2050 planning horizon. The maximum allowable TN and TP concentrations for the Option 1 2050 design scenario are higher than the observed average values achieved with the existing MBR facilities. This indicates that the existing MBR arrangement can provide the necessary level of treatment to meet the 2050 Basis of Design Criteria.

Based on a detailed review of treated effluent data from comparable facilities in the Mid-Atlantic region, the maximum acceptable TN and TP concentrations for the 2050 Basis of Design Flows can be achieved by an activated sludge treatment facility with tertiary effluent filtration, similar to existing facilities owned and operated by Sussex County.

Therefore, for concept development purposes, it has been assumed that an activated sludge treatment facility, with tertiary effluent filtration, will be installed for all Option 2 and Option 3 facilities.

Note: Concept development for Option 3 treatment facilities was not included in the scope of the long-range planning study. However, a treatment methodology has been assumed for evaluation purposes (see Section 4.2, below).

A summary of the treated effluent water quality Basis of Design Criteria is provided in Table 11.

Table 11 Basis of Design Criteria, Treated Effluent Water Quality

Design Average Daily Flow (mgd)	Discharge Arrangement	Secondary Treatment Method	Applicable Options	Maximum Treated Effluent Monthly Average Concentration Total N (mg/L)	Maximum Treated Effluent Monthly Average Concentration Total P (mg/L)
1.75	To Existing Canal via Existing Permitted Outfall	MBR	Option 1	6.8	1.7
		Activated Sludge Treatment w/	Option 2b		

Design Average Daily Flow (mgd)	Discharge Arrangement	Secondary Treatment Method	Applicable Options	Maximum Treated Effluent Monthly Average Concentration Total N (mg/L)	Maximum Treated Effluent Monthly Average Concentration Total P (mg/L)
		Tertiary Effluent Filtration			
	Land Application	Activated Sludge Treatment w/ Tertiary Effluent Filtration	Option 2a		
	New Ocean Outfall	Activated Sludge Treatment w/ Tertiary Effluent Filtration	Option 2c		
3.5	To Existing Canal via Existing Permitted Outfall	Activated Sludge Treatment w/ Tertiary Effluent Filtration	Option 3a	3.4	0.9
	To Existing Canal via Constructed Wetland	Activated Sludge Treatment w/ Tertiary Effluent Filtration	Option 3b		

3.2 Option 1: Existing WWTF Hardening

3.2.1 Overview

A network schematic for the Option 1 upgrade concept is provided in Figure 11.

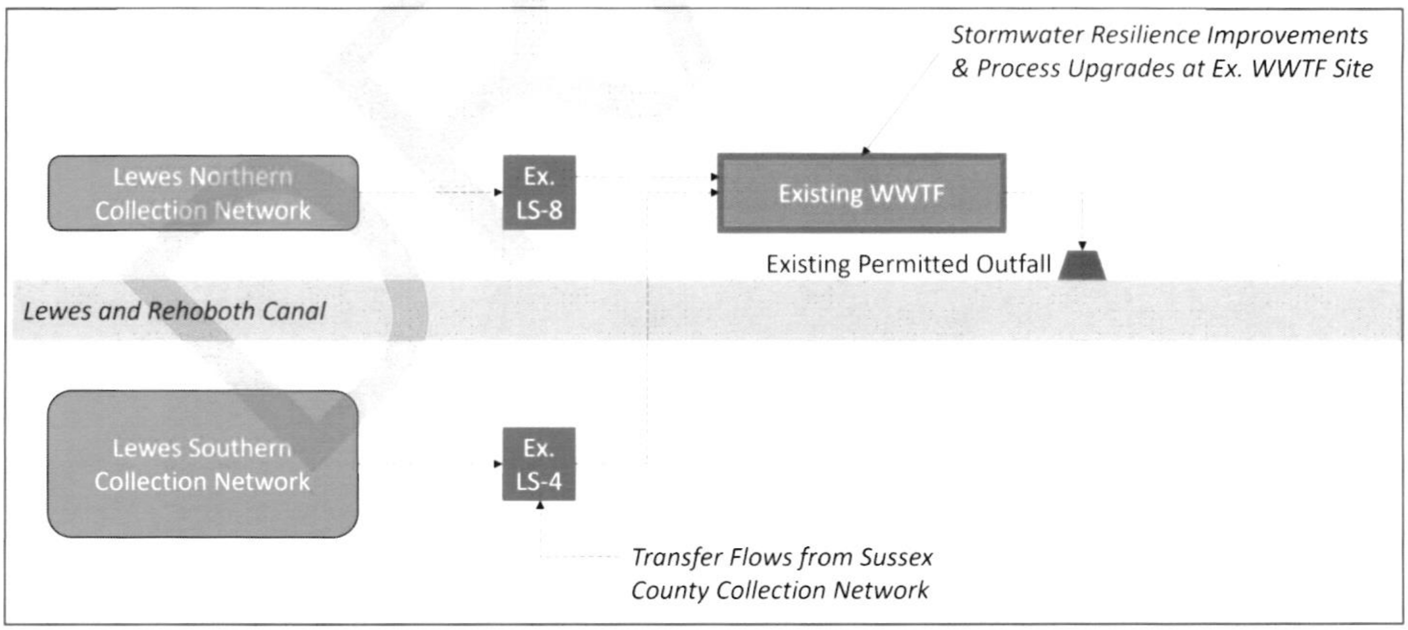

Figure 11 Option 1, Network Schematic

Option 1 would involve process upgrades at the existing WWTF to meet the 2050 Basis of Design Criteria, as well as additional flood mitigation measures to protect the low-lying site from future flooding scenarios.

3.2.2 Process Upgrades

Table 12 contains a list of the upgrades required to critical treatment facilities to enable the existing Lewes WWTF site to meet the 2050 Basis of Design Criteria for the BPW Collection Network up to 2050:

Table 12 Option 1, Required Upgrades to Treatment Facilities

Treatment Stage	Critical Equipment	Existing Capacity	Required Capacity	Year Installed	Expected Operational Life (Yrs)	Expected Remaining Life (Yrs)	Upgrades Required (Capital Expenditure)
Headworks	5mm Screen (1) and Lipactor (1)	4.4 mgd	5.13 mgd [1]	2006	15	0	Install new 5mm screen and compactor unit to treat 2050 Peak Hour Flow.
	Grit Removal Unit (1) and Pumps (1)	4.4 mgd	5.13 mgd [1]	2006	15	0	Install new grit removal unit and pump to treat 2050 Peak Hour Flow.
	2mm Screen (1)	2.25 mgd	2.10 mgd [2]	2006	15	0	Install new 2mm screens (2) and compactor (2) unit to treat 2050 Max. Month Flow. Recommend additional unit to provide additional redundancy to protect MBR facilities.
Flow Equalization	Flow EQ Tank (1)	526,000 gal	3,030,000 gal [3]	1987	25	0	Demolish existing tank and construct two new tanks to provide required EQ volume.
	EQ Lift Pumps (3)	1250 gpm (each)	730 gpm (each) [2]	2005	20	3	Replace existing pumps like-for-like.
Secondary Treatment	Aeration Basins (2)	408,000 gal	875,000 gal [4]	1986	75	39	Construct additional tank volume to provide the required volume.
	MBR Facilities (3)	1.62 mgd (total)	2.1 mgd [2]	2009 (Refurb. 2021)	10	9	Install fourth MBR cassette in space previously allocated (will increase capacity to 2.16 mgd) Ongoing replacement of MBR cassettes (at 10-yr intervals) to be included in O&M cost estimates.
Disinfection	UV Reactors (2)	4.5 mgd (total)	4.2 mgd [2]	2009	15	0	Replace existing units like-for-like.

Notes:

1. Treatment facilities sized to treat peak hour flow.
2. Treatment facilities sized to treat max month flow.
3. Flow Equalization facilities sized to provide 24-hrs storage of equalized flow. Equalized flow is the difference between Peak Hour Flow and Max. Month Flow.
4. Treatment facilities sized to provide 12-hrs hydraulic retention time at Average Day Flow.

Sussex County has confirmed that thickened solids could be trucked to the Inland Bays WWTF for drying, avoiding the need to improve existing solids handling facilities at Lewes WWTF to meet 2050 Basis of Design Criteria. However, the increased solids production will result in an increase in ongoing operational costs for BPW – this has been included in the analysis in Section 4.1.2.

A schematic layout showing the process upgrades required for Option 1 is provided in Figure 12.

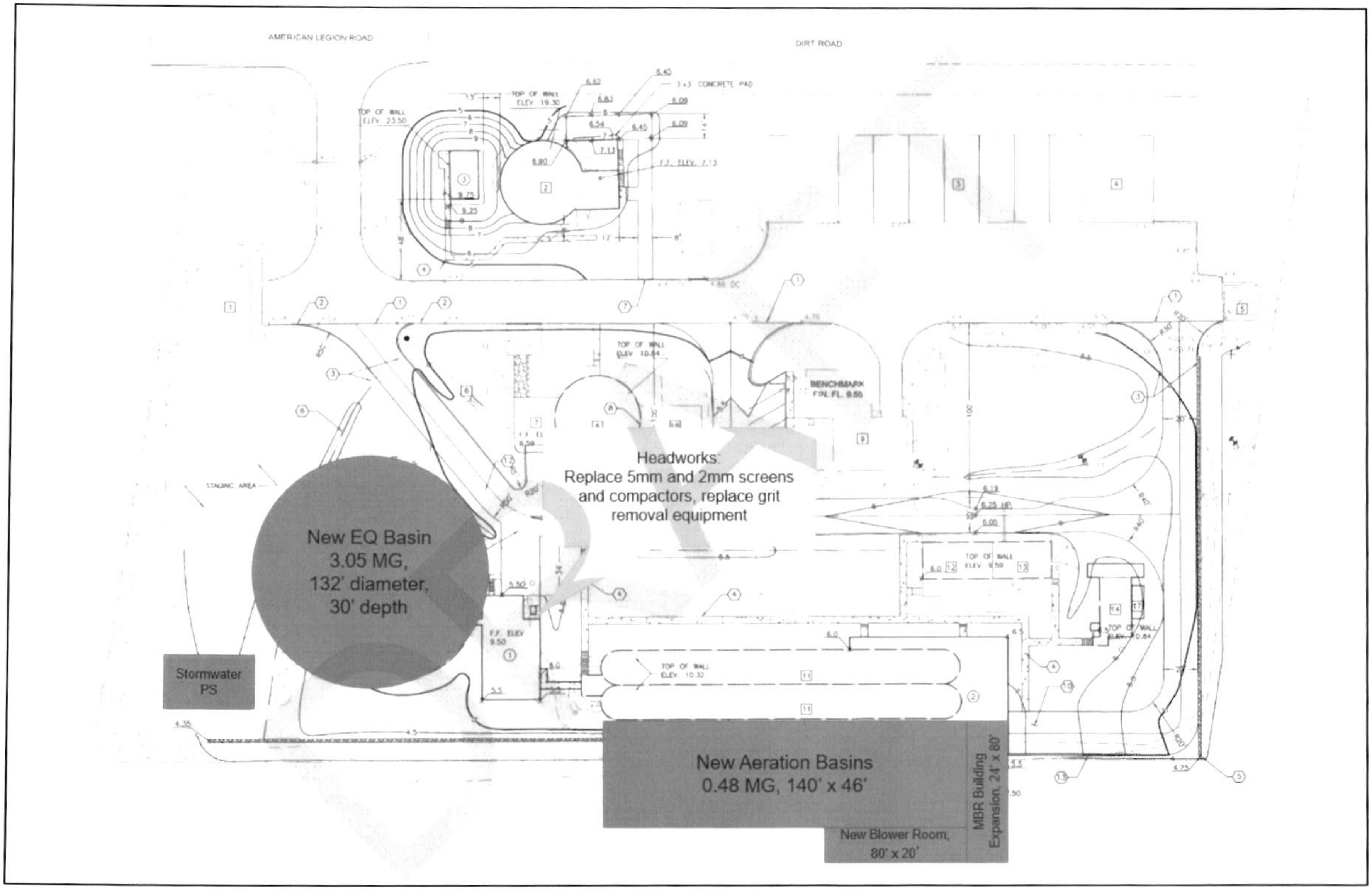

Figure 12 *Option 1, WWTF Site Layout Schematic*

As indicated in Figure 12, the site perimeter fence will need to be moved approximately 60 feet to accommodate the proposed expanded aeration basins. Due to existing yard piping and electrical conduits, there is not available site space to the north of the existing basins in which to construct the additional volume required.

Lewes BPW owns the land around the existing WWTF site and therefore it is assumed that this alteration to the site area would be feasible.

The new Flow Equalization Basin would be constructed above grade; the existing flow equalization pumps would be upgraded to meet the 2050 Basis of Design Criteria.

The proposed Stormwater Pump Station is outlined in more detail below.

3.2.3 Flood Risk Mitigation

The conceptual arrangement for Option 1 was developed on the basis of increasing flood resilience at the existing WWTF site via the following methods:

- A perimeter flood barrier to protect the site from ocean surges and stormwater runoff from surrounding areas.
- A stormwater pump station to discharge stormwater runoff generated from within the site.

The concept development for each component of the flood resilience approach is described below.

3.2.3.1 Perimeter Flood Barrier

A schematic layout for the proposed perimeter flood barrier is provided in Figure 13.

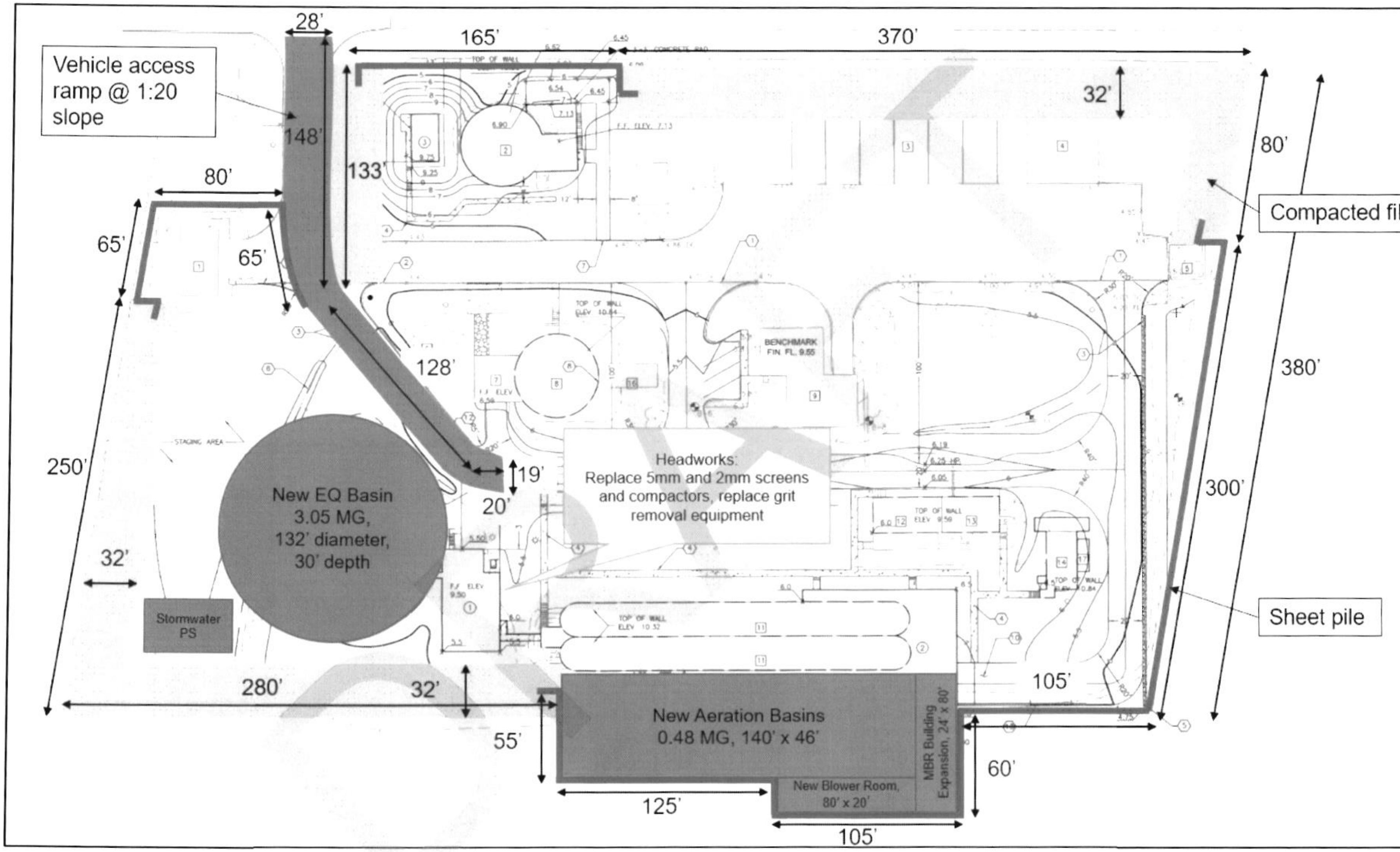

Figure 13 *Option 1, Perimeter Flood Barrier Concept Arrangement, Plan View*

The sizing of the perimeter flood barriers provides two feet of freeboard above the projected 2050 Flood Elevation of 8.64 feet.

The flood barrier system would be composed primarily of compacted fill; a typical section through the compacted fill barrier is provided in Figure 14.

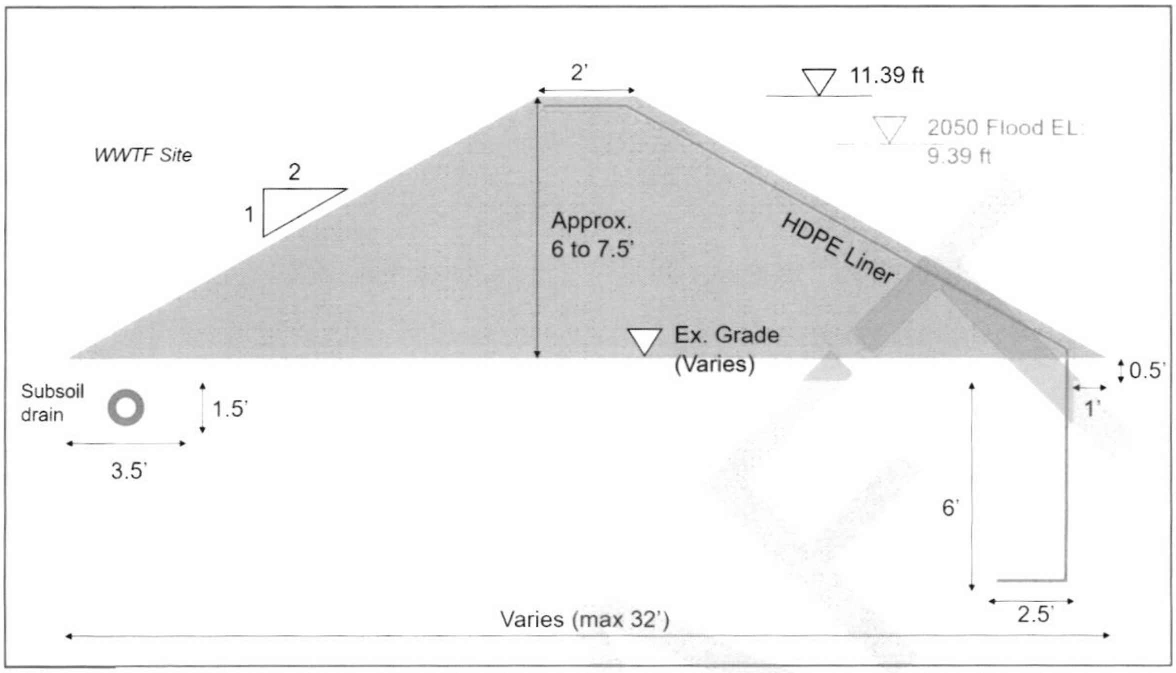

Figure 14 Option 1, Perimeter Flood Barrier Concept Arrangement, Typical Section

The height of the barrier will vary between 5 and 6 feet above grade to accommodate the varying site elevations. With a 2-foot crest width and 2:1 side slope, the barrier will have a maximum width of 29 feet. It should be noted that the 2:1 slope of the flood barriers is too steep to be mowed with a conventional lawnmower. However, site geometry does not permit a shallower slope which would further increase the barrier width. A specialized lawnmower will be required to maintain the barrier.

The City of Lewes regulations do not typically allow the addition of new fill on floodplains. Therefore, it has been assumed that a variance would be required in order to construct the proposed perimeter flood barrier.

To prevent the flow of groundwater into the site area, an impermeable HDPE liner will be included on the flood side. The liner will be anchored in a 6-foot trench. A perforated pipe will be included on the facility side of the barrier to provide subsoil drainage within the site.

Existing buried piping will be located below compacted fill barriers in several locations due to site geometry. This includes sludge feed piping to drying beds and portions of the influent and effluent force mains.

The concept layout was created under the assumption that all modifications must take place within the existing site area wherever possible (this is not feasible for the aeration basin expansion, as indicated above). For this reason, the compacted fill arrangement would be supplemented with sheet piling where the site layout does not permit the installation of a wider fill barrier. Sheet pile barriers will be required near the vehicle access ramp, oxidation basins, and sludge handling buildings to maintain access to these facilities and the site roads.

A static perimeter barrier (compacted fill berm and/ or sheet piling) is considered preferable to a flood gate, which would only be effective in the closed position during a major flooding event and could not be opened to allow site access until flood water has dissipated.

A ramp with a 20:1 slope will be used to allow vehicle access from American Legion Rd over the perimeter barrier. Because of the slope requirements, the vehicle access ramp must extend significantly into the site area. Some reconfigurations of site roads will be necessary to accommodate the ramp.

3.2.3.2 Stormwater Discharge

To manage stormwater from precipitation falling within the site, a stormwater pump station will be required at the low elevation point of the site. The low elevation point is located near the existing equalization tank as indicated in Figure 15.

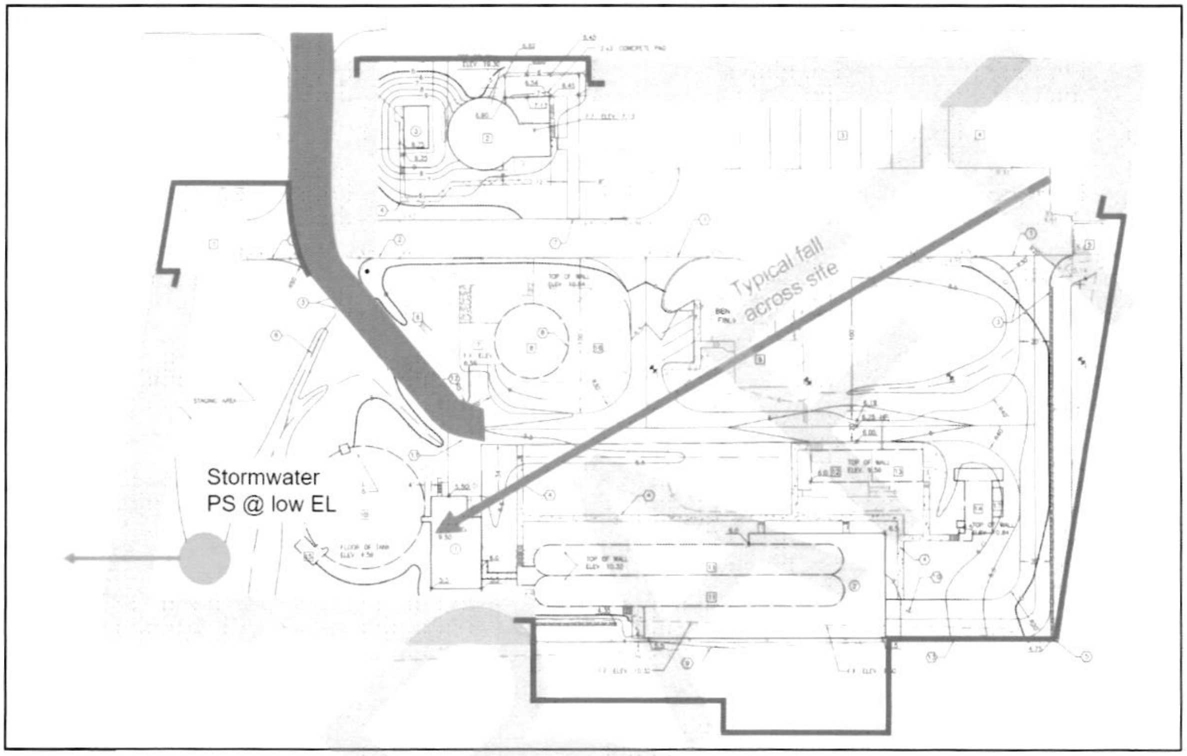

Figure 15 Option 1, Stormwater Discharge Pump Station Concept Arrangement, Plan View

A section view of the pump station, showing critical elevations, is provided in Figure 16.

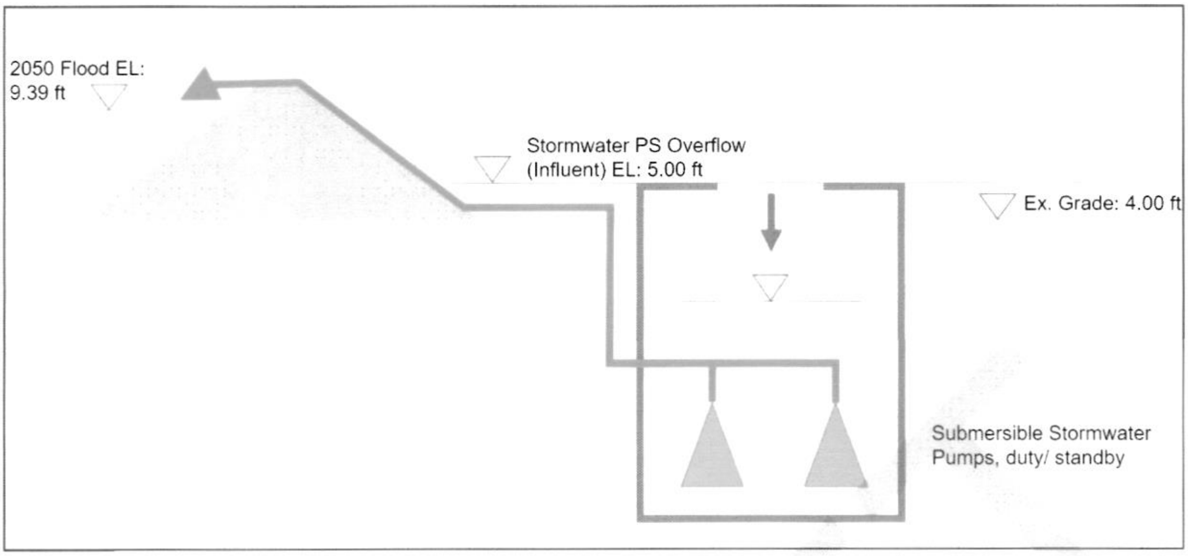

Figure 16 *Option 1, Stormwater Discharge Pump Station Concept Arrangement, Section View*

The overflow elevation for the stormwater pump station is recommended to be set at 5 feet. The elevation of site roads ranges from approximately 4.5 to 5.5 feet. Therefore, there could be a maximum of six inches of water on the site roads during a storm event, which allows safe vehicle access to be maintained across the site. This will also maintain the water level below the sludge beds, which are at approximately 6 feet in elevation.

The stormwater pumps will be in a duty/standby configuration. Pump sizing is based on the 100-year, 6-hour storm for Sussex County, as defined by DelDOT Road Design Manual, 2008. While it is noted that the statistical basis for a100-year storm has been affected by ongoing climate change, the 100-year return period is still recommended for concept development to ensure that Option 1 is consistent with the broader Basis of Design criteria for the long-range planning study.

The stormwater runoff flow for the 100-year, 6-hour storm was calculated to be 1870 gpm; the required pump head is approximately 10 feet, based on the overflow and flood elevations and assuming the discharge pipe is 100 feet in length.

It is possible that stormwater runoff from the WWTF site could contain contamination that would adversely affect the marshland areas on the external side of the proposed perimeter flood barrier. It's possible that additional stormwater treatment would be required prior to discharge from the WWTF site – this would be reviewed during a future design development stage, should Option 1 become the preferred alternative.

3.2.3.3 Residual Flood Risk

Following installation of the proposed perimeter flood barrier and stormwater PS, the flood elevation within the WWTF site will be maintained at 5ft, which is the overflow elevation to the stormwater PS. Revising the freeboard calculations on that basis, the residual flood risk is assessed as follows:

Table 13 *Residual Flood Risk Assessment Summary*

WWTF Area	Site Flood Elevation Post-Mitigation (ft)[1]	Existing Grade (ft)[2]	Threshold Elevation (ft)[3]	Calculated Freeboard to Site Flood Elevation (ft) [4]
Site Access (American Legion Road)	9.39	3.78	3.78	-5.61
Headworks Building: Lower Level, Structural Slab	5	5.5	9.50	4.50

WWTF Area	Site Flood Elevation Post-Mitigation (ft)[1]	Existing Grade (ft)[2]	Threshold Elevation (ft)[3]	Calculated Freeboard to Site Flood Elevation (ft) [4]
WWTF Office & Administration Building	5	6.31	9.55	4.55
Aeration Basins, Top of Wall	5	5.5	10.32	5.32
Process Building: Structural Slab	5	6.0	7.50	2.50
Process Building: MBR Tanks, Top of Wall	5	N/A	10.13	5.13
Digester Blower Building, Structural Slab	5	6	7.13	2.13
Sludge Drying Beds	5	6.60	6.60	1.40

Notes:
1. The new stormwater pump station will be configured to maintain the site flood elevation at 5.00 ft. See Figure 16 (above).
2. Existing grade elevations per GMB Contract Ref 1998002.D1, "WWTF Upgrade and Expansion", Drawing C-4 – Site Plan.
3. Threshold elevation is the lowest elevation at which water ingress may occur for a given building or structure.
4. Freeboard is the difference between the post-mitigation site flood elevation and the threshold elevation.

Following installation of the proposed improvements, all critical WWTF areas will be above the anticipated flood elevation within the WWTF site.

All buildings will have at least 2 ft of freeboard to the site flood elevation, per GHD's recommendations.

The sludge drying beds will only have 1.40 ft of freeboard; there is no major equipment in this area but flooding of dewatered sludge would constitute a major environmental issue. BPW could transfer dewatered sludge to Sussex County's Inland Bays facility for drying, rather than utilizing the drying beds onsite. However, this would increase hauling costs and create challenges in maintaining the dewatered sludge within the moisture limits for the County's facility.

While all WWTF critical areas will be above the flood elevation, vehicle access to the site (via American Legion Road) will be difficult or impossible under flood conditions. Under a coastal inundation scenario of 2.0 feet, water will cover large portions of both American Legion Road and East Savannah Road. This is a wider issue for the coastal area and cannot be mitigated by upgrades to the WWTF site alone, and therefore represents a significant residual risk for Option 1.

3.2.4 Summary of Upgrade Requirements

The following capital works are required as part of the Option 1 scope of work:

- Upgrades to the following treatment facilities to enable the existing Lewes WWTF to meet the Basis of Design Criteria up to 2050:
  - New 5mm mechanical screen, compactor installed within the existing Headworks Building.
  - New grit removal unit and pump installed within the existing Headworks Building.
  - New 2mm screens (2) and compactors (2) installed within the existing Headworks Building.
  - Demolish existing Flow EQ tank and install a new 3.03 MG tank.
  - Increase the volume of the Aeration Basins to provide 12-hrs storage at average daily flow.
  - Install a fourth MBR cassette to increase the treatment capacity to 2.16 mgd.
  - Replace the existing UV reactors (2) like-for-like.
- Construction of a new Perimeter Flood Barrier and Vehicle Access Ramp.
- Construction of a Stormwater Discharge Pump Station.

3.3 Option 2: Site Relocation within the Greater Lewes Area

3.3.1 Overview

Each of the Option 2 concept arrangements would involve relocating the Lewes WWTF to a new site within the Lewes postal area, located above the 2050 flood elevation. The three sub-options vary in the proposed discharge method for treated effluent.

The concept arrangements are outlined in further detail below.

3.3.1.1 Option 2a

A network schematic for the Option 2a upgrade concept is provided in Figure 17.

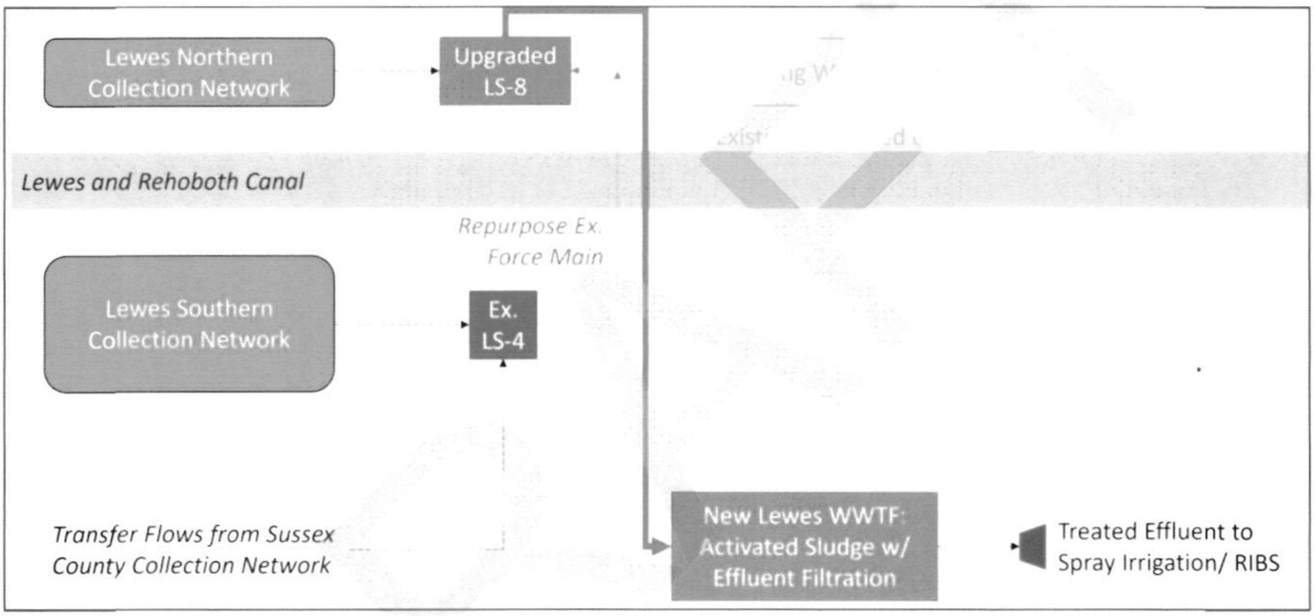

Figure 17 Option 2a, Network Schematic

Option 2a would involve consolidating the wastewater flows from the Lewes collection networks and pumping to a new WWTF at a high elevation site, located within the greater Lewes area. An activated sludge treatment process with tertiary effluent filtration would be suitable and the new WWTF would discharge treated effluent to ground, either via spray irrigation or RIBS.

Note: supplemental transfer flows from Sussex County would continue to be conveyed to LS-4 (and therefore to the new WWTF) under this concept arrangement.

3.3.1.2 Option 2b

A network schematic for the Option 2b upgrade concept is provided in Figure 18.

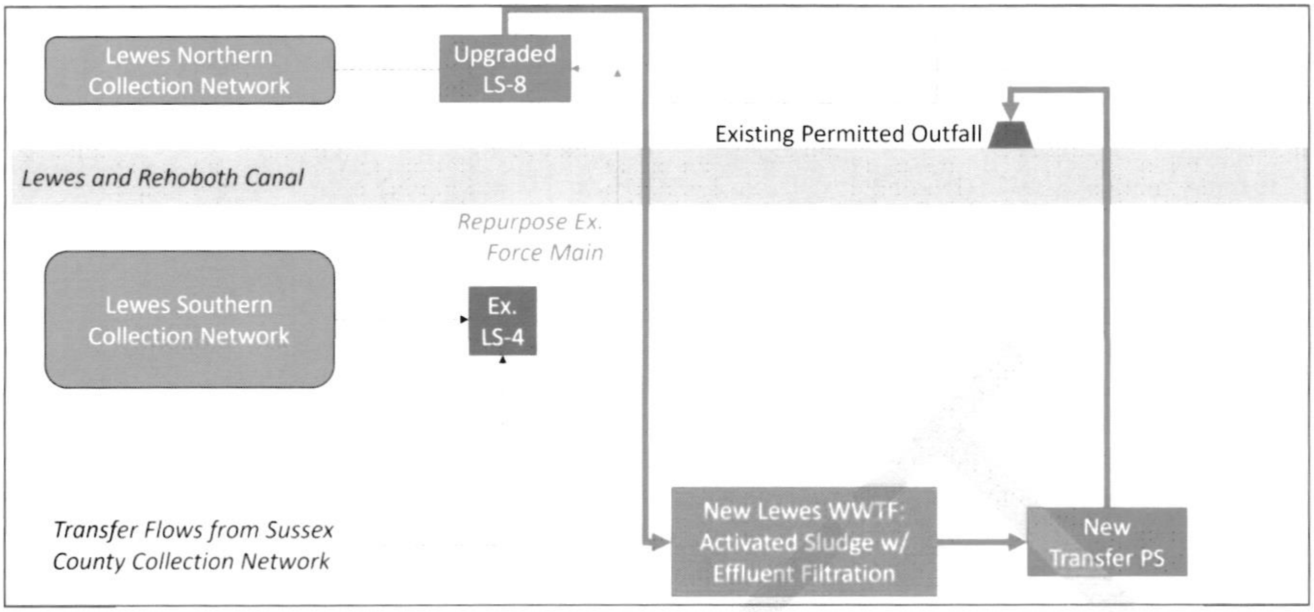

Figure 18 Option 2b, Network Schematic

Option 2b would involve consolidating the wastewater flows from the Lewes collection networks and pumping to a new WWTF at a high elevation site, located within the greater Lewes area. An activated sludge treatment process with tertiary effluent filtration would be suitable and the new WWTF would discharge treated effluent to the existing permitted outfall at the Lewes and Rehoboth Canal, via a new transfer PS.

Note: supplemental transfer flows from Sussex County would continue to be conveyed to LS-4 (and therefore to the new WWTF) under this concept arrangement.

3.3.1.3 Option 2c

A network schematic for the Option 2c upgrade concept is provided in Figure 19.

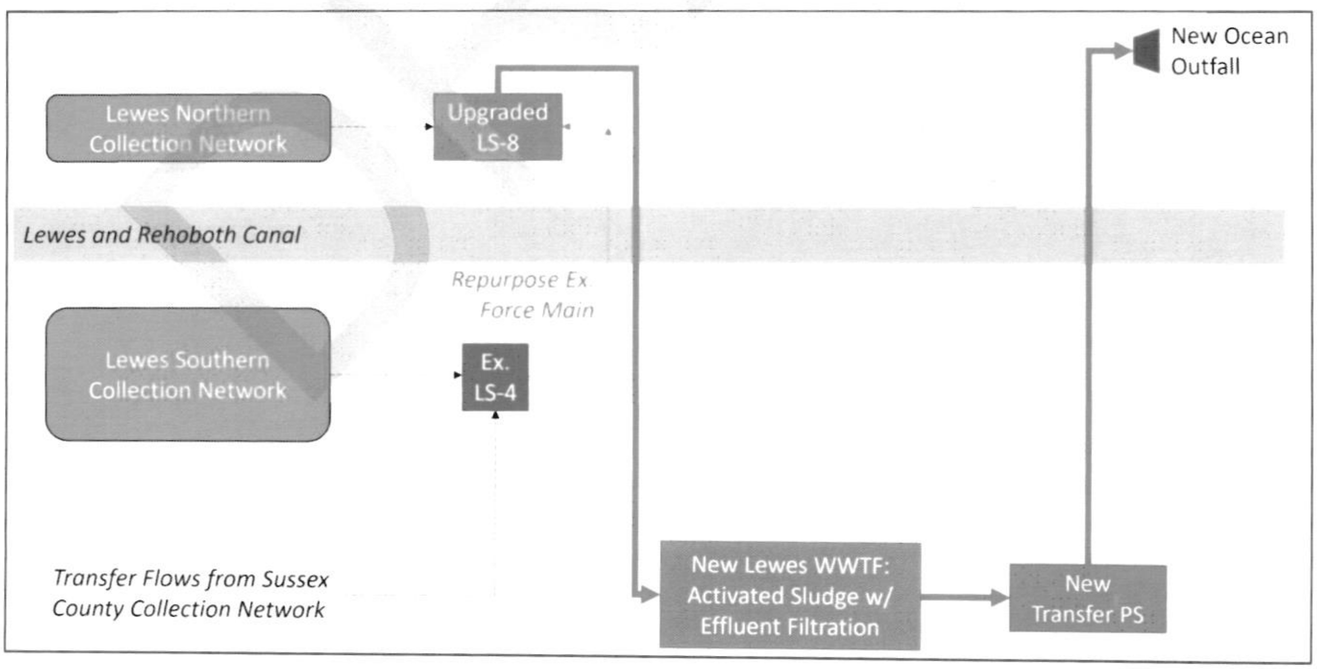

Figure 19 Option 2c, Network Schematic

Option 2c would involve consolidating the wastewater flows from the Lewes collection networks and pumping to a new WWTF at a high elevation site, located within the greater Lewes area. An activated sludge treatment process with tertiary effluent filtration would be suitable and the new WWTF would discharge treated effluent via a new ocean outfall.

Note: supplemental transfer flows from Sussex County would continue to be conveyed to LS-4 (and therefore to the new WWTF) under this concept arrangement.

3.3.2 Site Sizing Requirements

3.3.2.1 Treatment Facilities

All of the Option 2 concepts have been developed on the basis of constructing a new activated sludge facility with effluent filtration.

A typical layout for the facility was developed with the understanding that it would be adapted to suit the final site selection. The treatment processes and basis for site sizing for the new facility are summarized in Table 14.

Table 14 Treatment Stage Sizing

Item	Treatment Stages	Sizing Approach	WWTF Site, sf
1	Headworks	Sized for Peak Hour Flow. Includes grit removal, 5 mm screen and compactor	2,000
2	Aeration Lagoon	Assume 2 units (rectangular). Size so that combined volume gives a 24-hr hydraulic retention time at Average Day flow. Sidewater depth 15 ft.	15,600
3	Secondary Clarifiers	Assume 2 circular units. Sized based on 10 States Standards (surface overflow rate and side depth). Sized using Max Month Flow as peak flow. Assume 12ft side depth.	2,100
4	Effluent Filter and UV Disinfection Building	Assume 2 units each of effluent cloth disc filters and UV disinfection system. Sized for the Max Month flow.	2,700
5	Effluent Storage Lagoons	Required for land application of treated effluent only. Assume 4 units (rectangular). Sized so that combined volume gives a 45 day hydraulic retention time at Average Day flow (per DNREC requirements). Sidewater depth 15 ft. Depth adjusted to balance cut and fill.	810,000
6	Flow EQ Tanks	Sized to store 24-hrs of equalized flow. Equalized flow = Peak Hour flow – Max Month flow.	27,100
7	Sludge Handling Building	Includes sludge dewatering and thickener.	3,000

Item	Treatment Stages	Sizing Approach	WWTF Site, sf
		Size adapted from comparable WWTF sites.	
8	Effluent Pump Station	Sized for: - Peak Hour Flow	840
		Total Surface Area for Key Equipment, sf	**835,700**
		Total Surface Area for Key Equipment, acre	**19.2**

Allowing for access roads and other site features, for the activated sludge treatment process with tertiary effluent filtration concept, approximately 20 acres would be required for the treatment facility area, not including land required for effluent discharge.

Note: these facilities have been developed for the Option 2 concepts only and may not be suitable for the Option 3 concepts. Schematic site layouts for Option 3 concepts are not included in the scope of this report.

A typical schematic site layout for the new treatment facility is provided in Figure 20.

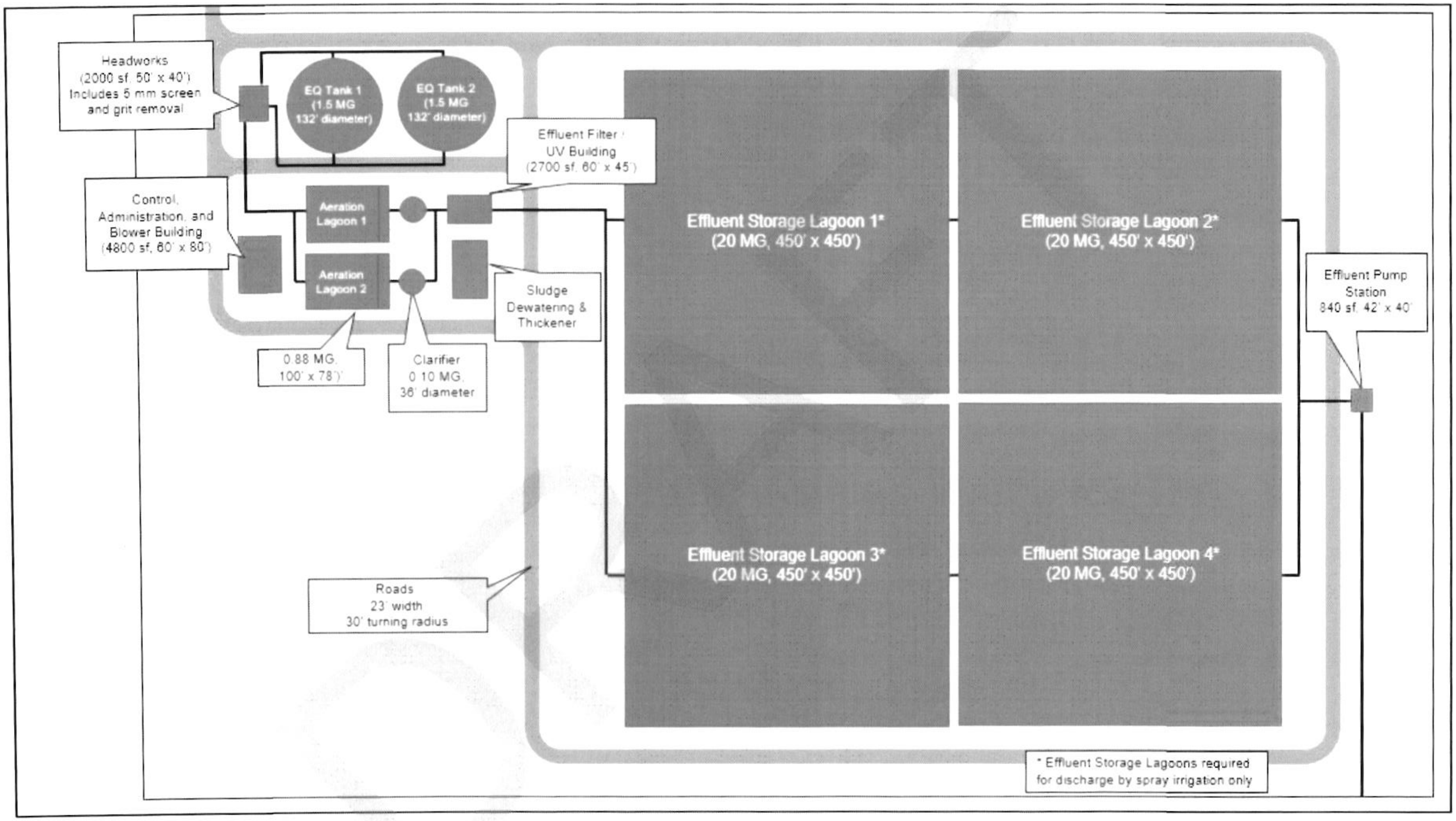

Figure 20 ***New WWTF Schematic Layout, Activated Sludge Treatment Process with Effluent Filtration***

3.3.2.2 Effluent Discharge: Spray Irrigation & RIBS

3.3.2.2.1 Regional Hydrogeology Desktop Summary

The Lewes WWTF site is located in the Atlantic Coastal Plain Physiographic Province, which is generally characterized by unconsolidated sediments overlying older sedimentary formations composed primarily of interbedded sands. The Lewes WWTF is underlain by the shallow, unconsolidated aquifer, which lies above the Pocomoke – Ocean City Aquifer (~approx. -10ft msl).

The Pocomoke-Ocean City Aquifer is made up of three hydraulically connected aquifers, the Manokin, Ocean City, and Pocomoke aquifers. These units are modelled and investigated as one because of the hydrologic connection which occurs as confining beds become discontinuous. North and West of Lewes the Pocomoke and Ocean City Aquifers become one, as the confining beds are discontinued in this area. Aquifer tests circa 1984 show that the Pocomoke-Manokin-Ocean City aquifer has a transmissivity around 5000 ft^2/day [1].

The primary constituent of these aquifers is sand, and the literature points toward rapid hydraulic conductivity (50 ft/d)[1], and low coefficients of storage (3.57×10^{-4}). These values point toward a hydrogeologic setting where the surficial aquifer rapidly translates recharge vertically to the underlying aquifer. These aquifers remain saturated and upon recharging rainfall, begin to saturate the unconsolidated aquifer.

The surface waters of the Pocomoke-Ocean City Aquifer extent derive much of their flow from groundwater. This is evidenced by coupled variation in water level and stream gage height during periods of baseflow[2]. This connection is bridged by the unconsolidated sediments of the surficial unconfined aquifer.

A Delaware Geological Society geologic map of Lewes is provided as Appendix B.

3.3.2.2.1.1 References for Regional Hydrogeology Review

The following studies and reports were used to develop the Regional Hydrogeology Desktop Summary described in the previous paragraphs.

1. Hodges, Arthur, Hydrology Of The Manokin, Ocean City, And Pocomoke Aquifers of Southeastern Delaware, January 1984, Delaware Geologic Survey, United States Geologic Survey

2. Johnston, Richard, Digital Model of the Unconfined Aquifer in Central and Southeastern Delaware, United States Geological Survey in Cooperation with the Delaware Geologic Survey, Newark Delaware, May 1977

3. Principal Aquifers in Delaware: A. Geographic Distribution; B. Generalized Cross Section. Sources: Cushing and others, 1973; Sundstrom and Pickett, 1971; Hodges, 1984. Figure copied from USGS Water Supply Paper 2275 DE

3.3.2.2.2 Spray Irrigation

According to DNREC Division of Water, Groundwater Discharges Section (7 DEL.C. Ch.60 6.3.2), the following restrictions apply for land applicated of treated wastewater:

- Soils with a permeability <0.02 inches/hour are prohibited from irrigation of treated wastewater
- Soils with a depth to water <24 inches are prohibited from irrigation of treated wastewater

Based on the desktop study summarized in Section 3.3.2.2.1 (above), the hydrogeological conditions in the Lewes area are **generally suitable for land application of treated wastewater effluent.**

Limited groundwater monitoring borehole data was available for review and therefore additional field investigation would be required to confirm the suitability of any specific sites, should Option 2a be selected for further design development.

In terms of site sizing requirements, DNREC notes that:

- Wastewater application rates may not exceed a maximum of 2.5 inches/acre/7 day period absent Department written authorization.

However, Sussex County have advised that on previous permit applications a more stringent application rate of 1.5 inches/acre/7day period was required. The required spray-irrigation application area for a range of application rates is summarized in Table 15.

Table 15 Spray Irrigation Require Application Area

Application Rate (in/acre/7 day period)	Required Application Area at 1.75 mgd ADF (acres)
1.5	310
2.0	**230**
2.5	190

For concept development purposes, GHD has agreed with BPW and Sussex County that an application rate of 2.0 in/acre/ 7-day period will be assumed for Option 2a. Effluent filtration will be included for options that utilize spray irrigation and therefore no additional buffer zones have been included in the estimates of required application area summarized above.

Therefore, a **total lot size of 230 acres will be required for spray-irrigation purposes.** Spray irrigation fields will need to be planted with cover crops and the cover crops require management and periodic harvesting to maintain optimum growth conditions.

DNREC notes the following additional operations and maintenance requirements for spray irrigation sites:

- Sites with seasonal high groundwater less than 5 feet deep (after consideration of mounding due to wastewater irrigation) must perform depth to water monitoring prior to spray irrigation to ensure the depth to water is greater than two feet during irrigation.
- The Design Engineer Report must contain monthly water balance calculations to determine the design hydraulic loading.
- Annual loading rates and site life limitations must be determined for phosphorus and heavy metals present in the wastewater.
- Average monthly values for potential evapotranspiration generated from vegetative, soil, and climatological data are to be used in the water balance calculations.
- Surface water bodies adjacent to wastewater spray irrigation sites must be monitored by the wastewater treatment facility.

Furthermore, if the treated wastewater is to be reused for irrigation activities, background and decennial soils sampling must be performed for the parameters listed in Figure 21. A minimum of one (1) composite sample must be taken for each 50 acre area, unless otherwise provided in the permit.

Parameter	Unit Measurement	Sample Type
pH	S.U.	Soil Composite
Organic Matter	%	Soil Composite
Phosphorus (as P_2O_5)	mg/kg	Soil Composite
Potassium	mg/kg	Soil Composite
Sodium Adsorption Ratio		Soil Composite
Cadmium	mg/kg	Soil Composite
Nickel	mg/kg	Soil Composite
Lead	mg/kg	Soil Composite
Zinc	mg/kg	Soil Composite
Copper	mg/kg	Soil Composite
Cation Exchange Capacity	meq/100g	Soil Composite
Phosphorus Adsorption	meq/100g	Soil Composite
Percent Base Saturation	%	Soil Composite

Figure 21 DNREC Soil Composite Sampling Requirements for Reuse of Treated Wastewater for Irrigation Purposes

3.3.2.2.3 RIBS

As noted above, based on the desktop study summarized in Section 3.3.2.2.1 (above), the hydrogeological conditions in the Lewes area are generally suitable for land application of treated wastewater effluent.

However, Sussex County and BPW have each noted concerns related to algal growth in RIBS facilities, which can lead to blinding of the infiltration beds. This subsequently affects the feasibility of discharging treated wastewater effluent and can lead to increased ongoing maintenance and cleaning requirements for the RIBS facilities

As a result of these concerns, **RIBS has not been considered any further for the purposes of concept development**.

3.3.2.3 Summary of Site Sizing Requirements

A summary of the total site area required, both for treatment facilities and discharge areas (if applicable), for each of the Option 2 concepts is provided in Table 16.

Table 16 Option 2 Concepts, Summary of Total Site Area Required

Applicable Options	Plant Design Flow (ADF, mgd)	Effluent Discharge	Secondary Treatment Process	Total Site Area Required (acres)
Option 2a	1.75	Spray Irrigation (with Effluent Storage Lagoons)	Activated Sludge Treatment with Tertiary Effluent Filtration	250
Option 2b	1.75	Permitted Outfall (Canal)	Activated Sludge Treatment with Tertiary Effluent Filtration	20
Option 2c	1.75	Permitted Outfall (Ocean)	Activated Sludge Treatment with Tertiary Effluent Filtration	20

Following a high-level review of undeveloped plots of land within the Lewes postal area, it has been assumed for concept development purposes that a suitable plot could be identified for each of the Option 2 concepts.

In the event that one of the Option 2 concepts is identified as the preferred option (see Section 5, below) a detailed siting study would be required as part of the future design development.

3.3.3 Pumping Requirements

3.3.3.1 Overview

The following approach has been used to develop the concept arrangements for the Option 2 wastewater pump stations:

- Raw wastewater pump stations and treated effluent pump stations shall be sized to convey the 2050 Peak Hour Design Flow for the Lewes collection network
    - 5.13 mgd; 3560 gpm
- Each pump station shall have two pumps in duty/ standby configuration.
- All new force mains shall be HDPE
    - Hazen-Williams roughness coefficient, C = 150
    - Force main lengths will be approximated assuming that a suitable site can be identified for a new WWTF within the Lewes postal area.
    - It is assumed that Option 2a would require a longer force main than Option 2b and 2c as the larger required site area is unlikely to be available close to the existing WWTF/ downtown area.

- Maximum force main velocity shall not exceed 8 ft/s
  - Force main nominal diameter of 16 inches has been selected for all force mains.
- Wet wells shall be configured to achieve 4 pump starts per hour at 2050 Peak Hour Design Flow
  - Per pump supplier (Gorman-Rupp) recommendations.
- Wet wells shall have a maximum drawdown depth per pump cycle of 3 ft
  - Per pump supplier (Gorman-Rupp) recommendations.
- Wet wells slabs shall have a minimum slope of 5%.
- Wet well shall be fitted within grinders on incoming pipes due to the known issues with rags and wipes in the Lewes wastewater collection network.
- A minimum of 2ft of freeboard shall be provided between the wet well high-water level and the lowest incoming gravity pipe.
- Raw wastewater force mains discharge at an elevation equal to max. WWTF site elevation + 20 ft.
- In the treated effluent wet wells, the finished grade shall be assumed to 2050 Flood Elevation (9.39 64ft) + 3ft freeboard, i.e., 12.39 ft. The incoming treated effluent pipe shall be assumed to have an invert elevation 6 ft below finished grade, i.e., 6.39 ft.
- Treated effluent force mains discharging to receiving water discharge at an elevation of 0 ft.
- Assume a standard pump efficiency of 70%.

The pumping requirements for specific components of the upgrade options are summarized below.

Hydraulic calculations are provided in Appendix C.

3.3.3.2 Raw Wastewater

In order to pump raw wastewater to a proposed new site at high elevation, wastewater flows from the Lewes Collection network first have to be consolidated at a single site for transfer pumping. As indicated previously, the Lewes collection network has two terminal pump stations: LS-4 (south of the Canal) and LS-8 (north of the Canal).

BPW's preference is for a new transfer pump station to be located at the LS-8 site; LS-4 is located in downtown Lewes, immediately adjacent to prominent businesses and busy roads, and therefore significant construction work at this site would be considerably more challenging and disruptive to stakeholders.

Therefore, the existing LS-4 arrangement will be used to transfer flows from the southern collection network to the LS-8 site, which will be modified to transfer raw wastewater flows to the feasible site for each concept arrangement.

Due to the increased flow and significantly higher delivery head, the existing LS-8 pumping arrangement would need to be upgraded to meet the Basis of Design Criteria. The existing wet well would also need to be expanded, which would require the existing LS-8 facilities to be taken offline for a significant period of time.

Furthermore, the existing building threshold at LS-8 (6.94 ft) is below the 2050 Basis of Design Flood Elevation, and the existing flood door is in poor condition.

Therefore, for concept development purposes, it is assumed that a new LS-8 pump station will be constructed offline, adjacent to the existing structure, and utilized to transfer all flow from the Lewes collection network to the new high elevation WWTF.

A schematic arrangement showing the proposed transfer piping from LS-4 to the new LS-8 pump station is shown in Figure 22.

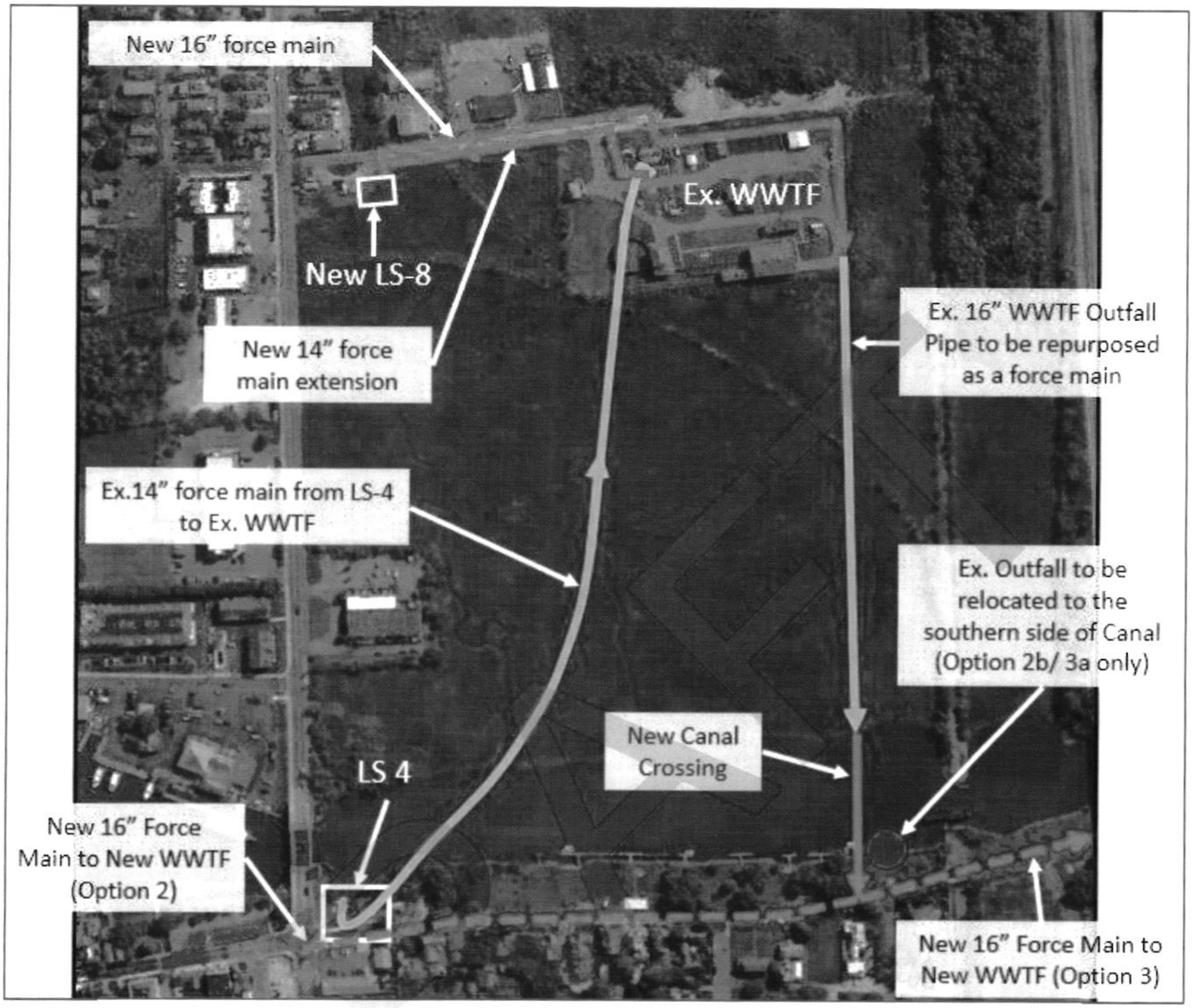

Figure 22 *Raw Wastewater Diversion to LS-8*

The existing 14" force main from LS-4 to the existing WWTF would be extended to the new LS-8 and a new 16" force main would be required from LS-8 to the existing WWTF site. The new pipe would then connect into the existing WWTF 16" outfall pipe, which could be relined and repurposed as a force main to convey flows to the canal.

A new canal crossing would be required to transfer flows to the southern side of the Canal, and then new 16" force mains would convey raw wastewater to the new WWTF sites.

As the existing WWTF outfall pipe will be repurposed, the existing permitted outfall will need to be relocated to the southern side of the Canal for the purposes of Option 2b.

Note: this piping configuration would apply for Option 3 concepts as well – see Section 3.4.3, below.

A schematic plan view showing the new LS-8 piping and pump station arrangement is provided in Figure 23.

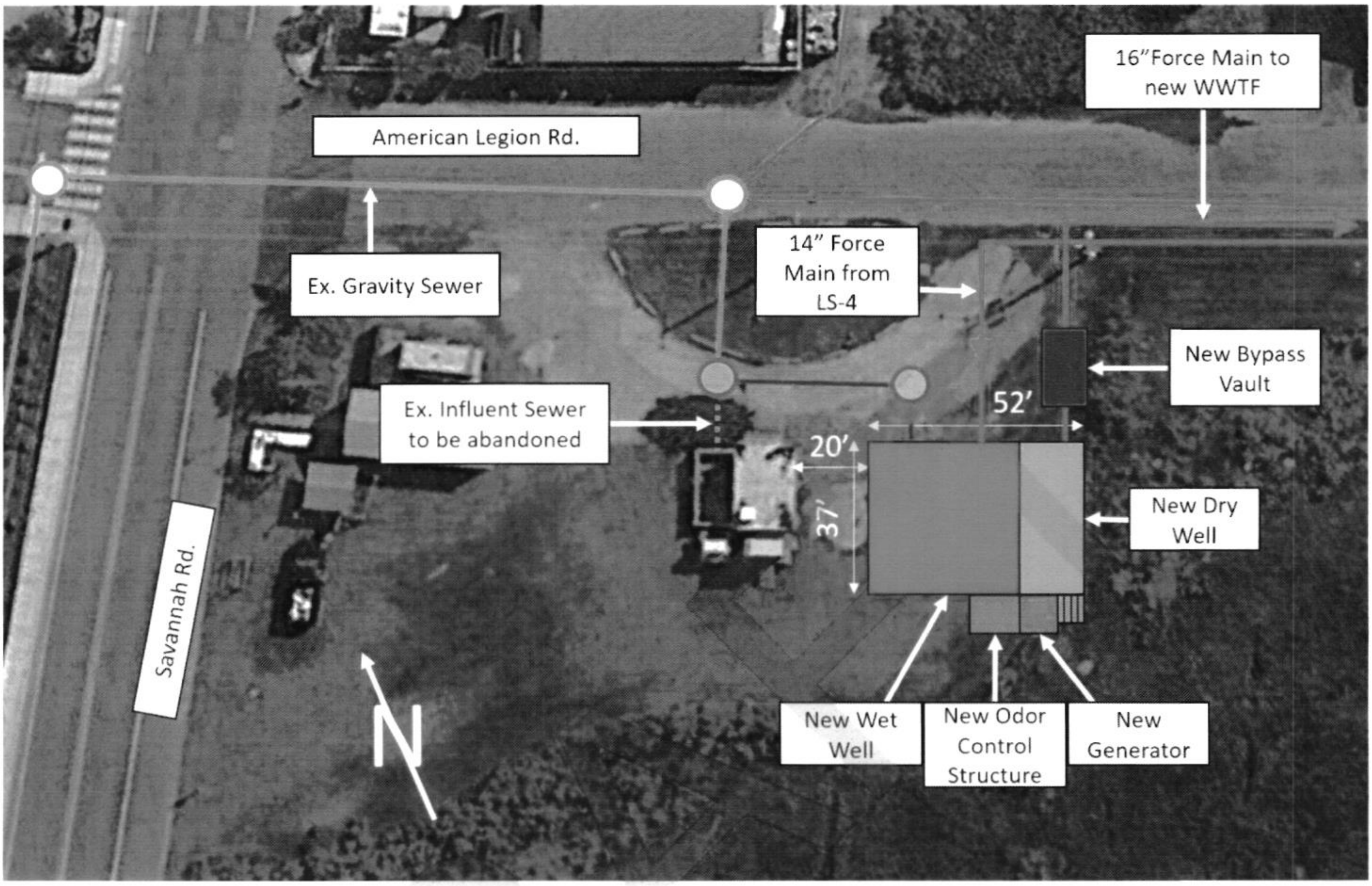

Figure 23 Options 2a/b/c, Raw Wastewater Pump Station, LS-8 Site Plan

The reconstructed LS-8 would need to include upsized pumps and a larger wet well in order to meet the requirements set out in Section 3.3.3.1, above. Auxiliary structures and machinery, including an emergency generator with raised concrete pad, bypass vault, and odor control structure would complement the reconstructed station.

A sectional view of the reconstructed LS-8 wet well is provided in Figure 24.

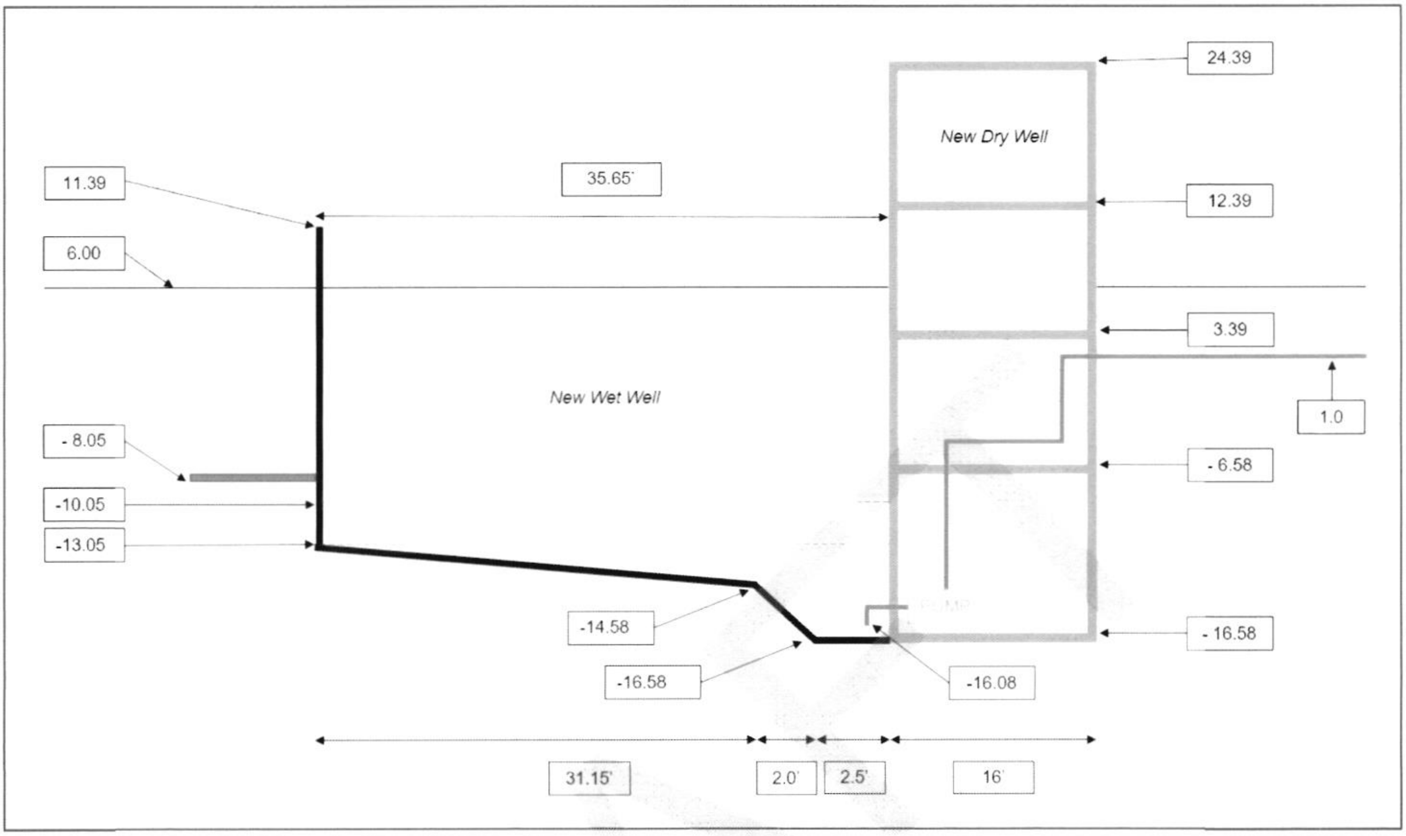

Figure 24 *Options 2a/b/c, Raw Wastewater Pump Station, LS-8 Sectional View*

The new LS-8 threshold elevation will need to be to 12.39 ft to provide 3ft of freeboard to the pumps, which would be located at the lower level. The critical structures exterior to the drywell, generator and odor control, would share a common raised platform with the same 3 feet of freeboard as the LS-8 entry threshold. Access stairs would be required to enter the new dry well operational level as well as to access the generator/odor control platform.

The raw wastewater pumping requirements for the Option 2 concept arrangements are summarized in Table 17.

Table 17 *Option 2, Raw Wastewater Pumping Requirements*

Ref	Duty Point	Force Main Length (LF) [1]	Wet Well WSE (ft)	Discharge WSE (ft)	Wet Well Operational Volume (CF)	Power Demand (HP)
Option 2a	3560 gpm, 228 ft	32,000	-10.1	49.0	3,600	293
Option 2b/2c	3560 gpm, 176 ft	24,000	--10.1	39.0	3,600	226

Note:
1. Force main lengths have been approximated assuming that a suitable site can be identified for a new WWTF within the Lewes postal area. It is assumed that Option 2a would require a longer force main than Option 2b and 2c as the larger required site area is unlikely to be available close to the existing WWTF/ downtown area.

Following consultation with BPW's preferred pump supplier, Gorman-Rupp, the new pumps required to deliver the duty points noted above are suitably sized to allow them to be retro-fitted within the existing dry well, and therefore no structural modifications are required to the dry well arrangement.

3.3.3.3 Treated Effluent

A Treated Effluent pump stations will be required for Option 2b and 2c to transfer treated effluent from the new WWTF to the associated outfall locations

Treated effluent pump station wet well sizing schematics for Option 2 are provided in Figure 25 and Figure 26.

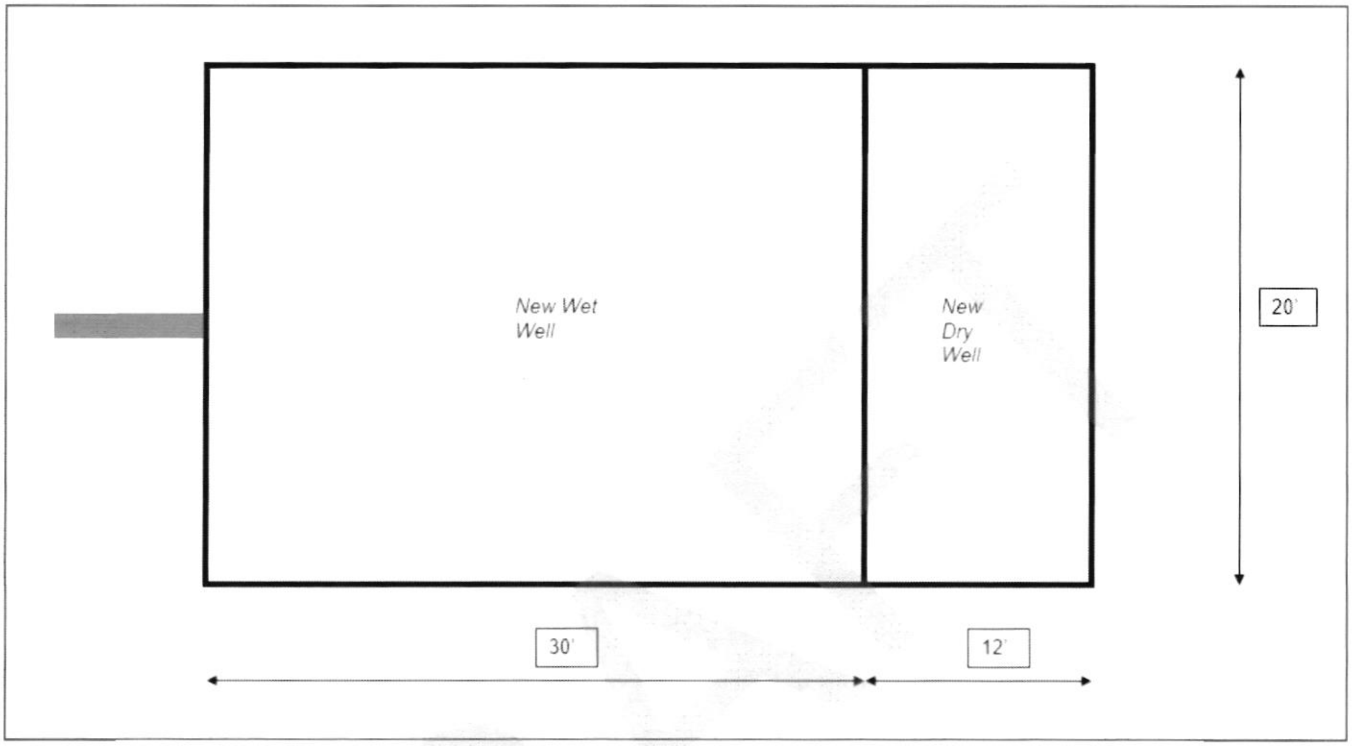

Figure 25 Options 2b/c, Treated Effluent Pump Station Schematic (Plan)

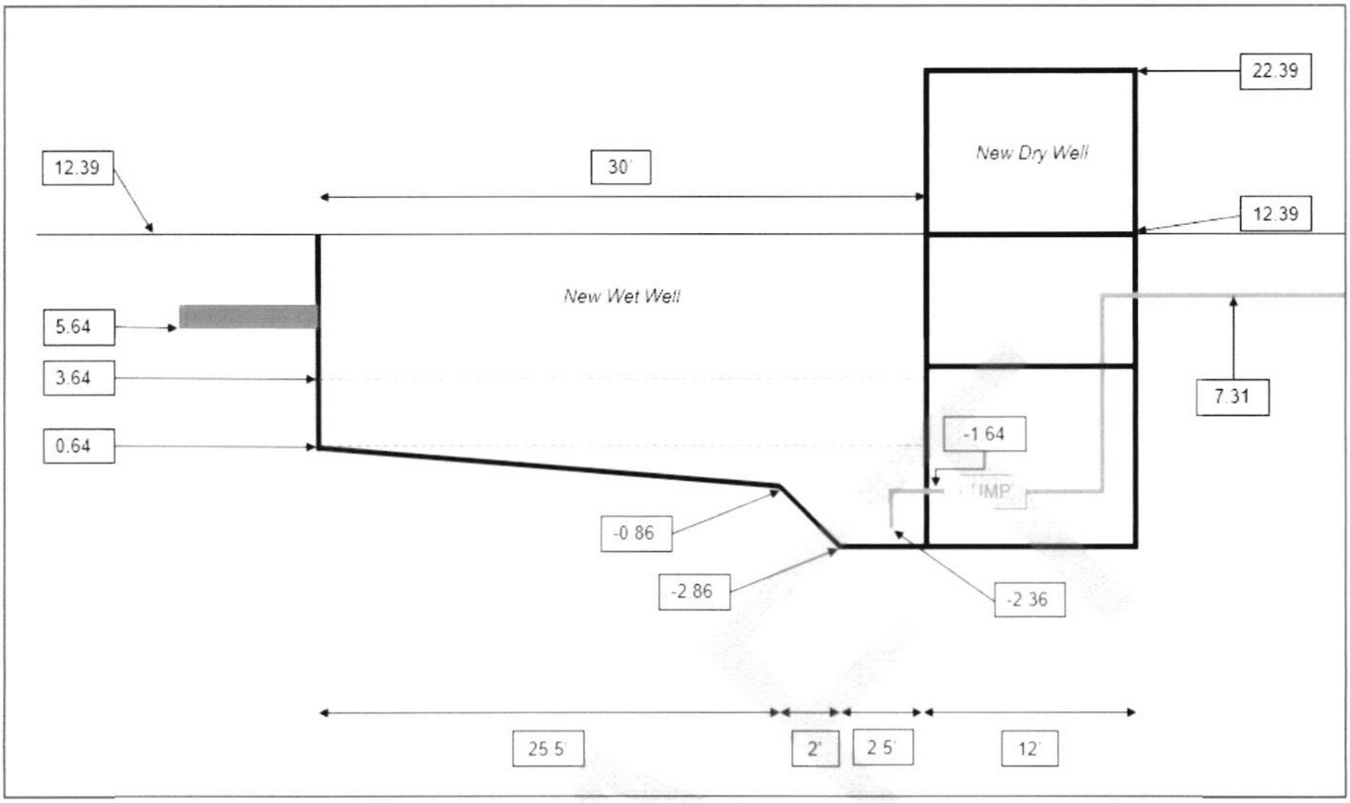

Figure 26 *Options 2b/c, Treated Effluent Pump Station Schematic (Section)*

The treated effluent pumping requirements for the Option 2 concept arrangements are summarized in Table 18.

Table 18 *Option 2, Treated Effluent Pumping Requirements*

Ref	Duty Point	Force Main Length (LF)	Wet Well WSE (ft)	Discharge WSE (ft)	Wet Well Operational Volume (CF)	Power Demand (HP)
Option 2b	3560 gpm, 123 ft	24,000	3.64	0.00	1,800	159
Option 2c	3560 gpm, 221 ft	42,000	3.64	0.00	1,800	284

The treated effluent force main length for Option 2b was estimated assuming a suitable site can be identified for a new WWTF within the Lewes postal area.

The Option 2c force main length was estimated assuming that additional sections of pipeline (beyond the location of the existing permitted outfall) would be required to a form a new ocean outfall, as indicated in Figure 27.

The ocean outfall alignment would continue past the existing WWTF and follow E Savannah Rd until it meets Cape Henlopen Drive. The route would then continue east within the paved roadway of Cape Henlopen Drive, following Post Lane through an existing paved parking lot, until reaching the beach.

Following this route would allow the alignment to minimize the impact to Cape Henlopen State Park and avoid the Delaware Bay. To mitigate concerns from stakeholders and the public, the outfall would discharge into the Atlantic Ocean rather than the Delaware Bay and would extend 6000-feet offshore.

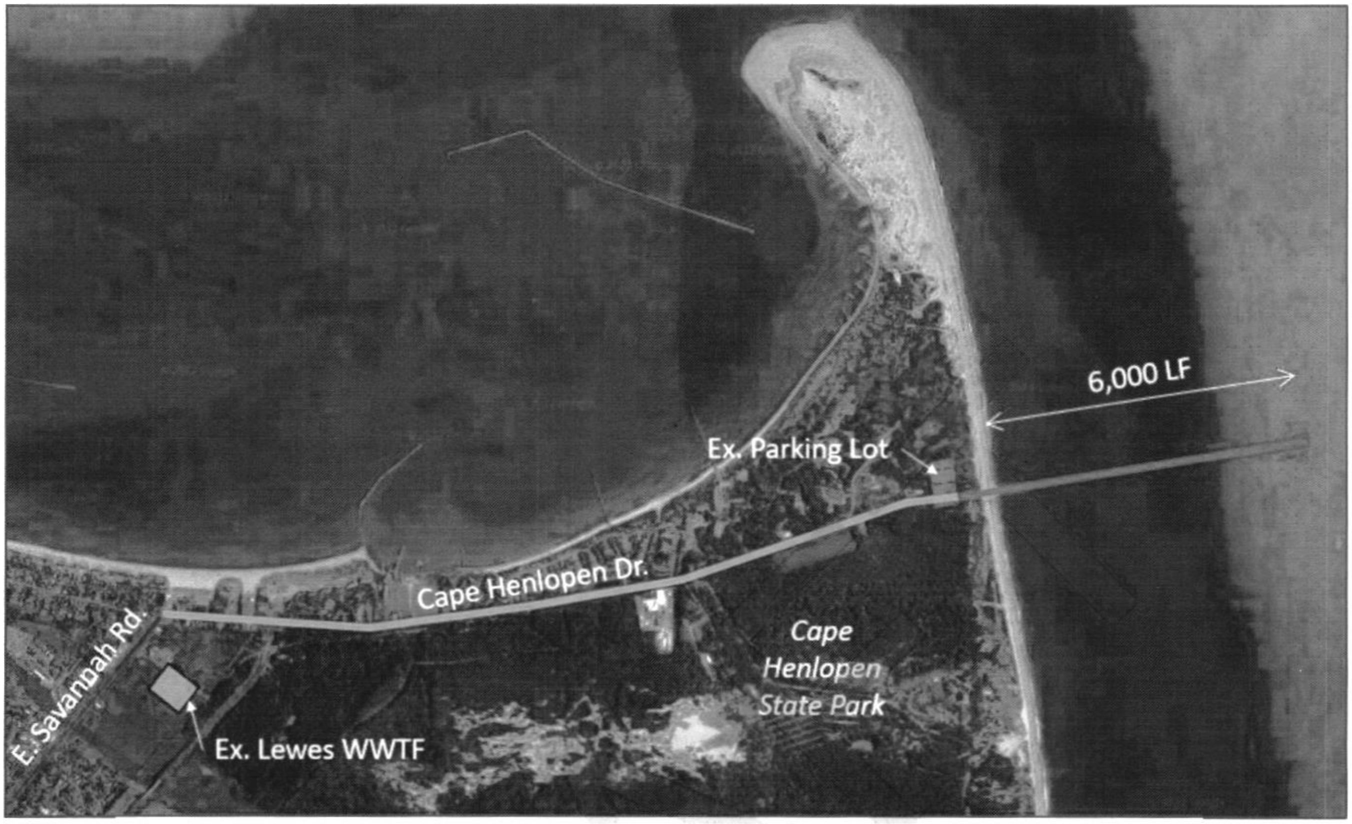

Figure 27 *Options 2c, Treated Effluent Force Main to New Ocean Outfall*

Note: for Option 2a a treated effluent booster pump station has been included in the site arrangements and the capital cost estimates to transfer treated effluent from the effluent storage lagoons to the spray irrigation equipment. Detailed treated effluent booster pump station wet well sizing calculations have not been undertaken as part of the Option 2a concept arrangement.

3.3.4 Summary of Upgrade Requirements

The following capital works are required as part of the Option 2a scope of works:

- Reconfiguration of LS-4 and LS-8 piping to consolidate all Lewes wastewater collection network flows at LS-8.
- LS-8 modifications to create new raw wastewater pump station.
- New Activated Sludge WWTF at high elevation, discharging via spray irrigation.

The following capital works are required as part of the Option 2b scope of works:

- Reconfiguration of LS-4 and LS-8 piping to consolidate all Lewes wastewater collection network flows at LS-8.
- LS-8 modifications to create new raw wastewater pump station.
- New Activated Sludge WWTF at high elevation, discharging to existing (relocated) outfall at Lewes and Rehoboth Canal.

The following capital works are required as part of the Option 2c scope of works:

- Reconfiguration of LS-4 and LS-8 piping to consolidate all Lewes wastewater collection network flows at LS-8.
- LS-8 modifications to create new raw wastewater pump station.
- New Activated Sludge WWTF at high elevation, discharging via new ocean outfall.

3.4 Option 3: Partnership with Sussex County

3.4.1 Overview

Each of the Option 3 concept arrangements would involve transferring raw wastewater from the Lewes collection network to a new combined treatment facility at Sussex County's Wolfe Neck site. The new facility would treat wastewater from both the Lewes and Sussex County collection network.

The two sub-options vary in the proposed discharge method for treated effluent.

The concept arrangements are outlined in further detail below.

Note: concept development for a new combined WWTF at Wolfe Neck is not included in the scope of this report. The Option 3 concept development scope only includes the transfer pumping stations and force mains required to convey raw wastewater to/ from the Lewes collection network.

3.4.1.1 Partnership Scope and Responsibilities

For the purposes of concept development, it is assumed that the terms of the existing Lewes BPW/ Sussex County Agreement for Wastewater Service Transfer will apply for the Option 3 facilities.

The key terms of the agreement are as follows:

- The scope boundary between Lewes BPW and Sussex County, is on Gills Neck Road at the intersection with Rodaline Avenue.
  - See Figure 28.
- New wastewater transfer infrastructure constructed to the west of the scope boundary is funded and maintained by Lewes BPW.
- New wastewater transfer infrastructure constructed to the east of the scope boundary is funded and maintained by Sussex County.
- Sussex County will contribute to any costs associated with increasing the treatment capacity of the Lewes WWTF in proportion to the amount of flow that is transferred from Sussex County to BPW's facilities.

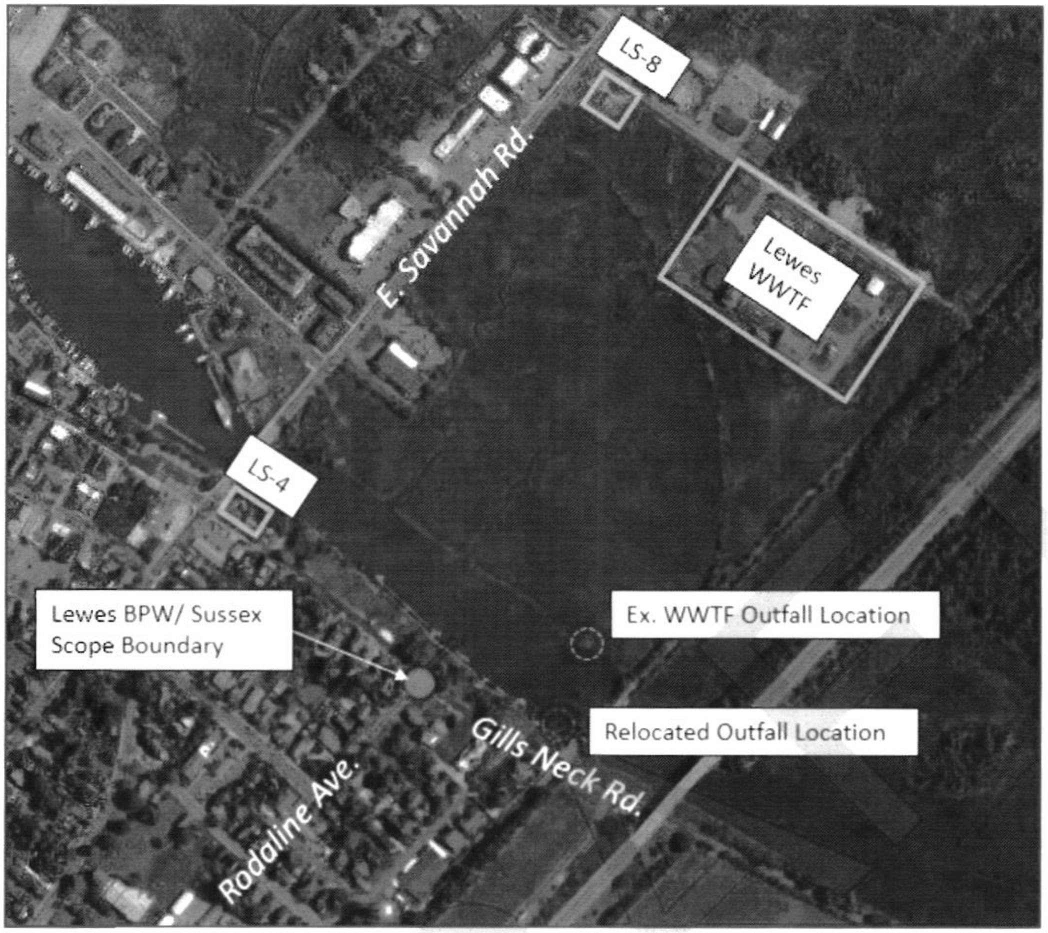

Figure 28 Lewes BPW/ Sussex County Partnership Handshake Point

Per the agreed scope of the Long Range Planning Study (see Section 1.2, above), estimates will only be produced for costs (capital and operation & maintenance) that Lewes BPW would be responsible for.

Based on the key terms of the BPW/ County partnership outline above, Lewes BPW would be responsible for funding and maintaining the following elements for the Option 3 concept arrangements:

- Raw wastewater pump station.
- Raw wastewater force main from the pumping station to the handshake point.

Conversely, Sussex County would be responsible for funding and maintaining the following elements for the Option 3 concept arrangements:

- Raw wastewater force main from the handshake point to the Wolfe Neck site.
- New combined wastewater treatment facilities at the Wolfe Neck site.
- Treated effluent pump station (Option 3a only).
- Treated effluent force main from Wolfe Neck to Relocated Outfall Location (Option 3a only).
- Relocated Outfall (Option 3a only).

3.4.2 Concept Development

3.4.2.1 Option 3a

A network schematic for the Option 3a upgrade concept is provided in Figure 29.

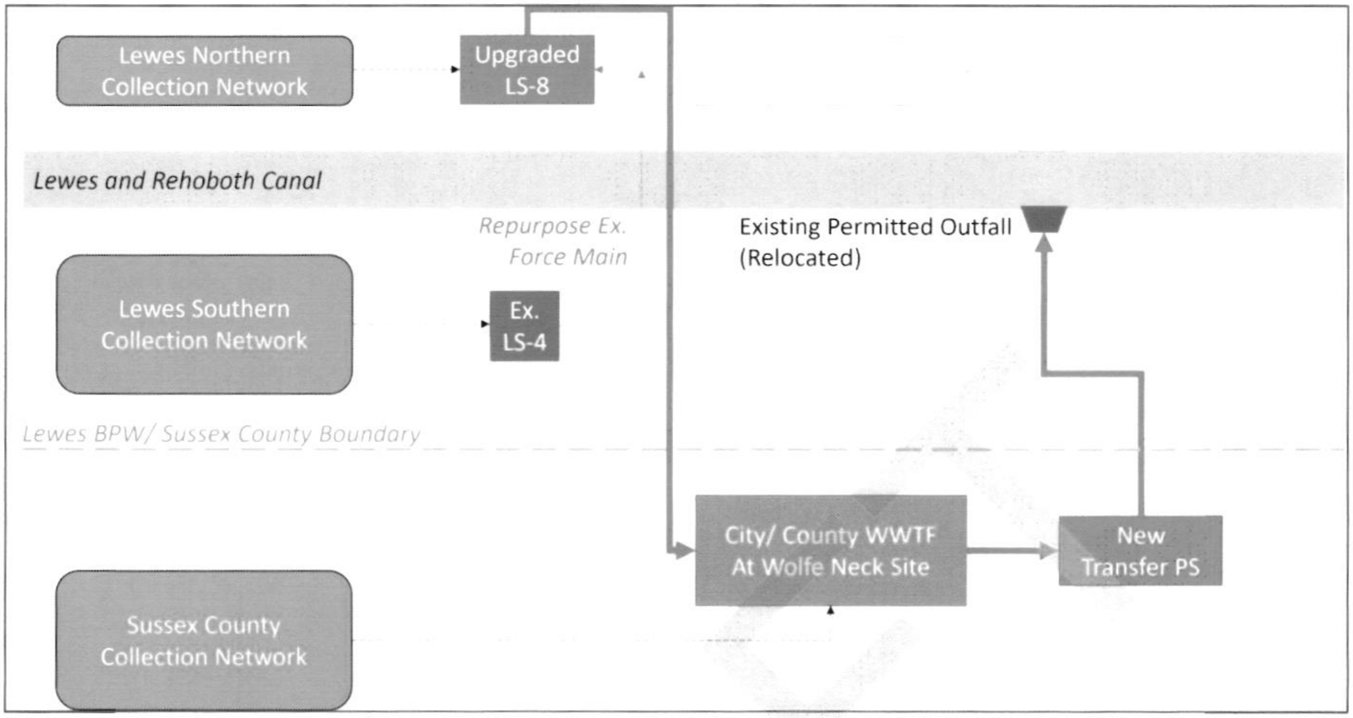

Figure 29 Option 3a, Network Schematic

Option 3a would involve consolidating the wastewater flows from the Lewes collection networks and pumping to a new City/ County WWTF located within Sussex County, at the existing Wolfe Neck site. The new WWTF would treat the combined raw wastewater from the Lewes and Sussex County collection networks.

Influent fluctuations would be equalized in the existing lagoon system and treated effluent would only be pumped back to the existing permitted outfall at the Lewes and Rehoboth Canal under outgoing tidal conditions. The benefits of discharging under outgoing tidal conditions would be assessed through additional modeling works, as part of a future design development stage – refer to Section 5 for further details.

3.4.2.2 Option 3b

A network schematic for the Option 3b upgrade concept is provided in Figure 30.

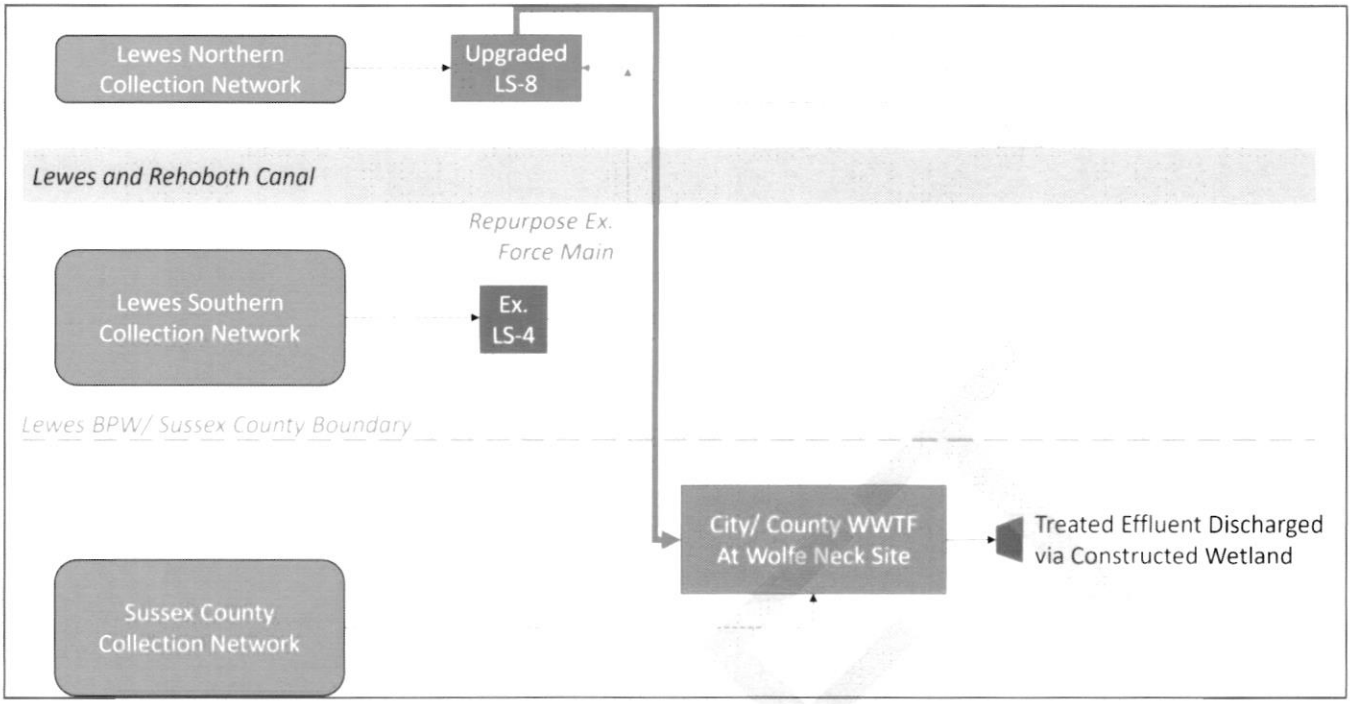

Figure 30 Option 3b, Network Schematic

Option 3b would involve consolidating the wastewater flows from the Lewes collection networks and pumping to a new City/ County WWTF located within Sussex County, at the existing Wolfe Neck site. The new WWTF would treat the combined raw wastewater from the Lewes and Sussex County collection networks.

Treated effluent would be discharged via a constructed wetland with vertical discharge, at a site within Sussex County.

Constructed wetlands are defined by the EPA as, "treatment systems that use natural processes involving wetland vegetation, soils, and their associated microbial assemblages to improve water quality". Note: concept development for the constructed wetland is not included within the scope of this report. It is assumed that the final treated effluent would then be discharged into the Canal.

The County's preferred site for the constructed wetland is on a plot of land which the County currently leases from the State. The existing lease would need to be modified; however, the term of the existing lease extends well beyond the 2050 project planning horizon.

3.4.3 Force Mains

3.4.3.1 Overview

The following approach has been used to develop the concept arrangements for force main alignments:

- Per the Option 2 concept development, all raw wastewater force mains originate at LS-8 (see Section 3.3.3.2, above, for further details)
  - Likewise, the treated effluent force main (Option 3a only) will discharge via the existing outfall, which will be relocated to the southern side of the Canal.
- Force mains shall follow existing roads and walking paths wherever possible.
- Force mains shall not be installed on private land.

3.4.3.2 Raw Wastewater from Lewes Collection Network

For concept development purposes it is assumed that raw wastewater flows from the Lewes collection network will be consolidated at LS-8 (per Option 2 concepts) – refer to Section 3.3.3.2 above, for the required piping configuration.

As indicated in Section 3.3.3.2, the new 16" raw wastewater force main will cross the canal and proceed east along Gills Neck Road.

An extract from the Sussex County GIS database, showing the existing wastewater infrastructure in the area between the BPW/ Sussex County handshake point and the Wolfe Neck site, is provided in Figure 31.

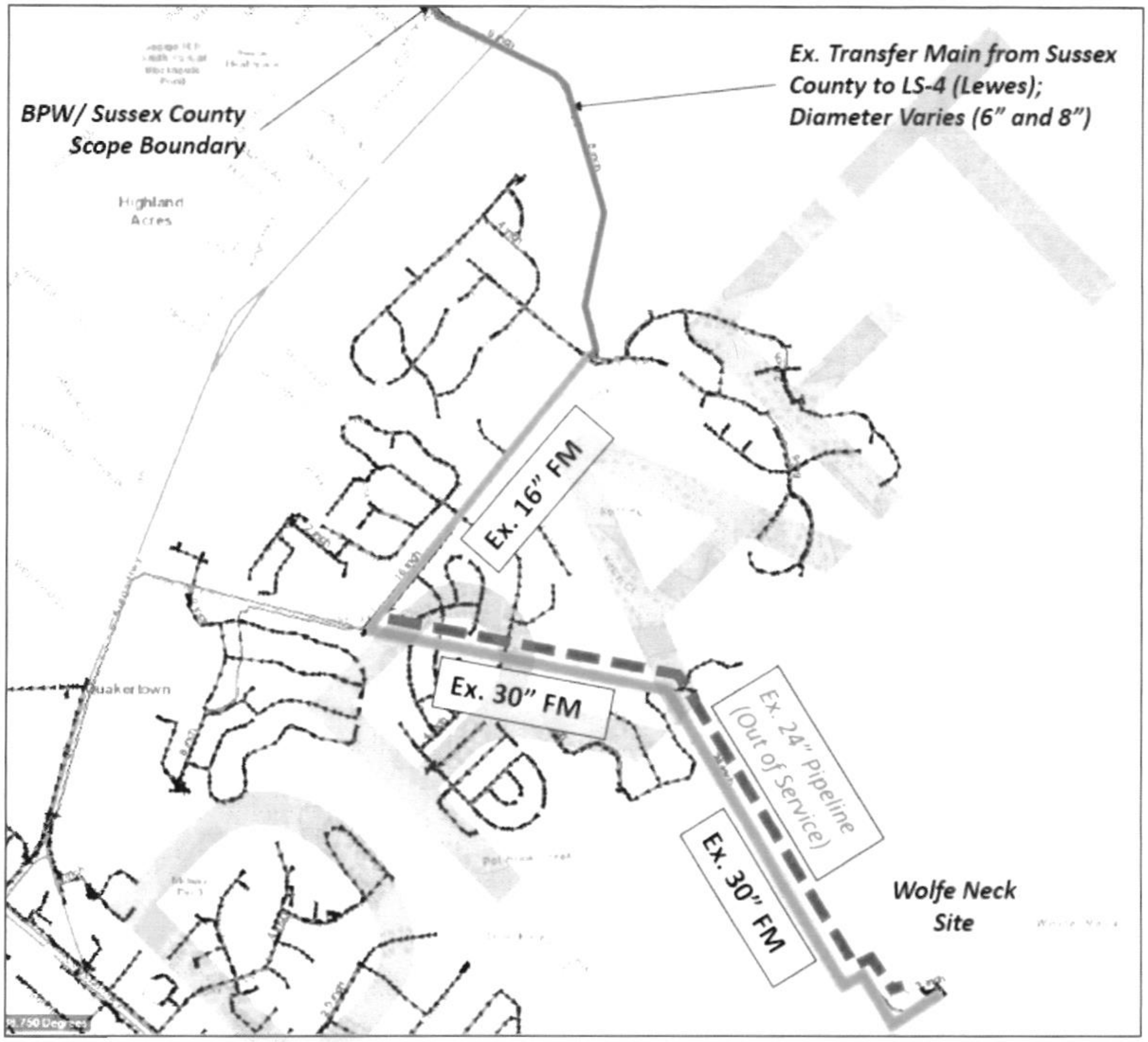

Figure 31 Existing Sussex County Wastewater Network (GIS Extract)

The existing 6"/ 8" Sussex County transfer main extends along Gills Neck Road for approximately 5,000 linear feet, up to the intersection of Gills Neck Road and Black Martin Drive.

In the event that an Option 3 concept arrangement is implemented, this transfer main would no longer be required. Therefore, it is assumed that this pipe would be replaced along the same alignment with a new 16" raw wastewater force main.

At the intersection of Gills Neck Road and Black Martin Drive the County has an existing 16" force main, which conveys flows from a small lift pump station located in the adjacent development. The 16" force main connects to a larger 30" force main, which then conveys raw wastewater to the existing Wolfe Neck site.

Sussex County have advised the 16" force main currently conveys very low flows, approximately 0.1 mgd. On that basis, there would be sufficient remaining capacity in the force main to convey the transfer flows from the Lewes collection network to the larger 30" trunk main.

For concept development purposes it is assumed that the existing 16" and 30" force mains can be used to transfer Lewes wastewater flows to Wolfe Neck and that the only new section of force main would be a new 16" main on the same alignment as the existing 6"/ 8" transfer main.

A summary of the Option 3 raw wastewater force mains is provided in Table 19.

Table 19 Options 3a/3b, Raw Wastewater Force Main Lengths

Type	From	To	Details	Force Main Length (mi)
Raw Wastewater	LS-8	BPW/ County Handshake Point	New 16" Force Main, Reuse portion of Ex. WWTF Outfall pipe, New 16" Creek Crossing	0.55
	BPW/ County Handshake Point	Intersection of Gills Neck Road and Black Martin Drive	New 16" Force Main (replace existing 6"/ 8" transfer main)	0.97
	Intersection of Gills Neck Road and Black Martin Drive	Gills Neck Road, east of intersection with Cadbury Circle East	Existing 16" Force Main	0.81
	Gills Neck Road, east of intersection with Cadbury Circle East	Wolfe Neck Site	Existing 30" Force Main	1.75
			TOTAL	**4.08**

3.4.3.3 Treated Effluent to Canal Outfall (Option 3a Only)

For Option 3a, a treated effluent force main will be required to transfer combined treated flow from the Wolfe Neck site to the existing (relocated) outfall.

Several potential alignment alternatives have been identified for the force main, and these are presented in Figure 32.

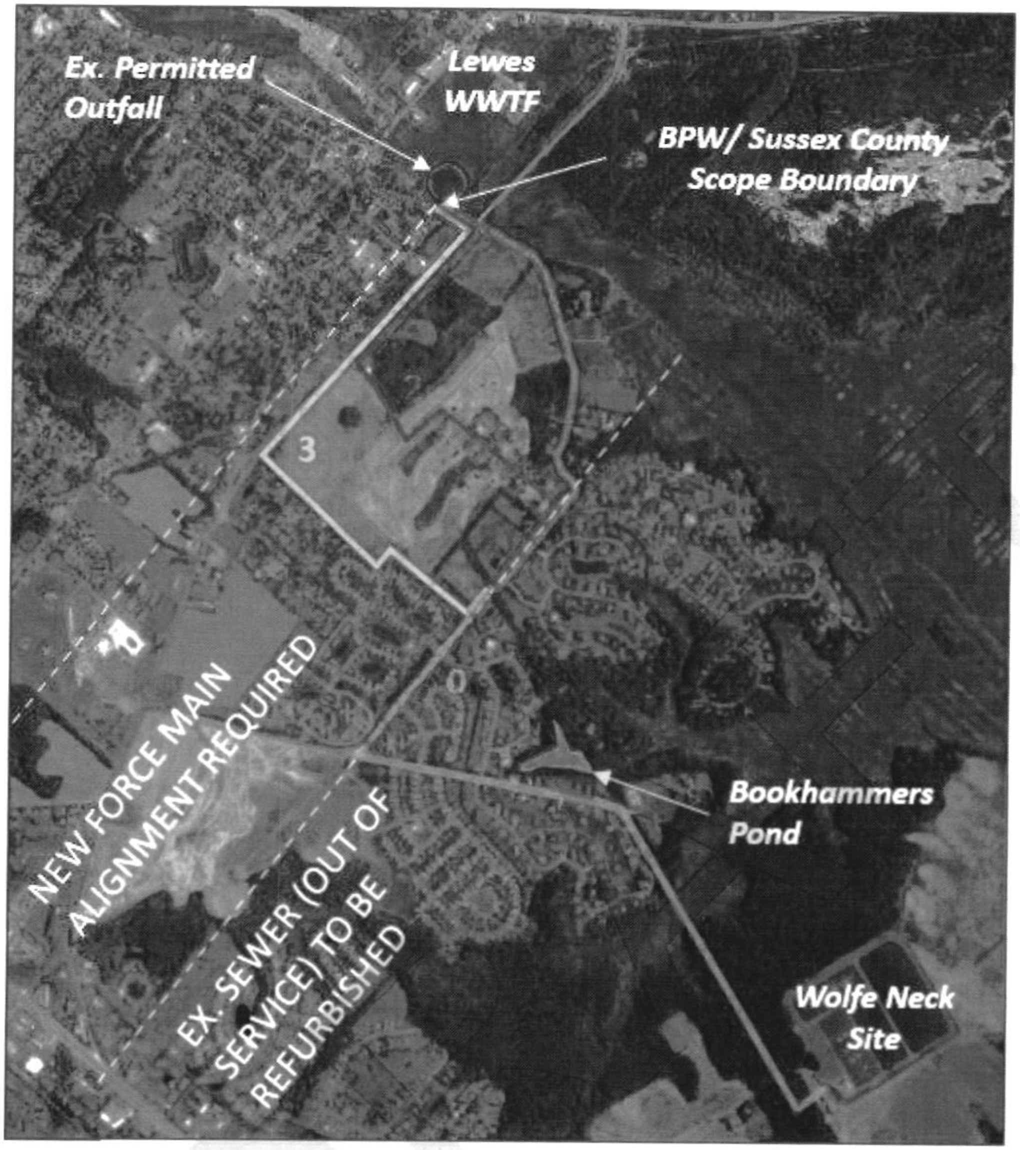

Figure 32 Option 3a, Potential Treated Effluent Force Main Alignment Alternatives

As indicated in Figure 31 and Figure 32, Sussex County owns an existing, out-of-service 24" pipeline, which runs parallel to the existing 30" force main between Gills Neck Road (east of the intersection with Cadbury Circle East) and the Wolfe Neck site. For concept development purposes, it has been assumed that this sewer can be lined with butt-fusion welded HDPE piping to form the upstream portion of the new treated effluent force main.

Note: the County has advised that the 24" pipeline is constructed from ductile iron and was recently pressure-tested to confirm operability for force main applications. However, for concept development purposes, it has been assumed that the pipeline will need to be relined in order to remain in service up to the 2050 project planning horizon.

Downstream of this location, a new force main will be required to convey treated effluent to the permitted outfall.

Three alignment options have been identified between the end of the ex. 24" pipeline (to be relined) and the permitted outfall. The three alignments have a common section between Cadbury Circle East and the intersection of Gills Neck Road and Spinnaker Drive, which has been labelled as "Alignment 0" in Figure 32.

The three unique alignment options for the new force main have been assessed by assigning a risk rating to reflect the expected difficulty of implementing each option.

Risk rating scores vary as follows:

- 1 = Low Risk
- 2 = Moderate Risk
- 3 = High Risk

Risk ratings were evaluated for the following criteria for each alignment option:

- Utility Congestion
- Traffic Density
- Construction Access
- Permitting
- Operation & Maintenance

The risk ratings for the new force main alignment options 1, 2 and 3 are summarized in Table 20.

Table 20 Option 3a, Treated Effluent Force Main, New Section Alignment Options

Criteria	Alignment Option 1 - Gills Neck Rd (North of Spinnaker Dr.)			Alignment Option 2 - Show Jumper Ln & Monroe Ave			Alignment Option 3 – Junction & Breakwater Trail		
	Risk Rating	Comment	Score	Risk Rating	Comment	Score	Risk Rating	Comment	Score
Utility Congestion	Low	Ex. Force main (to be upsized for raw wastewater main) located along this alignment. Opportunity to install both pipes in common trench.	1	High	Ex. Utilities in place to supply new housing development. Ex. Wastewater pipes in place on Gills Neck Road.	3	Low	No know services in this portion of the trail.	1
Traffic Density	High	Works would lead to prolonged disruption along portion of Gills Neck Road.	3	Moderate	Works within housing development would disrupt local traffic.	2	Low	Works completed within walking trail, away from roadways.	1
Construction Access	Low	Works undertaken along roadway.	1	Moderate	Works undertaken predominantly in roadway, however access within the housing development would need to be coordinated with residents.	2	Moderate	Truck access to section of trail adjacent to Horseshoe crescent may require crossing private land.	2
Permitting	Low	Assumed existing easements in place along alignment due to existing force mains.	1	High	Access required to construct in recently completed private development. Section of alignment require temporary closure of walking trail.	3	Moderate	Requires temporary closure of walking trail, no existing easements in this area.	2
Operation and Maintenance	Low	Publicly accessible roads.	1	Moderate	Some publicly accessible trails/ roads but coordination also required with residents within housing development.	2	Moderate	Publicly accessible trail, however access for maintenance vehicles/ equipment would be difficult	2
TOTAL			**7**			**12**			**8**

Option 1 has the lowest total risk rating and therefore is considered the preferred option for concept development purposes.

A summary of preferred force main alignment options is provided in Table 21.

Table 21 Option 3a, Treated Effluent Force Main Lengths

Type	Zone	Alignment Option	Force Main Length (mi)
Treated Effluent	Ex. Pipeline to be relined with HDPE	Existing	1.30
	New Force Main, Gills Neck Road (South of Spinnaker Dr.)	0	0.50
	New Force Main, Gills Neck Road (North of Spinnaker Dr.)	1	1.50
		TOTAL	**3.30**

3.4.4 Pumping Requirements

3.4.4.1 Overview

The approach used to develop the concept arrangements for the Option 3 wastewater pump stations is the same as was used for Option 2 pump station (see Section 3.3.3.1, above), with the exception of the following items:

- The Raw wastewater pump station shall be sized to convey the 2050 Peak Hour Design Flow for the Lewes collection network
  - 5.13 mgd; 3560 gpm
  - 16" nominal diameter HDPE force main assumed
  - Hazen-Williams roughness coefficient, C = 150
- The Treated effluent pump station and shall be sized to convey the 2050 Max. Month Design Flow for the combined Lewes & Sussex County collection networks
  - 4.10 mgd; 2850 gpm
  - 14" nominal diameter HDPE force main assumed
  - Hazen-Williams roughness coefficient, C = 150

Hydraulic calculations are provided in Appendix C.

3.4.4.2 Raw Wastewater

The raw wastewater pump station for Option 3 will be located at LS-8 and will have the same arrangement and convey the same flow rate as for the Option 2 concepts – refer to Section 3.3.3.2 for schematic layout details.

The raw wastewater pumping requirements for the Option 3 concept arrangements are summarized in Table 22.

Table 22 Option 3, Raw Wastewater Pumping Requirements

Ref	Duty Point	Force Main Length (LF)	Wet Well WSE (ft)	Discharge WSE (ft)	Wet Well Operational Volume (CF)	Power Demand (HP)
Option 3a/3b	3560 gpm, 107 ft	21,600	-10.05	50.00	1,800	138

3.4.4.3 Treated Effluent (Option 3a Only)

A Treated Effluent pump station will be required for Option 3a to transfer treated effluent from the new combined WWTF at the Wolfe Neck site to the existing (relocated) outfall at the Canal.

Treated effluent pump station wet well sizing schematics for Option 3a are provided in Figure 33 and Figure 34.

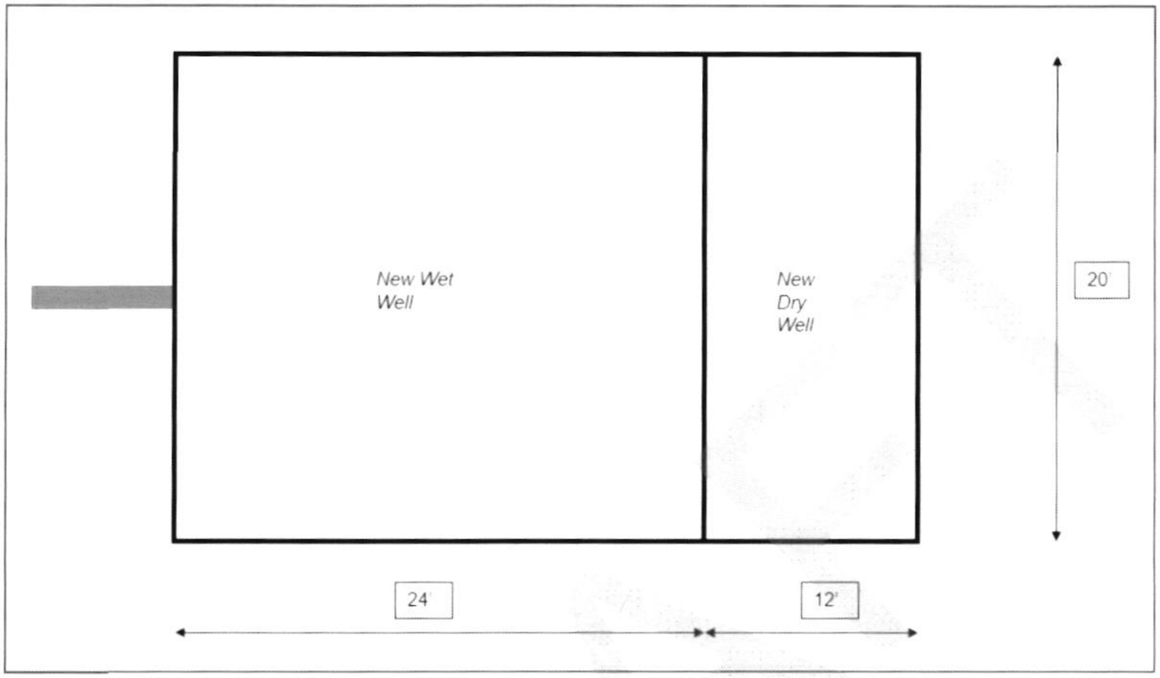

Figure 33 Option 3a, Treated Effluent Pump Station Schematic (Plan)

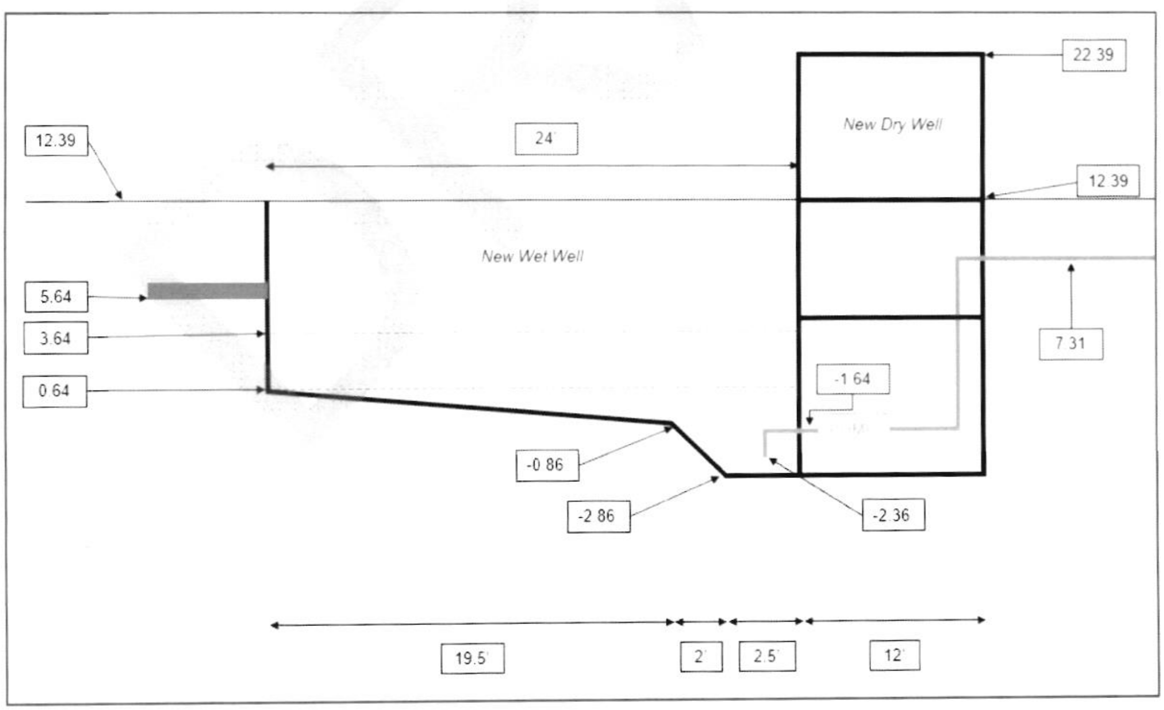

Figure 34 Option 3a, Treated Effluent Pump Station Schematic (Section)

The treated effluent pumping requirements for the Option 3a concept arrangement are summarized in Table 23.

Table 23 Option 3a, Treated Effluent Pumping Requirements

Ref	Duty Point	Force Main Length (LF)	Wet Well WSE (ft)	Discharge WSE (ft)	Wet Well Operational Volume (CF)	Power Demand (HP)
Option 3a	2850 gpm, 115 ft	17,500	3.64	0.00	1,440	118

3.4.5 Summary of Upgrade Requirements

The following capital works are required as part of the Option 3a scope of work:

- Lewes BPW Responsibility:
  - Raw wastewater pump station.
  - Raw wastewater force main from the pumping station to the scope boundary.
- Sussex County Responsibility:
  - Raw wastewater force main from the scope boundary to the Wolfe Neck site.
  - New combined wastewater treatment facilities at the Wolfe Neck site.
  - Treated effluent pump station.
  - Treated effluent force main from Wolfe Neck to Relocated Outfall Location.
  - Relocated Outfall.

The following capital works are required as part of the Option 3b scope of works:

- Lewes BPW Responsibility:
  - Raw wastewater pump station.
  - Raw wastewater force main from the pumping station to the scope boundary.
- Sussex County Responsibility:
  - Raw wastewater force main from the scope boundary to the Wolfe Neck site.
  - New combined wastewater treatment facilities at the Wolfe Neck site, including a constructed wetland with vertical discharge.

Note: concept development for a new combined WWTF at Wolfe Neck is not included in the scope of this report. The Option 3 concept development scope only includes the transfer pumping stations and force mains required to convey raw wastewater to/ from the Lewes collection network.

4. Long Range Upgrade Options: Evaluation

4.1 Cost

Preliminary Capital Cost Estimates and 2050 Net Present Value (NPV) Operation & Maintenance (O&M) Cost Estimates for the long range planning study concepts are outlined below.

All costs are presented in 2022 US Dollars.

Note: concept development and capital cost estimation for a new combined WWTF at Wolfe Neck is not included in the scope of this report. The Option 3 concept development scope only includes the transfer pumping stations and force mains required to convey raw wastewater to/ from the Lewes collection network. Capital costs associated with upgrading the treatment facilities at Wolfe Neck will be completed under a separate work order.

However, estimates have been developed for the O&M costs associated with a combined facility (Option 3), using existing budgetary figures from a comparable WWTF owned and operated by Sussex County. Per the terms of the existing BPW/ Sussex County Agreement for Wastewater Service Transfer, it has been assumed that BPW would be responsible for a proportion of the total O&M costs for a combined facility based on the proportion of the total treated flow that is transferred from the Lewes collection network to the new facility. The Basis of Design flow rates for a combined facility (see Section 3.1.2, above) assume a 50% flow contribution from the Lewes collection network, and therefore it has been assumed that BPW will be responsible for 50% of the O&M costs for a combined facility.

Land valuation estimates were provided to GHD by Lewes BPW.

4.1.1 Preliminary Capital Cost Estimates

The preliminary capital cost estimates for the long range planning study concepts are summarized in Table 24.

Table 24 Preliminary Capital Cost Estimates

	Option 1	Option 2a	Option 2b	Option 2c	Option 3a[1]	Option 3b[2]
General Conditions	$2,000,000	$13,500,000	$10,000,000	$16,000,000	$1,500,000	$1,500,000
Land Purchase	$0	$12,500,000	$1,000,000	$1,000,000	$0	$0
Demolition – Ex. Facility	$0	$3,500,000	$3,500,000	$3,500,000	$3,500,000	$3,500,000
Network Upgrades	$0	$9,500,000	$13,500,000	$49,000,000	$4,000,000	$4,000,000
Civil – WWTF	$1,500,000	$14,500,000	$4,500,000	$4,500,000	$0	$0
Arch/HVAC	$500,000	$2,000,000	$2,000,000	$2,000,000	$0	$0
Structural Concrete	$3,000,000	$7,500,000	$7,000,000	$7,000,000	$0	$0
Mech/Equipment	$4,000,000	$13,500,000	$13,000,000	$13,500,000	$0	$0
Electrical	$2,500,000	$15,500,000	$13,000,000	$14,000,000	$2,500,000	$2,500,000
Construction Subtotal	**$13,500,000**	**$92,000,000**	**$67,500,000**	**$110,500,000**	**$11,500,000**	**$11,500,000**
Contingency (35%)	$4,700,000	$32,400,000	$23,700,000	$38,700,000	$4,100,000	$4,100,000
Construction Total	**$18,200,000**	**$124,400,000**	**$91,200,000**	**$149,200,000**	**$15,600,000**	**$15,600,000**
Legal, Admin., and Eng. (25%)	$4,600,000	$31,200,000	$22,800,000	$37,300,000	$4,000,000	$4,000,000
TOTAL	**$22,800,000**	**$155,600,000**	**$114,000,000**	**$186,500,000**	**$19,600,000**	**$19,600,000**

Notes:

1. Cost Estimates presented for Option 3a are for Lewes BPW's component of the total project cost only; The total project costs, excluding the WWTF upgrades, would be $34,500,000; Sussex County's component of the project costs would be $14,500,000.
2. Cost Estimates presented for Option 3b are for Lewes BPW's component of the total project cost only; The total project costs, excluding the WWTF upgrades, would be $22,500,000; Sussex County's component of the project costs would be $3,000,000.

A detailed breakdown for the Preliminary Capital Cost Estimates is provided in Appendix D.

4.1.2 Operation & Maintenance Cost Estimates

Operation & Maintenance (O&M) cost estimates are provided below; costs presented in the following sections are the costs that would be incurred by Lewes BPW only.

4.1.2.1 Estimate of Annual O&M costs

The estimated annual O&M costs for the long range planning study concepts are summarized in Table 25.

Table 25 Estimated Annual O&M Costs for Concept Options

Parameter	Option 1	Option 2a	Option 2b	Option 2c	Option 3a[1]	Option 3b[1]
WWTF Operations & Maintenance	$1,520,000	$720,000	$720,000	$720,000	$720,000	$720,000
Periodic Equipment Replacement	$500,000	$330,000	$320,000	$320,000	$240,000	$240,000
Transfer Pump Station Energy Use	$0	$30,000	$50,000	$60,000	$20,000	$20,000
TOTAL	**$2,020,000**	**$1,080,000**	**$1,090,000**	**$1,100,000**	**$980,000**	**$980,000**

Note:
1. Cost Estimates presented for Option 3a and Option 3b are for Lewes BPW's component of the total project cost only. It has been assumed that BPW would be responsible for 50% of the O&M costs for a combined facility.

4.1.2.2 Estimate of 2050 Net Present Value O&M Costs

The estimated 2050 NPV for O&M costs for the long range planning study concepts are summarized in Table 26 and Figure 35.

Table 26 Estimated 2050 NPV O&M Costs for Concept Options

Parameter	Option 1	Option 2a	Option 2b	Option 2c	Option 3a[1]	Option 3b[1]
WWTF Operations & Maintenance	$61,500,000	$29,000,000	$29,000,000	$29,000,000	$29,000,000	$29,000,000
Periodic Equipment Replacement	$14,000,000	$9,500,000	$9,000,000	$9,000,000	$6,500,000	$6,500,000
Transfer Pump Station Energy Use	$0	$1,500,000	$2,000,000	$2,500,000	$500,000	$500,000
NET PRESENT WORTH	**$75,500,000**	**$40,000,000**	**$40,000,000**	**$40,500,000**	**$36,000,000**	**$36,000,000**

Note:
1. Cost Estimates presented for Option 3a and Option 3b are for Lewes BPW's component of the total project cost only. Per the terms of the existing BPW/ Sussex County Agreement for Wastewater Service Transfer, it has been assumed that BPW would be responsible for 50% of the O&M costs for a combined facility.

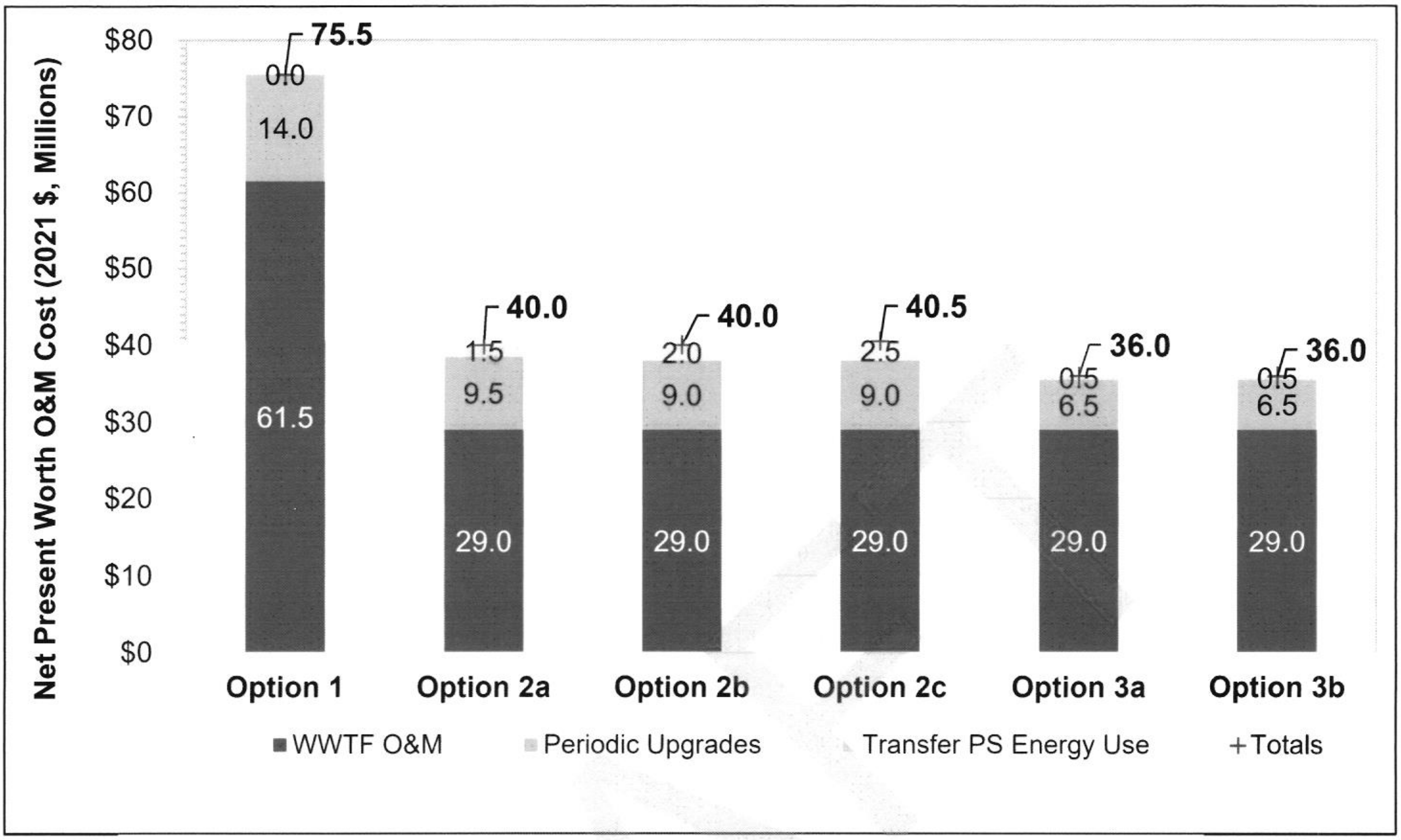

Figure 35 2050 NPV O&M Cost Summary for Concept Options

A detailed breakdown for the Operation & Maintenance Cost Estimates is provided in Appendix E.

4.2 Multi-Criteria Analysis

A multi-criteria analysis was performed to evaluate the concept options based on a series of non-cost criteria.

Table 27 shows the evaluation criteria, performance measures, rating scale, and weighting factors used for the multi-criteria analysis for the long range planning study concepts.

Each evaluation category has been assigned a weighting to reflect the relatively criticality of each category.

Table 27 MCA Evaluation Criteria

Evaluation Category	Evaluation Criteria	Performance Measure	Weighting	Rating = 1 (Worst)	Rating = 3 (Average)	Rating = 5 (Best)
Permitting & Schedule	Permitting Complexity	The expected volume and complexity of permitting procedures	**1**	Greater than other options	Comparable to other options	Less than other options
	Delivery Schedule	The length of the overall project implementation schedule including design, permitting and construction stages	**2**	Greater than other options	Comparable to other options	Less than other options

Evaluation Category	Evaluation Criteria	Performance Measure	Weighting	Rating = 1 (Worst)	Rating = 3 (Average)	Rating = 5 (Best)
	Property & Easement Acquisition	The complexity of obtaining required additional property and easement acquisition for treatment facilities and conveyance piping	2	Greater than other options	Comparable to other options	Less than other options
	Interagency & Regulatory Coordination	The schedule risk associated with coordination and approvals from other political bodies (such as Sussex County) or regulatory approvals which are outside of the control of the Lewes Board of Public Works	1	Greater than other options	Comparable to other options	Less than other options
Community & Environmental Impacts	Stakeholder Impacts - Construction Stage	Temporary impacts to the community during the construction stage due to traffic volume, road closures, noise and other factors	1	Greater than other options	Comparable to other options	Less than other options
	Stakeholder Impacts - Long Term	Long term impacts to the community due to ongoing site traffic, odor, aesthetics and other factors	2	Greater than other options	Comparable to other options	Less than other options
	Water Quality Impacts for Inland Bays	The likelihood that the proposed treatment process will negatively impact the water quality of the Inland Bays	3	More Likely than other options	Comparable to other options	Less Likely than other options

Evaluation Category	Evaluation Criteria	Performance Measure	Weighting	Rating = 1 (Worst)	Rating = 3 (Average)	Rating = 5 (Best)
	Overall Environmental Risk	Likelihood of environmental impacts due to failure/ flood damage at treatment facilities, force mains, pumping facilities or other components	3	More Likely than other options	Comparable to other options	Less Likely than other options
	Sustainability and Energy & Chemical Use	Energy, chemical usage and overall sustainability associated with the proposed treatment and conveyance facilities	1	Less Sustainable than other options	Comparable to other options	More Sustainable than other options
	Land Use within City of Lewes	Amount of land required within the City of Lewes for wastewater treatment infrastructure	1	Greater than other options	Comparable to other options	Less than other options
Operation & Maintenance	Impact to WWTF Operations During Construction	The extent to which the proposed upgrades will affect the operation and resilience of existing treatment and conveyance facilities	1	More Likely than other options	Comparable to other options	Less Likely than other options
	Operational Complexity	The level of operational effort required to maintain treatment performance and the difficulty in obtaining qualified staff	3	Greater than other options	Comparable to other options	Less than other options
	Future Flexibility	The extent to which the proposed treatment and conveyance facilities can be adapted to meet future environmental and compliance conditions	2	Less Likely than other options	Comparable to other options	More Likely than other options

The MCA scoring and evaluation comments for the long range planning study concepts are summarized in Table 28.

Table 28 MCA Scoring and Evaluation

Category/ Criteria	Performance Measures	Criteria Weighting	Option 1			Option 2a			Option 2b			Option 2c			Option 3a			Option 3b		
			Rating	Score (Weight * Rating)	Comments	Rating	Score (Weight * Rating)	Comments	Rating	Score (Weight * Rating)	Comments	Rating	Score (Weight * Rating)	Comments	Rating	Score (Weight * Rating)	Comments	Rating	Score (Weight * Rating)	Comments
Permitting & Schedule																				
Permitting Complexity	The expected volume and complexity of permitting procedures	1	4	4	Adding flood berms around the site will require significant permitting effort within the flood plain, but since site already owned by City and already used for treatment this will mitigate complexity	2	2	Permitting a new greenfield facility with on-site discharge requires extensive permitting depending on the site and existing environmental features	3	3	Similar to Option 2 with regards to permitting the greenfield site, but does not require permitting associated with on-site disposal	1	1	New ocean outfall permitting will be extensive	5	5	Permitting on existing Wolfe Neck treatment plant site is anticipated to be easier since site is already used for treatment and author believes it to be above 100 year flood plain	3	3	While treatment permitting should be simplified, permitting for expanded onsite disposal using wetlands will be challenging (Sussex County has already done some advance work, scoring could change if positively received by DNREC and full approval is granted for wetlands concept at Inland Bays)'

Category/ Criteria	Performance Measures	Criteria Weighting	Option 1			Option 2a			Option 2b			Option 2c			Option 3a			Option 3b		
			Rating	Score (Weight * Rating)	Comments	Rating	Score (Weight * Rating)	Comments	Rating	Score (Weight * Rating)	Comments	Rating	Score (Weight * Rating)	Comments	Rating	Score (Weight * Rating)	Comments	Rating	Score (Weight * Rating)	Comments
Delivery Schedule	The length of the overall project implementation schedule including design, permitting and construction stages	**2**	5	**10**	All work on existing City treatment plant property, least amount of required new facilities	2	**4**	Significant time anticipated to finalize, acquire, permit new treatment plant site and onsite disposal, along with easements for transfer piping	2	**4**	Similar to Option 2a	1	**2**	Timeline for new ocean outfall permitting is extensive, on top of all else in Option 2 for greenfield plant	4	**8**	Work anticipated to be able to proceed relatively fast following design at Wolfe Neck site	3	**6**	Longer schedule for delivery than Option 3b due to anticipated longer schedule to obtain wetlands discharge permits
Property & Easement Acquisition	The complexity of obtaining required additional property and easement acquisition for treatment facilities and conveyance piping	**2**	5	**10**	City already owns all required property	1	**2**	City must obtain both treatment plant property and conveyance easements	1	**2**	Similar to Option 2a	1	**2**	Similar to Option 2b	4	**8**	County owns treatment plant property, but some easements needed for transfer piping	4	**8**	County owns treatment plant property, but some easements needed for transfer piping

Category/ Criteria	Performance Measures	Criteria Weighting	Option 1			Option 2a			Option 2b			Option 2c			Option 3a			Option 3b		
			Rating	Score (Weight * Rating)	Comments	Rating	Score (Weight * Rating)	Comments	Rating	Score (Weight * Rating)	Comments	Rating	Score (Weight * Rating)	Comments	Rating	Score (Weight * Rating)	Comments	Rating	Score (Weight * Rating)	Comments
Interagency & Regulatory Coordination	The schedule risk associated with coordination and approvals from other political bodies (such as Sussex County) or regulatory approvals which are outside of the control of the Lewes Board of Public Works	1	5	5	N/A	5	5	N/A	5	5	N/A	1	1	Likely additional approvals required for ocean outfall since not on current City property	2	2	Requires interagency coordination with Sussex Co	2	2	Requires interagency coordination with Sussex Co
Community & Environmental Impacts																				
Stakeholder Impacts - Construction Stage	Temporary impacts to the community during the construction stage due to traffic volume, road closures, noise and other factors	1	4	4	Increase truck traffic and construction noise near downtown at existing WWTP site, but already industrial use site	2	2	Less construction required at existing WWTP site which is near downtown, but will have piping work in community disrupting traffic and work at greenfield site will disrupt local residents	2	2	Similar to Option 2a	2	2	Ocean outfall construction may be visible to public	3	3	Similar to Option 2a	3	3	Similar to Option 2a
Stakeholder Impacts - Long Term	Long term impacts to the community due to ongoing site traffic, odor, aesthetics and other factors	2	1	2	Ongoing industrial site use and truck traffic in central Lewes near downtown	2	4	Depends on selected site, may be less impactful to broader community if site is further from downtown and more isolated, but could still impact surrounding residents	2	4	Similar to Option 2a	2	4	Similar to Option 2a	5	10	Limited long term impact to Lewes residents	5	10	Similar to Option3a
Water Quality Impacts for Inland Bays	The likelihood that the proposed treatment process will negatively impact the water quality of the Inland Bays	3	3	9	Should be no better or worse than current situation	5	15	should be improvement from current situation since no more direct discharge into Lewes canal or (indirectly) the inland bays	3	9	Similar to Option 1	5	15	Similar to Option 2a	3	9	Similar to Option 1	5	15	Similar to Option 2a

Category/ Criteria	Performance Measures	Criteria Weighting	Option 1			Option 2a			Option 2b			Option 2c			Option 3a			Option 3b		
			Rating	Score (Weight * Rating)	Comments	Rating	Score (Weight * Rating)	Comments	Rating	Score (Weight * Rating)	Comments	Rating	Score (Weight * Rating)	Comments	Rating	Score (Weight * Rating)	Comments	Rating	Score (Weight * Rating)	Comments
Overall Environmental Risk	Likelihood of environmental impacts due to failure/ flood damage at treatment facilities, force mains, pumping facilities or other components	**3**	1	**3**	Existing site is subject to limited access and isolation during flood events	3	**9**	Assuming new site is above floodplain, should not be significantly impacted by flooding events. However, may have issues with effluent disposal during excessive precipitation/cold weather periods	5	**15**	Assuming new site is above floodplain, least risk of impacts from flood or weather related events	5	**15**	Similar to Option 2b	5	**15**	Similar to Option 2b	4	**12**	Proposed wetlands disposal less impacted by weather than RIBS or spray proposed for Option 2a
Sustainability and Energy & Chemical Use	Energy, chemical usage and overall sustainability associated with the proposed treatment and conveyance facilities	**1**	1	**1**	Existing MBR process more energy and chemical intense than other alts	5	**5**	Aerated lagoon process less energy intense, onsite disposal so limited effluent pumping	4	**4**	Similar to Option 2a, but requires pumping back to existing outfall	4	**4**	Similar to Option 2b	4	**4**	Similar to Option 2b	5	**5**	Similar to Option 2a
Land Use within City of Lewes	Amount of land required within the City of Lewes for wastewater treatment infrastructure	**1**	3	**3**	Same as existing	1	**1**	Likely larger property required than existing for treatment and disposal	2	**2**	Larger than existing, but not as large as Option 2a since no onsite disposal	2	**2**	Similar to Option 2b	5	**5**	Only small property needed for PSs	5	**5**	Similar to Option 3a
Operation & Maintenance																				
Impact to WWTF Operations During Construction	The extent to which the proposed upgrades will affect the operation and resilience of existing treatment and conveyance facilities	**1**	1	**1**	Process upgrades at existing plant will need to be coordinated to maintain operations and permit compliance	5	**5**	Almost all new work is greenfield, just limited to switchover for PS discharge	4	**4**	Similar to Option 2a, but also need switchover of outfall connection	5	**5**	Similar to Option 2a	5	**5**	Similar to Option 2a	5	**5**	Similar to Option 2a
Operational Complexity	The level of operational effort required to maintain treatment performance and the difficulty in obtaining qualified staff	3	1	**3**	City will be responsible for operating facility - either with own staff or by retaining a contract operator	2	**6**	Similar to Option 1, but conventional process easier to operate and maintain than a MBR	2	**6**	Similar to Option 2a	2	**6**	Similar to Option 2a	5	**15**	City will have no plant operations responsibilities, only the collection system. County is a large organization and has qualified operators	5	**15**	Similar to Option 3a

Category/ Criteria	Performance Measures	Criteria Weighting	Option 1			Option 2a			Option 2b			Option 2c			Option 3a			Option 3b		
			Rating	Score (Weight * Rating)	Comments	Rating	Score (Weight * Rating)	Comments	Rating	Score (Weight * Rating)	Comments	Rating	Score (Weight * Rating)	Comments	Rating	Score (Weight * Rating)	Comments	Rating	Score (Weight * Rating)	Comments
Future Flexibility	The extent to which the proposed treatment and conveyance facilities can be adapted to meet future environmental and compliance conditions	2	5	10	MBR treatment is state of the art, can potentially meet lower effluent limits	3	6	Aerated lagoon treatment followed by filtration may need supplemental processes (like membranes) added to meet future lower limits	3	6	Similar to Option 2a	3	6	Similar to Option 2a	3	6	Similar to Option 2a	3	6	Similar to Option 2a
TOTAL				65			66			66			65			95			95	

The MCA scoring is summarized in Figure 36.

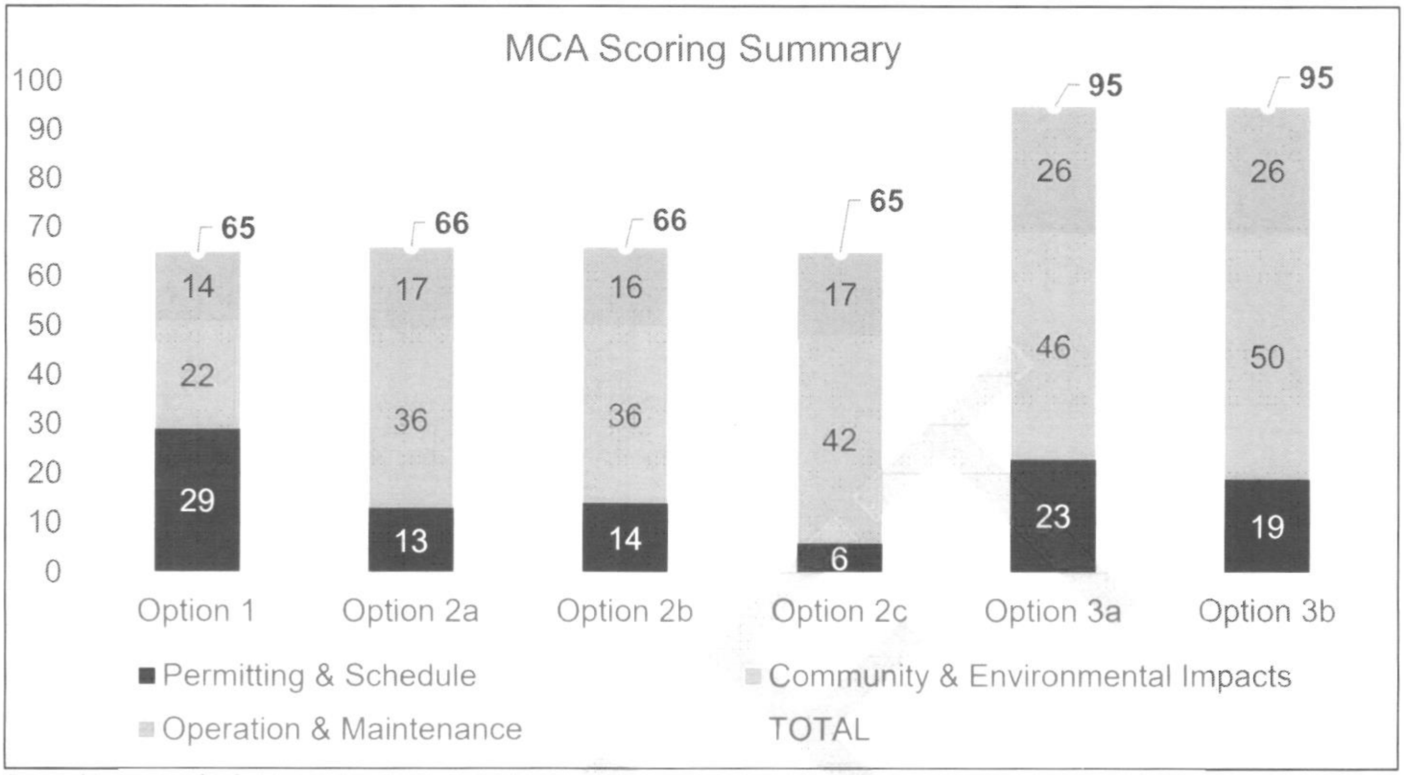

Figure 36 MCA Scoring Summary

4.3 Project Lifecycle Cost Estimates

The estimated Project Lifecycle Cost is the sum of the Preliminary Capital Cost Estimate and the 2050 NPV O&M Cost Estimate and represents the total cost of each concept option to Lewes BPW over the operational life of the new facilities.

The Project Lifecycle Costs incurred by Lewes BPW for the long range planning study concepts are summarized in Table 29 and Figure 37.

Table 29 Project Lifecycle Cost Estimates

	Option 1	Option 2a	Option 2b	Option 2c	Option 3a	Option 3b
Preliminary Capital Cost Estimate	$22,800,000	$155,600,000	$114,000,000	$186,500,000	$19,600,000	$19,600,000
2050 NPV O&M Cost Estimate	$75,500,000	$40,000,000	$40,000,000	$40,500,000	$36,000,000	$36,000,000
Project Lifecycle Cost	**$98,300,000**	**$195,600,000**	**$154,000,000**	**$227,000,000**	**$55,600,000**	**$55,600,000**
MCA Score	65	66	66	65	95	95
Cost per MCA Scoring Point	$1,510,000	$2,960,000	$2,330,000	$3,490,000	$590,000	$590,000

All costs are presented in 2022 US Dollars.

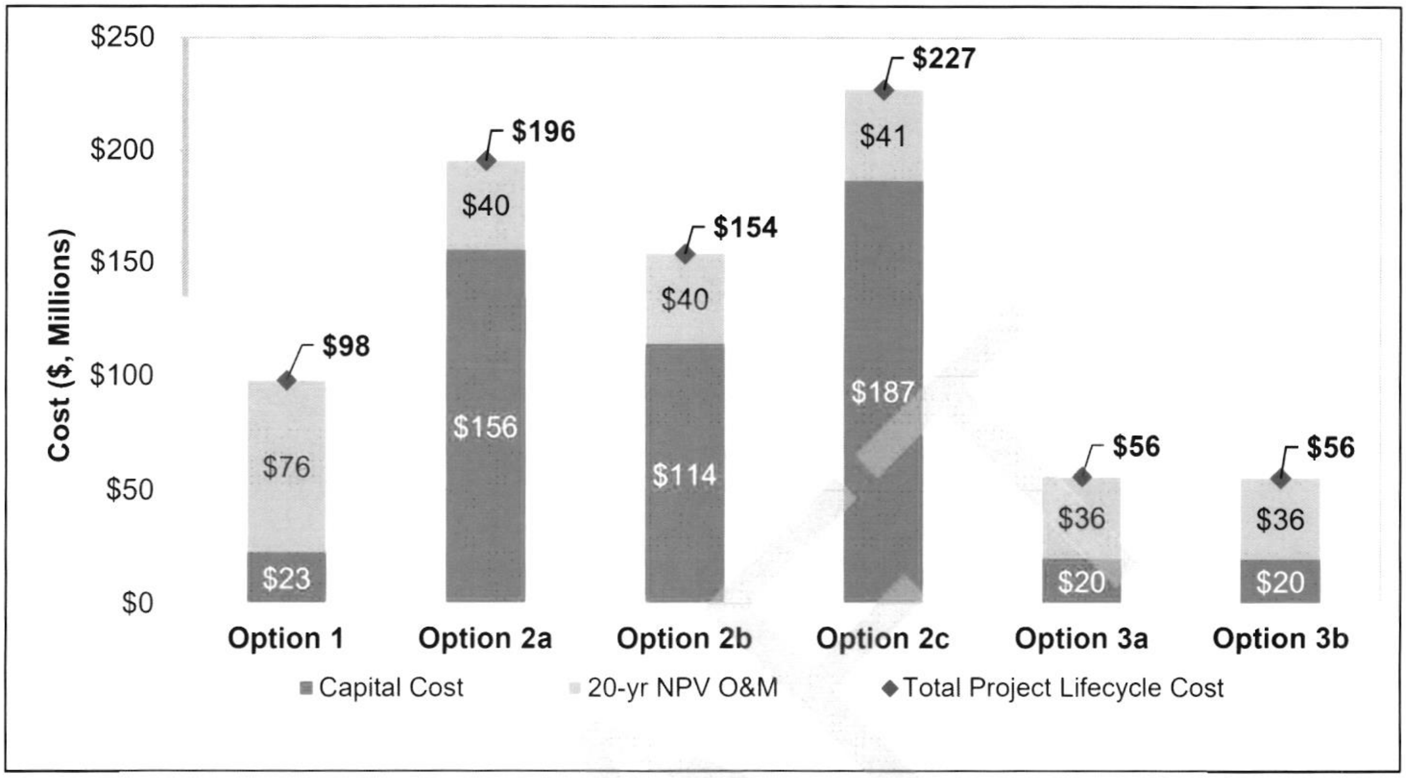

Figure 37 *Project Lifecyle Costs*

4.4 Evaluation Summary

Option 3a and Option 3b have the lowest estimated Project Lifecycle Costs for Lewes BPW, as well as the joint-highest MCA scores. Therefore, these options also have the lowest cost per MCA scoring point, which indicates that they provide the best value for Lewes BPW.

Option 3a scores higher for the Permitting & Schedule category, primary due to the relative uncertainty associated with acquiring permitting approvals for the constructed wetland discharge arrangement under Option 3b. Option 3b scores higher for the Community & Environmental Impacts category as there is no requirement to pump treated effluent back to the existing outfall location in Lewes.

Option 2c has the highest estimated Project Lifecyle Costs for Lewes BPW, primarily due to the requirement to purchase land and the complexities associated with a new ocean outfall.

The Option 1 and Option 2 concepts have very similar overall MCA scores; Option 1 scores lower for Community & Environmental Impacts due to the residual risk of flood damage at the coastal location, leading to failure at the treatment plant. The Option 2 concepts score lower for Permitting & Schedule due to the requirement to acquire land and install significant lengths of transfer force mains in public roads. Option 2c scores particularly low in this category due to the permitting complexities associated with constructing a new ocean outfall. However, Option 2c scores relatively well in the Community & Environmental Impacts category as treated effluent would no longer be discharged to the Canal or surrounding bays.

5. Next Steps

The next steps to advance the Lewes WWTF Long Range Planning Study and address the underlying issues are as follows:

1. BPW will include the Long Range Planning Study on the agenda for an upcoming Board meeting and at that time the BPW Board will discuss the findings of this report.
2. Sussex County will present the findings of this report to the County Council.
3. BPW will arrange a Special Meeting to present the findings to the public, engage with the community stakeholders and provide an opportunity for stakeholders to comment on the findings before a preferred option is identified by the BPW Board.
4. BPW will include the Long Range Planning Study on the agenda for a further Board meeting and at that time the Board will make its final decision on a preferred option for further design development.
5. The preferred option will advance for further development, including (but not limited to): field investigations, modeling, conceptual design and permitting design stages.

The following specific tasks should be undertaken as part of future design development, as a means of validating the preferred option:

- Hydraulic Modeling and Analysis for the Lewes and Rehoboth Canal
  - A well-calibrated model is required to predict future conditions in the Lewes and Rehoboth Canal, following implementation of the proposed WWTF upgrades.
  - The model will be able to simulate the flows inside the channel, potential net unidirectional flow along the channel and residence time in the canal for masses discharged into it.
  - A canal model will be developed to analyze the impacts for Option 2 and Option 3 concepts, but is not required for Option 1.
  - The model will need to calibrated following a sustained period of data monitoring and sample collection.
- Greenhouse Gas Emissions Analysis
  - The MCA evaluation undertaken as part of the concept development includes consideration of environmental impacts and sustainability; energy use is included in the O&M cost analysis.
  - Additional analyses should be completed to quantitively assess the Greenhouse Gas (GHG) emissions associated with each Option.
  - A GHG Analysis would include:
    - Estimation of tons of GHG emissions for each Option.
    - Consideration of construction and operational stages (lifecycle analysis).
    - Identification of opportunities to reduce GHG emissions, including cost estimates to implement.
  - GHG Analysis will further inform public discussions on sustainability associated with the proposed WWTF upgrades

Appendices

Appendix A

SUEZ Design Review for Lewes WWTF

suez

Water Technologies & Solutions

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June 10, 2022

At the request of GHD, SUEZ has completed a preliminary biological and UF capacity review for the Lewes Wastewater Treatment Plant. Based on our analysis of the as-built drawings, the flow condition maximums are set out below:

Biological – Maximum Month Flow (MMF) = 1,800,000 GPD

UF – The following ZeeWeed configuration table details the UF flow condition maximums based on two scenarios. See notes below the table for scenario details.

		scenario 1	scenario 2
configuration data	units	fill all existing membrane & cassette spaces with RX12 430ft2 modules	full plant population with RX12 430ft[2] modules in 52M cassettes[3]
number of trains. plant		4	4
type of ZeeWeed membrane		500D	500D
module surface area	ft²	370 & 430[2]	430
total number of cassette spaces per train		4	4
maximum number of modules per cassette		48 & 52[1]	52
fully populated cassettes installed per train		4	4
flex cassettes installed per train		---	---
installed number of modules per flex cassette		---	---
total module count. train		196	208
total surface area in operation. train	ft²	77.080	89.440
total module count, plant		784	832
total surface area in operation. plant	ft²	308.320	357.760
% surface area change from existing. plant	%	73.6%	101.4%
minimum temperature	°C	11	11
flow capacity, average daily flow ADF	GPD	4.347.300	5.044.400
design net flux at ADF at min. temp	GFD	14.1	14.1
flow capacity. maximum month flow MMF	GPD	4.809.800	5.581.000
design net flux at MMF at min. temp	GFD	15.6	15.6
flow capacity. maximum week flow MWF	GPD	5.796.400	6.725.900
design net flux at MWF at min. temp	GFD	18.8	18.8
flow capacity. maximum day flow MDF	GPD	6.875.500	7.978.000
design net flux at MDF at min. temp	GFD	22.3	22.3
flow capacity. peak hour flow PHF	GPD	7.677.168	8.908.200
design net flux at PHF at min. temp	GFD	24.9	24.9

notes:

1 - scenario 1: Existing cassettes are 48M LEAP - cassettes being added to empty cassette spaces (1 per train) will be 52M LEAP cassettes.

2 - scenario 1: Existing cassettes are 40/48M 370ft^2. Modules added to empty membrane spaces (8 in each of 12 existing cassettes) will be RX12 430ft^2.

3 - scenario 2: Plant will be fully populated with 52/52M cassettes and RX12 430ft^2 membranes (4 trains, 4 cassettes per train).

We would be pleased to further discuss any aspect of this review.

Sincerely,

Matt Stapleford, P.Eng.
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SUEZ Water Technologies & Solutions
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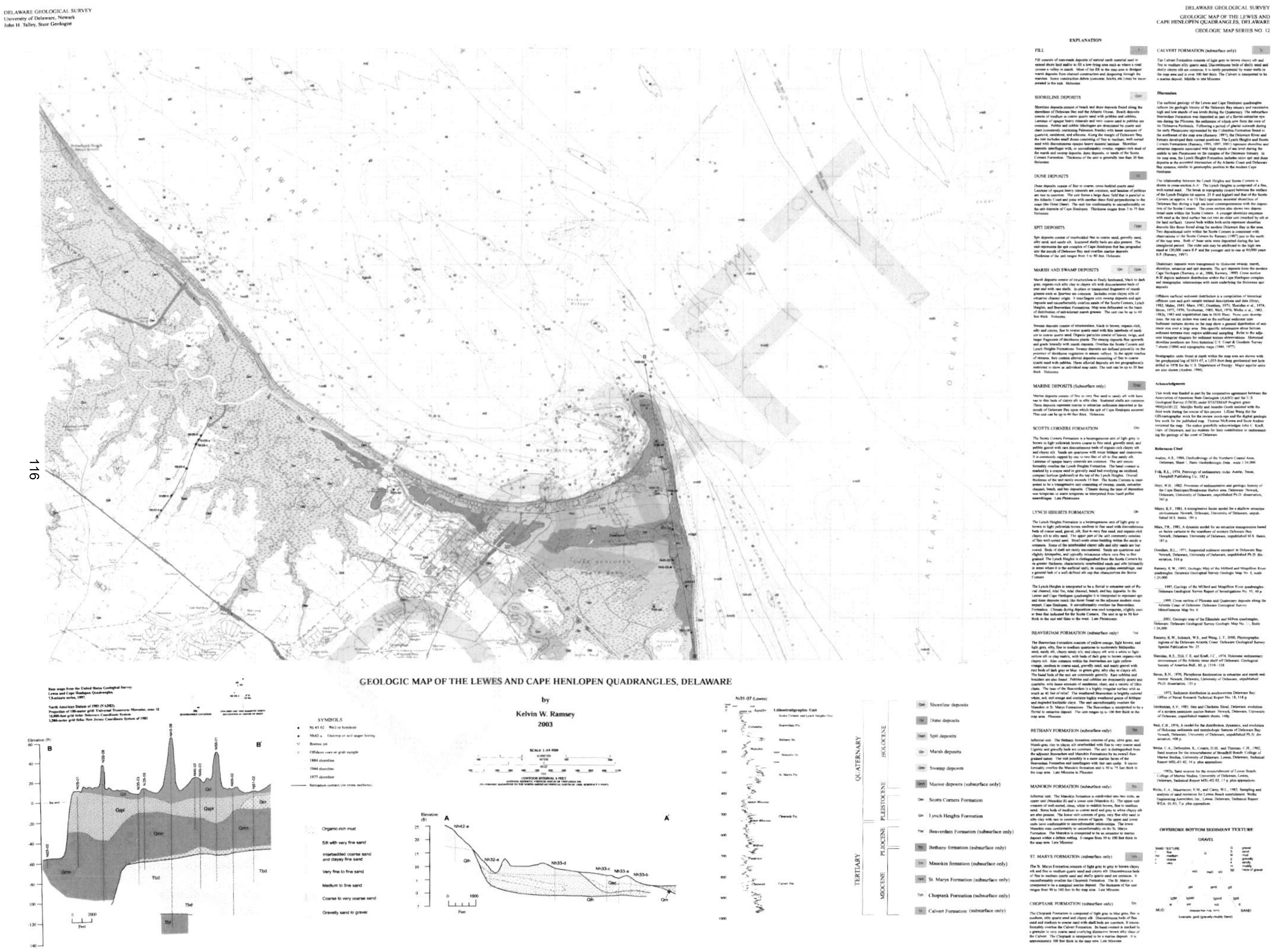
doc. control author: JE
last modified: 6/10/2022 2:08 PM
filename: Lewes 508864 design review for GHD Jun-10 2022
technical review: JW commercial review: MS

Appendix B

Lewes Geological Map


DELAWARE GEOLOGICAL SURVEY
University of Delaware, Newark
John H. Talley, State Geologist
DELAWARE GEOLOGICAL SURVEY
GEOLOGIC MAP OF THE LEWES AND
CAPE HENLOPEN QUADRANGLES, DELAWARE
GEOLOGIC MAP SERIES NO. 12
EXPLANATION
FILL
SHORELINE DEPOSITS
DUNE DEPOSITS
SPIT DEPOSITS
MARSH AND SWAMP DEPOSITS
MARINE DEPOSITS (Subsurface only)
SCOTTS CORNERS FORMATION
LYNCH HEIGHTS FORMATION
BEAVERDAM FORMATION (subsurface only)
BETHANY FORMATION (subsurface only)
MANOKIN FORMATION (subsurface only)
ST. MARYS FORMATION (subsurface only)
CHOPTANK FORMATION (subsurface only)
CALVERT FORMATION (subsurface only)
Discussion
Acknowledgments
References Cited
DELAWARE
BAY
ATLANTIC
OCEAN
CAPE HENLOPEN
GEOLOGIC MAP OF THE LEWES AND CAPE HENLOPEN QUADRANGLES, DELAWARE
by
Kelvin W. Ramsey
2003
SYMBOLS
1884 shoreline
1944 shoreline
1977 shoreline
SCALE 1:24 000
CONTOUR INTERVAL 5 FEET
Organic-rich mud
Silt with very fine sand
Interbedded coarse sand and clayey fine sand
Very fine to fine sand
Medium to fine sand
Coarse to very coarse sand
Gravelly sand to gravel
Elevation (ft)
B
B'
A
A'
Feet
Nh42-a
Nh32-a
Nh33-d
Nh33-c
Nh33-a
Nh33-b
Qlh
Qsc
Qm
Qmm
Qspl
Qsl
Tbd
Nj31-07 (Lewes)
Lithostratigraphic Unit
QUATERNARY
HOLOCENE
PLEISTOCENE
TERTIARY
PLIOCENE
MIOCENE
Shoreline deposits
Dune deposits
Spit deposits
Marsh deposits
Swamp deposits
Marine deposits (subsurface only)
Scotts Corners Formation
Lynch Heights Formation
Beaverdam Formation (subsurface only)
Bethany formation (subsurface only)
Manokin formation (subsurface only)
St. Marys Formation (subsurface only)
Choptank Formation (subsurface only)
Calvert Formation (subsurface only)
OFFSHORE BOTTOM SEDIMENT TEXTURE
GRAVEL
MUD
SAND

Appendix C

Hydraulic Calculations

Project Name: Lewes WWTF Long Range Planning Study
Project Number: 12582813
Client: Lewes BPW and Sussex County
Calculation Title: Option 2a Raw Wastewater Pump Station - Force Main Hydraulics

Author: VC 10/21/2022
Checked: TB 10/24/2022

Pipeline Start LS-8 Wet Well WSE: -10.05 ft
Pipeline Finish Option 2a Site Wet Well WSE: 49 ft site elevation + 20 ft

Output Summary:

Design Flow 5.13 mgd Lewes collection network Peak Hour Flow
3563 gpm
TDH 228 ft
Pump Power 293 HP

DESCRIPTION	Flow (mgd)	Flow (cfs)	Width/Diameter (in)	Width/Diameter (ft.)	Length (ft.)	Invert (ft.)	Depth (ft.)	X-Sect (ft^2)	Perim (ft.)	Vel (fps)	$V^2/2g$	n or C Coef	Fitting Loss	No. Fittings	Headloss (ft.)	HGL (ft.)
																49
Discharge orifice	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50		1	1	0.50	49.50
HDPE pipe section	5.13	7.94	16	1.33	32016			1.40	4.19	5.69	0.50	150			162.22	211.72
90 L	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	150	0.3	9	1.36	213.08
45 degree bend	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	150	0.2		0.00	213.08
22.5 degree bend	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	150	0.2	4	0.40	213.48
11.25 degree bend	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	150	0.05	7	0.18	213.65
DIP pipe to HDPE coupler	5.13	7.94	16	1.33	10			1.40	4.19	5.69	0.50	110			0.09	213.74
Butterfly valve	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	0.3	1	0.15	213.89
Bypass Tee (through)	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	0.3	1	0.15	214.05
Butterfly Valve	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	0.3	1	0.15	214.20
DIP pipe section	5.13	7.94	16	1.33	10			1.40	4.19	5.69	0.50	110			0.09	214.29
90 elbow	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	0.3	1	0.15	214.44
DIP pipe section though PS wall	5.13	7.94	16	1.33	20			1.40	4.19	5.69	0.50	110		1	0.18	214.62
90 elbow	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	0.3	1	0.15	214.77
DIP pipe section	5.13	7.94	16	1.33	10			1.40	4.19	5.69	0.50	110		1	0.09	214.86
90 elbow	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	0.3	1	0.15	215.01
DIP pipe section	5.13	7.94	16	1.33	10			1.40	4.19	5.69	0.50	110		1	0.09	215.10
flow meter (assume wrap around)	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	0	1	0.00	215.10
DIP pipe section	5.13	7.94	16	1.33	8			1.40	4.19	5.69	0.50	110		1	0.07	215.17
90 elbow	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	0.3	1	0.15	215.32
DIP pipe section	5.13	7.94	16	1.33	8			1.40	4.19	5.69	0.50	110		1	0.07	215.39
90 elbow	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	0.3	1	0.15	215.54
DIP pipe section	5.13	7.94	16	1.33	5			1.40	4.19	5.69	0.50	110		1	0.04	215.59
Pump 1 Wye (through)	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	0.3	1	0.15	215.74
DIP pipe section	5.13	7.94	16	1.33	5			1.40	4.19	5.69	0.50	110		1	0.04	215.78
check valve	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	2.5	1	1.26	217.04
90 elbow	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	0.3	1	0.15	217.19
PUMP																
90 El	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	0.3	1	0.15	-10.81
90 EL	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	0.3	1	0.15	-10.66
DIP pipe section	5.13	7.94	16	1.33	12			1.40	4.19	5.69	0.50	110		1	0.11	-10.51
90 EL	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	0.3	1	0.15	-10.40
DIP pipe	5.13	7.94	16	1.33	3			1.40	4.19	5.69	0.50	110		1	0.03	-10.25
90 El	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	0.3	1	0.15	-10.23
bellmouth in wet well	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	0.05	1	0.03	-10.08
Upstream Wet Well TWL																-10.05

Project Name:	Lewes WWTF Long Range Planning Study	Author: VC	10/21/2022
Project Number:	12582813	Checked: TB	10/24/2022
Client:	Lewes BPW and Sussex County		
Calculation Title:	Option 2b/c Raw Wastewater Pump Station - Force Main Hydraulics		

Pipeline Start	LS-8	Wet Well WSE:	-10.05 ft	
Pipeline Finish	Option 2b/c Site	Wet Well WSE:	39 ft	site elevation + 20 ft

Output Summary:

Design Flow	5.13 mgd	Lewes collection network Peak Hour Flow
	3563 gpm	
TDH	176 ft	
Pump Power	226 HP	

	Flow		Width/Diameter		Length	Invert	Depth	X-Sect	Perim	Vel	$V^2/2g$	n or C	Fitting	No.	Headloss	HGL
DESCRIPTION	(mgd)	(cfs)	(in)	(ft.)	(ft.)	(ft.)	(ft.)	(ft^2)	(ft.)	(fps)		Coef	Loss	Fittings	(ft.)	(ft.)
																39
Discharge orifice	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50		1	1	0.50	39.50
HDPE pipe section	5.13	7.94	16	1.33	23936			1.40	4.19	5.69	0.50	150			121.28	160.78
90 L	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	150	0.3	4	0.60	161.38
45 degree bend	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	150	0.2		0.00	161.38
22.5 degree bend	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	150	0.2	2	0.20	161.58
11.25 degree bend	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	150	0.05		0.00	161.58
DIP pipe to HDPE coupler	5.13	7.94	16	1.33	10			1.40	4.19	5.69	0.50	110			0.09	161.67
Butterfly valve	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	0.3	1	0.15	161.82
Bypass Tee (through)	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	0.3	1	0.15	161.98
Butterfly Valve	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	0.3	1	0.15	162.13
DIP pipe section	5.13	7.94	16	1.33	10			1.40	4.19	5.69	0.50	110			0.09	162.22
90 elbow	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	0.3	1	0.15	162.37
DIP pipe section though PS wall	5.13	7.94	16	1.33	20			1.40	4.19	5.69	0.50	110		1	0.18	162.55
90 elbow	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	0.3	1	0.15	162.70
DIP pipe section	5.13	7.94	16	1.33	10			1.40	4.19	5.69	0.50	110		1	0.09	162.79
90 elbow	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	0.3	1	0.15	162.94
DIP pipe section	5.13	7.94	16	1.33	10			1.40	4.19	5.69	0.50	110		1	0.09	163.03
flow meter (assume wrap around)	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	0	1	0.00	163.03
DIP pipe section	5.13	7.94	16	1.33	8			1.40	4.19	5.69	0.50	110		1	0.07	163.10
90 elbow	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	0.3	1	0.15	163.25
DIP pipe section	5.13	7.94	16	1.33	8			1.40	4.19	5.69	0.50	110		1	0.07	163.32
90 elbow	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	0.3	1	0.15	163.47
DIP pipe section	5.13	7.94	16	1.33	5			1.40	4.19	5.69	0.50	110		1	0.04	163.52
Pump 1 Wye (through)	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	0.3	1	0.15	163.67
DIP pipe section	5.13	7.94	16	1.33	5			1.40	4.19	5.69	0.50	110		1	0.04	163.71
check valve	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	2.5	1	1.26	164.97
90 elbow	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	0.3	1	0.15	165.12
gate valve	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	0.07	1	0.04	165.16
PUMP 2																
90 El	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	0.3	1	0.15	-10.81
90 EL	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	0.3	1	0.15	-10.66
DIP pipe section	5.13	7.94	16	1.33	12			1.40	4.19	5.69	0.50	110		1	0.11	-10.51
90 EL	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	0.3	1	0.15	-10.40
DIP pipe	5.13	7.94	16	1.33	3			1.40	4.19	5.69	0.50	110		1	0.03	-10.25
90 El	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	0.3	1	0.15	-10.23
bellmouth in wet well	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	0.05	1	0.03	-10.08
Upstream Wet Well TWL																-10.05

Project Name:	Lewes WWTF Long Range Planning Study	Author: VC	10/21/2022
Project Number:	12582813	Checked: TB	10/24/2022
Client:	Lewes BPW and Sussex County		
Calculation Title:	Option 2b Treated Effluent Pump Station - Force Main Hydraulics		

Pipeline Start	Treated Effluent PS	Wet Well WSE:	3.64 ft
Pipeline Finish	Canal Outfall	Wet Well WSE:	0 ft

Output Summary:

Design Flow	5.13 mgd	Lewes collection network Peak Hour Flow
	3563 gpm	
TDH	123 ft	
Pump Power	159 HP	

	Flow		Width/Diameter		Length	Invert	Depth	X-Sect	Perim	Vel	$V^2/2g$	n or C	Fitting	No.	Headloss	HGL
DESCRIPTION	(mgd)	(cfs)	(in)	(ft.)	(ft.)	(ft.)	(ft.)	(ft^2)	(ft.)	(fps)		Coef	Loss	Fittings	(ft.)	(ft.)
																0
Discharge orifice	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50		1	1	0.50	0.50
HDPE pipe section	5.13	7.94	16	1.33	23936			1.40	4.19	5.69	0.50	150			121.28	121.78
90 L	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	150	0.3	8	1.21	122.99
45 degree bend	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	150	0.2		0.00	122.99
22.5 degree bend	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	150	0.2	2	0.20	123.19
11.25 degree bend	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	150	0.05		0.00	123.19
DIP pipe to HDPE coupler	5.13	7.94	16	1.33	10			1.40	4.19	5.69	0.50	110			0.09	123.28
Butterfly valve	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	0.3	1	0.15	123.43
Bypass Tee (through)	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	0.3	1	0.15	123.58
Butterfly Valve	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	0.3	1	0.15	123.73
DIP pipe section	5.13	7.94	16	1.33	10			1.40	4.19	5.69	0.50	110			0.09	123.82
90 elbow	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	0.3	1	0.15	123.97
DIP pipe section though PS wall	5.13	7.94	16	1.33	20			1.40	4.19	5.69	0.50	110		1	0.18	124.15
90 elbow	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	0.3	1	0.15	124.30
DIP pipe section	5.13	7.94	16	1.33	10			1.40	4.19	5.69	0.50	110		1	0.09	124.39
90 elbow	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	0.3	1	0.15	124.54
DIP pipe section	5.13	7.94	16	1.33	10			1.40	4.19	5.69	0.50	110		1	0.09	124.63
flow meter (assume wrap around)	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	0	1	0.00	124.63
DIP pipe section	5.13	7.94	16	1.33	8			1.40	4.19	5.69	0.50	110		1	0.07	124.70
90 elbow	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	0.3	1	0.15	124.85
DIP pipe section	5.13	7.94	16	1.33	8			1.40	4.19	5.69	0.50	110		1	0.07	124.93
90 elbow	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	0.3	1	0.15	125.08
DIP pipe section	5.13	7.94	16	1.33	5			1.40	4.19	5.69	0.50	110		1	0.04	125.12
Pump 1 Wye (through)	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	0.3	1	0.15	125.27
DIP pipe section	5.13	7.94	16	1.33	5			1.40	4.19	5.69	0.50	110		1	0.04	125.32
check valve	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	2.5	1	1.26	126.57
90 elbow	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	0.3	1	0.15	126.72
gate valve	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	0.07	1	0.04	126.76
PUMP																
gate valve	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	0.3	1	0.15	3.27
DIP pipe	5.13	7.94	16	1.33	3			1.40	4.19	5.69	0.50	110		1	0.03	3.42
90 El	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	0.3	1	0.15	3.45
DIP pipe	5.13	7.94	16	1.33	2			1.40	4.19	5.69	0.50	110		1	0.02	3.60
bellmouth in wet well	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	0.05	1	0.03	3.61
Upstream Wet Well TWL																3.64

Project Name:	Lewes WWTF Long Range Planning Study		Author: VC	10/21/2022
Project Number:	12582813		Checked: TB	10/24/2022
Client:	Lewes BPW and Sussex County			
Calculation Title:	Option 2c Treated Effluent Pump Station - Force Main Hydraulics			

Pipeline Start	Treated Effluent PS	Wet Well WSE:	3.64 ft
Pipeline Finish	Ocean Outfall	Wet Well WSE:	0 ft

Output Summary:

Design Flow	5.13 mgd	Lewes collection network Peak Hour Flow
	3563 gpm	
TDH	221 ft	
Pump Power	284 HP	

DESCRIPTION	Flow (mgd)	(cfs)	Width/Diameter (in)	(ft.)	Length (ft.)	Invert (ft.)	Depth (ft.)	X-Sect (ft^2)	Perim (ft.)	Vel (fps)	$V^2/2g$	n or C Coef	Fitting Loss	No. Fittings	Headloss (ft.)	HGL (ft.)
																0
Discharge orifice	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50		1	1	0.50	0.50
HDPE pipe section	5.13	7.94	16	1.33	41579			1.40	4.19	5.69	0.50	150			210.67	211.17
90 L	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	150	0.3	9	1.36	212.53
45 degree bend	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	150	0.2		0.00	212.53
22.5 degree bend	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	150	0.2	5	0.50	213.03
11.25 degree bend	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	150	0.05	2	0.05	213.08
DIP pipe to HDPE coupler	5.13	7.94	16	1.33	10			1.40	4.19	5.69	0.50	110			0.09	213.17
Butterfly valve	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	0.3	1	0.15	213.32
Bypass Tee (through)	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	0.3	1	0.15	213.47
Butterfly Valve	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	0.3	1	0.15	213.62
DIP pipe section	5.13	7.94	16	1.33	10			1.40	4.19	5.69	0.50	110			0.09	213.71
90 elbow	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	0.3	1	0.15	213.86
DIP pipe section though PS wall	5.13	7.94	16	1.33	20			1.40	4.19	5.69	0.50	110		1	0.18	214.04
90 elbow	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	0.3	1	0.15	214.20
DIP pipe section	5.13	7.94	16	1.33	10			1.40	4.19	5.69	0.50	110		1	0.09	214.29
90 elbow	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	0.3	1	0.15	214.44
DIP pipe section	5.13	7.94	16	1.33	10			1.40	4.19	5.69	0.50	110		1	0.09	214.53
flow meter (assume wrap around)	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	0	1	0.00	214.53
DIP pipe section	5.13	7.94	16	1.33	8			1.40	4.19	5.69	0.50	110		1	0.07	214.60
90 elbow	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	0.3	1	0.15	214.75
DIP pipe section	5.13	7.94	16	1.33	8			1.40	4.19	5.69	0.50	110		1	0.07	214.82
90 elbow	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	0.3	1	0.15	214.97
DIP pipe section	5.13	7.94	16	1.33	5			1.40	4.19	5.69	0.50	110		1	0.04	215.02
Pump 1 Wye (through)	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	0.3	1	0.15	215.17
DIP pipe section	5.13	7.94	16	1.33	5			1.40	4.19	5.69	0.50	110		1	0.04	215.21
check valve	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	2.5	1	1.26	216.47
90 elbow	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	0.3	1	0.15	216.62
gate valve	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	0.07	1	0.04	216.65
PUMP																
gate valve	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	0.3	1	0.15	-4.01
DIP pipe	5.13	7.94	16	1.33	3			1.40	4.19	5.69	0.50	110		1	0.03	-3.86
90 El	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	0.3	1	0.15	-3.83
DIP pipe	5.13	7.94	16	1.33	2			1.40	4.19	5.69	0.50	110		1	0.02	-3.68
bellmouth in wet well	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	0.05	1	0.03	-3.67
Upstream Wet Well TWL																-3.64

Project Name:	Lewes WWTF Long Range Planning Study	Author: VC	10/21/2022
Project Number:	12582813	Checked: TB	10/24/2022
Client:	Lewes BPW and Sussex County		
Calculation Title:	Option 3a/b Raw Wastewater Pump Station - Force Main Hydraulics		

Pipeline Start	LS-8	Wet Well WSE:	-10.05 ft	
Pipeline Finish	Wolfe Neck Site	Wet Well WSE:	50 ft	site elevation + 20 ft

Output Summary:

Design Flow	5.13 mgd	Lewes collection network Peak Hour Flow
	3563 gpm	
TDH	107 ft	
Pump Power	138 HP	

DESCRIPTION	Flow (mgd)	Flow (cfs)	Width/Diameter (in)	Width/Diameter (ft.)	Length (ft.)	Invert (ft.)	Depth (ft.)	X-Sect (ft^2)	Perim (ft.)	Vel (fps)	$V^2/2g$	n or C Coef	Fitting Loss	No. Fittings	Headloss (ft.)	HGL (ft.)
Invert of discharge pipe into screens																50
Discharge orifice	10.26	15.88	24	2.00				3.14	6.28	5.05	0.40		1	1	0.40	50.40
HDPE pipe section - ex. 24" main	10.26	15.88	24	2.00	9244			3.14	6.28	5.05	0.40	150			23.48	23.48
HDPE pipe section - ex. 16" main	5.13	7.94	16	1.33	4276			1.40	4.19	5.69	0.50	150			21.67	71.67
HDPE pipe section	5.13	7.94	16	1.33	8040			1.40	4.19	5.69	0.50	150			40.74	91.13
90 L	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	150	0.3	9	1.36	92.49
45 degree bend	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	150	0.2		0.00	92.49
22.5 degree bend	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	150	0.2	4	0.40	92.89
11.25 degree bend	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	150	0.05	7	0.18	93.07
DIP pipe to HDPE coupler	5.13	7.94	16	1.33	10			1.40	4.19	5.69	0.50	110			0.09	93.16
Butterfly valve	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	0.3	1	0.15	93.31
Bypass Tee (through)	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	0.3	1	0.15	93.46
Butterfly Valve	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	0.3	1	0.15	93.61
DIP pipe section	5.13	7.94	16	1.33	10			1.40	4.19	5.69	0.50	110			0.09	93.70
90 elbow	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	0.3	1	0.15	93.85
DIP pipe section though PS wall	5.13	7.94	16	1.33	20			1.40	4.19	5.69	0.50	110		1	0.18	94.03
90 elbow	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	0.3	1	0.15	94.18
DIP pipe section	5.13	7.94	16	1.33	10			1.40	4.19	5.69	0.50	110		1	0.09	94.27
90 elbow	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	0.3	1	0.15	94.42
DIP pipe section	5.13	7.94	16	1.33	10			1.40	4.19	5.69	0.50	110		1	0.09	94.51
flow meter (assume wrap around)	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	0	1	0.00	94.51
DIP pipe section	5.13	7.94	16	1.33	8			1.40	4.19	5.69	0.50	110		1	0.07	94.58
90 elbow	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	0.3	1	0.15	94.73
DIP pipe section	5.13	7.94	16	1.33	8			1.40	4.19	5.69	0.50	110		1	0.07	94.81
90 elbow	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	0.3	1	0.15	94.96
DIP pipe section	5.13	7.94	16	1.33	5			1.40	4.19	5.69	0.50	110		1	0.04	95.00
Pump 1 Wye (through)	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	0.3	1	0.15	95.15
DIP pipe section	5.13	7.94	16	1.33	5			1.40	4.19	5.69	0.50	110		1	0.04	95.20
check valve	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	2.5	1	1.26	96.45
90 elbow	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	0.3	1	0.15	96.60
PUMP																
90 El	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	0.3	1	0.15	-10.81
90 EL	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	0.3	1	0.15	-10.66
DIP pipe section	5.13	7.94	16	1.33	12			1.40	4.19	5.69	0.50	110		1	0.11	-10.51
90 EL	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	0.3	1	0.15	-10.40
DIP pipe	5.13	7.94	16	1.33	3			1.40	4.19	5.69	0.50	110		1	0.03	-10.25
90 El	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	0.3	1	0.15	-10.23
bellmouth in wet well	5.13	7.94	16	1.33				1.40	4.19	5.69	0.50	110	0.05	1	0.03	-10.08
Upstream Wet Well TWL																-10.05

Project Name:	Lewes WWTF Long Range Planning Study	Author: VC	10/21/2022
Project Number:	12582813	Checked: TB	10/24/2022
Client:	Lewes BPW and Sussex County		
Calculation Title:	Option 3a Treated Effluent Pump Station - Force Main Hydraulics		

Pipeline Start	Treated Effluent PS	Wet Well WSE:	3.64 ft
Pipeline Finish	Canal Outfall	Wet Well WSE:	0 ft

Output Summary:

Design Flow	4.1 mgd	Combined Lewes and Sussex County collection network Max Month Flow
	2847 gpm	
TDH	115 ft	
Pump Power	118 HP	

DESCRIPTION	Flow (mgd)	(cfs)	Width/Diameter (in)	(ft.)	Length (ft.)	Invert (ft.)	Depth (ft.)	X-Sect (ft^2)	Perim (ft.)	Vel (fps)	$V^2/2g$	n or C Coef	Fitting Loss	No. Fittings	Headloss (ft.)	HGL (ft.)
																0
Discharge orifice	4.1	6.34	14	1.17				1.07	3.67	5.93	0.55		1	1	0.55	0.55
HDPE pipe section	4.1	6.34	14	1.17	17500			1.07	3.67	5.93	0.55	150			112.17	112.71
90 L	4.1	6.34	14	1.17				1.07	3.67	5.93	0.55	150	0.3	8	1.31	114.03
45 degree bend	4.1	6.34	14	1.17				1.07	3.67	5.93	0.55	150	0.2		0.00	114.03
22.5 degree bend	4.1	6.34	14	1.17				1.07	3.67	5.93	0.55	150	0.2	2	0.22	114.25
11.25 degree bend	4.1	6.34	14	1.17				1.07	3.67	5.93	0.55	150	0.05		0.00	114.25
DIP pipe to HDPE coupler	4.1	6.34	14	1.17	10			1.07	3.67	5.93	0.55	110			0.11	114.36
Butterfly valve	4.1	6.34	14	1.17				1.07	3.67	5.93	0.55	110	0.3	1	0.16	114.52
Bypass Tee (through)	4.1	6.34	14	1.17				1.07	3.67	5.93	0.55	110	0.3	1	0.16	114.69
Butterfly Valve	4.1	6.34	14	1.17				1.07	3.67	5.93	0.55	110	0.3	1	0.16	114.85
DIP pipe section	4.1	6.34	14	1.17	10			1.07	3.67	5.93	0.55	110			0.11	114.97
90 elbow	4.1	6.34	14	1.17				1.07	3.67	5.93	0.55	110	0.3	1	0.16	115.13
DIP pipe section though PS wall	4.1	6.34	14	1.17	20			1.07	3.67	5.93	0.55	110		1	0.23	115.36
90 elbow	4.1	6.34	14	1.17				1.07	3.67	5.93	0.55	110	0.3	1	0.16	115.52
DIP pipe section	4.1	6.34	14	1.17	10			1.07	3.67	5.93	0.55	110		1	0.11	115.64
90 elbow	4.1	6.34	14	1.17				1.07	3.67	5.93	0.55	110	0.3	1	0.16	115.80
DIP pipe section	4.1	6.34	14	1.17	10			1.07	3.67	5.93	0.55	110		1	0.11	115.91
flow meter (assume wrap around)	4.1	6.34	14	1.17				1.07	3.67	5.93	0.55	110	0	1	0.00	115.91
DIP pipe section	4.1	6.34	14	1.17	8			1.07	3.67	5.93	0.55	110		1	0.09	116.00
90 elbow	4.1	6.34	14	1.17				1.07	3.67	5.93	0.55	110	0.3	1	0.16	116.17
DIP pipe section	4.1	6.34	14	1.17	8			1.07	3.67	5.93	0.55	110		1	0.09	116.26
90 elbow	4.1	6.34	14	1.17				1.07	3.67	5.93	0.55	110	0.3	1	0.16	116.42
DIP pipe section	4.1	6.34	14	1.17	5			1.07	3.67	5.93	0.55	110		1	0.06	116.48
Pump 1 Wye (through)	4.1	6.34	14	1.17				1.07	3.67	5.93	0.55	110	0.3	1	0.16	116.65
DIP pipe section	4.1	6.34	14	1.17	5			1.07	3.67	5.93	0.55	110		1	0.06	116.70
check valve	4.1	6.34	14	1.17				1.07	3.67	5.93	0.55	110	2.5	1	1.37	118.07
90 elbow	4.1	6.34	14	1.17				1.07	3.67	5.93	0.55	110	0.3	1	0.16	118.23
gate valve	4.1	6.34	14	1.17				1.07	3.67	5.93	0.55	110	0.07	1	0.04	118.27
PUMP																
gate valve	4.1	6.34	14	1.17				1.07	3.67	5.93	0.55	110	0.3	1	0.16	3.23
DIP pipe	4.1	6.34	14	1.17	3			1.07	3.67	5.93	0.55	110		1	0.03	3.39
90 El	4.1	6.34	14	1.17				1.07	3.67	5.93	0.55	110	0.3	1	0.16	3.43
DIP pipe	4.1	6.34	14	1.17	2			1.07	3.67	5.93	0.55	110		1	0.02	3.59
bellmouth in wet well	4.1	6.34	14	1.17				1.07	3.67	5.93	0.55	110	0.05	1	0.03	3.61
Upstream Wet Well TWL																3.64

Appendix D

Preliminary Capital Cost Estimates

Lewes Board of Public Works and Sussex County
WWTF Long Range Planning Study
Option 1: Existing WWTF Hardening
Preliminary Capital Cost Estimate

Updated By:	K Beaudoin
Date:	10/21/2022
Checked By:	T Biagioli
Date:	10/24/2022

Item	Qty	Unit	Unit Cost	Total Cost
General Contract Conditions				
General Conditions (12% of Total)	1	LS	$1,380,647.29	$ 1,380,647.29
Mobilization/Demobilization (5% of Total)	1	LS	$575,269.71	$ 575,269.71
Civil				
Demolition				
Demolish Ex. EQ basin	530	CY	$ 500.00	$ 265,000.00
Concrete disposal - existing EQ basin	530	CY	$ 35.00	$ 18,550.00
Flood Barrier				
Excavation	1,650	CY	$ 30.00	$ 49,500.00
Fill - onsite material	40	CY	$ 30.00	$ 1,200.00
Fill - offsite material	6,160	CY	$ 40.00	$ 246,400.00
HDPE liner, 60 mm thick	34,000	SF	$ 3.13	$ 106,420.00
Drainage pipe, 4" perforated PVC	1,200	LF	$ 13.07	$ 15,684.00
Sheet Piling, steel	15,480	SF	$ 36.13	$ 559,292.40
12" HDPE Pipe for stormwater discharge	400	LF	$ 78.22	$ 31,287.36
Excavation				
Stormwater PS	40	CY	$ 30.00	$ 1,200.00
Sheeting for temporary excavation support (salvageable)				
Stormwater PS	570	SF	$ 90.00	$ 51,300.00
Dewatering				
Stormwater PS	6	MO	$ 36,000.00	$ 216,000.00
WWTF Site Roads				
Asphalt Pavement (7.5 inches)	8,000	SF	$ 10.00	$ 80,000.00
Aggregate Base for Asphalt Paving	8,000	SF	$ 5.00	$ 40,000.00
Structural				
New EQ Basin				
Base Slab	1,020	CY	$ 1,200.00	$ 1,224,000.00
Side Walls	470	CY	$ 1,200.00	$ 564,000.00
Walkways and Stairs	1	LS	$ 100,000.00	$ 100,000.00
Headworks				
6" core drill existing structure to install grit suction influent line	1	EA	$ 2,500.00	$ 2,500.00
Footings for extended walkway	1	LS	$ 5,000.00	$ 5,000.00
New Metal Walkway				
Extend existing walkway from exit to screenings dumpster	200	SF	$ 50.00	$ 10,000.00
Extend hand rails around new walkway	60	LF	$ 100.00	$ 6,000.00
Aeration Basin Expansion				
Base Slab	480	CY	$ 1,200.00	$ 576,000.00
Side Walls	250	CY	$ 1,200.00	$ 300,000.00
MBR Building Expansion				
Base Slab	140	CY	$ 1,200.00	$ 168,000.00
Stormwater PS				
Base Slab	10	CY	$ 1,200.00	$ 12,000.00
Side Walls	10	CY	$ 1,200.00	$ 12,000.00
Architectural and HVAC				
MBR Building Expansion				
Architectural Allowance	3,520	SF	$ 150.00	$ 528,000.00
AC for Control/Blower/Electrical Rooms	1	LS	$25,000.00	$ 25,000.00
Ventilation System	1	LS	$35,000.00	$ 35,000.00
Unit Heater	4	1000 SF	$1,500.00	$ 6,000.00

Lewes Board of Public Works and Sussex County
WWTF Long Range Planning Study
Option 1: Existing WWTF Hardening
Preliminary Capital Cost Estimate

Updated By: K Beaudoin
Date: 10/21/2022
Checked By: T Biagioli
Date: 10/24/2022

Item	Qty	Unit	Unit Cost	Total Cost
Mechanical/Equipment and Process Piping				
Demolition & Disposal				
Dispose of existing grit equipment at headworks	1	EA	$10,000.00	$ 10,000.00
Dispose of existing suction pumps and motors at LS-4	1	LS	$ 10,000.00	$ 10,000.00
Equipment:				
Fuel tank, 4000 gal	1	LS	$ 40,400.00	$ 40,400.00
Steep slope lawnmower	1	EA	$ 10,000.00	$ 10,000.00
Stormwater Pump Station				
Stormwater Pump	1	LS	$ 117,039.00	$ 117,039.00
Headworks				
Flow EQ Pumps	3	EA	$127,920.00	$ 383,760.00
Refurbish Existing 5mm Screen	1	EA	$ 121,836.00	$ 121,836.00
New Compactor for 5mm Screen, incl. control panel	1	EA	$ 300,456.00	$ 300,456.00
New JETA Grit Unit installed in existing structure, new control panel	1	EA	$ 183,768.00	$ 183,768.00
New Grit Pump	2	EA	$ 48,516.00	$ 97,032.00
New Grit Classifier and Cyclone	1	EA	$ 143,364.00	$ 143,364.00
Refurbish Existing 2mm Screen	1	EA	$ 131,040.00	$ 131,040.00
New 2mm Screen to be installed in ex. Bypass channel, new control pan	1	EA	$ 583,596.00	$ 583,596.00
New Compactor for 2mm Screen	2	EA	$ 75,660.00	$ 151,320.00
New Control Panel for 2mm screen compactors	1	EA	$ 171,756.00	$ 171,756.00
MBR Building				
Additional MBR Casette	1	LS	$1,131,825.00	$ 1,131,825.00
UV disinfection system replacement	1	LS	$347,880.00	$ 347,880.00
Plumbing Allowance	1	LS	$ 20,000.00	$ 20,000.00
Electrical/Instrumentation				
Electrical Allowance (20% of project costs, ex. land purchase)	1	LS	$1,842,081.15	$ 1,842,081.15
Instrumentation Allowance (10% of project costs, ex. land purchase)	1	LS	$452,907.20	$ 452,907.20
			Subtotal (rounded to nearest $1,000):	$ 13,461,000.00
			Contingency (rounded to nearest $1,000):	$ 4,711,000.00
			Total (rounded to nearest $1,000):	$ 18,172,000.00

Lewes Board of Public Works and Sussex County
WWTF Long Range Planning Study
Option 2a - Relocation and Spray Irrigation and/or RIBS
Preliminary Capital Cost Estimate

Updated By: K Beaudoin
Date: 10/21/2022
Checked By: T Biagioli
Date: 10/24/2022

Item	Qty	Unit	Unit Cost	Total Cost
General Contract Conditions				
General Conditions (12% of Total)	1	LS	$9,486,375.19	$ 9,486,375.19
Mobilization/Demobilization (5% of Total)	1	LS	$3,952,656.33	$ 3,952,656.33
Land Purchase	250	AC	$ 50,000.00	$ 12,500,000.00
Network Upgrades				
Excavation and Backfill				
Excavation for new LS-8	1,210	CY	$ 30.00	$ 36,300.00
Excavation for new Influent Force Main piping	16,140	CY	$ 30.00	$ 484,192.59
Excavation for new effluent force main piping	2,670	CY	$ 30.00	$ 80,100.00
Off-site disposal of soil material	3,140	CY	$ 40.00	$ 125,600.00
Backfill - Onsite Material, for FM pipe excavation	16,880	CY	$ 30.00	$ 506,400.00
Influent Force Main: Reinstatement of Existing Roads				
Asphalt Pavement (7.5 inches)	74,800	SF	$ 10.00	$ 748,000.00
Aggregate Base for Asphalt Paving	74,800	SF	$ 5.00	$ 374,000.00
Influent Force Main: Temporary Traffic Management	1	LS	$ 100,000.00	$ 100,000.00
Bypass Pumping				
LS-4 Bypass	3	MO	$ 24,000.00	$ 72,000.00
LS-8 Bypass	6	MO	$ 24,000.00	$ 144,000.00
Influent Force Main Piping				
16" SDR 11 HDPE Butt-Fusion Welded	32,100	LF	$ 123.24	$ 3,956,004.00
16" HDPE 90° elbow	7	EA	$ 1,950.00	$ 13,650.00
16" HDPE 45° elbow	3	EA	$ 1,177.80	$ 3,533.40
Effluent Force Main Piping				
16" SDR 11 HDPE Butt-Fusion Welded	5,280	LF	$ 123.24	$ 650,707.20
New Wet and Dry Wells at LS-8				
Below grade precast concrete vault for new grinder arrangement	1	EA	$ 10,000.00	$ 10,000.00
Base Slab	120	CY	$ 1,200.00	$ 144,000.00
Walls	170	CY	$ 1,200.00	$ 204,000.00
Cover Slab	60	CY	$ 1,200.00	$ 72,000.00
Bypass vault	12	CY	$ 1,200.00	$ 14,400.00
Equipment pads - generator and odor control	26	CY	$ 1,200.00	$ 31,200.00
Sheeting for temporary excavation support (salvageable)	10,310	SF	$ 90.00	$ 927,900.00
Dewatering	6	MO	$ 36,000.00	$ 216,000.00
LS-8 Equipment				
Raw Wastewater Pumps	2	EA	$329,160.00	$ 658,320.00
Odor control system	1	LS	$12,500.00	$ 12,500.00
115 kW generator	1	LS	$ 67,080.00	$ 67,080.00
Grinder arrangement on wet well influent (16")	1	LS	$ 10,000.00	$ 10,000.00
Civil				
Decommissioning of existing WWTF				
Process equipment building	1	LS	$ 900,000.00	$ 900,000.00
Headworks	1	LS	$ 600,000.00	$ 600,000.00
Aeration basins	1	LS	$ 420,000.00	$ 420,000.00
Aerobic digester	1	LS	$ 240,000.00	$ 240,000.00
Chemical building & pump station	1	LS	$ 240,000.00	$ 240,000.00
Service building	1	LS	$ 180,000.00	$ 180,000.00
Anoxic & membrane tanks	1	LS	$ 150,000.00	$ 150,000.00
Belt filter press building	1	LS	$ 120,000.00	$ 120,000.00
EQ tank	1	LS	$ 120,000.00	$ 120,000.00
Control building	1	LS	$ 96,000.00	$ 96,000.00
Emergency storage tank	1	LS	$ 96,000.00	$ 96,000.00
Sludge drying beds	1	LS	$ 60,000.00	$ 60,000.00
Sludge storage	1	LS	$ 60,000.00	$ 60,000.00

Lewes Board of Public Works and Sussex County
WWTF Long Range Planning Study
Option 2a - Relocation and Spray Irrigation and/or RIBS
Preliminary Capital Cost Estimate

Updated By: K Beaudoin
Date: 10/21/2022
Checked By: T Biagioli
Date: 10/24/2022

Item	Qty	Unit	Unit Cost	Total Cost
Meter vault	1	LS	$ 60,000.00	$ 60,000.00
Plant pump station	1	LS	$ 30,000.00	$ 30,000.00
Diesel fuel storage	1	LS	$ 30,000.00	$ 30,000.00
Generator pad	1	LS	$ 12,000.00	$ 12,000.00
Pavement	6,350	SY	$ 18.00	$ 114,300.00
Excavation and Backfill				
Excavation for new WWTF piping	1,240	CY	$ 30.00	$ 37,200.00
Excavation for Biolac lagoons	8,670	CY	$ 30.00	$ 260,100.00
Excavation for clarifiers	910	CY	$ 30.00	$ 27,300.00
Effluent storage lagoons				
Excavation for effluent storage lagoons	97,300	CY	$ 30.00	$ 2,919,000.00
Backfill for effluent storage lagoons	100,800	CY	$ 30.00	$ 3,024,000.00
HDPE Liner for effluent storage lagoons, 60 mm thick	752,300	SF	$ 3.13	$ 2,354,699.00
Excavation for effluent pump station	390	CY	$ 30.00	$ 11,700.00
Off-site disposal of soil material	6,720	CY	$ 40.00	$ 268,800.00
Backfill - Onsite Material, for WWTF excavation	990	CY	$ 30.00	$ 29,700.00
Sheeting for temporary excavation support (salvageable)				
Aeration lagoons	16,020	SF	$ 90.00	$ 1,441,800.00
Clarifiers	8,150	SF	$ 90.00	$ 733,500.00
Effluent pump station	4,650	SF	$ 90.00	$ 418,500.00
Dewatering				
Aeration lagoons	6	MO	$ 36,000.00	$ 216,000.00
Clarifiers	6	MO	$ 36,000.00	$ 216,000.00
Effluent pump station	6	MO	$ 36,000.00	$ 216,000.00
WWTF Site Roads				
Asphalt Pavement (7.5 inches)	138,000	SF	$ 10.00	$ 1,380,000.00
Aggregate Base for Asphalt Paving	138,000	SF	$ 5.00	$ 690,000.00
WWTF Yard Piping				
20" DIP, mechanical	330	LF	$ 180.00	$ 59,400.00
14" DIP, mechanical	2,160	LF	$ 105.00	$ 226,800.00
6" DIP, mechanical	190	LF	$ 45.00	$ 8,550.00
20" DIP tee, mechanical	1	EA	$ 2,400.00	$ 2,400.00
20" DIP 90° elbow, mechanical	2	EA	$ 3,225.00	$ 6,450.00
14" DIP tee, mechanical	5	EA	$ 1,305.00	$ 6,525.00
14" DIP 90° elbow, mechanical	10	EA	$ 915.00	$ 9,150.00
6" DIP tee, mechanical	1	EA	$ 495.00	$ 495.00
6" DIP 90° elbow, mechanical	1	EA	$ 270.00	$ 270.00
Erosion and Sedimentation Control	1	LS	$ 50,000.00	$ 50,000.00
Stormwater Management Basin	1	LS	$ 100,000.00	$ 100,000.00
Architectural and HVAC				
Admin Building				
Architectural Allowance	3,000	SF	$ 150.00	$ 450,000.00
AC for Control/Blower/Electrical Rooms	1	LS	$25,000.00	$ 25,000.00
Ventilation System	1	LS	$35,000.00	$ 35,000.00
Unit Heater	3	1000 SF	$1,500.00	$ 4,500.00
Headworks				
Architectural Allowance	4,000	SF	$ 150.00	$ 600,000.00
AC for Control/Blower/Electrical Rooms	1	LS	$25,000.00	$ 25,000.00
Ventilation System	1	LS	$10,000.00	$ 10,000.00
Unit Heater	2	1000 SF	$1,500.00	$ 3,000.00
Effluent Filter/UV Building				
Architectural Allowance	2,700	SF	$ 150.00	$ 405,000.00
AC for Control/Blower/Electrical Rooms	1	LS	$25,000.00	$ 25,000.00
Ventilation System	1	LS	$35,000.00	$ 35,000.00
Unit Heater	3	1000 SF	$1,500.00	$ 4,500.00
Effluent Pump Station				
Architectural Allowance	625	SF	$ 150.00	$ 93,750.00

Lewes Board of Public Works and Sussex County
WWTF Long Range Planning Study
Option 2a - Relocation and Spray Irrigation and/or RIBS
Preliminary Capital Cost Estimate

Updated By:	K Beaudoin
Date:	10/21/2022
Checked By:	T Biagioli
Date:	10/24/2022

Item	Qty	Unit	Unit Cost	Total Cost
AC for Control/Blower/Electrical Rooms	1	LS	$25,000.00	$ 25,000.00
Ventilation System	1	LS	$10,000.00	$ 10,000.00
Unit Heater	1	1000 SF	$1,500.00	$ 1,500.00
Digester Building				
Architectural Allowance	3,000	SF	$ 150.00	$ 450,000.00
AC for Control/Blower/Electrical Rooms	1	LS	$25,000.00	$ 25,000.00
Ventilation System	1	LS	$10,000.00	$ 10,000.00
Unit Heater	3	1000 SF	$1,500.00	$ 4,500.00
Structural				
Headworks				
Base Slab	80	CY	$ 1,200.00	$ 96,000.00
Walkways and Stairs	1	LS	$ 100,000.00	$ 100,000.00
EQ Tanks				
Base Slab	2,010	CY	$ 1,200.00	$ 2,412,000.00
Tank Walls	470	CY	$ 1,200.00	$ 564,000.00
Walkways and Stairs	2	LS	$ 250,000.00	$ 500,000.00
Parkson Biolac Lagoons				
Base Slab	1,160	CY	$ 1,200.00	$ 1,392,000.00
Tank Walls	400	CY	$ 1,200.00	$ 480,000.00
Walkways and Stairs	2	LS	$ 250,000.00	$ 500,000.00
Secondary Clarifiers				
Base Slab	160	CY	$ 1,200.00	$ 192,000.00
Tank Walls	110	CY	$ 1,200.00	$ 132,000.00
Walkways and Stairs	2	LS	$ 100,000.00	$ 200,000.00
Effluent Filter/UV Building				
Base Slab	100	CY	$ 1,200.00	$ 120,000.00
Walkways and Stairs	1	LS	$ 100,000.00	$ 100,000.00
Anoxic + Membrane Tank				
Base Slab	50	CY	$ 1,200.00	$ 60,000.00
Cover Slab	30	CY	$ 1,200.00	$ 36,000.00
Tank Walls	110	CY	$ 1,200.00	$ 132,000.00
Walkways and Stairs	1	LS	$ 100,000.00	$ 100,000.00
Effluent Pump Station				
Wet Well Base Slab	50	CY	$ 1,200.00	$ 60,000.00
Wet Well Walls	50	CY	$ 1,200.00	$ 60,000.00
Dry Well Base Slab	10	CY	$ 1,200.00	$ 12,000.00
Dry Well Walls	40	CY	$ 1,200.00	$ 48,000.00
Cover Slab	40	CY	$ 1,200.00	$ 48,000.00
Mechanical/Equipment and Process Piping				
WWTF Equipment:				
Fuel tank, 4000 gal	1	LS	$ 40,400.00	$ 40,400.00
Headworks				
5 mm screen and compactor	2	EA	$702,000.00	$ 1,404,000.00
Grit removal	2	EA	$683,280.00	$ 1,366,560.00
Grit pumps	2	EA	$31,200.00	$ 62,400.00
Biolac Lagoons				
Turbo Blowers	1	LS	$509,400.00	$ 509,400.00
Biolac System	1	LS	$608,400.00	$ 608,400.00
Secondary Clarifier Mechanism	2	EA	$234,000.00	$ 468,000.00
Cloth disc filters	1	LS	$1,244,724.00	$ 1,244,724.00
UV disinfection system	1	LS	$347,880.00	$ 347,880.00
Sludge Dewatering				
Belt Filter Press	1	LS	$506,532.00	$ 506,532.00
Polymer Dosing System	1	LS	$62,556.00	$ 62,556.00
Dewatered Cake Conveyor	1	LS	$68,796.00	$ 68,796.00

Lewes Board of Public Works and Sussex County		Updated By:	K Beaudoin
WWTF Long Range Planning Study		Date:	10/21/2022
Option 2a - Relocation and Spray Irrigation and/or RIBS		Checked By:	T Biagioli
Preliminary Capital Cost Estimate		Date:	10/24/2022

Item	Qty	Unit	Unit Cost	Total Cost
WWTF Pumps:				
Flow EQ Pumps	3	EA	$127,920.00	$ 383,760.00
Sludge Feed Pumps	2	EA	$68,796.00	$ 137,592.00
Scum Pumps	2	EA	$31,200.00	$ 62,400.00
Effluent pumps	2	EA	$241,800.00	$ 483,600.00
Spray irrigation	1	LS	$386,100.00	$ 386,100.00
Process Piping, Valves, Flow Meter and Plumbing Allowance (15% of project c	1	LS	$5,561,336.58	$ 5,561,336.58
Electrical/Instrumentation				
Electrical Allowance (20% of project costs, ex. land purchase)	1	LS	$10,238,942.55	$ 10,238,942.55
Instrumentation Allowance (10% of project costs, ex. land purchase)	1	LS	$5,119,471.28	$ 5,119,471.28
			Subtotal (rounded to nearest $1,000):	$ 92,492,000.00
			Contingency (rounded to nearest $1,000):	$ 32,372,000.00
			Total (rounded to nearest $1,000):	$ 124,864,000.00

Lewes Board of Public Works and Sussex County
WWTF Long Range Planning Study
Option 2b - Relocation & Utilization of Existing WWTP Outfall
Preliminary Capital Cost Estimate

Updated By: K Beaudoin
Date: 10/21/2022
Checked By: T Biagioli
Date: 10/24/2022

Item	Qty	Unit	Unit Cost	Total Cost
General Contract Conditions				
General Conditions (12% of Total)	1	LS	$6,930,558.83	$ 6,930,558.83
Mobilization/Demobilization (5% of Total)	1	LS	$2,887,732.84	$ 2,887,732.84
Land Purchase	20	AC	$ 50,000.00	$ 1,000,000.00
Network Upgrades				
Excavation and Backfill				
Excavation for new LS-8	1,210	CY	$ 30.00	$ 36,300.00
Excavation for new Influent Force Main piping	12,070	CY	$ 30.00	$ 362,100.00
Excavation for new Effluent Force Main piping	12,070	CY	$ 30.00	$ 362,100.00
Excavation for effluent pump station	390	CY	$ 30.00	$ 11,700.00
Off-site disposal of soil material	4,080	CY	$ 40.00	$ 163,200.00
Backfill - Onsite Material, for FM pipe excavation	21,660	CY	$ 30.00	$ 649,800.00
Influent Force Main: Reinstatement of Existing Roads				
Asphalt Pavement (7.5 inches)	55,860	SF	$ 10.00	$ 558,600.00
Aggregate Base for Asphalt Paving	55,860	SF	$ 5.00	$ 279,300.00
Effluent Force Main: Reinstatement of Existing Roads				
Asphalt Pavement (7.5 inches)	55,860	SF	$ 10.00	$ 558,600.00
Aggregate Base for Asphalt Paving	55,860	SF	$ 5.00	$ 279,300.00
Force Mains: Temporary Traffic Management	1	LS	$ 100,000.00	$ 100,000.00
Influent Force Main Piping				
16" SDR 11 HDPE Butt-Fusion Welded	24,000	LF	$ 123.24	$ 2,957,760.00
16" HDPE 90° elbow	2	EA	$ 1,950.00	$ 3,900.00
16" HDPE 45° elbow	2	EA	$ 1,177.80	$ 2,355.60
Effluent Force Main Piping				
16" SDR 11 HDPE Butt-Fusion Welded	24,000	LF	$ 123.24	$ 2,957,760.00
16" HDPE 90° elbow	2	EA	$ 1,950.00	$ 3,900.00
16" HDPE 45° elbow	2	EA	$ 1,177.80	$ 2,355.60
Bypass Pumping				
LS-4 Bypass	3	MO	$ 24,000.00	$ 72,000.00
LS-8 Bypass	6	MO	$ 24,000.00	$ 144,000.00
New Wet and Dry Wells at LS-8				
Below grade precast concrete vault for new grinder arrangement	1	EA	$ 10,000.00	$ 10,000.00
Base Slab	120	CY	$ 1,200.00	$ 144,000.00
Walls	170	CY	$ 1,200.00	$ 204,000.00
Cover Slab	60	CY	$ 1,200.00	$ 72,000.00
Bypass vault	12	CY	$ 1,200.00	$ 14,400.00
Equipment pads - generator and odor control	26	CY	$ 1,200.00	$ 31,200.00
Sheeting for temporary excavation support (salvageable)	10,310	SF	$ 90.00	$ 927,900.00
Dewatering	6	MO	$ 36,000.00	$ 216,000.00
LS-8 Equipment				
Raw Wastewater Pumps	2	EA	$257,400.00	$ 514,800.00
Odor control system	1	LS	$12,500.00	$ 12,500.00
115 kW generator	1	LS	$ 67,080.00	$ 67,080.00
Grinder arrangement on wet well influent (16")	1	LS	$ 10,000.00	$ 10,000.00
Effluent Pump Station				
Effluent pumps	2	EA	$241,800.00	$ 483,600.00
Architectural Allowance	1,800	SF	$ 150.00	$ 270,000.00
AC for Control/Blower/Electrical Rooms	1	LS	$25,000.00	$ 25,000.00
Ventilation System	1	LS	$10,000.00	$ 10,000.00
Unit Heater	2	1000 SF	$1,500.00	$ 3,000.00
Wet Well Base Slab	50	CY	$ 1,200.00	$ 60,000.00
Wet Well Walls	50	CY	$ 1,200.00	$ 60,000.00

Lewes Board of Public Works and Sussex County
WWTF Long Range Planning Study
Option 2b - Relocation & Utilization of Existing WWTP Outfall
Preliminary Capital Cost Estimate

Updated By:	K Beaudoin
Date:	10/21/2022
Checked By:	T Biagioli
Date:	10/24/2022

Item	Qty	Unit	Unit Cost	Total Cost
Dry Well Base Slab	10	CY	$ 1,200.00	$ 12,000.00
Dry Well Walls	40	CY	$ 1,200.00	$ 48,000.00
Cover Slab	40	CY	$ 1,200.00	$ 48,000.00
Sheeting for temporary excavation support (salvageable)	4,650	SF	$ 90.00	$ 418,500.00
Dewatering	6	MO	$ 36,000.00	$ 216,000.00
Civil				
Decommissioning of existing WWTF				
Process equipment building	1	LS	$ 900,000.00	$ 900,000.00
Headworks	1	LS	$ 600,000.00	$ 600,000.00
Aeration basins	1	LS	$ 420,000.00	$ 420,000.00
Aerobic digester	1	LS	$ 240,000.00	$ 240,000.00
Chemical building & pump station	1	LS	$ 240,000.00	$ 240,000.00
Service building	1	LS	$ 180,000.00	$ 180,000.00
Anoxic & membrane tanks	1	LS	$ 150,000.00	$ 150,000.00
Belt filter press building	1	LS	$ 120,000.00	$ 120,000.00
EQ tank	1	LS	$ 120,000.00	$ 120,000.00
Control building	1	LS	$ 96,000.00	$ 96,000.00
Emergency storage tank	1	LS	$ 96,000.00	$ 96,000.00
Sludge drying beds	1	LS	$ 60,000.00	$ 60,000.00
Sludge storage	1	LS	$ 60,000.00	$ 60,000.00
Meter vault	1	LS	$ 60,000.00	$ 60,000.00
Plant pump station	1	LS	$ 30,000.00	$ 30,000.00
Diesel fuel storage	1	LS	$ 30,000.00	$ 30,000.00
Generator pad	1	LS	$ 12,000.00	$ 12,000.00
Pavement	6,350	SY	$ 18.00	$ 114,300.00
Excavation and Backfill				
Excavation for Biolac lagoons	8,670	CY	$ 30.00	$ 260,100.00
Excavation for clarifiers	910	CY	$ 30.00	$ 27,300.00
Excavation for effluent pump station	390	CY	$ 30.00	$ 11,700.00
Excavation for new WWTF piping	920	CY	$ 30.00	$ 27,600.00
Off-site disposal of soil material	10,190	CY	$ 40.00	$ 407,600.00
Backfill - Onsite Material, for WWTF pipe excavation	700	CY	$ 30.00	$ 21,000.00
Sheeting for temporary excavation support (salvageable)				
Aeration lagoons	16,020	SF	$ 90.00	$ 1,441,800.00
Clarifiers	8,150	SF	$ 90.00	$ 733,500.00
Dewatering				
Aeration lagoons	6	MO	$ 36,000.00	$ 216,000.00
Clarifiers	6	MO	$ 36,000.00	$ 216,000.00
WWTF Site Roads				
Asphalt Pavement (7.5 inches)	55,100	SF	$ 10.00	$ 551,000.00
Aggregate Base for Asphalt Paving	55,100	SF	$ 5.00	$ 275,500.00
WWTF Yard Piping				
20" DIP, mechanical	330	LF	$ 180.00	$ 59,400.00
14" DIP, mechanical	1,440	LF	$ 105.00	$ 151,200.00
6" DIP, mechanical	190	LF	$ 45.00	$ 8,550.00
20" DIP tee, mechanical	1	EA	$ 2,400.00	$ 2,400.00
20" DIP 90° elbow, mechanical	2	EA	$ 3,225.00	$ 6,450.00
14" DIP tee, mechanical	3	EA	$ 1,305.00	$ 3,915.00
14" DIP 90° elbow, mechanical	6	EA	$ 915.00	$ 5,490.00
6" DIP tee, mechanical	1	EA	$ 495.00	$ 495.00
6" DIP 90° elbow, mechanical	1	EA	$ 270.00	$ 270.00
Erosion and Sedimentation Control	1	LS	$ 50,000.00	$ 50,000.00
Stormwater Management Basin	1	LS	$ 100,000.00	$ 100,000.00

Lewes Board of Public Works and Sussex County
WWTF Long Range Planning Study
Option 2b - Relocation & Utilization of Existing WWTP Outfall
Preliminary Capital Cost Estimate

Updated By: K Beaudoin
Date: 10/21/2022
Checked By: T Biagioli
Date: 10/24/2022

Item	Qty	Unit	Unit Cost	Total Cost
Architectural and HVAC				
Admin Building				
Architectural Allowance	3,000	SF	$ 150.00	$ 450,000.00
AC for Control/Blower/Electrical Rooms	1	LS	$25,000.00	$ 25,000.00
Ventilation System	1	LS	$35,000.00	$ 35,000.00
Unit Heater	3	1000 SF	$1,500.00	$ 4,500.00
Headworks				
Architectural Allowance	4,000	SF	$ 150.00	$ 600,000.00
AC for Control/Blower/Electrical Rooms	1	LS	$25,000.00	$ 25,000.00
Ventilation System	1	LS	$10,000.00	$ 10,000.00
Unit Heater	2	1000 SF	$1,500.00	$ 3,000.00
Effluent Filter/UV Building				
Architectural Allowance	2,700	SF	$ 150.00	$ 405,000.00
AC for Control/Blower/Electrical Rooms	1	LS	$25,000.00	$ 25,000.00
Ventilation System	1	LS	$10,000.00	$ 10,000.00
Unit Heater	3	1000 SF	$1,500.00	$ 4,500.00
Digester Building				
Architectural Allowance	3,000	SF	$ 150.00	$ 450,000.00
AC for Control/Blower/Electrical Rooms	1	LS	$25,000.00	$ 25,000.00
Ventilation System	1	LS	$10,000.00	$ 10,000.00
Unit Heater	2	1000 SF	$1,500.00	$ 3,000.00
Structural				
Headworks				
Base Slab	80	CY	$ 1,200.00	$ 96,000.00
Walkways and Stairs	1	LS	$ 100,000.00	$ 100,000.00
EQ Tanks				
Base Slab	2,010	CY	$ 1,200.00	$ 2,412,000.00
Tank Walls	470	CY	$ 1,200.00	$ 564,000.00
Walkways and Stairs	2	LS	$ 250,000.00	$ 500,000.00
Parkson Biolac Lagoons				
Base Slab	1,160	CY	$ 1,200.00	$ 1,392,000.00
Tank Walls	400	CY	$ 1,200.00	$ 480,000.00
Walkways and Stairs	2	LS	$ 250,000.00	$ 500,000.00
Secondary Clarifiers				
Base Slab	160	CY	$ 1,200.00	$ 192,000.00
Tank Walls	110	CY	$ 1,200.00	$ 132,000.00
Walkways and Stairs	2	LS	$ 100,000.00	$ 200,000.00
Effluent Filter/UV Building				
Base Slab	100	CY	$ 1,200.00	$ 120,000.00
Walkways and Stairs	1	LS	$ 100,000.00	$ 100,000.00
Anoxic + Membrane Tank				
Base Slab	50	CY	$ 1,200.00	$ 60,000.00
Cover Slab	30	CY	$ 1,200.00	$ 36,000.00
Tank Walls	110	CY	$ 1,200.00	$ 132,000.00
Walkways and Stairs	1	LS	$ 100,000.00	$ 100,000.00
Mechanical/Equipment and Process Piping				
WWTF Equipment:				
Fuel tank, 4000 gal	1	LS	$ 40,400.00	$ 40,400.00
Headworks				
5 mm screen and compactor	2	EA	$702,000.00	$ 1,404,000.00
Grit removal	2	EA	$683,280.00	$ 1,366,560.00

Lewes Board of Public Works and Sussex County	Updated By:	K Beaudoin
WWTF Long Range Planning Study	Date:	10/21/2022
Option 2b - Relocation & Utilization of Existing WWTP Outfall	Checked By:	T Biagioli
Preliminary Capital Cost Estimate	Date:	10/24/2022

Item	Qty	Unit	Unit Cost	Total Cost
Grit pumps	2	EA	$31,200.00	$ 62,400.00
Biolac Lagoons				
Turbo Blowers	1	LS	$509,400.00	$ 509,400.00
Biolac System	1	LS	$608,400.00	$ 608,400.00
Secondary Clarifier Mechanism	2	EA	$234,000.00	$ 468,000.00
Cloth disc filters	1	LS	$1,244,724.00	$ 1,244,724.00
UV disinfection system	1	LS	$347,880.00	$ 347,880.00
Sludge Dewatering				
Belt Filter Press	1	LS	$506,532.00	$ 506,532.00
Polymer Dosing System	1	LS	$62,556.00	$ 62,556.00
Dewatered Cake Conveyor	1	LS	$68,796.00	$ 68,796.00
WWTF Pumps:				
Flow EQ Pumps	3	EA	$127,920.00	$ 383,760.00
Sludge Feed Pumps	2	EA	$68,796.00	$ 137,592.00
Scum Pumps	2	EA	$31,200.00	$ 62,400.00
Process Piping, Valves, Flow Meter and Plumbing Allowance (15% of project	1	LS	$5,694,447.18	$ 5,694,447.18
Electrical/Instrumentation				
Electrical Allowance (20% of project costs, ex. land purchase)	1	LS	$8,731,485.68	$ 8,731,485.68
Instrumentation Allowance (10% of project costs, ex. land purchase)	1	LS	$4,365,742.84	$ 4,365,742.84
			Subtotal (rounded to nearest $1,000):	$ 67,573,000.00
			Contingency (rounded to nearest $1,000):	$ 23,651,000.00
			Total (rounded to nearest $1,000):	$ 91,224,000.00

Lewes Board of Public Works and Sussex County
WWTF Long Range Planning Study
Option 2c - Relocation & New Ocean Outfall
Preliminary Capital Cost Estimate

Updated By: K Beaudoin
Date: 10/21/2022
Checked By: T Biagioli
Date: 10/24/2022

Item	Qty	Unit	Unit Cost	Total Cost
General Contract Conditions				
General Conditions (12% of Total)	1	LS	$11,332,168.41	$ 11,332,168.41
Mobilization/Demobilization (5% of Total)	1	LS	$4,721,736.84	$ 4,721,736.84
Land Purchase	20	AC	$ 50,000.00	$ 1,000,000.00
Network				
Excavation for new LS-8	1,210	CY	$ 30.00	$ 36,300.00
Excavation for new Influent Force Main piping	12,070	CY	$ 30.00	$ 362,100.00
Excavation for new Effluent Force Main piping	17,940	CY	$ 30.00	$ 538,200.00
Off-site disposal of soil material	4,290	CY	$ 40.00	$ 171,600.00
Backfill - Onsite Material, FM pipe excavation	26,930	CY	$ 30.00	$ 807,900.00
Influent Force Main: Reinstatement of Existing Roads				
Asphalt Pavement (7.5 inches)	55,860	SF	$ 10.00	$ 558,600.00
Aggregate Base for Asphalt Paving	55,860	SF	$ 5.00	$ 279,300.00
Effluent Force Main: Reinstatement of Existing Roads				
Asphalt Pavement (7.5 inches)	83,020	SF	$ 10.00	$ 830,200.00
Aggregate Base for Asphalt Paving	83,020	SF	$ 5.00	$ 415,100.00
Influent Force Main: Temporary Traffic Management	1	LS	$ 100,000.00	$ 100,000.00
Effluent Force Main: Temporary Traffic Management	1	LS	$ 100,000.00	$ 100,000.00
Bypass Pumping				
LS-4 Bypass	3	MO	$ 24,000.00	$ 72,000.00
LS-8 Bypass	6	MO	$ 24,000.00	$ 144,000.00
Influent Force Main Piping				
16" SDR 11 HDPE Butt-Fusion Welded	23,940	LF	$ 123.24	$ 2,950,365.60
16" HDPE 90° elbow	2	EA	$ 1,950.00	$ 3,900.00
16" HDPE 45° elbow	2	EA	$ 1,177.80	$ 2,355.60
Effluent Force Main Piping				
16" SDR 11 HDPE Butt-Fusion Welded	35,580	LF	$ 123.24	$ 4,384,879.20
16" HDPE 90° elbow	2	EA	$ 1,950.00	$ 3,900.00
16" HDPE 45° elbow	2	EA	$ 1,177.80	$ 2,355.60
New Wet and Dry Wells at LS-8				
Below grade precast concrete vault for new grinder arrangement	1	EA	$ 10,000.00	$ 10,000.00
Base Slab	120	CY	$ 1,200.00	$ 144,000.00
Walls	170	CY	$ 1,200.00	$ 204,000.00
Cover Slab	60	CY	$ 1,200.00	$ 72,000.00
Bypass vault	12	CY	$ 1,200.00	$ 14,400.00
Equipment pads - generator and odor control	26	CY	$ 1,200.00	$ 31,200.00
Sheeting for temporary excavation support (salvageable)	10,310	SF	$ 90.00	$ 927,900.00
Dewatering	6	MO	$ 36,000.00	$ 216,000.00
LS-8 Equipment				
Raw Wastewater Pumps	2	EA	$257,400.00	$ 514,800.00
Odor control system	1	LS	$12,500.00	$ 12,500.00
115 kW generator	1	LS	$ 67,080.00	$ 67,080.00
Grinder arrangement on wet well influent (16")	1	LS	$ 10,000.00	$ 10,000.00
Effluent Pump Station				
Effluent pumps	2	EA	$257,400.00	$ 514,800.00
Wet Well Base Slab	50	CY	$ 1,200.00	$ 60,000.00
Wet Well Walls	50	CY	$ 1,200.00	$ 60,000.00
Dry Well Base Slab	10	CY	$ 1,200.00	$ 12,000.00
Dry Well Walls	40	CY	$ 1,200.00	$ 48,000.00
Cover Slab	40	CY	$ 1,200.00	$ 48,000.00
Sheeting for temporary excavation support (salvageable)	4,650	SF	$ 90.00	$ 418,500.00
Dewatering	6	MO	$ 36,000.00	$ 216,000.00

Lewes Board of Public Works and Sussex County
WWTF Long Range Planning Study
Option 2c - Relocation & New Ocean Outfall
Preliminary Capital Cost Estimate

Updated By: K Beaudoin
Date: 10/21/2022
Checked By: T Biagioli
Date: 10/24/2022

Item	Qty	Unit	Unit Cost	Total Cost
Architectural Allowance	625	SF	$ 150.00	$ 93,750.00
AC for Control/Blower/Electrical Rooms	1	LS	$25,000.00	$ 25,000.00
Ventilation System	1	LS	$35,000.00	$ 35,000.00
Unit Heater	1	1000 SF	$1,500.00	$ 1,500.00
Ocean Outfall				
Maintenance of traffic	1	LS	$ 195,000.00	$ 195,000.00
Staging area, beach dune and land based site restoration	1	LS	$ 59,150.00	$ 59,150.00
Sediment and erosion control	1	LS	$ 19,500.00	$ 19,500.00
HDD monitoring/Fluid specialist	1	LS	$ 104,000.00	$ 104,000.00
Concrete thrust collar	1	LS	$ 162,500.00	$ 162,500.00
Outfall diffuser assembly	1	LS	$ 2,210,000.00	$ 2,210,000.00
Concrete piling and pile caps at diffuser	1	LS	$ 3,770,000.00	$ 3,770,000.00
HDD entry pit	1	LS	$ 130,000.00	$ 130,000.00
HDD exit pit	1	LS	$ 1,326,000.00	$ 1,326,000.00
16" HDPE outfall pipe via HDD	3,000	LF	$ 1,885.00	$ 5,655,000.00
16" HDPE via marine open-cut trench	3,000	LF	$ 6,240.00	$ 18,720,000.00
Concrete ballast collars for open-cut	165	EA	$ 4,810.00	$ 793,650.00
Parking lot	70,000	SF	$ 2.60	$ 182,000.00
Connection between outfall and force main	1	LS	$ 130,000.00	$ 130,000.00
Misc. excavation and replacement of sand	100	CY	$ 130.00	$ 13,000.00
Silt fence	300	LF	$ 32.50	$ 9,750.00
Beach sand fencing	50	LF	$ 130.00	$ 6,500.00
Civil				
Decommissioning of existing WWTF				
Process equipment building	1	LS	$ 900,000.00	$ 900,000.00
Headworks	1	LS	$ 600,000.00	$ 600,000.00
Aeration basins	1	LS	$ 420,000.00	$ 420,000.00
Aerobic digester	1	LS	$ 240,000.00	$ 240,000.00
Chemical building & pump station	1	LS	$ 240,000.00	$ 240,000.00
Service building	1	LS	$ 180,000.00	$ 180,000.00
Anoxic & membrane tanks	1	LS	$ 150,000.00	$ 150,000.00
Belt filter press building	1	LS	$ 120,000.00	$ 120,000.00
EQ tank	1	LS	$ 120,000.00	$ 120,000.00
Control building	1	LS	$ 96,000.00	$ 96,000.00
Emergency storage tank	1	LS	$ 96,000.00	$ 96,000.00
Sludge drying beds	1	LS	$ 60,000.00	$ 60,000.00
Sludge storage	1	LS	$ 60,000.00	$ 60,000.00
Meter vault	1	LS	$ 60,000.00	$ 60,000.00
Plant pump station	1	LS	$ 30,000.00	$ 30,000.00
Diesel fuel storage	1	LS	$ 30,000.00	$ 30,000.00
Generator pad	1	LS	$ 12,000.00	$ 12,000.00
Pavement	6,350	SY	$ 18.00	$ 114,300.00
Excavation and Backfill				
Excavation for Biolac lagoons	8,670	CY	$ 30.00	$ 260,100.00
Excavation for clarifiers	910	CY	$ 30.00	$ 27,300.00
Excavation for effluent pump station	390	CY	$ 30.00	$ 11,700.00
Excavation for new WWTF piping	920	CY	$ 30.00	$ 27,600.00
Off-site disposal of soil material	10,190	CY	$ 40.00	$ 407,600.00
Backfill - Onsite Material, for WWTF pipe excavation	700	CY	$ 30.00	$ 21,000.00
Sheeting for temporary excavation support (salvageable)				
Aeration lagoons	16,020	SF	$ 90.00	$ 1,441,800.00
Clarifiers	8,150	SF	$ 90.00	$ 733,500.00
Dewatering				

Item	Qty	Unit	Unit Cost	Total Cost
Aeration lagoons	6	MO	$ 36,000.00	$ 216,000.00
Clarifiers	6	MO	$ 36,000.00	$ 216,000.00
WWTF Site Roads				
Asphalt Pavement (7.5 inches)	55,100	SF	$ 10.00	$ 551,000.00
Aggregate Base for Asphalt Paving	55,100	SF	$ 5.00	$ 275,500.00
WWTF Yard Piping				
20" DIP, mechanical	330	LF	$ 180.00	$ 59,400.00
14" DIP, mechanical	1,440	LF	$ 105.00	$ 151,200.00
6" DIP, mechanical	190	LF	$ 45.00	$ 8,550.00
20" DIP tee, mechanical	1	EA	$ 2,400.00	$ 2,400.00
20" DIP 90° elbow, mechanical	2	EA	$ 3,225.00	$ 6,450.00
14" DIP tee, mechanical	3	EA	$ 1,305.00	$ 3,915.00
14" DIP 90° elbow, mechanical	6	EA	$ 915.00	$ 5,490.00
6" DIP tee, mechanical	1	EA	$ 495.00	$ 495.00
6" DIP 90° elbow, mechanical	1	EA	$ 270.00	$ 270.00
Erosion and Sedimentation Control	1	LS	$ 50,000.00	$ 50,000.00
Stormwater Management Basin	1	LS	$ 100,000.00	$ 100,000.00
Architectural and HVAC				
Admin Building				
Architectural Allowance	3,000	SF	$ 150.00	$ 450,000.00
AC for Control/Blower/Electrical Rooms	1	LS	$25,000.00	$ 25,000.00
Ventilation System	1	LS	$35,000.00	$ 35,000.00
Unit Heater	3	1000 SF	$1,500.00	$ 4,500.00
Headworks				
Architectural Allowance	4,000	SF	$ 150.00	$ 600,000.00
AC for Control/Blower/Electrical Rooms	1	LS	$25,000.00	$ 25,000.00
Ventilation System	1	LS	$10,000.00	$ 10,000.00
Unit Heater	2	1000 SF	$1,500.00	$ 3,000.00
Effluent Filter/UV Building				
Architectural Allowance	2,700	SF	$ 150.00	$ 405,000.00
AC for Control/Blower/Electrical Rooms	1	LS	$25,000.00	$ 25,000.00
Ventilation System	1	LS	$10,000.00	$ 10,000.00
Unit Heater	3	1000 SF	$1,500.00	$ 4,500.00
Digester Building				
Architectural Allowance	3,000	SF	$ 150.00	$ 450,000.00
AC for Control/Blower/Electrical Rooms	1	LS	$25,000.00	$ 25,000.00
Ventilation System	1	LS	$10,000.00	$ 10,000.00
Unit Heater	2	1000 SF	$1,500.00	$ 3,000.00
Structural				
Headworks				
Base Slab	80	CY	$ 1,200.00	$ 96,000.00
Walkways and Stairs	1	LS	$ 100,000.00	$ 100,000.00
EQ Tanks				
Base Slab	2,010	CY	$ 1,200.00	$ 2,412,000.00
Tank Walls	470	CY	$ 1,200.00	$ 564,000.00
Walkways and Stairs	2	LS	$ 250,000.00	$ 500,000.00
Parkson Biolac Lagoons				
Base Slab	1,160	CY	$ 1,200.00	$ 1,392,000.00
Tank Walls	400	CY	$ 1,200.00	$ 480,000.00
Walkways and Stairs	2	LS	$ 250,000.00	$ 500,000.00
Secondary Clarifiers				
Base Slab	160	CY	$ 1,200.00	$ 192,000.00

Lewes Board of Public Works and Sussex County
WWTF Long Range Planning Study
Option 2c - Relocation & New Ocean Outfall
Preliminary Capital Cost Estimate

Updated By: K Beaudoin
Date: 10/21/2022
Checked By: T Biagioli
Date: 10/24/2022

Item	Qty	Unit	Unit Cost	Total Cost
Tank Walls	110	CY	$ 1,200.00	$ 132,000.00
Walkways and Stairs	2	LS	$ 100,000.00	$ 200,000.00
Effluent Filter/UV Building				
Base Slab	100	CY	$ 1,200.00	$ 120,000.00
Walkways and Stairs	1	LS	$ 100,000.00	$ 100,000.00
Anoxic + Membrane Tank				
Base Slab	50	CY	$ 1,200.00	$ 60,000.00
Cover Slab	30	CY	$ 1,200.00	$ 36,000.00
Tank Walls	110	CY	$ 1,200.00	$ 132,000.00
Walkways and Stairs	1	LS	$ 100,000.00	$ 100,000.00
Mechanical/Equipment and Process Piping				
WWTF Equipment:				
Fuel tank, 4000 gal	1	LS	$ 40,400.00	$ 40,400.00
Headworks				
5 mm screen and compactor	2	EA	$702,000.00	$ 1,404,000.00
Grit removal	2	EA	$683,280.00	$ 1,366,560.00
Grit pumps	2	EA	$31,200.00	$ 62,400.00
Biolac Lagoons				
Turbo Blowers	1	LS	$509,400.00	$ 509,400.00
Biolac System	1	LS	$608,400.00	$ 608,400.00
Secondary Clarifier Mechanism	2	EA	$234,000.00	$ 468,000.00
Cloth disc filters	1	LS	$1,244,724.00	$ 1,244,724.00
UV disinfection system	1	LS	$347,880.00	$ 347,880.00
Sludge Dewatering				
Belt Filter Press	1	LS	$506,532.00	$ 506,532.00
Polymer Dosing System	1	LS	$62,556.00	$ 62,556.00
Dewatered Cake Conveyor	1	LS	$68,796.00	$ 68,796.00
WWTF Pumps:				
Flow EQ Pumps	3	EA	$127,920.00	$ 383,760.00
Sludge Feed Pumps	2	EA	$68,796.00	$ 137,592.00
Scum Pumps	2	EA	$31,200.00	$ 62,400.00
Process Piping, Valves, Flow Meter and Plumbing Allowance (15% of project co	1	LS	$6,014,918.40	$ 6,014,918.40
Electrical/Instrumentation				
Electrical Allowance (20% of project costs, ex. land purchase & ocean outfall)	1	LS	$9,222,874.88	$ 9,222,874.88
Instrumentation Allowance (10% of project costs, ex. land purchase & ocean ou	1	LS	$4,611,437.44	$ 4,611,437.44
	Subtotal (rounded to nearest $1,000):			$ 110,489,000.00
	Contingency (rounded to nearest $1,000):			$ 38,671,000.00
	Total (rounded to nearest $1,000):			$ 149,160,000.00

Lewes Board of Public Works and Sussex County	Updated By:	K Beaudoin
WWTF Long Range Planning Study	Date:	10/21/2022
Option 3a - Partnership with Sussex County & Utilization of Existing WWTP Outfall (BPW Costs)	Checked By:	T Biagioli
Preliminary Capital Cost Estimate	Date:	10/24/2022

Item	Qty	Unit	Unit Cost	Total Cost
General Contract Conditions				
General Conditions (12% of Total)	1	LS	$1,215,573.86	$ 1,215,573.86
Mobilization/Demobilization (5% of Total)	1	LS	$506,489.11	$ 506,489.11
Decommissioning of existing WWTF				
Process equipment building	1	LS	$ 900,000.00	$ 900,000.00
Headworks	1	LS	$ 600,000.00	$ 600,000.00
Aeration basins	1	LS	$ 420,000.00	$ 420,000.00
Aerobic digester	1	LS	$ 240,000.00	$ 240,000.00
Chemical building & pump station	1	LS	$ 240,000.00	$ 240,000.00
Service building	1	LS	$ 180,000.00	$ 180,000.00
Anoxic & membrane tanks	1	LS	$ 150,000.00	$ 150,000.00
Belt filter press building	1	LS	$ 120,000.00	$ 120,000.00
EQ tank	1	LS	$ 120,000.00	$ 120,000.00
Control building	1	LS	$ 96,000.00	$ 96,000.00
Emergency storage tank	1	LS	$ 96,000.00	$ 96,000.00
Sludge drying beds	1	LS	$ 60,000.00	$ 60,000.00
Sludge storage	1	LS	$ 60,000.00	$ 60,000.00
Meter vault	1	LS	$ 60,000.00	$ 60,000.00
Plant pump station	1	LS	$ 30,000.00	$ 30,000.00
Diesel fuel storage	1	LS	$ 30,000.00	$ 30,000.00
Generator pad	1	LS	$ 12,000.00	$ 12,000.00
Pavement	6,350	SY	$ 18.00	$ 114,300.00
Network Upgrades				
Civil				
Excavation and Backfill				
Excavation for new LS-8	1,210	CY	$ 30.00	$ 36,300.00
Excavation for new Influent Force Main piping	940	CY	$ 30.00	$ 28,200.00
Off-site disposal of soil material	1,310	CY	$ 40.00	$ 52,400.00
Backfill - Onsite Material, for pipe excavation	840	CY	$ 30.00	$ 25,200.00
LS-8 sheeting for temporary excavation support	10,310	SF	$ 90.00	$ 927,900.00
LS-8 dewatering	6	MO	$ 36,000.00	$ 216,000.00
Influent Force Main: Reinstatement of Existing Roads				
Asphalt Pavement (7.5 inches)	4,320	SF	$ 10.00	$ 43,200.00
Aggregate Base for Asphalt Paving	4,320	SF	$ 5.00	$ 21,600.00
Influent Force Main: Temporary Traffic Management	1	LS	$ 100,000.00	$ 100,000.00
Influent Force Main Piping				
16" SDR 11 HDPE Butt-Fusion Welded	1,850	LF	$ 123.24	$ 227,994.00
16" HDPE 90° elbow	2	EA	$ 1,950.00	$ 3,900.00
Bypass Pumping				
LS-4 Bypass	3	MO	$ 24,000.00	$ 72,000.00
LS-8 Bypass	6	MO	$ 24,000.00	$ 144,000.00
Erosion and Sedimentation Control	1	LS	$ 50,000.00	$ 50,000.00
New canal outfall	1	LS	$ 50,000.00	$ 50,000.00
Temporary facilities for canal crossing	1	LS	$ 100,000.00	$ 100,000.00
Stormwater Management Basin	1	LS	$ 100,000.00	$ 100,000.00
Structural				
New Wet and Dry Wells at LS-8				
Below grade precast concrete vault for new grinder arrangement	1	EA	$ 10,000.00	$ 10,000.00
Base Slab	120	CY	$ 1,200.00	$ 144,000.00
Walls	170	CY	$ 1,200.00	$ 204,000.00
Cover Slab	60	CY	$ 1,200.00	$ 72,000.00
Bypass vault	12	CY	$ 1,200.00	$ 14,400.00

Lewes Board of Public Works and Sussex County	Updated By:	K Beaudoin
WWTF Long Range Planning Study	Date:	10/21/2022
Option 3a - Partnership with Sussex County & Utilization of Existing WWTP Outfall (BPW Costs)	Checked By:	T Biagioli
Preliminary Capital Cost Estimate	Date:	10/24/2022

Item	Qty	Unit	Unit Cost	Total Cost
Equipment pads - generator and odor control	26	CY	$ 1,200.00	$ 31,200.00
Mechanical/Equipment and Process Piping				
LS-8 Raw Wastewater pumps	2	EA	$241,800.00	$ 483,600.00
Odor control system	1	LS	$12,500.00	$ 12,500.00
115 kW generator	1	LS	$ 67,080.00	$ 67,080.00
Grinder arrangement on wet well influent (16")	1	LS	$ 10,000.00	$ 10,000.00
Process Piping, Valves, Flow Meter and Plumbing Allowance (15% of project c	1	LS	$1,016,366.10	$ 1,016,366.10
Electrical/Instrumentation				
Electrical Allowance (20% of project costs, ex. land purchase)	1	LS	$1,558,428.02	$ 1,558,428.02
Instrumentation Allowance (10% of project costs, ex. land purchase)	1	LS	$779,214.01	$ 779,214.01
			Subtotal (rounded to nearest $1,000):	$ 11,852,000.00
			Contingency (rounded to nearest $1,000):	$ 4,148,000.00
			Total (rounded to nearest $1,000):	$ 16,000,000.00

Lewes Board of Public Works and Sussex County	Updated By:	K Beaudoin
WWTF Long Range Planning Study	Date:	10/21/2022
Option 3b - Partnership with Sussex County & Constructed Wetland (BPW Costs)	Checked By:	T Biagioli
Preliminary Capital Cost Estimate	Date:	10/24/2022

Item	Qty	Unit	Unit Cost	Total Cost
General Contract Conditions				
General Conditions (12% of Total)	1	LS	$1,206,603.86	$ 1,206,603.86
Mobilization/Demobilization (5% of Total)	1	LS	$ 502,751.61	$ 502,751.61
Civil				
Decommissioning of existing WWTF				
Process equipment building	1	LS	$ 900,000.00	$ 900,000.00
Headworks	1	LS	$ 600,000.00	$ 600,000.00
Aeration basins	1	LS	$ 420,000.00	$ 420,000.00
Aerobic digester	1	LS	$ 240,000.00	$ 240,000.00
Chemical building & pump station	1	LS	$ 240,000.00	$ 240,000.00
Service building	1	LS	$ 180,000.00	$ 180,000.00
Anoxic & membrane tanks	1	LS	$ 150,000.00	$ 150,000.00
Belt filter press building	1	LS	$ 120,000.00	$ 120,000.00
EQ tank	1	LS	$ 120,000.00	$ 120,000.00
Control building	1	LS	$ 96,000.00	$ 96,000.00
Emergency storage tank	1	LS	$ 96,000.00	$ 96,000.00
Sludge drying beds	1	LS	$ 60,000.00	$ 60,000.00
Sludge storage	1	LS	$ 60,000.00	$ 60,000.00
Meter vault	1	LS	$ 60,000.00	$ 60,000.00
Plant pump station	1	LS	$ 30,000.00	$ 30,000.00
Diesel fuel storage	1	LS	$ 30,000.00	$ 30,000.00
Generator pad	1	LS	$ 12,000.00	$ 12,000.00
Pavement	6,350	SY	$ 18.00	$ 114,300.00
Excavation and Backfill				
Excavation for new LS-8	1,210	CY	$ 30.00	$ 36,300.00
Excavation for new Influent Force Main piping	940	CY	$ 30.00	$ 28,200.00
Off-site disposal of soil material	1,310	CY	$ 40.00	$ 52,400.00
Backfill - Onsite Material, for pipe excavation	840	CY	$ 30.00	$ 25,200.00
LS-8 sheeting for temporary excavation support	10,310	SF	$ 90.00	$ 927,900.00
LS-8 dewatering	6	MO	$ 36,000.00	$ 216,000.00
Influent Force Main: Reinstatement of Existing Roads				
Asphalt Pavement (7.5 inches)	4,320	SF	$ 10.00	$ 43,200.00
Aggregate Base for Asphalt Paving	4,320	SF	$ 5.00	$ 21,600.00
Influent Force Main: Temporary Traffic Management	1	LS	$ 100,000.00	$ 100,000.00
Influent Force Main Piping				
16" SDR 11 HDPE Butt-Fusion Welded	1,850	LF	$ 123.24	$ 227,994.00
16" HDPE 90° elbow	2	EA	$ 1,950.00	$ 3,900.00
Bypass Pumping				
LS-4 Bypass	3	MO	$ 24,000.00	$ 72,000.00
LS-8 Bypass	6	MO	$ 24,000.00	$ 144,000.00
Erosion and Sedimentation Control	1	LS	$ 50,000.00	$ 50,000.00
Temporary facilities for canal crossing	1	LS	$ 100,000.00	$ 100,000.00
Stormwater Management Basin	1	LS	$ 100,000.00	$ 100,000.00
Structural				
New Wet Well at LS-8				
Below grade precast concrete vault for new grinder arrangement	1	EA	$ 10,000.00	$ 10,000.00
Base Slab	120	CY	$ 1,200.00	$ 144,000.00
Walls	170	CY	$ 1,200.00	$ 204,000.00
Cover Slab	60	CY	$ 1,200.00	$ 72,000.00
Bypass vault	12	CY	$ 1,200.00	$ 14,400.00
Equipment pads - generator and odor control	26	CY	$ 1,200.00	$ 31,200.00

Lewes Board of Public Works and Sussex County
WWTF Long Range Planning Study
Option 3b - Partnership with Sussex County & Constructed Wetland (BPW Costs)
Preliminary Capital Cost Estimate

Updated By: K Beaudoin
Date: 10/21/2022
Checked By: T Biagioli
Date: 10/24/2022

Item	Qty	Unit	Unit Cost	Total Cost
Mechanical/Equipment and Process Piping				
LS-8 Raw Wastewater pumps	2	EA	$241,800.00	$ 483,600.00
Grinder arrangement on wet well influent (16")	1	LS	$ 10,000.00	$ 10,000.00
Odor control system	1	LS	$12,500.00	$ 12,500.00
115 kW generator	1	LS	$ 67,080.00	$ 67,080.00
Process Piping, Valves, Flow Meter and Plumbing Allowance (15% of project c	1	LS	$1,008,866.10	$ 1,008,866.10
Electrical/Instrumentation				
Electrical Allowance (20% of project costs, ex. land purchase)	1	LS	$1,546,928.02	$ 1,546,928.02
Instrumentation Allowance (10% of project costs, ex. land purchase)	1	LS	$773,464.01	$ 773,464.01
			Subtotal (rounded to nearest $1,000):	$ 11,764,000.00
			Contingency (rounded to nearest $1,000):	$ 4,117,000.00
			Total (rounded to nearest $1,000):	$ 15,881,000.00

Appendix E

Operation & Maintenance Cost Estimates

Lewes WWTF Long Range Planning Study		10/25/22	12582813
Project		Date	Job No.
Lifecycle Cost Analysis - Option 1 Existing WWTF Hardening		K Beaudoin	T Biagioli
Subject		Comp. By	Checked By

Present Worth Calculations

Lifecycle Cost Analysis - Option 1 Existing WWTF Hardening

Year	Flow, MGD	WWTF Operations and Maintenance	Periodic Upgrades	p Station Energy Use	Net Annual Cost, $/Year	Inflation Factor	Net Annual Costs (with inflation)	Present Worth (2021 USD)	change to 2022 USD
1	0.87	$ 1,521,777	$ 496,613	$ -	$ 2,018,390	103%	$ 2,078,942	$ 2,018,390	
2	0.89	$ 1,561,535	$ 496,613	$ -	$ 2,058,148	106%	$ 2,183,490	$ 2,058,148	
3	0.92	$ 1,602,332	$ 496,613	$ -	$ 2,098,945	109%	$ 2,293,574	$ 2,098,945	
4	0.94	$ 1,644,194	$ 496,613	$ -	$ 2,140,807	113%	$ 2,409,498	$ 2,140,807	
5	0.97	$ 1,687,150	$ 496,613	$ -	$ 2,183,764	116%	$ 2,531,581	$ 2,183,764	
6	0.99	$ 1,731,229	$ 496,613	$ -	$ 2,227,842	119%	$ 2,660,160	$ 2,227,842	
7	1.02	$ 1,776,459	$ 496,613	$ -	$ 2,273,072	123%	$ 2,795,592	$ 2,273,072	
8	1.04	$ 1,822,871	$ 496,613	$ -	$ 2,319,484	127%	$ 2,938,253	$ 2,319,484	
9	1.07	$ 1,870,495	$ 496,613	$ -	$ 2,367,108	130%	$ 3,088,539	$ 2,367,108	
10	1.10	$ 1,919,363	$ 496,613	$ -	$ 2,415,977	134%	$ 3,246,871	$ 2,415,977	
11	1.13	$ 1,969,509	$ 496,613	$ -	$ 2,466,122	138%	$ 3,413,689	$ 2,466,122	
12	1.16	$ 2,020,964	$ 496,613	$ -	$ 2,517,577	143%	$ 3,589,463	$ 2,517,577	
13	1.19	$ 2,073,764	$ 496,613	$ -	$ 2,570,377	147%	$ 3,774,685	$ 2,570,377	
14	1.22	$ 2,127,943	$ 496,613	$ -	$ 2,624,556	151%	$ 3,969,876	$ 2,624,556	
15	1.25	$ 2,183,537	$ 496,613	$ -	$ 2,680,151	156%	$ 4,175,587	$ 2,680,151	
16	1.28	$ 2,240,584	$ 496,613	$ -	$ 2,737,198	160%	$ 4,392,399	$ 2,737,198	
17	1.32	$ 2,299,122	$ 496,613	$ -	$ 2,795,735	165%	$ 4,620,924	$ 2,795,735	
18	1.35	$ 2,359,189	$ 496,613	$ -	$ 2,855,802	170%	$ 4,861,812	$ 2,855,802	
19	1.39	$ 2,420,825	$ 496,613	$ -	$ 2,917,438	175%	$ 5,115,745	$ 2,917,438	
20	1.42	$ 2,484,071	$ 496,613	$ -	$ 2,980,684	181%	$ 5,383,448	$ 2,980,684	
21	1.46	$ 2,548,970	$ 496,613	$ -	$ 3,045,583	186%	$ 5,665,682	$ 3,045,583	
22	1.50	$ 2,615,564	$ 496,613	$ -	$ 3,112,178	192%	$ 5,963,254	$ 3,112,178	
23	1.54	$ 2,683,898	$ 496,613	$ -	$ 3,180,512	197%	$ 6,277,015	$ 3,180,512	
24	1.58	$ 2,754,018	$ 496,613	$ -	$ 3,250,631	203%	$ 6,607,864	$ 3,250,631	
25	1.62	$ 2,825,969	$ 496,613	$ -	$ 3,322,583	209%	$ 6,956,750	$ 3,322,583	
26	1.66	$ 2,899,800	$ 496,613	$ -	$ 3,396,414	216%	$ 7,324,676	$ 3,396,414	
27	1.71	$ 2,975,561	$ 496,613	$ -	$ 3,472,174	222%	$ 7,712,702	$ 3,472,174	
28	1.75	$ 3,053,300	$ 496,613	$ -	$ 3,549,913	229%	$ 8,121,945	$ 3,549,913	
Net Present Worth		**$ 61,673,991**	**$ 13,905,173**	**$ -**				**$ 75,579,164**	

Present Worth Calculations

Lifecycle Cost Analysis - Option 2a Relocation and Spray Irrigation and/or RIBS

Year	Flow, MGD	WWTF Operations and Maintenance		Periodic Upgrades	Station Energy Use		Net Annual Cost, $/Year	Inflation Factor	Net Annual Costs (with inflation)	Present Worth (2021 USD)
1	0.87	$ 719,830		$ 334,973	$ 32,920	$ -	$ 1,087,724	103%	$ 1,120,355	$ 1,087,724
2	0.89	$ 738,636		$ 334,973	$ 33,780	$ -	$ 1,107,390	106%	$ 1,174,830	$ 1,107,390
3	0.92	$ 757,934		$ 334,973	$ 34,663	$ -	$ 1,127,570	109%	$ 1,232,126	$ 1,127,570
4	0.94	$ 777,736		$ 334,973	$ 35,568	$ -	$ 1,148,277	113%	$ 1,292,396	$ 1,148,277
5	0.97	$ 798,055		$ 334,973	$ 36,498	$ -	$ 1,169,526	116%	$ 1,355,801	$ 1,169,526
6	0.99	$ 818,905		$ 334,973	$ 37,451	$ -	$ 1,191,329	119%	$ 1,422,509	$ 1,191,329
7	1.02	$ 840,299		$ 334,973	$ 38,430	$ -	$ 1,213,702	123%	$ 1,492,701	$ 1,213,702
8	1.04	$ 862,253		$ 334,973	$ 39,434	$ -	$ 1,236,660	127%	$ 1,566,564	$ 1,236,660
9	1.07	$ 884,780		$ 334,973	$ 40,464	$ -	$ 1,260,217	130%	$ 1,644,298	$ 1,260,217
10	1.10	$ 907,896		$ 334,973	$ 41,521	$ -	$ 1,284,390	134%	$ 1,726,113	$ 1,284,390
11	1.13	$ 931,616		$ 334,973	$ 42,606	$ -	$ 1,309,195	138%	$ 1,812,232	$ 1,309,195
12	1.16	$ 955,955		$ 334,973	$ 43,719	$ -	$ 1,334,647	143%	$ 1,902,888	$ 1,334,647
13	1.19	$ 980,930		$ 334,973	$ 44,861	$ -	$ 1,360,765	147%	$ 1,998,329	$ 1,360,765
14	1.22	$ 1,006,558		$ 334,973	$ 46,033	$ -	$ 1,387,565	151%	$ 2,098,816	$ 1,387,565
15	1.25	$ 1,032,855		$ 334,973	$ 47,236	$ -	$ 1,415,065	156%	$ 2,204,624	$ 1,415,065
16	1.28	$ 1,059,840		$ 334,973	$ 48,470	$ -	$ 1,443,283	160%	$ 2,316,046	$ 1,443,283
17	1.32	$ 1,087,529		$ 334,973	$ 49,736	$ -	$ 1,472,239	165%	$ 2,433,386	$ 1,472,239
18	1.35	$ 1,115,942		$ 334,973	$ 51,036	$ -	$ 1,501,951	170%	$ 2,556,971	$ 1,501,951
19	1.39	$ 1,145,097		$ 334,973	$ 52,369	$ -	$ 1,532,439	175%	$ 2,687,142	$ 1,532,439
20	1.42	$ 1,175,014		$ 334,973	$ 53,737	$ -	$ 1,563,724	181%	$ 2,824,260	$ 1,563,724
21	1.46	$ 1,205,712		$ 334,973	$ 55,141	$ -	$ 1,595,827	186%	$ 2,968,707	$ 1,595,827
22	1.50	$ 1,237,212		$ 334,973	$ 56,582	$ -	$ 1,628,768	192%	$ 3,120,887	$ 1,628,768
23	1.54	$ 1,269,536		$ 334,973	$ 58,060	$ -	$ 1,662,569	197%	$ 3,281,224	$ 1,662,569
24	1.58	$ 1,302,704		$ 334,973	$ 59,577	$ -	$ 1,697,254	203%	$ 3,450,168	$ 1,697,254
25	1.62	$ 1,336,738		$ 334,973	$ 61,133	$ -	$ 1,732,845	209%	$ 3,628,192	$ 1,732,845
26	1.66	$ 1,371,662		$ 334,973	$ 62,731	$ -	$ 1,769,366	216%	$ 3,815,798	$ 1,769,366
27	1.71	$ 1,407,498		$ 334,973	$ 64,369	$ -	$ 1,806,841	222%	$ 4,013,515	$ 1,806,841
28	1.75	$ 1,444,270		$ 334,973	$ 66,051	$ -	$ 1,845,295	229%	$ 4,221,900	$ 1,845,295
Net Present Worth		**$ 29,172,991**		**$ 9,379,253**	**$ 1,334,176**	**$ -**				**$ 39,886,421**

Present Worth Calculations

Lifecycle Cost Analysis - Option 2b Relocation & Utilization of Existing WWTP Outfall

Year	Flow, MGD	WWTF Operations and Maintenance		Periodic Upgrades	p Station Energy Use			Net Annual Cost, $/Year	Inflation Factor	Net Annual Costs (with inflation)	Present Worth (2021 USD)
1	0.87	$ 719,830		$ 317,873	$ 50,544	$ -	$ -	$ 1,088,247	103%	$ 1,120,895	$ 1,088,247
2	0.89	$ 738,636		$ 317,873	$ 51,865	$ -	$ -	$ 1,108,374	106%	$ 1,175,874	$ 1,108,374
3	0.92	$ 757,934		$ 317,873	$ 53,220	$ -	$ -	$ 1,129,027	109%	$ 1,233,718	$ 1,129,027
4	0.94	$ 777,736		$ 317,873	$ 54,610	$ -	$ -	$ 1,150,219	113%	$ 1,294,582	$ 1,150,219
5	0.97	$ 798,055		$ 317,873	$ 56,037	$ -	$ -	$ 1,171,965	116%	$ 1,358,628	$ 1,171,965
6	0.99	$ 818,905		$ 317,873	$ 57,501	$ -	$ -	$ 1,194,279	119%	$ 1,426,031	$ 1,194,279
7	1.02	$ 840,299		$ 317,873	$ 59,003	$ -	$ -	$ 1,217,176	123%	$ 1,496,973	$ 1,217,176
8	1.04	$ 862,253		$ 317,873	$ 60,545	$ -	$ -	$ 1,240,671	127%	$ 1,571,645	$ 1,240,671
9	1.07	$ 884,780		$ 317,873	$ 62,126	$ -	$ -	$ 1,264,780	130%	$ 1,650,251	$ 1,264,780
10	1.10	$ 907,896		$ 317,873	$ 63,749	$ -	$ -	$ 1,289,519	134%	$ 1,733,005	$ 1,289,519
11	1.13	$ 931,616		$ 317,873	$ 65,415	$ -	$ -	$ 1,314,904	138%	$ 1,820,135	$ 1,314,904
12	1.16	$ 955,955		$ 317,873	$ 67,124	$ -	$ -	$ 1,340,952	143%	$ 1,911,877	$ 1,340,952
13	1.19	$ 980,930		$ 317,873	$ 68,878	$ -	$ -	$ 1,367,681	147%	$ 2,008,486	$ 1,367,681
14	1.22	$ 1,006,558		$ 317,873	$ 70,677	$ -	$ -	$ 1,395,109	151%	$ 2,110,227	$ 1,395,109
15	1.25	$ 1,032,855		$ 317,873	$ 72,524	$ -	$ -	$ 1,423,252	156%	$ 2,217,381	$ 1,423,252
16	1.28	$ 1,059,840		$ 317,873	$ 74,418	$ -	$ -	$ 1,452,132	160%	$ 2,330,245	$ 1,452,132
17	1.32	$ 1,087,529		$ 317,873	$ 76,363	$ -	$ -	$ 1,481,765	165%	$ 2,449,132	$ 1,481,765
18	1.35	$ 1,115,942		$ 317,873	$ 78,358	$ -	$ -	$ 1,512,173	170%	$ 2,574,373	$ 1,512,173
19	1.39	$ 1,145,097		$ 317,873	$ 80,405	$ -	$ -	$ 1,543,375	175%	$ 2,706,318	$ 1,543,375
20	1.42	$ 1,175,014		$ 317,873	$ 82,506	$ -	$ -	$ 1,575,393	181%	$ 2,845,334	$ 1,575,393
21	1.46	$ 1,205,712		$ 317,873	$ 84,661	$ -	$ -	$ 1,608,247	186%	$ 2,991,812	$ 1,608,247
22	1.50	$ 1,237,212		$ 317,873	$ 86,873	$ -	$ -	$ 1,641,959	192%	$ 3,146,163	$ 1,641,959
23	1.54	$ 1,269,536		$ 317,873	$ 89,143	$ -	$ -	$ 1,676,552	197%	$ 3,308,820	$ 1,676,552
24	1.58	$ 1,302,704		$ 317,873	$ 91,472	$ -	$ -	$ 1,712,049	203%	$ 3,480,242	$ 1,712,049
25	1.62	$ 1,336,738		$ 317,873	$ 93,861	$ -	$ -	$ 1,748,473	209%	$ 3,660,914	$ 1,748,473
26	1.66	$ 1,371,662		$ 317,873	$ 96,314	$ -	$ -	$ 1,785,849	216%	$ 3,851,346	$ 1,785,849
27	1.71	$ 1,407,498		$ 317,873	$ 98,830	$ -	$ -	$ 1,824,201	222%	$ 4,052,078	$ 1,824,201
28	1.75	$ 1,444,270		$ 317,873	$ 101,412	$ -	$ -	$ 1,863,555	229%	$ 4,263,680	$ 1,863,555
Net Present Worth		**$ 29,172,991**		**$8,900,453.33**	**$ 2,048,432**	**$ -**	**$ -**				**$ 40,121,877**

Present Worth Calculations **Lifecycle Cost Analysis - Option 2c Relocation & New Ocean Outfall**

Year	Flow, MGD	WWTF Operations and Maintenance		Periodic Upgrades	p Station Energy Use			Net Annual Cost, $/Year	Inflation Factor	Net Annual Costs (with inflation)	Present Worth (2021 USD)
1	0.87	$ 719,830		$ 323,283	$ 56,973		$ -	$ 1,100,086	103%	$ 1,133,089	$ 1,100,086
2	0.89	$ 738,636		$ 323,283	$ 58,461		$ -	$ 1,120,381	106%	$ 1,188,612	$ 1,120,381
3	0.92	$ 757,934		$ 323,283	$ 59,989		$ -	$ 1,141,206	109%	$ 1,247,027	$ 1,141,206
4	0.94	$ 777,736		$ 323,283	$ 61,556		$ -	$ 1,162,575	113%	$ 1,308,488	$ 1,162,575
5	0.97	$ 798,055		$ 323,283	$ 63,164		$ -	$ 1,184,502	116%	$ 1,373,163	$ 1,184,502
6	0.99	$ 818,905		$ 323,283	$ 64,815		$ -	$ 1,207,003	119%	$ 1,441,224	$ 1,207,003
7	1.02	$ 840,299		$ 323,283	$ 66,508		$ -	$ 1,230,091	123%	$ 1,512,856	$ 1,230,091
8	1.04	$ 862,253		$ 323,283	$ 68,245		$ -	$ 1,253,782	127%	$ 1,588,253	$ 1,253,782
9	1.07	$ 884,780		$ 323,283	$ 70,028		$ -	$ 1,278,092	130%	$ 1,667,620	$ 1,278,092
10	1.10	$ 907,896		$ 323,283	$ 71,858		$ -	$ 1,303,037	134%	$ 1,751,173	$ 1,303,037
11	1.13	$ 931,616		$ 323,283	$ 73,735		$ -	$ 1,328,634	138%	$ 1,839,141	$ 1,328,634
12	1.16	$ 955,955		$ 323,283	$ 75,662		$ -	$ 1,354,900	143%	$ 1,931,764	$ 1,354,900
13	1.19	$ 980,930		$ 323,283	$ 77,638		$ -	$ 1,381,852	147%	$ 2,029,296	$ 1,381,852
14	1.22	$ 1,006,558		$ 323,283	$ 79,667		$ -	$ 1,409,508	151%	$ 2,132,008	$ 1,409,508
15	1.25	$ 1,032,855		$ 323,283	$ 81,748		$ -	$ 1,437,887	156%	$ 2,240,181	$ 1,437,887
16	1.28	$ 1,059,840		$ 323,283	$ 83,884		$ -	$ 1,467,007	160%	$ 2,354,116	$ 1,467,007
17	1.32	$ 1,087,529		$ 323,283	$ 86,076		$ -	$ 1,496,888	165%	$ 2,474,128	$ 1,496,888
18	1.35	$ 1,115,942		$ 323,283	$ 88,324		$ -	$ 1,527,550	170%	$ 2,600,551	$ 1,527,550
19	1.39	$ 1,145,097		$ 323,283	$ 90,632		$ -	$ 1,559,012	175%	$ 2,733,737	$ 1,559,012
20	1.42	$ 1,175,014		$ 323,283	$ 93,000		$ -	$ 1,591,297	181%	$ 2,874,059	$ 1,591,297
21	1.46	$ 1,205,712		$ 323,283	$ 95,429		$ -	$ 1,624,425	186%	$ 3,021,909	$ 1,624,425
22	1.50	$ 1,237,212		$ 323,283	$ 97,923		$ -	$ 1,658,418	192%	$ 3,177,701	$ 1,658,418
23	1.54	$ 1,269,536		$ 323,283	$ 100,481		$ -	$ 1,693,300	197%	$ 3,341,874	$ 1,693,300
24	1.58	$ 1,302,704		$ 323,283	$ 103,106		$ -	$ 1,729,093	203%	$ 3,514,890	$ 1,729,093
25	1.62	$ 1,336,738		$ 323,283	$ 105,800		$ -	$ 1,765,821	209%	$ 3,697,238	$ 1,765,821
26	1.66	$ 1,371,662		$ 323,283	$ 108,564		$ -	$ 1,803,509	216%	$ 3,889,432	$ 1,803,509
27	1.71	$ 1,407,498		$ 323,283	$ 111,400		$ -	$ 1,842,181	222%	$ 4,092,017	$ 1,842,181
28	1.75	$ 1,444,270		$ 323,283	$ 114,311		$ -	$ 1,881,864	229%	$ 4,305,569	$ 1,881,864
Net Present Worth		**$ 29,172,991**		**$ 9,051,933**	**$ 2,308,978**		**$ -**				**$ 40,533,903**

Present Worth Calculations

Lifecycle Cost Analysis - Option 3a Partnership with Sussex County & Utilization of Existing WWTP Outfall (BPW Costs)

Year	Flow, MGD	WWTF Operations and Maintenance		Periodic Upgrades	mp Station Energy Use			Net Annual Cost, $/Year	Inflation Factor	Net Annual Costs (with inflation)	Present Worth (2021 USD)
1	0.87	$ 719,830		$ 238,583	$ 15,740		$ -	$ 974,153	103%	$ 1,003,378	$ 974,153
2	0.89	$ 738,636		$ 238,583	$ 16,151		$ -	$ 993,370	106%	$ 1,053,867	$ 993,370
3	0.92	$ 757,934		$ 238,583	$ 16,573		$ -	$ 1,013,090	109%	$ 1,107,031	$ 1,013,090
4	0.94	$ 777,736		$ 238,583	$ 17,006		$ -	$ 1,033,325	113%	$ 1,163,016	$ 1,033,325
5	0.97	$ 798,055		$ 238,583	$ 17,450		$ -	$ 1,054,088	116%	$ 1,221,977	$ 1,054,088
6	0.99	$ 818,905		$ 238,583	$ 17,906		$ -	$ 1,075,394	119%	$ 1,284,077	$ 1,075,394
7	1.02	$ 840,299		$ 238,583	$ 18,374		$ -	$ 1,097,256	123%	$ 1,349,487	$ 1,097,256
8	1.04	$ 862,253		$ 238,583	$ 18,854		$ -	$ 1,119,690	127%	$ 1,418,390	$ 1,119,690
9	1.07	$ 884,780		$ 238,583	$ 19,346		$ -	$ 1,142,710	130%	$ 1,490,977	$ 1,142,710
10	1.10	$ 907,896		$ 238,583	$ 19,852		$ -	$ 1,166,331	134%	$ 1,567,452	$ 1,166,331
11	1.13	$ 931,616		$ 238,583	$ 20,370		$ -	$ 1,190,569	138%	$ 1,648,027	$ 1,190,569
12	1.16	$ 955,955		$ 238,583	$ 20,903		$ -	$ 1,215,441	143%	$ 1,732,928	$ 1,215,441
13	1.19	$ 980,930		$ 238,583	$ 21,449		$ -	$ 1,240,962	147%	$ 1,822,395	$ 1,240,962
14	1.22	$ 1,006,558		$ 238,583	$ 22,009		$ -	$ 1,267,151	151%	$ 1,916,679	$ 1,267,151
15	1.25	$ 1,032,855		$ 238,583	$ 22,584		$ -	$ 1,294,023	156%	$ 2,016,045	$ 1,294,023
16	1.28	$ 1,059,840		$ 238,583	$ 23,174		$ -	$ 1,321,597	160%	$ 2,120,776	$ 1,321,597
17	1.32	$ 1,087,529		$ 238,583	$ 23,780		$ -	$ 1,349,892	165%	$ 2,231,166	$ 1,349,892
18	1.35	$ 1,115,942		$ 238,583	$ 24,401		$ -	$ 1,378,926	170%	$ 2,347,529	$ 1,378,926
19	1.39	$ 1,145,097		$ 238,583	$ 25,038		$ -	$ 1,408,719	175%	$ 2,470,197	$ 1,408,719
20	1.42	$ 1,175,014		$ 238,583	$ 25,693		$ -	$ 1,439,290	181%	$ 2,599,517	$ 1,439,290
21	1.46	$ 1,205,712		$ 238,583	$ 26,364		$ -	$ 1,470,659	186%	$ 2,735,859	$ 1,470,659
22	1.50	$ 1,237,212		$ 238,583	$ 27,053		$ -	$ 1,502,848	192%	$ 2,879,613	$ 1,502,848
23	1.54	$ 1,269,536		$ 238,583	$ 27,759		$ -	$ 1,535,879	197%	$ 3,031,189	$ 1,535,879
24	1.58	$ 1,302,704		$ 238,583	$ 28,485		$ -	$ 1,569,772	203%	$ 3,191,023	$ 1,569,772
25	1.62	$ 1,336,738		$ 238,583	$ 29,229		$ -	$ 1,604,550	209%	$ 3,359,572	$ 1,604,550
26	1.66	$ 1,371,662		$ 238,583	$ 29,992		$ -	$ 1,640,237	216%	$ 3,537,322	$ 1,640,237
27	1.71	$ 1,407,498		$ 238,583	$ 30,776		$ -	$ 1,676,857	222%	$ 3,724,784	$ 1,676,857
28	1.75	$ 1,444,270		$ 238,583	$ 31,580		$ -	$ 1,714,433	229%	$ 3,922,500	$ 1,714,433
Net Present Worth		**$29,172,991**	**$ -**	**$ 6,680,333**	**$ 637,889**	**$ -**	**$ -**				**$ 36,491,214**

Present Worth Calculations

Lifecycle Cost Analysis - Option 3b Partnership with Sussex County & Constructed Wetland (BPW Costs)

Year	Flow, MGD	WWTF Operations and Maintenance		Periodic Upgrades	Station Energy Use			Net Annual Cost, $/Year	Inflation Factor	Net Annual Costs (with inflation)	Present Worth (2021 USD)
1	0.87	$ 719,830	$ -	$ 238,583	$ 15,740	$ -	$ -	$ 974,153	103%	$ 1,003,378	$ 974,153
2	0.89	$ 738,636	$ -	$ 238,583	$ 16,151	$ -	$ -	$ 993,370	106%	$ 1,053,867	$ 993,370
3	0.92	$ 757,934	$ -	$ 238,583	$ 16,573	$ -	$ -	$ 1,013,090	109%	$ 1,107,031	$ 1,013,090
4	0.94	$ 777,736	$ -	$ 238,583	$ 17,006	$ -	$ -	$ 1,033,325	113%	$ 1,163,016	$ 1,033,325
5	0.97	$ 798,055	$ -	$ 238,583	$ 17,450	$ -	$ -	$ 1,054,088	116%	$ 1,221,977	$ 1,054,088
6	0.99	$ 818,905	$ -	$ 238,583	$ 17,906	$ -	$ -	$ 1,075,394	119%	$ 1,284,077	$ 1,075,394
7	1.02	$ 840,299	$ -	$ 238,583	$ 18,374	$ -	$ -	$ 1,097,256	123%	$ 1,349,487	$ 1,097,256
8	1.04	$ 862,253	$ -	$ 238,583	$ 18,854	$ -	$ -	$ 1,119,690	127%	$ 1,418,390	$ 1,119,690
9	1.07	$ 884,780	$ -	$ 238,583	$ 19,346	$ -	$ -	$ 1,142,710	130%	$ 1,490,977	$ 1,142,710
10	1.10	$ 907,896	$ -	$ 238,583	$ 19,852	$ -	$ -	$ 1,166,331	134%	$ 1,567,452	$ 1,166,331
11	1.13	$ 931,616	$ -	$ 238,583	$ 20,370	$ -	$ -	$ 1,190,569	138%	$ 1,648,027	$ 1,190,569
12	1.16	$ 955,955	$ -	$ 238,583	$ 20,903	$ -	$ -	$ 1,215,441	143%	$ 1,732,928	$ 1,215,441
13	1.19	$ 980,930	$ -	$ 238,583	$ 21,449	$ -	$ -	$ 1,240,962	147%	$ 1,822,395	$ 1,240,962
14	1.22	$ 1,006,558	$ -	$ 238,583	$ 22,009	$ -	$ -	$ 1,267,151	151%	$ 1,916,679	$ 1,267,151
15	1.25	$ 1,032,855	$ -	$ 238,583	$ 22,584	$ -	$ -	$ 1,294,023	156%	$ 2,016,045	$ 1,294,023
16	1.28	$ 1,059,840	$ -	$ 238,583	$ 23,174	$ -	$ -	$ 1,321,597	160%	$ 2,120,776	$ 1,321,597
17	1.32	$ 1,087,529	$ -	$ 238,583	$ 23,780	$ -	$ -	$ 1,349,892	165%	$ 2,231,166	$ 1,349,892
18	1.35	$ 1,115,942	$ -	$ 238,583	$ 24,401	$ -	$ -	$ 1,378,926	170%	$ 2,347,529	$ 1,378,926
19	1.39	$ 1,145,097	$ -	$ 238,583	$ 25,038	$ -	$ -	$ 1,408,719	175%	$ 2,470,197	$ 1,408,719
20	1.42	$ 1,175,014	$ -	$ 238,583	$ 25,693	$ -	$ -	$ 1,439,290	181%	$ 2,599,517	$ 1,439,290
21	1.46	$ 1,205,712	$ -	$ 238,583	$ 26,364	$ -	$ -	$ 1,470,659	186%	$ 2,735,859	$ 1,470,659
22	1.50	$ 1,237,212	$ -	$ 238,583	$ 27,053	$ -	$ -	$ 1,502,848	192%	$ 2,879,613	$ 1,502,848
23	1.54	$ 1,269,536	$ -	$ 238,583	$ 27,759	$ -	$ -	$ 1,535,879	197%	$ 3,031,189	$ 1,535,879
24	1.58	$ 1,302,704	$ -	$ 238,583	$ 28,485	$ -	$ -	$ 1,569,772	203%	$ 3,191,023	$ 1,569,772
25	1.62	$ 1,336,738	$ -	$ 238,583	$ 29,229	$ -	$ -	$ 1,604,550	209%	$ 3,359,572	$ 1,604,550
26	1.66	$ 1,371,662	$ -	$ 238,583	$ 29,992	$ -	$ -	$ 1,640,237	216%	$ 3,537,322	$ 1,640,237
27	1.71	$ 1,407,498	$ -	$ 238,583	$ 30,776	$ -	$ -	$ 1,676,857	222%	$ 3,724,784	$ 1,676,857
28	1.75	$ 1,444,270	$ -	$ 238,583	$ 31,580	$ -	$ -	$ 1,714,433	229%	$ 3,922,500	$ 1,714,433
Net Present Worth		**$29,172,991**	**$ -**	**$ 6,680,333**	**$ 637,889**	**$ -**	**$ -**				**$ 36,491,214**

GHD

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→ The Power of Commitment

Appendix 3a: August 21, 2023, Contingency Committee Minutes

WWTF Contingency Committee Meeting No.1
August 21, 2023
Lewes BPW Conference Room
3:00pm

Committee Members

- Barbara Curtis, BPW Board Director, Chair
- Earl Webb, BPW Board Director
- Austin Calaman, BPW General Manager
- Tim Ritzert, City Councilperson ex-officio
- Donna Colton, Committee Member
- Mark Prouty, Committee Member
- Sumner Crosby, Committee Member- Virtual
- Bob Heffernan, Committee Member- Absent
- Daphne Fuentevilla, Committee Member- Absent

Others Present

- Jay Lagree
- Sharon Sexton, BPW Executive Assistant

The meeting was called to order at 3:04pm.

Key Takeaways

- The purpose of the meeting was to discuss and establish the framework for future meetings and handle administrative matters. The committee is to review and further evaluate options 1 and 2 as described in the draft November 28, 2022 GHD Lewes WWTP Long Range Study and make recommendations to the Board for consideration. This includes research, review, and evaluation of costs, benefits, and feasibility of proven and operational technologies.
- The main topics discussed were review of resolution 23-006, meeting frequency and scheduling, and review of GHD proposed options 1 and 2. Other topics included potential alternative technologies for the wastewater treatment plant.
- Discussion on Nereda technology.

Positive Moment

- Highlighted the importance of gathering more information and asking tough questions when evaluating treatment options.
- Anticipation for technology demonstration.
- Suggested reviewing the batch reactor system as a viable option for replacing the wastewater treatment facility.
- Discussed utilizing partners and resources to achieve goals.

- Expressed willingness to conduct research and reach out to treatment plants for data gathering.
- Discussed agenda items and the possibility of a slide deck presentation for the next meeting.

Goals

- Expressed interest in finding technologies that can save space.
- Discussed visiting the Berlin plant to see the batch reactor system in action.
- Asked questions about saltwater compatibility and other technologies to assess suitability for needs.
- Need further discussions and information gathering regarding DNREC's potential changes to the nutrient loading factors of the permit.
- Exploring other treatment system locations and seeking DNREC's agreement on the suitability of the new technology.
- Requirement to retrofit pump stations with flow meters to monitor infiltration and test increase in salinity at specific locations.
- Plan to gather data from other treatment plants for comparison.
- Make a decision by January after evaluating all options thoroughly to present to the Board.

Challenges

- Obtaining a permit for an ocean outfall can be challenging due to the complexities of the regulatory process and the need to meet environmental standards. The Rehoboth Bay TMDL, which sets limits on pollutant discharges into the bay, further complicates the permit process and has raised concerns about obtaining an ocean outfall permit.
- Expanding facility flow capacity may pose challenges, such as uncertainties surrounding technology changes without increasing the flows.
- Changing the nutrient loading factors of the permit, triggering regulatory involvement.
- Discussed the impact of shutting off power in high-risk areas during an evacuation.
- Discussed the water treatment system, emphasizing its strict parameters and demanding maintenance.
- Discussed the impact of an increase in flow on membrane technology efficiency.
- Discussed the pressure to make a decision on the recommendation to the Board by January 31, 2024, while prioritizing the need for reliable information before deciding.

Discussions

- Mentioned the need for additional information to further evaluate the technology, including square footage and flood zone data.
- Discussed involving the city in a land swap or taking over an existing facility.
- Questioned the need for land acquisition and infrastructure modifications. Mr. Prouty believes that there is room on the current site for a new plant while the current facility is

active. BPW would continue discharge to the canal. Some existing equipment could be reused and retrofitted.

- Mr. Prouty stated that the best way to discharge is by spray irrigation. BPW does not have space for spray irrigation. Concern with discharging treated effluent to tidal wetlands.
- Ongoing discussions and studies are exploring the feasibility and impact of various wastewater discharge options.
- Discussed technology in treatment options, one scenario with membrane filtration and the other with activated sludge.
- Acknowledged the use of drying beds, which have had issues with the modules.
- Acknowledged the need to consider the increasing number of storms and potential impact on the treatment plant.
- Discussed Aqua Nereda technology and compared it to the current MBR system. Aqua Nereda system is activated sludge granules and uses minimal space and is more energy efficient.
- Aqua Nereda system resiliency to be explored.
- Noted that they haven't seen salinity issues in the system yet.
- Gather information from treatment plants in Alabama and other locations to compare costs and feasibility.
- Mr. Ritzert questioned if there would still be a relationship with Sussex County if another option other than option three was chosen. BPW holds agreements with the county now, and those agreements will continue.
- Mr. Prouty discussed the Batch Reactor System as an alternative technology.
- Discussed the impact of the state archaeological study at the Sussex County site on the committee and the Board. GHD to provide another option under Sussex County.

Action Items

- Ms. Curtis requested that all members submit questions for the next meeting to be addressed regarding alternative technology.
- Mr. Crosby will research salinity of the adjacent wetlands and the effects on freshwater (i.e., treated effluent) wetlands.
- Mr. Calaman will be attending a conference later this month and will possibly have a chance to talk about alternative technologies.
- Mr. Prouty will present a slideshow on Batch Reactor technology and contact the Berlin wastewater treatment facility to schedule a tour.

The meeting was adjourned at 6:08pm. Meeting video can be viewed at https://www.youtube.com/watch?v=0eMKA8lwrWQ&t=238s

Respectfully Submitted
Sharon Sexton
BPW Executive Assistant

Appendix 3b: August 29, 2023, Contingency Committee Minutes

Lewes Board of Public Works
Contingency Committee Meeting Minutes
August 29, 2023
11:00am

Committee Members

- Barbara Curtis, BPW Assistant Treasurer, chair
- Tim Ritzert, City Council Ex-Officio
- Mark Prouty, Committee Member
- Donna Colton, Committee Member- Virtual
- Sumner Crosby-Virtual
- Austin Calaman, BPW General manager- Absent
- Earl Webb, BPW Board Director- Absent
- Daphne Fuentevilla, Committee Member-Absent
- Bob Heffernan, Committee Member, Absent

Others Present

- Sharon Sexton, BPW Executive Assistant

The meeting was called to order at 11:02pm.

Key Takeaways

- The meeting addressed Aqua-Nereda technology and its potential benefits. The outcome was to continue reviewing and discussing it in future meetings, addressing concerns and evaluating feasibility.
- The main topics discussed were the Aerobic Granular Sludge treatment process and Sequencing Batch Reactor (SBR)treatment process, technical difficulties with the current technology, and discharging to wetlands.
- The open questions revolved around working with existing wetlands, advantages, and disadvantages of different treatment systems, and handling different water situations.

Discussions

- Discussed benefits of Aqua-Nereda process, Membrane Bioreactor (MBR), and Biological Nutrient Removal (BNR) systems in wastewater treatment.
- Discussed Aqua Aerobic Sequencing Batch Reactor (SBR) system as a reliable and cost-effective solution for nutrient removal and energy efficiency.
- Discussed Aqua-Nereda system for its small footprint and ability to remove nutrients without chemicals.
- Reviewed slides related to Aqua-Nereda technology.
- Reviewed comparison of technology chart.
- Discussed benefits of a different location and efficient operational costs.

- Discussed limitations of current MBR system.
- Mr. Prouty acknowledges the need for effluent filtration in the SBR systems. The Berlin plant uses disc filters that are easy to operate. The SBR filters produce good water.
- SBR systems would not need an equalization tank at the headworks, but a smaller equalization tank would be needed after secondary treatment.
- SBR could be built in the existing BPW site.
- Discussed technical data and permit limits from GHD study for vendor selection.
- Suggested providing materials to Aqua-Nereda before their presentation.
- Suggested: Include questions about the number of operators required and certification requirements for the plant.
- Training and resiliency were good additions to the list.

Challenges

- The low elevation of the drying beds is a significant vulnerability of the current plant.
- Cost implications of retrofitting the existing plant versus finding a new site were discussed.
- Faced issues with the plant's floodplain that could be solved by relocating or elevating the facility.
- Expressed interest in the idea of a program that can run efficiently with lower operational costs.
- Challenges of finding people to man the plant.
- Discussed the need for additional information regarding technology, water quality, and managing sudden influx of rain (freshwater) into the impacts on the treatment system. Mr. Prouty stated that the influx of freshwater is not a biological or chemical issue, but more of a hydraulic problem.
- The classic SBR process has higher operating expenses compared to the Aqua-Nereda process.
- The addition of chemicals to the sludge production results in an added cost for the SBR process.
- Let's think about it in a different way.
- There is a significant level of concern about disrupting the existing biological activity in a functioning Marsh or Wetland when using it as the receiving end of a treated effluent process.
- Concerned about the potential impact of non-saline treated effluent on tidal wetlands' biological balance.
- The challenge of working the volume of treated water through the well heads if below-grade injection is considered.
- Frustrated with poor audio quality on Zoom causing miscommunication.
- The county must have a solution for taking the water through the Marsh.
- The lack of subject matter experts within our team is hindering our ability to address certain areas of concern.

- Relying on experts to work with existing wetlands can be challenging based on recent readings.
- Working with existing wetlands can be challenging when dumping quantities of water into them.
- Finding land for spray irrigation in constructed wetlands is challenging due to the requirement of a large area for construction.
- Concerned about the trade-off of growing their own AGS versus importing AGS from another Nereda plant, the need for more data on sludge management and its impact on space requirements and energy use, and the uncertainty over the system's performance during storms and potential effects of saltwater intrusion.
- Growing one's own AGS would be less expensive, but problematic if starting with a new plan, as it may be necessary to meet permit limits from the start. If retrofitting the existing plant, may be feasible to run both systems simultaneously.
- The claim about how the Aqua-Nereda system works during storms is an important component that needs further clarification.
- The challenge with the BPW plant is finding qualified operators due to the design of our plant. It's hard to find people who are certified to work on our plant.

Action Items

- Mark Prouty
    - Arrange a visit to a treatment plant in Berlin, Maryland, after Labor Day for insights into the system's operation.
- Austin Calaman
    - Follow-up contact with the Riveria Aqua-Nereda site in Alabama.
- Sumner Crosby
    - Gather information about salinity levels in wetlands near the canal.
    - Contact University of Delaware for wetlands information and assistance

Decision

- Agreed that inviting representatives of technology-selling plants would be useful.
- Agreed to invite County's presence to committee meetings, especially to vendor presentations.
- Decided to continue the presentation by Mr. Crosby about storm resiliency and long-term saline situations.
- Agreed the need for accurate data and mathematics in making informed decisions.
- Determined need for further exploration and analysis before making board recommendations.

Goals

- Aims to compare water quality and cost of the proposed technology with their current system.
- Understand salinity levels in wetlands near the canal.

- Understand the challenges of working with existing wetlands.
- Define design needs and include desirable average daily flow.
- Address permit limits and discharge quality data.
- Intends to ask vendors about the advantages and disadvantages of MBR and SBR systems.

Technologies

- The BPW currently uses the MBR system.

Follow-up Meeting

Next contingency committee meeting will be held on September 14, 2023, at 2:30 pm.

Adjournment

Mr. Crosby motioned to adjourn the meeting. Mr. Prouty seconded the motion, which passed unanimously. Meeting was adjourned at 12:40pm and can be viewed at https://www.youtube.com/watch?v=DnC8_9H3w-c&t=8s.

Respectfully Submitted
Sharon Sexton
Executive Assistant

Appendix 3c: September 12, 2023, Contingency Committee Minutes

WWTF Contingency Committee Meeting no. 3
September 12, 2023
Lewes BPW Conference Room
2:30pm

Participants

- Barbara Curtis, BPW Board Director, Chair
- Earl Webb, BPW Board Director
- Mark Prouty, Committee Member
- Donna Colton, Committee Member-Virtual
- Bob Heffernan, Committee Member
- Tim Ritzert, City Council Ex-Officio
- Austin Calaman, BPW General Manager
- Daphne Fuentevilla, Committee Member- Absent
- Sumner Crosby, Committee Member- Absent

Others

- Michael Wolgemuth, Inframark- Virtual
- Jeffrey Kerrin, Inframark
- Mike Mazetti, Inframark
- Hans Medlarz, Sussex County
- Sharon Sexton, BPW Executive Assistant

The meeting was called to order at 2:37pm.

Key Takeaways

- The main topics discussed were regulations, operations plan, water flow and discharge, sludge processing, and potential technology changes.
- Discussion of batch reactor systems and potential to visit a local facility.
- Reviewed and finalized question list for technology vendors.
- Open questions included concerns about the impact of new technology on the current system and the need for better waste management solutions.
- The next steps include scheduling future meetings, gathering more information from utilities in Alabama, and exploring possible solutions for improved efficiency and sustainability.

Goals

- Gather more information for informed decision-making.
- Interest in exploring new technology for solid waste handling, focusing on improved efficiency and sustainability.

- Discussed reaching out to utilities in Alabama for more information.
- Schedule future tour of Berlin SBR system and Aqua-Nereda presentation.

Discussions

- Postponing discussion on discharging to the wetlands to a future meeting. Concern is with salinity discrepancy to the wetlands. Further investigation into state regulations is needed.
- Encouraged committee members to attend a virtual presentation by Aqua-Nereda to highlight technology aspects and current facility operations.
- The committee would like to host Aqua Nereda representatives to discuss BPW needs more specifically.
- Discussed solid handling agreement with Sussex County for waste disposal.
- The process of removing effluent during the settling period in the SBR system involves two different methods of effluent removal.
- Mentioned Aqua Aerobics SBR system as a possible solution in addition to the Aqua Nereda.
- Concerns about having to change the current sludge management process due to the introduction of a new technology (Nereda) and its impact on workflow. Mr. Medlarz stated that Sussex County would not be able to move the granules. Sussex County and BPW currently have a solid handling agreement.
- Nereda advantage is flow can be taken during the settling process.
- Discussed flaws in current system where sludge gets pumped back up via a grinder pump.
- Discussed the need for a comprehensive solution that effectively emphasizes more than just a compact system.
- The Berlin Parkson facility utilizes jet aeration and mixing.
- Discussed current workflow involving flow equalization and highlighted benefits of a batch reactor where items are processed immediately upon arrival.
- Extended duration process and time-consuming nature of existing system.
- Reaching out to utility companies in Alabama to gain insights on technology implementation.
- The Q&A session with Aqua Nereda is an important part of the upcoming presentation as it allows the audience to actively engage and seek clarification on any unclear or confusing points.
- Mr. Medlarz stated that the South Coastal facility produces very similar effluent to the BPW facility.
- Lewes' seasonality works to the benefit of both Sussex County and BPW to keep the plant stabilized. BPW was Sussex County's first wastewater partner.

Alternative Technologies

- Aqua Nereda and SBR technologies are being considered as alternatives to the current MBR system. Still in the information gathering process.

Challenges

- Discharging fresh water into the marsh is probably not feasible.
- Raised issues with the MBR option, citing higher maintenance requirements and energy consumption as drawbacks.
- Concerns raised about the new technology disrupting the sludge management process and causing operational issues due to potential changes in the process.

Action Items

- Sharon Sexton
    - Send virtual meeting details to everyone for the webinar from Aqua Nereda scheduled for Thursday, September 14, 2023.
    - Send a poll for Aqua Nereda presentation dates to committee members.
    - Send a poll to determine the best date for the next meeting.
- Mark Prouty
    - Contact Megan to schedule a visit to Berlin, MD SBR facility.
- Austin Calaman
    - Contact Aqua-Aerobic and other utility companies for information on their technology, processes, size, disposal methods, and more.

The meeting was adjourned at 3:54pm. Meeting video can be viewed at https://www.youtube.com/watch?v=ka6qpxs4hqQ&t=68s

Respectfully Submitted
Sharon Sexton
Executive Assistant

Appendix 3d: October 17, 2023, Contingency Committee Minutes

Lewes Board of Public Works
Contingency Committee Meeting Minutes
October 17, 2023
2:00pm

Committee Members

- Barbara Curtis, BPW Assistant Treasurer, chair
- Earl Webb, BPW Board Director
- Austin Calaman, BPW General manager
- Tim Ritzert, City Council Ex-Officio
- Mark Prouty, Committee Member
- Donna Colton, Committee Member- Virtual
- Sumner Crosby-Committee Member-Virtual
- Daphne Fuentevilla, Committee Member-Absent
- Bob Heffernan, Committee Member

Others Present

- Sharon Sexton, BPW Executive Assistant

The meeting was called to order at 2:05pm.

Key Takeaways

- The committee discussed the new format of minutes, recommended enhancements, and agreed to review and provide feedback within two weeks.
- The main topics discussed were wetland discharge, wastewater treatment plant locations, and continued discussion on Aqua Nereda Aerobic Granular Sludge technology. Open questions included wetland regulation, treatment plant locations, and permit challenges. Next steps include implementing improvements, meeting with wetland discharge experts, and collaborating with stakeholders on regulation and treatment.

Wastewater Treatment and Wetland Regulation

- Discussed locations for wastewater treatment plant and ownership of areas.
- Explored regulating wetlands instead of constructing a wetland approach.
- Talked about collaboration with the State of Delaware and conducting a study to address State Park issues.
- Considering options like freshwater effluent to hold back saltwater intrusion, ocean outfall, and treating water in the park.
- Mr. Crosby has an upcoming meeting with Dr. Allman, from the University of Delaware, to discuss wetland discharge.

Aqua Nereda Technology

- Many committee members attended Aqua Nereda Webinar held on October 14, 2023.
- "In the webinar, they shared their positive opinions about the technology's resilience and water-saving aspects." There are 68 Aqua Nereda Granular Sludge plants operational worldwide, with 6 in the U.S.
- The granule waste can be handled like regular waste. Mr. Medlarz from Sussex County confirmed that this type of waste could be managed by the county.
- Talked about plants in Downingtown, Pennsylvania considering adopting the Aqua Nereda technology.
- Difficult to price demolition and reuse of existing equipment. The committee would like to repurpose current equipment if possible.
- Aqua Nereda will be making a presentation to the Contingency Committee on October 23, 2023. The Board is invited to attend, but Ms. Curtis highlighted a directive from council stating board members shouldn't ask questions at the meeting so that the Board remain in compliance with FOIA regulations. Mr. Medlarz will attend.

Goals

- Exploring the takeover of Cape Henlopen State Park wastewater treatment plant and implementing new technologies.
- Showcase an alternative wastewater treatment approach.
- Building a treatment plan on a small footprint.
- Explore wetland regulations with the introduction of freshwater effluent to saltwater wetlands.
- Encourage BPW Board of Directors, Sussex County, and public officials to attend upcoming presentation of alternative technology; Aqua Nereda Aerobic Granule Sludge. Collaboration with stakeholders is important.

Concerns

- Inefficient review and approval process for well pumping permits in construction projects, causing frustration and delays.
- Encountering delays in obtaining permits for water division construction projects.
- Wolfneck plant plans have frozen project status due to archeological findings. Detailed information unavailable.
- Saltwater intrusion is a concern for the current BPW wastewater treatment plant site. Saltwater intrusion did not affect the Aqua Nereda system in Dublin.
- Voiced concerns about the wasted space related to the parcel of land across the street from current wastewater treatment plant site and the height of the suggested elevated footprint.

Timeline

- The Contingency Committee must present their recommendations to the BPW Board of Directors by January 31, 2024.

Follow-up Meeting

- Aqua Nereda presentation will be held October 23, 2023, at 2:00pm.
- Berlin Wastewater Treatment Plant tour will be on October 26, 2023, at 10am.
- Scheduled a tentative meeting for November 6, 2023, at 2:00pm.
- Agreed to review minutes and provide comments within two weeks.
- Mr. Calaman to arrange a meeting with the Alabama Aqua Nereda Plant manager.

The meeting was adjourned at 3:46 pm.

Respectfully Submitted
Sharon Sexton
Executive Assistant

Appendix 3e: October 23, 2023, Contingency Committee Minutes

Lewes Board of Public Works
Contingency Committee Meeting Minutes
October 23, 2023
2:00pm

Committee Members

- Barbara Curtis, BPW Assistant Treasurer, chair
- Earl Webb, BPW Board Director
- Tim Ritzert, City Council Ex-Officio
- Mark Prouty, Committee Member
- Bob Heffernan, Committee Member
- Austin Calaman, BPW General manager
- Donna Colton, Committee Member- Absent
- Sumner Crosby-Absent
- Daphne Fuentevilla, Committee Member-Absent

Others Present

- Sharon Sexton, BPW Executive Assistant
- D. Preston Lee, P.E., BPW Secretary
- Richard Nichols, BPW Treasurer
- Robin Davis, BPW Assistant Manager
- Paula Dorn, Aqua Nereda
- Bill LaPorte, Envirep, Inc
- Joshua Gritton, BPW IT Director
- Michael Wolgemuth, Inframark

The meeting was called to order at 2:19pm.

Aqua Nereda presented an overview of Aerobic Granular Sludge Technology.

Discussion/Presentation

- The meeting covered Aqua Aerobic Systems and the wastewater industry, including their products, history, licensing agreement, and operator qualifications.
- Expressed the need for maintaining a good food-to-mass ratio and balancing granulation targets with effluent objectives during long-term operation.
- Discussed the need for a redundant design to accommodate reactor downtime and meet effluent limits.
- Highlighted design considerations for operator access and compliance with current regulations.
- Discussed use of current membranes with filters for higher quality results.
- Discussed filter cleaning process and equipment placement for new plant.
- Highlight the variability in the startup process, existing systems, or new installations.

- Aqua Nereda's technology offers specific features such as rapid settling, enhanced nutrient removal, energy savings, and operational simplicity.
- The importance of continuous data organization and communication during the startup and operation of a plant.

- The design flow allows for different options, giving the client the ability to choose the best system for their needs.
- Mention the granulation process and the timeline for full granulation.
- The importance of characterizing seed sludge and being aware of effluent requirements during the startup process was discussed. The procedure for seeding a plant or starting up was highlighted, with considerations of seed sludge and effluent requirements.
- Discussed potential use of digester sludge during startup.
    - The most ideal sludge to use as seed would be conventional activated sludge (CAS) from aeration tanks, MBR systems, SBRs, etc. If not available from the site's existing system or a nearby plant then a site can also consider RAS (return activated sludge – activated sludge that is wasted from a reactor but immediately sent to another basin in flow-through CAS systems), WAS (waste activated sludge – activated sludge that is wasted from reactors of any CAS treatment technology), or digester sludge. Digester sludge is generally seen as the least desirable simply because it has already been partially digested! I warn that digester sludge can take a bit longer to "turn over" and develop a strong microbial community. The one pro is that it is more concentration so less volume of seed is required. This can be important for more rural areas that may have to haul sludge a further distance. The most ideal sludge would be CAS as the desired biology should already be present and active.
- Emphasize monitoring waste and sludge yields and adjusting settle time.
- Compare the appearance of the system after startup to the demonstration reactor, highlighting the rapid increase in granulation.
- Potential reduction in polymer uses and increase in dry solids production in dewatering.
- Advantages of the system include handling variable flows and flexibility with the number of reactors.
- Shared potential for retrofitting systems based on design, flow rates, and load requirements, implying varied cost structures.
- Emphasized company's capability to remotely control programming changes for smoother operation and desired any beneficial changes or upgrades.
- The system allows for a flexible and efficient treatment process, especially for industrial sites with variable flows.
- Provided an overview of applications and flow rates ranging from small plants (50,000-100,000 gallons/day) to a large facility in Dublin, Ireland (165,000,000 gallons/day).
- Additional tanks can be added for more flow if needed.
- The Montana plant modifies its operation during lower load months like January and February.
- The Alabama plant reached 10,000 milligrams per liter last year, causing the food to mass ratio to go too low.

    - 10,000 mg/L of mixed liquor suspended solids (MLSS) aka biomass, sludge. Food to mass (F/M) ratios are ideally within the 0.020-0.200 lb BOD/lb MLSS range. Running at too low of an F/M can lead to scum; too high can cause a surplus of dispersed sludge – this is the same for all CAS systems as well. The solution is straight-forward: if you have a low F/M, you have too much MLSS and need to waste more; if you have a high F/M, you need more MLSS and will thus reduce the waste amount. Again, this is the same approach for CAS systems. Most of our AquaNereda plants are designed to operate at a MLSS of 8,000 mg/L *at full design flow and load conditions.* Most sites will not see full design conditions for a number of years so will operate with a lower MLSS concentration just as a CAS system would. Wolf Creek let their MLSS climb too high, they started to notice some "floaties" on their reactor surface, then they increased their wasting over a period of 1-2 weeks to bring the MLSS down to around 6,000-7,000 mg/L at the time. Problem solved and no significant impact on effluent quality!

- The COVID situation emphasized the necessity of a process-driven approach and data tracking.
- Discussed wastewater treatment and anaerobic treatment for phosphorus removal.
- The food to mass ratio guides wastewater treatment system operation instead of solids retention time (SRT).
    - Both F/M and SRT are functions of the MLSS concentration and are good assessments of system health for both CAS and AquaNereda, but F/M considers the influent carbon load whereas the SRT only looks at solids. The main reason we let the F/M guide us is because the SRT of aerobic granular sludge is variable: tiny granules have a shorter retention time while the large granules have obviously been in the reactor longer as they have grown larger. There is still an average SRT within an AquaNereda reactor that is fairly like the SRT that would be seen in a comparable CAS system. The Idaho Springs, Colorado operator prefers to adjust his wasting strategy based off SRT which is perfectly fine if his F/M is also in an acceptable range.
- Operators use data tracking to adjust operations based on the load.

Challenges

- Retrofitting systems based on varied design, flow rates, and load dictates cost differential. Need to identify what can be reused from current site to reduce costs.
- Suggested a process focus, possibly challenging for operators used to mechanical-focused systems.
    - More focused on sites that move from fairly basic treatment such as a lagoon that requires little attention other than some pumps to move water. A plant such as Lewes is already operating advanced CAS treatment technology (MBR) so operators should be able to easily transition to AquaNereda. Experience with any type of activated sludge process is helpful as the same biological principles apply.
- The AquaNereda system has a higher concentration of slow-growing organisms which leads to better phosphorus removal rates. Phosphorus removal is also linked to granulation in the AquaNereda system; the technology is designed to favor slow-growing organisms in its operation compared to traditional CAS technologies. Expressed concern over the delay caused by additional time for sludge growth versus shipping established granules at initial startup.
- Mr. Webb questioned changes being made to the systems to balance system operation. Ms. Dorn stated on incremental changes, nothing drastic. No visual difference across plants.
- Operators need to adjust their operations based on the load, which can be challenging.
    - Any type of technology will likely need to adjust system control one way or another if there is a large enough change in influent conditions to encourage it; this is not at all challenging with the AquaNereda process. This is usually as simple as changing the cycle time or wasting rate to handle swings in flow and/or load.

Positive Moment

- Aqua Nereda's technology offers a small footprint, cost savings, manageable biological nutrient removal, operational simplicity, and data provision on energy and long-term cost savings. It improves batch processes and makes wastewater handling easier for operators.
- Aqua Nereda was able to recover quickly from a toxic shock.

- The system is designed to selectively waste every single cycle within the reactor itself.
- Aqua Nereda has the flexibility in handling uncertain future flow requirements, ensuring carbon availability for nitrogen and phosphorus removal.
- AGS has rapid recovery and offers benefits such as improved settling time, simultaneous nitrification and denitrification, and greater robustness in handling upsets.
- Complete granulation is achieved within 3 to 6 months. Plants with higher influent carbon concentrations will likely see more rapid granulation as they are bringing in more "food to feed the bugs." Primary effluent plants (that is, those with primary clarifiers before the Nereda system) will be on the longer side as the clarifiers are removing carbon/food before the Nereda. Regardless of granule content, the system will be operated to achieve effluent conditions from start-up. Complete granulation and operation at the design MLSS (generally 8,00 mg/L mentioned under #2) is only of absolute importance when the plant is at or nearing design flow and loads which is generally not the case for a municipal plant at start-up.
- The benefit of having two or three reactors is that when doing maintenance, there are two to play with, giving more flexibility with the cycle structure.
- Demonstrated the cleaning process of the filters through an animation, showing effectiveness and simplicity.
- Highlighted the company's filter manufacturing arm in Switzerland, indicating confidence in cloth quality.
- Showed enthusiasm about the filter system and ease of maintenance, discussing the use of Velcro and cloth longevity.
- Reactor dimensions are flexible, and the volume is more important than the exact dimensions.
- Appreciated clarification on filters' chlorine resistance and efficiency in algae growth applications.
- Discussed startup timeline for Wolf Creek plant and time to meet effluent needs.

Respectfully Submitted
Sharon Sexton
Executive Assistant

Appendix 3f: November 6, 2023, Contingency Committee Minutes

Lewes Board of Public Works
Contingency Committee Meeting Minutes
November 6, 2023
2:00pm

Committee Members

- Barbara Curtis, BPW Assistant Treasurer, chair
- Earl Webb, BPW Board Director
- Tim Ritzert, City Council Ex-Officio
- Mark Prouty, Committee Member- Absent
- Bob Heffernan, Committee Member
- Austin Calaman, BPW General manager- Virtual
- Donna Colton, Committee Member
- Sumner Crosby, Committee Member
- Daphne Fuentevilla, Committee Member-Absent

Others Present

- Sharon Sexton, BPW Executive Assistant

The meeting was called to order at 2:05pm.

Key Takeaways

- The purpose of the meeting was to discuss wastewater treatment plant topics.
- The main topics discussed included discharge of effluent, potential spray irrigation locations, partnerships, research needs, challenges, and involvement of Sea Grant. The main issues included saltwater intrusion, phragmites growth, political and financial challenges, nutrient loadings, and purchasing a sludge press.
- Reviewed the presentation from Aqua Nereda on the Aerobic Granule Sludge technology. The committee was disappointed in the presentation and the lack preliminary visuals, even though aerials were provided. The cost estimates provided did not include tank costs, construction costs, or engineering costs. The simplicity of Aqua Nereda Granule Sludge technology is attractive.
- Reviewed the Berlin Sequencing Batch Reactor (SBR) plant tour. Impressions of the plant: Clean, efficient, small footprint, capability to build while still in operation, and the spray irrigation was miles away,
- Next steps included sending minutes for approval, investigating spray irrigation options, gathering information, assessing saltwater exposure and sea level rise, negotiating with the county, and scheduling the next meeting.

Current Workflow

- Suggested spray irrigation across the street from the wastewater treatment plant.
- Explored potential discharge locations, including wetlands.

- Continue to explore Aqua-Nereda Aerobic Granular Sludge technology and its potential benefits, including reduced energy consumption and chemical use.
- Consideration is being given to renting a sludge press from Sussex as a possible solution. The cost implications of purchasing a sludge press versus existing payments to Sussex are being discussed by the Board. Decision on hold due to the Wastewater treatment facility long-range planning study.
- Discussed the sludge press at the Berlin facility, which achieved a solid state of 19-20 percent.
- Investigate the possibility of using BNR technology while seeking clarification on its chemical dependence.
- The potential problems with saltwater intrusion and phragmites growth include loss of freshwater resources, ecosystem disruption, and damage to infrastructure and agriculture.
- Discuss using the existing membrane system in conjunction with new technology to achieve desired water quality if possible.
- Mr. Crosby provided an update on his meeting with Mr. Ullman and Mr. Wozniak from the University of Delaware. The wetlands adjacent to the current wastewater treatment plant may not be ideal for effluent discharge. Changing the salinity of the wetlands changes the preferred species of plants.

Goals

- Determine a cost-effective, efficient, and environmentally friendly waste treatment solution.
- Discussed the importance of understanding shoreline and assimilation studies related to ocean discharge.
- Deliver high-quality water that exceeds state requirements.
- Maintain system functionality while facing challenges of saltwater exposure and sea level rise.
- Develop a proposal to present and negotiate utilizing new efficient technology with the county and get a feel of the county's thoughts on the Aqua Nereda Aerobic Granule Sludge technology. Sussex County is considering a Biological Nutrient Removal (BNR) system.
- The Contingency Committee must present to the BPW Board of Directors by January 31, 2023.

Concerns

- Difficulty proceeding forward with research without the authorization to spend money on study options.

Decision

- During the meeting, the August 21, 2023, August 29, 2023, and September 12, 2023, minutes were motioned by Mr. Heffernan to be sent to the board for approval. The committee agreed unanimously. (Mark Prouty and Daphne Fuentevilla absent)

Follow-up Meeting

- Scheduled the next meeting for November 14, 2023, at 2:00pm.
- Second meeting scheduled for December 1, 2023, at 3:00pm.

Action Items

  - Request the process design report and gather additional information from the Aqua Nereda Aerobic Systems company.
  - Gather information on the feasibility of different options.
  - Contact consultants from operating Aqua Nereda plants for further details on meeting water quality standards.

Respectfully Submitted
Sharon Sexton
Executive Assistant

Appendix 3g: November 14, 2023, Contingency Committee Minutes

Lewes Board of Public Works
Contingency Committee Meeting Minutes
November 14, 2023
3:00pm

Committee Members

- Barbara Curtis, BPW Assistant Treasurer, chair
- Earl Webb, BPW Board Director- Absent
- Tim Ritzert, City Council Ex-Officio
- Mark Prouty, Committee Member- Absent
- Bob Heffernan, Committee Member
- Austin Calaman, BPW General manager
- Donna Colton, Committee Member
- Sumner Crosby, Committee Member
- Daphne Fuentevilla, Committee Member-Absent

Others Present

- Paula Dorn, Aqua Nereda

The meeting was called to order at 3:00pm.

Key Takeaways

- The purpose of the meeting was to discuss inquiries and concerns related to the wastewater treatment facility and gather information.
- The main topics of discussion included the use of Aqua Nereda technology, preliminary design for a SBR system, protecting drying beds from storm events, options for elevating buildings and tanks, access to the site, and waste disposal methods.
- The main issues discussed were the labor-intensive maintenance with current technology, vulnerability to salinity levels, cost-effectiveness, and vulnerabilities of drying beds to sea level rise.
- Open questions were raised about Aqua Nereda Aerobic Granule Sludge project scale, sludge management capacity, and lifespan (15-20years) and maintenance of the headworks project.
- Complaints were addressed and solved regarding water quality, reduction in chemical use, saline water handling, salt-related issues, and system viability by Aqua Nereda representative.

Current Workflow

- Discussed concerns over the Aqua Nereda presentation focusing on building new infrastructure instead of utilizing exiting infrastructure.
- Addressed concerns about meeting effluent requirements during the initial three months of granulation and reassured that the objectives can still be met with activated sludge.

- Suggested using an existing or new site for the startup.
- Discussed use of current membrane filters and addition of disc filters to improve water quality.
- Discussed the need for building clarifiers with a filter system.
- Discussed the Berlin wastewater treatment facility tour. Berlin uses SBR technology that avoids chemical use in treatment processing, specifically for phosphorus removal.
- Starting up a plant from scratch using the technology highlighted its resiliency and ability to achieve nitrification and phosphorus removal quickly.
- Depending on the quality of seed sludge selected for start up there could be the possibility of scum or foam development with digester sludge.
- Mentioned that flexibility exists with the food to microorganism ratio.
- Discussed implications for meeting effluent objectives and the need to adjust seeding concentration or implement flow diversion to avoid overwhelming the system.
- Emphasize the importance of understanding the seed sludge process and the time required for granulation.
- Reassured the team that they can still meet permit limits by using conventional activated sludge.
- If starting at full flow rate, they may consider supplementing with AGS seed if necessary.
- Emphasized that Aqua Nereda ensures compliance with the permit.
- Discussed how saline water needs slow bleeding to maintain low salt levels and prevent system damage.
- Raised concerns about system vulnerability to intrusions and high salinity's impact on the biological process.
- Discussed options for running current and future systems in parallel.
- The amount of seed sludge used would vary based on the location.
- Shared experience with streamlining operations and suggested that having in-house operations may be more cost-effective.
- Discussed splitting the system and relocating it to a new facility.

Positive Moment

- The cost-benefit analysis of avoiding chemical use in treatment processing was positive due to lower costs associated with chemical use.
- Paula Dorn mentioned that there is flexibility with the seed amount, suggesting that it could be increased.
- Paula Dorn mentioned that the Aqua Nereda plant saw nitrification resume in a couple of cycles and was hitting their full nitrification target again, which was a positive result.

Goals

- Highlighted goal: handle saline water effectively without compromising the biological treatment process.
- Improve water quality at the wastewater treatment facility by exploring technologies and approaches, such as filters and chemical use.

- Stated the goal of using a treatment system less vulnerable to salt intrusion than current activated sludge processes.

Concerns

- Concerns with sea level rise and the low elevation of the current drying beds.
- Raised concerns about system vulnerability to intrusions and high salinity levels' impact on biological processes.
- Discussed meeting effluent objectives and adjusting seeding concentration or implementing flow diversion to avoid overwhelming the system.
- Expressed concerns about maintaining the bug population in low or high flow situations.
- Concerns about water quality from the wastewater treatment facility when using the Aqua Nereda technology.
- A toxic dye manufacturer's input disrupted a wastewater treatment plant, emphasizing the need for careful input management. This incident exposed the sensitivity of the plant's bugs to salt, causing frustration over potential issues it can cause.
- Discussed challenges in the fear of unknown technology.
- Discussed concerns about changing management and the preference for hiring in-house staff.
- Expressed the need for analysis and proving the value and benefits of any investment. Uncertain if board will approve management changes and allocate funds for further studies and engineering.

Action Items

- Gather capacity and power information for the existing plant to assess feasibility of integrating new technology.

Respectfully Submitted
Sharon Sexton
Executive Assistant

Appendix 3h: December 1, 2023, Contingency Committee Minutes

Lewes Board of Public Works
Contingency Committee Meeting Minutes
December 1, 2023
3:00pm

Committee Members

- Barbara Curtis, BPW Assistant Treasurer, chair
- Earl Webb, BPW Board Director
- Tim Ritzert, City Council Ex-Officio
- Mark Prouty, Committee Member
- Bob Heffernan, Committee Member
- Austin Calaman, BPW General Manager
- Donna Colton, Committee Member
- Sumner Crosby, Committee Member
- Daphne Fuentevilla, Committee Member-Virtual

Others Present

- Sharon Sexton, BPW Executive Assistant

The meeting was called to order at 3:00pm.

Key Takeaways

- The purpose of the meeting was to continue discussions on Aqua Nereda AGS technology, review of current plant costs, layout options and possible locations for wastewater treatment facility.
- The main issues discussed included uncertainty about tank sizes, sludge handling, and power usage, and concerns about the cost and logistics of rebuilding the treatment plant.
- Open questions arose about power requirements, sludge digestion, tank sizes, and sludge handling at a new site.
- Next steps include gathering more information, scheduling future meetings, and requesting clarification from the vendor.

Current Workflow

- Aqua Nereda responded to questions sent by the committee and a SBR preliminary design.
- Discussed reusing existing equipment and evaluating alternative approaches to save costs.
- Discussed costs and strategy of sludge handling at treatment plant.
- Discussed the advantages of the Sequential Batch Reactor (SBR) treatment system that requires less manpower and has similar electricity costs to other systems. Mr. Prouty expressed familiarity and expertise with SBR, having designed multiple systems in the past.

- Explored solutions such as building a dike and upgrading the roadbed for improved access during high water.
- Highlighted the interconnection agreement with Sussex County in wastewater treatment process.
- Proposed alternative plant location and highlighted maintenance cost-effectiveness.
- Reviewed Whitefish, Montana project. The original design was SBR but modified to AGS during final design and construction.
- Compared current BPW wastewater treatment plant, SBR plant, and AGS plant. Refer to spreadsheet.
- Committee member suggested exploring solar panel installation to reduce electricity costs.

Goals

- Aimed to reduce operational costs through technology.
- Focusing on adhering to wastewater treatment ordinances.
- Discussed exploring technology options that would benefit all parties.

Team Size for Alternative Technologies

- Discussed allocating manpower and potentially hiring personnel for handling the treatment system.
- Dissatisfaction with use and costs of third-party firm to operate WWTF and whether this would be needed with an alternative technology.

Challenges

- The current design flow of 1,500,000 gallons per day.
- Sludge handling will need to be addressed at the new site.
- There is a dramatic difference in power use per day between the SBR technology and the Aqua Nereda Technology.
- Lack of specific electrical use data for different parts of current system.
- Voiced frustration with relying on external parties for plant operation.
- Expressed the need for an alternative site due to concerns about access during high water.
- Ms. Colton does not believe that it was reasonable to spend money on increasing capacity at a vulnerable location due to the potential for a storm event.
- Expressed concerns about starting a new treatment system and potential setbacks.
- Emphasized the need to conduct a relevant analysis to identify problems.
- The GHD report is based on 2050 Base Flood Elevation design. The BPW would potentially consider a 30-year debt service that would extend beyond 2050.

Decision

- The committee will contact Whitefish plant to discuss the level of efficiency.

Feature Request

- Idaho Springs Wastewater Treatment Plant looked at five potential treatment technologies and went with Aqua Nereda AGS system.
- The advantages of the AGS system include its smaller footprint and lower lifecycle cost due to reduced energy usage.

Follow-up Meeting

- The next meeting is scheduled for Friday, December 13, 2023, at one o'clock.

Respectfully submitted,
Sharon Sexton
Executive Assistant

	CURRENT	SBR	AGS (NEREDA)
DESIGN INFLUENT CONDITIONS	AVE 1.5 MGD	AVE 2.1 MGD	AVE 2.1 MGD
HEADWORKS SCREENING	5 mm & 2 mm	6 mm/ 1/4"	6 mm/ 1/4"
EQ BASIN OR INFLUENT BUFFER SIZE	526,000 GAL		29' x 92' x 17' (?); 285,310 GAL
AVE POWER /DAY			225 kWhr
BASIN COST		?	?
SECONDARY TREATMENT TECHNOLOGY	OXIDATION DITCHES	SEQUENCING BATCH REACTORS	AGS (NEREDA)
EQUIPMENT COST		$1,833,630	$2,822,460
TREATMENT TANK/BASIN SIZE, # & GEOMETRY		2 @ 80' x 96' x 24'; RECTANGULAR	2 @ 59' x45.5' x 24'; RECTANGULAR
BASIN COST	?	?	?
TREATMENT TANK/BASIN GALLONS	2 anoxic zones @ 67,300 + 2 aerobic @ 146,000 = 426,000 (408,000 per GHD report)	1,206,000	420,000
HYDRAULIC RETENTION TIME	0.34 DAYS	1.09 DAYS	0.40 DAYS
POWER USE/DAY		2621.9 kWhr	689 kWhr @ 80%
POST-EQ TANK		33' x 74' X ? 191,746 GAL	80' x 20' x 24'(?) 227,980 GAL
POWER USE/DAY		341.8 kWhr	225.5 kWhr
SLUDGE BUFFER			11' x 20' x 24'(?) 25,106 GAL
POWER USE/DAY			16 kWhr
AEROBIC DIGESTER	ANOXIC TANK 20,000 GAL 1ST & STAGE TANKS @ 125,000 GAL	62' x 74' x 24' 720,683 GAL	
POWER USE/DAY		1,538.74 kWhr	
TERTIARY TREAMENT	MBR	2 AQUA-DISK FILTERS@ 4 DISKS/FILTER	2 AQUA-DISK FILTERS@ 4 DISKS/FILTER
TANK/BASIN GALLONS	4 @ 23,000 = 92,000		
POWER USE/DAY		20.7 kWhr	20.7 kWhr
EQUIPMENT COST		$482,740	$482,740
DISINFECTION	UV: CAPACITY 3 MGD	UV	UV
POWER USE			
CHEMICALS USE	$967/ DAY	?	
TOTAL POWER USE/DAY	6538 kWhr	4523 ++	1176 ++

WHITEFISH PREDESIGN SBR TOTAL POWER USE/DAY (not AquaNereda)		**6,903 kWhr**	
MAIN LIFT PUMPS		2,685	
PRETREATMENT (SCREEN, WASH, COMPACT, VENTILATION)		80	
GRIT REMOVAL		116 kWhr	
SBR		2,649	
SOLIDS HANDLING		859	
UV DISINFECTION		120	
OTHER (CHEM FEED, HVAC, ETC)		358	

Appendix 3i: December 13, 2023, Contingency Committee Minutes

Lewes Board of Public Works
Contingency Committee Meeting Minutes
December 13, 2023
1:00pm

Committee Members

- Barbara Curtis, BPW Assistant Treasurer, chair
- Earl Webb, BPW Board Director
- Tim Ritzert, City Council Ex-Officio
- Mark Prouty, Committee Member
- Bob Heffernan, Committee Member
- Austin Calaman, BPW General Manager
- Donna Colton, Committee Member- Absent
- Sumner Crosby, Committee Member- Absent
- Daphne Fuentevilla, Committee Member-Absent

Others Present

- Sharon Sexton, BPW Executive Assistant

The meeting was called to order at 1:14 pm.

Key Takeaways

- The meeting was a continued discussion on Aqua Nereda Aerobic Granule Sludge (AGS) technology.
- The main issues discussed were concerns about technology reliability and the retirement of a key team member from Sussex County, Hans Medlarz.

Current Workflow

- Mr. Prouty outlined the treatment process at the Whitefish plant, involving extracting sewage from sewers, using alum chemical to precipitate phosphorus, and addressing ammonia removal issues in cold weather.
- The Whitefish team currently has four members working on the project.
- The Whitefish team Expressed satisfaction with the effectiveness of the wastewater treatment system in Whitefish, Montana.
- The BPW plant currently operates for 8 hours a day with one person on call.
- The sludge buffer tank serves an important purpose in the plant's operation.
- Discussed the AGS technology at the Whitefish plant and its benefits in terms of energy savings, lower overall costs, smaller tank sizes, and reduced concrete requirements. The sludge buffer tank serves an important purpose in the plant's operation. Impressed with the speed with which the facility was able to be built.

- Mr. Prouty shared that he has had a positive experience with Aqua Nereda, highlighting their customer support and 24/7 phone service.
- Smaller tanks of AGS technology and the decrease in operational cost are beneficial.
- Discussed the granulation process in the AGS system, especially for new sites with time constraints.
- Discussing the Cape Henlopen State Park treatment system and the option of discharging waste into the ocean.
- Emphasize the need for improved screening at treatment plants to prevent contamination.
- BPW has already committed to upgrading headworks and looking to put a reinforcement ring around the top of the EQ tank. Would need to invest 500,000 to 1,000,000 dollars in the EQ tank if staying at current site.
- The board approved a sludge line to be installed from the bottom of the digester building to a cam lock so that the county can easily access the digester.
- Mr. Prouty advocates for reusing water or using it for irrigation instead of pumping it into the ocean or a canal.

Objections

- May be skepticism from Board Members about the proven technology, implying potential objections from stakeholders.
- Board Members have raised concerns about the reliability and effectiveness of the AGS system.

Goals

- Learning about Wolcott, Kansas' systems implementation and improvements.
- Exploring greenfield sites for building. Discussed Schley Avenue as an option.

Challenges

- Need to do an impact study on the receiving water body due to the discharge pipe being at a different location.

Action Items

- Contact Wolcott plant and discuss the pros and cons of the AGS technology.

Follow-up Meeting

- Contingency Meeting will hold another meeting on January 11, 2024, at 1:30pm.
- Sussex County Council meeting on January 9, 2024. GHD report will present with

Respectfully submitted,
Sharon Sexton
Executive Assistant

Appendix 3j: January 11, 2023, Contingency Committee Minutes

IN PROGRESS

Appendix 3j: January 23, 2023, Contingency Committee Minutes

IN PROGRESS

Appendix 4: Aqua-Aerobic Granular Sludge Technology Preliminary Process Design Report

AQUA-AEROBIC SYSTEMS, INC.
A Metawater Company

Process Design Report

LEWES WWTP DE

Design# 173061
Option: Preliminary AquaNereda Design

AquaNereda®
Aerobic Granular Sludge
Technology

October 03, 2023
Designed By: Takuya Sakomoto

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Upstream Recommendations

- For primary influent designs, ¼ inch (6 mm) perforated plate-style screening and grit removal, consisting of 95% removal at 140 mesh, is required ahead of the AquaNereda system. For primary effluent designs, screening requirements may be relaxed at the discretion of Aqua-Aerobic Systems. If alternative screening and grit removal methods are planned ahead of the AquaNereda system, please discuss screening with Aqua-Aerobic Systems to understand the impacts of the approach.

- Neutralization is required ahead of the biological system if the pH is expected to fall outside of 6.5-8.5 for significant durations.

- Elevated concentration of hydrogen sulfide can be detrimental to both civil and mechanical structures. If anaerobic conditions exist in the collection system, steps should be taken to eliminate hydrogen sulfide prior to the treatment system.

- Fats, oils, and grease (FOG) removal may be necessary (by others) if the wastewater contains significant amounts of FOG. Historical data suggests levels less than 60 mg/l on a daily average basis (based on a 24 hour composite sample), along with a maximum of 90 mg/l is appropriate for biological treatment. If FOG levels above this are anticipated, please discuss with Aqua-Aerobic Systems to understand the impacts of elevated FOG on the system performance.

Flow Considerations

- The maximum flow, as shown on the design, has been assumed as a hydraulic maximum and does not represent an additional organic load.

Aeration

- The aeration system has been designed to provide 1.25 lbs. O2/lb. BOD5 applied and 4.6 lbs. O2/lb. TKN applied at the design average loading conditions, while maintaining a residual DO concentration of 1.0 mg/l.

- A common standby blower will be shared among the biological reactor.

- Depending on the actual yard piping from the blowers to the diffuser system and the heat losses associated with the yard piping, additional provisions for cooling of the air (i.e. incorporating heat exchangers) and/or modification of in-basin piping and/or diffuser sleeve material may be required. Aqua-Aerobic Systems, Inc. may need to modify the following equipment offering to ensure compatibility of all in-basin components with actual air temperatures.

Process/Site

- The anticipated effluent nitrogen requirement is predicated upon an influent waste temperature of 10 °C or greater. While lower temperatures may be acceptable for a short-term duration, nitrification and (if required) denitrification below 10 °C can be unpredictable, requiring special operator attention.

- Sufficient alkalinity is required for nitrification, as approximately 7.1 mg alkalinity (as CaCO3) is required for every mg of NH3-N nitrified. If the raw water alkalinity cannot support this consumption, while maintaining a residual concentration of 50 mg/l, supplemental alkalinity shall be provided (by others).

- A minimum of twelve (12) daily composite samples per month (both influent and effluent) shall be obtained for total phosphorus analysis.

- Influent to the biological system is a typical municipal wastewater application. Influent TP shall be either in a particle associated form or in a reactive soluble phosphate form or in a soluble form that can be converted to reactive phosphorus in the biological system. Soluble hydrolyzable and organic phosphates are not removable by chemical precipitation with metal salts. A water quality analysis is required to determine the phosphorus speciation with respect to soluble and insoluble reactive, acid hydrolyzable and total phosphorus at the system Influent, point(s) of chemical addition, and final effluent.

- The majority of secondary effluent phosphorus shall be in a filterable particulate form.

- The cloth media filter will only remove TP that is associated with the TSS removed by the filter. Since only insoluble, particle-associated phosphorous is capable of being removed by filtration, phosphorous speciation shall be provided by the owner to substantiate the concentrations of soluble and insoluble phosphorous in the filter influent. If the proportions of soluble (unfilterable) and insoluble phosphorous are such that removal to achieve the desired effluent limit is not practical, the owner will provide for proper conditioning of the wastewater, upstream of the filter system, to allow for the required removal.

- The average and maximum flow and loading conditions, shown within the report, are based on maximum month average and maximum day conditions, respectively.

Post-Secondary Treatment

-The following processes follow the Biological process:
- Tertiary filtration
- Ultraviolet disinfection (by others).

Filtration

- The cloth media filter recommendation and anticipated effluent quality are based upon influent water quality conditions as shown under "Design Parameters" of this Process Design Report.

- The filter influent should be free of algae and other solids that are not filterable through a nominal 5 micron pore size media. Provisions to treat algae and condition the solids to be filterable are the responsibility of others.

- This filter has been designed to handle 50% of the max flow with one (1) unit out of service.

Equipment

- Changes in basin geometry may require alterations in the equipment recommendation.

- The basins are not included and shall be provided by others.

- The influent enters the basin near the reactor floor. Adequate hydraulic capacity shall be made in the headworks to prevent backflow from one reactor to the other during transition of influent.

- Based on the process requirements and selected equipment, the reactor wall height should be at least 24 ft.

- Scope of supply includes freight, installation supervision and start-up services.

- Equipment selection is based upon the use of Aqua-Aerobic Systems' standard materials of construction and electrical components, suitable for non-classified electrical environments.

- Influent buffer and Post-EQ pumps are to be provided by others.

- The basin dimensions reported on the design have been assumed based upon the required volumes and assumed basin geometry. Actual basin geometry may be circular, square or rectangular with construction materials including concrete or steel.

- The control panel does not include motor starters or VFDs, which should be provided in a separate MCC (by others).

- Provisions should be made, by others, for overflows in each of the recommended basins.

- Aqua-Aerobic Systems, Inc. is familiar with various "Buy American" Acts (i.e. AIS, ARRA, Federal FAR 52.225, EXIM Bank, USAid, PA Steel Products Act, etc.). As the project develops Aqua-Aerobic Systems can work with you to ensure full compliance of our goods with various Buy American provisions if they are applicable/required for the project. When applicable, please provide us with the specifics of the project's "Buy American" provisions.

- If the cloth media filter will be offline for extended periods of time, protection from sunlight is required.

INFLUENT BUFFER DESIGN PARAMETERS

Avg. Daily Flow:	= 2.10 MGD	= 7,949 m3/day
Max. Daily Flow:	= 2.63 MGD	= 9,956 m3/day

No. of AGS Reactors: = 2

INFLUENT BUFFER VOLUME DETERMINATION

The volumes determined in this summary reflect the minimum volumes necessary to achieve the desired results based upon the input provided to Aqua. If other hydraulic conditions exist that are not mentioned in this design summary or associated design notes, additional volume may be warranted.

INFLUENT BUFFER BASIN DESIGN VALUES

No./Basin Geometry:	= 1 Rectangular Basin(s)				
Length of Basin:	= 29.0 ft	= (8.8 m)			
Width of Basin:	= 92.0 ft	= (28.0 m)			
Min. Water Depth:	= 0.0 ft	= (0.0 m)	**Min. Basin Vol. Basin:**	= 0 gallons	= (0.0 m^3)
Max. Water Depth:	= 14.4 ft	= (4.4 m)	**Max. Basin Vol. Basin:**	= 285,310.0 gallons	= (1,080.0 m^3)

INFLUENT BUFFER EQUIPMENT CRITERIA

Max. Flow Rate Required Basin:	= 4,046 GPM	= (919 m^3/hr)
Avg. Power Required:	= 225 kWhr/day	

AquaNereda® - Aerobic Granular Sludge Reactor - Design Summary

Design#: 173061

Project: LEWES WWTP DE

Option: Preliminary AquaNereda Design

Designed by Takuya Sakomoto on Tuesday, October 3, 2023

AQUA-AEROBIC SYSTEMS, INC.
A Metawater Company

DESIGN INFLUENT CONDITIONS

Avg. Design Flow	= 2.10 MGD	= 7,949 m³/day
Max Design Flow	= 2.63 MGD	= 9,956 m³/day

DESIGN PARAMETERS

	Influent	mg/l	Effluent (After Filtration) Required	<= mg/l	Anticipated	<= mg/l
Bio/Chem Oxygen Demand:	BOD5	180	BOD5	5	BOD5	5
Total Suspended Solids:	TSS	131	TSS	5	TSS	5
Total Kjeldahl Nitrogen:	TKN	27	TKN	--	TKN	--
Total Nitrogen:	--	--	TN	5.0	TN	5.0
Phosphorus:	Total P	4	Total P	0.6	Total P	0.6

SITE CONDITIONS

	Maximum		Minimum		Elevation (MSL)
Ambient Air Temperatures:	90 F	32.0 C	20 F	-7.0 C	7 ft
Influent Waste Temperatures:	68 F	20.0 C	50 F	10.0 C	2.0 m

AGS BASIN DESIGN VALUES

			Water Depth			Basin Vol./Basin	
No./Basin Geometry:	2 Rectangular Basin(s)		**Process Level (PWL):**	21.0 ft	(6.4 m)	0.42 MG	(1,596 m³)
Freeboard (from PWL):	2.6 ft	(0.8 m)	**Discharge Level (DWL):**	22.1 ft	(6.7 m)		
Length of Basin:	59.0 ft	(18.0 m)	**Top of Wall (TOW):**	24.0 ft	(7.3 m)		
Width of Basin:	45.5 ft	(13.9 m)					

PROCESS DETAILS

Cycle Duration:	= 5.0 Hours/Cycle	
Food/Mass (F/M) ratio:	= 0.056 lbs. BOD5/lb. MLSS-Day	
MLSS Concentration:	= 8000 mg/l	
Hydraulic Retention Time:	= 0.40 Days	
Solids Retention Time:	= 24.50 Days	
Est. Net Sludge Yield:	= 0.67 Lbs. WAS/lb. BOD5	
Est. Dry Solids Produced:	= 2127.0 lbs. WAS/Day	= (964.8 kg/Day)

AERATION DETAILS

Lbs. O2/lb. BOD5	= 1.25	
Lbs. O2/lb. TKN	= 4.60	
Peak O2 Factor:	= 1.00	
Actual Oxygen Required:	= 6116 lbs./Day	= (2774.2 kg/Day)
Max. Discharge Pressure:	= 10.67 PSIG	= (74 KPA)
Max. Air Flowrate/Basin:	= 987 SCFM	
Min. Air Flowrate/Basin:	= 247 SCFM	
Max. Simultaneous Air:	= 1,451 SCFM	
Min. Simultaneous Air:	= 482 SCFM	

RETURN FLOW ESTIMATES

Daily Estimated Return Flow:	= 0.20 MGD
Max. Instantaneous Return Flow:	= 323 GPM

POWER CONSUMPTION

Average Aeration Power Consumption:	= 689 kWh/day (at 80% design load)

SLUDGE BUFFER DESIGN VALUES

No./Basins Geometry:	= 1 Rectangular Basin(s)	
Minimum Level:	= 18.0 ft	= (0.3 m)
Max. Level:	= 15.4 ft	= (4.7 m)
Max. Basin Volume:	= 25,106 gallons	= (95.0 m^3)
Length of Basin:	= 11.0 ft	= (3.3 m)
Width of Basin:	= 20.0 ft	= (6.1 m)

SLUDGE BUFFER VOLUME DETERMINATION

The sludge buffer volume has been determined based on the sludge production and the concentration of sludge from the AquaNereda reactors. The Sludge from this basin will be pumped to the sludge handling system, and the supernatant back to the head of the plant.

SLUDGE BUFFER EQUIPMENT CRITERIA

Max. Sludge Flow Rate Required:	= 66 gpm	= (15 m^3/hr)
Max. Supernatant Flow Rate Required:	= 264 gpm	= (60 m^3/hr)
Average Power Consumption:	= 16 kWh/day (at 80% design load)	

POST-EQUALIZATION DESIGN PARAMETERS

Avg. Daily Flow (ADF):	= 2.10 MGD	= (7,949 m^3/day)
Max. Daily Flow (MDF):	= 2.63 MGD	= (9,956 m^3/day)
Decant Flow Rate from (Qd):	= 4,046 gpm	= (919 m^3/hr)
Decant Duration (Td):	= 60 min	

POST-EQUALIZATION VOLUME DETERMINATION

The volumes determined in this summary reflect the minimum volumes necessary to achieve the desired results based upon the input provided to Aqua-Aerobic. If other hydraulic conditions exist that are not mentioned in this design summary or associated design notes, additional volume may be warranted.

POST- EQUALIZATION BASIN DESIGN VALUES

No./Basin Geometry:	= 1 Rectangular Basin(s)				
Length of Basin:	= 80.0 ft	= (24.4 m)			
Width of Basin:	= 20.0 ft	= (6.1 m)			
Min. Water Depth:	= 0.0 ft	= (0.0 m)	**Min. Basin Vol. Basin:**	= 0 gal	= (0 m^3)
Max. Water Depth:	= 19.1 ft	= (5.8 m)	**Max. Basin Vol. Basin:**	= 227,980 gal	= (863 m^3)

POST- EQUALIZATION EQUIPMENT CRITERIA

Max. Flow Rate Required Basin:	= 1,933.7 gpm	= (439.2 m^3/hr)
Avg. Power Required:	= 225.5 kW-hr/day	

DESIGN INFLUENT CONDITIONS

Pre-Filter Treatment:	AquaNereda		
Avg. Design Flow	= 2.10 MGD	= 1458.33 gpm	= 7949.36 m³/day
Max Design Flow	= 2.63 MGD	= 1826.39 gpm	= 9955.63 m³/day

AquaDisk FILTER RECOMMENDATION

Qty Of Filter Units Recommended	= 2
Number Of Disks Per Unit	= 4
Total Number Of Disks Recommended	= 8
Total Filter Area Provided	= 430.4 ft² = (39.99 m²)
Filter Model Recommended	= AquaDisk Package: Model ADFSP-54 x 4E-PC
Filter Media Cloth Type	= OptiFiber PES-14®

AquaDisk FILTER CALCULATIONS

Filter Type:

Vertically Mounted Cloth Media Disks featuring automatically operated vacuum backwash . Tank shall include a rounded bottom and solids removal system.

Average Flow Conditions:

Average Hydraulic Loading
= Avg. Design Flow (gpm) / Recommended Filter Area (ft²)
= 1458.3 / 430.4 ft²
= 3.39 gpm/ft² (8.28 m/hr) at Avg. Flow

Maximum Flow Conditions:

Maximum Hydraulic Loading
= Max. Design Flow (gpm) / Recommended Filter Area (ft²)
= 1826.4 / 430.4 ft²
= 4.24 gpm/ft² (10.38 m/hr) at Max. Flow

Solids Loading:

Solids Loading Rate
= (lbs TSS/day at max flow and max TSS loading) / Recommended Filter Area (ft²)
= 329 lbs/day / 430.4 ft²
= 0.76 lbs. TSS /day/ft² (3.73 kg. TSS/day/m²)

The above recommendation is based upon the provision to maintain a satisfactory hydraulic surface loading at 50% of the Maximum Design Flow with (1) unit out of service. The resultant hydraulic loading rate at 50% of the Maximum Design Flow is: 4.2 gpm / ft² = (10.4 m/hr)

AquaNereda: Influent Buffer

Level Sensor Assemblies

1 Sensor installation(s) consisting of:

- Pressure transducer(s).
- Stainless steel sensor guide rail weldment(s).
- PVC sensor mounting pipe(s).
- Top support(s).

1 Level Sensor Assembly(ies) will be provided as follows:

- Float switch(es).
- Float switch mounting bracket(s).
- Stainless steel anchors.

AquaNereda

Influent Valves

2 Influent Valve(s) will be provided as follows:

- 16 inch electrically operated plug valve(s).

Influent Distribution System

2 Influent Distribution Assembly(ies) consisting of:

- Influent distribution system consisting of HDPE and PVC pipe with supports.

Effluent Weir Assembly

2 Effluent Weir Assembly(ies) consisting of:

- Concrete main effluent channel(s) provided by others.
- Stainless steel weir assembliy(ies) with supports.

Sludge Removal System

2 Solids Waste System(s) consisting of:

- HDPE or Stainless steel solids waste system(s).
- Pressure transmitter(s).

2 Sludge Decant/WLC Valve Set(s) consisting of:

- Each reactor includes two (2) of the following automatic control valves and two (2) of the following manual throttling valves:
- 14 inch electrically operated butterfly valve(s) with actuator.
- 14 inch diameter manual plug valve(s).

2 Air Valve Set(s) consisting of:

- Each reactor includes two (2) of the following automatic valves and one (1) of the following manual valves:
- 4 inch manually operated butterfly valve(s) with lever handle.
- 4 inch electrically operated butterfly valve(s) with actuator.

Fixed Fine Bubble Diffusers

2 Fixed Fine Bubble Diffuser Assembly(ies) consisting of:

- 304 SS, 12 Ga. drop pipe(s).
- PVC, Sch 40 Manifold(s) with connection to drop pipe.
- PVC, Air distributor(s) with connection to the manifold and required PVC pipe joint connections.
- 304 Stainless steel piping supports with vertical supports, clamps, adjusting mechanism and anchor bolts.
- Fine bubble diffuser assemblies.
- Air muffler(s).

Positive Displacement Blowers

3 Positive Displacement Blower Package(s), with each package consisting of:

- 60HP Rotary Positive Displacement Blower(s).
- Manual butterfly valve(s).

Air Valves

2 Air Control Valve(s) will be provided as follows:

- 6 inch electrically operated butterfly valve(s) with actuator.
- Auma actuator will be upgraded from open/close service to modulating service.
- Air flow meter(s).
- Flow conditioner(s).
- 6 inch manually operated butterfly valve(s) with lever handle.

Level Sensor Assemblies

2 Pressure Transducer Assembly(ies) each consisting of:

- Pressure transducer(s).
- Mounting bracket weldment(s).
- Transducer mounting pipe weldment(s).

2 Level Sensor Assembly(ies) will be provided as follows:

- Float switch(es).
- Float switch mounting bracket(s).
- Stainless steel anchors.

Instrumentation

1 Server Based Control and Monitoring System will be provided as follows:

- Process Controller Server.
- Small server monitor.

2 Dissolved Oxygen Assembly(ies) consisting of:

- DO probe(s).

2 TSS Sensor(s) will be provided as follows:

- TSS probe(s).

2 ORP Sensor(s) will be provided as follows:

- ORP sensor(s).

2 pH Sensor(s) will be provided as follows:

- pH probe(s).

2 NO3 Sensor(s) will be provided as follows:

- Nitrate sensor(s).

1 Phosphorus Analyzer(s) will be provided as follows:

- Phosphate analyzer(s).

1 Filtrax Sampling System(s) will be provided as follows:

- Sampling system.

3 Process Controller(s) consisting of:

- Controller and display module(s).

2 Process Controller(s) consisting of:

- Controller(s).

1 Process Control System will be provided as follows:

- Hach SC1000 display module.
- FRP enclosure(s) for SC1000 Display.

AquaNereda: Post-Equalization

Level Sensor Assemblies

1 Pressure Transducer Assembly(ies) each consisting of:

- Pressure transducer(s).
- Mounting bracket weldment(s).
- Transducer mounting pipe weldment(s).

1 Level Sensor Assembly(ies) will be provided as follows:

- Float switch(es).
- Float switch mounting bracket(s).
- Stainless steel anchors.

AquaNereda: Sludge Buffer

Transfer Pumps/Valves

1 External pump assembly(ies) consisting of the following items:

- 5HP Pump assembly(ies).
- 2 inch manual plug valve(s).

1 Sludge Valve(s) consisting of the following items:

- 3 inch electrically operated plug valve(s).

1 Supernatant Valve(s) consisting of the following items:

- 6 inch electrically operated plug valve(s).

Sludge Removal System

1 Solids Removal Assembly(ies) consisting of:

- Solids removal assembly(ies) consisting of PVC and/or HDPE pipe with supports.

Level Sensor Assemblies

1 Pressure Transducer Assembly(ies) each consisting of:

- Pressure transducer(s).
- Mounting bracket weldment(s).
- Transducer mounting pipe weldment(s).

1 Level Sensor Assembly(ies) will be provided as follows:

- Float switch(es).
- Float switch mounting bracket(s).

- Stainless steel anchors.

Instrumentation

1 Hach TSS WAS Sensor(s) will be provided as follows:

- Hach Solitax Inline sc stainless steel pipe isertion probe with stainless steel wiper and 33 ft electric cable. One (1) probe per basin.

1 Process Controller(s) consisting of:

- Controller and display module(s).

AquaNereda: PLC Controls

Controls wo/Starters

1 Controls Package(s) will be provided as follows:

- NEMA 12 panel enclosure suitable for indoor installation and constructed of painted steel.
- Fuse(s) and fuse block(s).
- Compactlogix Processor.
- Operator interface(s).
- Remote access Ethernet modem(s).

Cloth Media Filters

AquaDisk Tanks/Basins

2 AquaDisk Model # ADFSP-54x4E-PC Package Filter Painted Steel Tank(s) consisting of:

- 4 Disk painted steel tank(s).
- 3" ball valve(s).

AquaDisk Centertube Assemblies

2 Centertube(s) consisting of:

- 304 stainless steel centertube weldment(s).
- Centertube driven sprocket(s).
- Dual wheel assembly(ies).
- Rider wheel bracket assembly(ies).
- Effluent seal plate weldment.
- Centertube bearing kit(s).
- Effluent centertube lip seal(s).
- Pile cloth media and non-corrosive support frame assemblies.
- Disk segment 304 stainless steel support rods.
- Media sealing gaskets.

2 Cloth set(s) will have the following feature:

- Cloth will be OptiFiber PES-14.

AquaDisk Drive Assemblies

2 Drive System(s) consisting of:

- Gearbox with motor.
- Drive sprocket(s).
- Drive chain(s) with pins.
- Stationary drive bracket weldment(s).
- Adjustable drive bracket weldment(s).

- Chain guard weldment(s).
- Warning label(s).

AquaDisk Backwash/Sludge Assemblies

2 Backwash System(s) consisting of:

- Backwash shoe assemblies.
- Backwash shoe support weldment(s).
- 1 1/2" flexible hose.
- Stainless steel backwash shoe springs.
- Hose clamps.

2 Backwash/Solids Waste Pump(s) consisting of:

- Backwash/waste pump(s).
- Stainless steel anchors.
- 0 to 15 psi pressure gauge(s).
- 0 to 30 inches mercury vacuum gauge(s).
- Throttling gate valve(s).
- 2" bronze 3 way ball valve(s).

AquaDisk Instrumentation

2 Pressure Transmitter(s) consisting of:

- Level transmitter(s).

2 Float Switch(es) consisting of:

- Float switch(es).

2 Vacuum Transmitter(s) consisting of:

- Vacuum transmitter(s).

AquaDisk Valves

2 Set(s) of Backwash Valves consisting of:

- 2" full port, three piece, stainless steel body ball valve(s), grooved end connections with single phase electric actuator(s). Valve / actuator combination shall be TCI / RCI (RCI, a division of Rotork).
- 2" flexible hose.
- Victaulic coupler(s).

2 Solids Waste Valve(s) consisting of:

- 2" full port, three piece, stainless steel body ball valve(s), grooved end connections with single phase electric actuator(s). Valve / actuator combination shall be TCI / RCI (RCI, a division of Rotork).
- 2" flexible hose.
- Victaulic coupler(s).

AquaDisk Controls w/Starters

2 Conduit Installation(s) consisting of:

- PVC conduit and fittings.

2 Control Panel(s) consisting of:

- NEMA 4X fiberglass enclosure(s).
- Circuit breaker with handle.
- Transformer(s).
- Fuses and fuse blocks.
- Line filter(s).

- GFI convenience outlet(s).
- Control relay(s).
- Selector switch(es).
- Indicating pilot light(s).
- Compactlogix Processor.
- Power supply(s).
- Input card(s)
- Output card(s).
- Analog input card(s).
- Ethernet switch(es).
- Operator interface(s).
- Power supply(ies).
- Motor starter(s).
- Terminal blocks.
- UL label(s).

Appendix 5: Aqua-Aerobic Granular Sludge Technology Preliminary Process Design Report O&M Estimate

20-YEAR O&M ESTIMATE

AQUA-AEROBIC SYSTEMS, INC.
A Metawater Company

LEWES WWTP DE

Design#: 173061

Option: Preliminary AquaNereda Design

Designed By Takuya Sakomoto on Tuesday, October 3, 2023

Prepared By Takuya Sakomoto on Monday, October 2, 2023

The enclosed information is based on preliminary data which we have received from you. There may be factors unknown to us which would alter the enclosed recommendation. These recommendations are based on models and assumptions widely used in the industry. While we attempt to keep these current, Aqua-Aerobic Systems, Inc. assumes no responsibility for their validity or any risks associated with their use. Also, because of the various factors stated above, Aqua-Aerobic Systems, Inc. assumes no responsibility for any liability resulting from any use made by you of the enclosed recommendations.

O&M NOTES

* Stand-by blower unit included in estimate for budget purposes. Maintenance costs of stand-by unit may be reduced based upon the actual hours of operation.

** This is based upon operation at 80% of design conditions.

*** The values listed are for estimating purposes only. The actual amount of operator attention provided will be dependent upon local requirements and the size of the staff available for testing.

All estimates are based upon equipment maintenance and operation in accordance with the O & M instructions provided by Aqua-Aerobic Systems. They are based on typical AquaNereda installations with a normal preventative maintenance schedule for the equipment. The actual maintenance man hours required for each project will vary depending upon site and climate conditions, which may alter the frequency of the maintenance schedule.

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I. EQUIPMENT MAINTENANCE AND REPLACEMENT ESTIMATE

Qty	Unit	Service Required	Replacement Interval (Years)	Material Cost	20-Year Total
	Aerobic Granular Sludge Reactor				
3	Blower*	Oil Change	2	$45	$1,350
3	Blower*	Replace Inlet Air Filter Elements	1	$170	$10,200
3	Blower*	Replace Belt	2	$80	$2,400
2	D.O. Sensors	Replace Sensor Head	2	$224	$4,480
2	TSS Sensor	Replace Wiper (if available)	0.5	$16	$1,280
2	TSS Sensor	Seal Kit	2	$700	$14,000
2	pH Sensor	Replace Salt Bridge	1	$84	$3,360
2	ORP Sensor	Replace Salt Bridge	1	$84	$3,360
2	Nitrate Sensor	Seal Kit	2	$700	$14,000
1	Phosphate Analyzer	Reagent	0.25	$112	$8,960
532	FFB Disc Diff. Membranes	100% Diffuser Membrane Replacement	7	$5	$5,320
	Sludge Buffer				
1	Transfer Pump	Repair Kit	5	$1,565	$6,260
1	TSS WAS Probe	Replace Wiper (if available)	0.5	$16	$640
1	TSS WAS Probe	Seal Kit	2	$700	$7,000
	Controls				
1	Controller	Replace Relays, Switches, Fuses	1	$50	$1,000
1	Controller	Replace Microprocessor Battery	3	$26	$156

INTERVAL TOTALS:

1-Year	2-Year	3-Year	5-Year	7-Year
$1,440	$4,323	$26	$1,565	$2,660

Estimated 20-Year Total: $83,766

II. LABOR REQUIREMENTS ESTIMATE

Estimated General Operation & Maintenance ***

13.0 = Man Hours/week for Process Testing

6.0 = Man Hours/week for General Plant Cleanup and Routine Maintenance

III. POWER CONSUMPTION ESTIMATE

Power Costs of All Equipment as Proposed **

Influent Buffer	225	(kWh/day)
Aerobic Granular Sludge Reactor	689	(kWh/day)
Sludge Buffer	16	(kWh/day)
Post-Equalization	225	(kWh/day)
Total:	1155	(kWh/day)
Estimated $/kWh:	$0.08	
Total Annual Power Cost:	$33,726	

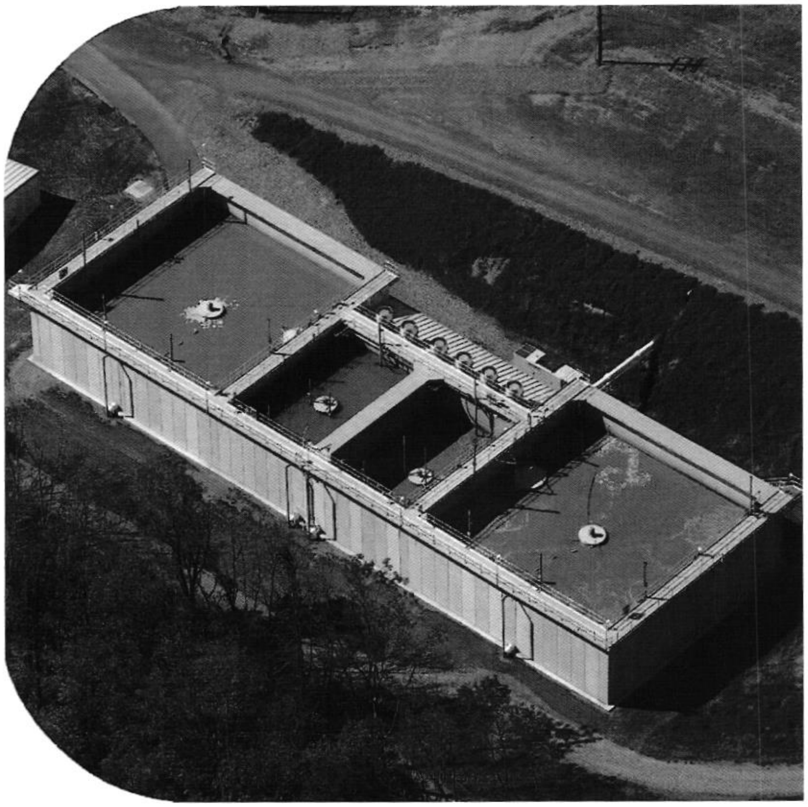
20-Year Estimated Power Cost: $674,520

Appendix 6: Aqua-Aerobic SBR Technology Process Preliminary Design Report

AQUA-AEROBIC SYSTEMS, INC.
A Metawater Company

Process Design Report

LEWES WWTP DE
Design# 173576
Option: Preliminary SBR Design



AquaSBR®
Sequencing Batch Reactor

November 17, 2023
Designed By: Takuya Sakomoto

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(815) 654-2501 www.aqua-aerobic.com

Design Notes

Upstream Recommendations

- Neutralization is required ahead of the biological system if the pH is expected to fall outside of 6.5-8.5 for significant durations.

- Coarse screening and grit removal is recommended (by others) ahead of the biological system.

- Elevated concentration of hydrogen sulfide can be detrimental to both civil and mechanical structures. If anaerobic conditions exist in the collection system, steps should be taken to eliminate hydrogen sulfide prior to the treatment system.

- Fats, oils, and grease (FOG) removal may be necessary (by others) if the wastewater contains significant amounts of FOG. Historical data suggests levels less than 60 mg/l on a daily average basis (based on a 24 hour composite sample), along with a maximum of 90 mg/l is appropriate for biological treatment. If FOG levels above this are anticipated, please discuss with Aqua-Aerobic Systems to understand the impacts of elevated FOG on the system performance.

Flow Considerations

- The maximum flow, as shown on the design, has been assumed as a hydraulic maximum and does not represent an additional organic load.

Biological Process

- The decanter performance is based upon a free-air discharge following the valve and immediately adjacent to the basin. Actual decanter performance depends upon the complete installation including specific liquid and piping elevations and any associated field piping losses to the final point of discharge. Modification of the high water level, low water level, centerline of discharge, and / or cycle structure may be required to achieve discharge of full batch volume based on actual site installation specifics.

Aeration

- The aeration system has been designed to provide 1.25 lbs. O2/lb. BOD5 applied and 4.6 lbs. O2/lb. TKN applied at the design average loading conditions, while maintaining a residual DO concentration of 2.0 mg/l.

- A common standby blower will be shared among the biological reactor and digester.

- Depending on the actual yard piping from the blowers to the diffuser system and the heat losses associated with the yard piping, additional provisions for cooling of the air (i.e. incorporating heat exchangers) and/or modification of in-basin piping and/or diffuser sleeve material may be required. Aqua-Aerobic Systems, Inc. may need to modify the following equipment offering to ensure compatibility of all in-basin components with actual air temperatures.

Digester

- The digester aeration system has been designed based on 2.0 lbs O2/lb VSS removed.

- The air supply for the digester system is based on each basin receiving 100% of the total sludge produced per day.

Process/Site

- The following parameters have been assumed, as displayed on the design (engineer to verify): Influent Total P.

- The anticipated effluent nitrogen requirement is predicated upon an influent waste temperature of 10 °C or greater. While lower temperatures may be acceptable for a short-term duration, nitrification and (if required) denitrification below 10 °C can be unpredictable, requiring special operator attention.

- Sufficient alkalinity is required for nitrification, as approximately 7.1 mg alkalinity (as CaCO3) is required for every mg of NH3-N nitrified. If the raw water alkalinity cannot support this consumption, while maintaining a residual concentration of 50 mg/l, supplemental alkalinity shall be provided (by others).

- To achieve the effluent monthly average total phosphorus limit, the biological process, chemical feed systems, and Cloth Media Filters need to be designed to facilitate optimum performance.

- A minimum of twelve (12) daily composite samples per month (both influent and effluent) shall be obtained for total phosphorus analysis.

- Influent to the biological system is a typical municipal wastewater application. Influent TP shall be either in a particle associated form or in a reactive soluble phosphate form or in a soluble form that can be converted to reactive phosphorus in the biological system. Soluble hydrolyzable and organic phosphates are not removable by chemical precipitation with metal salts. A water quality analysis is required to determine the phosphorus speciation with respect to soluble and insoluble reactive, acid hydrolyzable and total phosphorus at the system Influent, point(s) of chemical addition, and final effluent.

- The average and maximum flow and loading conditions, shown within the report, are based on maximum month average and maximum day conditions, respectively.

Post-Secondary Treatment

-The following processes follow the Biological process:
  - Effluent flow equalization.
  - Tertiary filtration

Filtration

- The cloth media filter recommendation and anticipated effluent quality are based upon influent water quality conditions as shown under "Design Parameters" of this Process Design Report.

- The filter influent should be free of algae and other solids that are not filterable through a nominal 5 micron pore size media. Provisions to treat algae and condition the solids to be filterable are the responsibility of others.

- The cloth media filter has been designed to handle the maximum design flow while maintaining one unit out of service.

- The cloth media filter will only remove Total Phosphorus (TP) that is associated with the TSS removed by the filter. Therefore, it is assumed that the secondary biological process will reduce the soluble fraction of the TP to a concentration sufficiently less than the effluent TP requirement so as to allow the effluent TP requirement to be met.

Equipment

- Changes in basin geometry may require alterations in the equipment recommendation.

- The basins are not included and shall be provided by others.

- Influent is assumed to enter the reactor above the water level, away from the decanter, and to avoid splashing or direct discharge in the immediate vicinity of other equipment. If the influent enters the basin below the water level, adequate hydraulic capacity shall be made in the headworks to prevent backflow from one reactor to the other during transition of influent.

- Based on the process requirements and selected equipment, the reactor wall height should be at least 23 ft.

- Scope of supply includes freight, installation supervision and start-up services.

- Equipment selection is based upon the use of Aqua-Aerobic Systems' standard materials of construction and electrical components, suitable for non-classified electrical environments.

- The basin dimensions reported on the design have been assumed based upon the required volumes and assumed basin geometry. Actual basin geometry may be circular, square or rectangular with construction materials including concrete or steel.

- The control panel does not include motor starters or VFDs, which should be provided in a separate MCC (by others).

- Provisions should be made, by others, for overflows in each of the recommended basins.

- Aqua-Aerobic Systems, Inc. is familiar with various "Buy American" Acts (i.e. AIS, ARRA, Federal FAR 52.225, EXIM Bank, USAid, PA Steel Products Act, etc.). As the project develops Aqua-Aerobic Systems can work with you to ensure full compliance of our goods with various Buy American provisions if they are applicable/required for the project. When applicable, please provide us with the specifics of the project's "Buy American" provisions.

- If the cloth media filter will be offline for extended periods of time, protection from sunlight is required.

AquaSBR® - Sequencing Batch Reactor - Design Summary

DESIGN INFLUENT CONDITIONS

Avg. Design Flow	= 2.1 MGD	= 7949 m3/day
Max Design Flow	= 2.63 MGD	= 9956 m3/day

DESIGN PARAMETERS

			Effluent (After Filtration)			
	Influent	**mg/l**	**Required**	**<= mg/l**	**Anticipated**	**<= mg/l**
Bio/Chem Oxygen Demand:	BOD5	300	BOD5	5	BOD5	5
Total Suspended Solids:	TSS	250	TSSa	5	TSSa	5
Total Kjeldahl Nitrogen:	TKN	40	TKN	--	TKN	--
Total Nitrogen:	--	--	TN	5	TN	5
Phosphorus:	Total P	8	Total P	0.60	Total P	0.60

SITE CONDITIONS

	Maximum		Minimum		Elevation (MSL)
Ambient Air Temperatures:	90 F	32.0 C	19 F	-7.0 C	14 ft
Influent Waste Temperatures:	68 F	20.0 C	50 F	10.0 C	4.3 m

SBR BASIN DESIGN VALUES

No./Basin Geometry:	= 2 Rectangular Basin(s)	
Freeboard:	= 2.0 ft	= (0.6 m)
Length of Basin:	= 80.0 ft	= (24.4 m)
Width of Basin:	= 96.0 ft	= (29.3 m)

	Water Depth			Basin Vol./Basin	
Min	= 15.3 ft	= (4.7 m)	**Min**	= 0.878 MG	= (3,322.4 m³)
Avg	= 19.8 ft	= (6.0 m)	**Avg**	= 1.140 MG	= (4,316.2 m³)
Max	= 21.0 ft	= (6.4 m)	**Max**	= 1.206 MG	= (4,567.0 m³)

Number of Cycles:	= 4 per Day/Basin (advances cycles beyond MDF)	
Cycle Duration:	= 6.0 Hours/Cycle	
Food/Mass (F/M) ratio:	= 0.080 lbs. BOD5/lb. MLSS-Day	
MLSS Concentration:	= 4500 mg/l @ Min. Water Depth	
Hydraulic Retention Time:	= 1.086 Days @ Avg. Water Depth	
Solids Retention Time:	= 15.9 Days	
Est. Net Sludge Yield:	= 0.753 lbs. WAS/lb. BOD5	
Est. Dry Solids Produced:	= 3955.9 lbs. WAS/Day	= (1794.4 kg/Day)
Est. Solids Flow Rate:	= 500 GPM (47433 GAL/Day)	= (179.6 m³/Day)
Decant Flow Rate @ MDF:	= 4383 GPM (as avg. from high to low water level)	= (276.5 l/sec)
LWL to CenterLine Discharge:	= 3.0 ft	= (0.9 m)
Lbs. O2/lb. BOD5	= 1.25	
Lbs. O2/lb. TKN	= 4.60	
Actual Oxygen Required:	= 9790 lbs./Day	= (4440.9 kg/Day)
Air Flowrate/Basin:	= 2821 SCFM	= (79.9 Sm3/min)
Max. Discharge Pressure:	= 10.7 PSIG	= (74 KPA)
Daily Max. Month Avg. Estimated Power*:	= 2621.9 KW-Hrs/Day	

* Power consumption calculations in this document are based on maximum month conditions. Detailed power vs. loading calculations can be provided if requested.

POST-SBR EQUALIZATION DESIGN PARAMETERS

Avg. Daily Flow (ADF):	= 2.1 MGD	= (7,949 m^3/day)
Max. Daily Flow (MDF):	= 2.63 MGD	= (9,956 m^3/day)
Decant Flow Rate from (Qd):	= 4,383 gpm	= (16.6 m^3M)
Decant Duration (Td):	= 75 min	
Number Decants/Day:	= 8	
Time Between Start of Decants:	= 180 min	

POST-SBR EQUALIZATION VOLUME DETERMINATION

The volume required for equalization/storage shall be provided between the high and the low water levels of the basin(s). This Storage Volume (Vs) has been determined by the following:

Vs = [(Qd -(MDF x 694.4)] x Td = 191,746 gal = (25,634.5 ft^3) = (725.9 m^3)

The volumes determined in this summary reflect the minimum volumes necessary to achieve the desired results based upon the input provided to Aqua. If other hydraulic conditions exist that are not mentioned in this design summary or associated design notes, additional volume may be warranted.

Based upon liquid level inputs from each SBR reactor prior to decant, the rate of discharge from the Post-SBR Equalization basin shall be pre-determined to establish the proper number of pumps to be operated (or the correct valve position in the case of gravity flow). Level indication in the Post-SBR Equalization basin(s) shall override equipment operation.

POST-SBR EQUALIZATION BASIN DESIGN VALUES

No./Basin Geometry:	= 1 Rectangular Basin(s)				
Length of Basin:	= 33.0 ft	= (10.1 m)			
Width of Basin:	= 74.0 ft	= (22.6 m)			
Min. Water Depth:	= 1.5 ft	= (0.5 m)	**Min. Basin Vol. Basin:**	= 27,399.2 gal	= (103.7 m^3)
Max. Water Depth:	= 12.0 ft	= (3.7 m)	**Max. Basin Vol. Basin:**	= 219,145.0 gal	= (829.6 m^3)

POST-SBR EQUALIZATION EQUIPMENT CRITERIA

Mixing Energy with Diffusers:	= 0.1 SCFM/ft^2 of reactor	
SCFM Required to Mix:	= 293 SCFM/basin	= (498 Nm^3/hr/basin)
Max. Discharge Pressure:	= 5.8 PSIG	= (39.81 KPA)
Max. Flow Rate Required Basin:	= 1,826 gpm	= (6.914 m^3/min)
Avg. Power Required:	= 341.8 kW-hr/day	

Aerobic Digester - Design Summary

AEROBIC DIGESTER DESIGN PARAMETERS

Sludge Flowrate to the Digester	= 47,439.0 gal/day	= (179.6 m^3/day)
Inlet Sludge Concentration	= 1.00%	
Solids Loading to the Digester	= 3,956.4 lb/day	= (1,794.6 kg/day)
Inlet Volatile Solids Fraction	= 74.7%	

AEROBIC DIGESTER BASIN DESIGN VALUES

No./Basin Geometry:	= 1 Rectangular Basin(s)				
Length of Basin:	= 62 ft	= (18.9 m)			
Width of Basin:	= 74 ft	= (22.6 m)			
Min. Water Depth:	= 14.7 ft	= (4.5 m)	**Min. Basin Vol. Basin:**	= 504,478.2 gal	= (1,909.8 m^3)
Max. Water Depth:	= 21 ft	= (6.4 m)	**Max. Basin Vol. Basin:**	= 720,683.1 gal	= (2,728.3 m^3)

AEROBIC DIGESTER PROCESS DESIGN PARAMETERS

Solids Retention Time:	= 30.4 days	
Digester Design Temperature:	= 20 C	
Volatile Solids Destruction:	= 41.5%	
Digester Solids Concentration:	= 2%	
Oxygen Supplied for Digestion:	= 2 lbs O2 per lb VSS Destroyed	
Oxygen Distribution Per Basin:	= 100.0%	
Actual Oxygen Required:	= 2,453 lb/day	= (1,112.7 kg/day)
Volatile Percentage After Digestion:	= 63.3%	
Estimated Dry Solids to be Removed:	= 2,729.9 lb/day	= (1,238.3 kg/day)
Volume of Solids to be Removed:	= 16,366.3 gal/day	= (61.95 m^3/day)
Estimated Supernatant Volume:	= 216,204.9 gal/basin	= (818.42 m^3/basin)
Assumed Supernatant Duration:	= 180 minutes	
Calculated Supernatant Flow:	= 1,201.1 gpm	= (75.8 l/sec)

1. The Volatile Solids Destruction listed above shall be used for determination of the oxygen demand during summer conditions. It should be noted that the actual VSS destruction will be dependant upon digester inlet condition, temperature, and operating conditions.
2. The Digester Solids Concentration is reflected as an average concentration, assuming the operations include frequent settling and supernating practices.

AEROBIC DIGESTER EQUIPMENT CRITERIA

SCFM Required for O2 Demand:	= 1,236/basin	= (2,100 m^3/hr/basin)
Max. Discharge Pressure:	= 9.67 PSIG	= (66.72 KPA)
Mixing Energy with DDMs	= 40 HP/MG	= (7.88 W/m^3)
NPHP Provided:	= 40	= (29.8 kW)
Max. Flow Rate Required Basin:	= 500 gpm	= (1.893 m^3/min)
Avg. Power Required:	= 1,538.74 kW-hr/day	

AquaDisk® Tertiary Filtration - Design Summary

DESIGN INFLUENT CONDITIONS

Pre-Filter Treatment:	SBR		
Avg. Design Flow	= 2.10 MGD	= 1458.33 gpm	= 7949.36 m^3/day
Max Design Flow	= 2.63 MGD	= 1826.39 gpm	= 9955.63 m^3/day

The filtration system shall be designed based upon flow equalization after the SBR and prior to filtration.

AquaDisk FILTER RECOMMENDATION

Qty Of Filter Units Recommended	= 2
Number Of Disks Per Unit	= 4
Total Number Of Disks Recommended	= 8
Total Filter Area Provided	= 430.4 ft^2 = (39.99 m^2)
Filter Model Recommended	= AquaDisk Package: Model ADFSP-54 x 4E-PC
Filter Media Cloth Type	= OptiFiber PES-14®

AquaDisk FILTER CALCULATIONS

Filter Type:

Vertically Mounted Cloth Media Disks featuring automatically operated vacuum backwash . Tank shall include a hopper-bottom and solids removal manifold system.

Average Flow Conditions:

Average Hydraulic Loading
= Avg. Design Flow (gpm) / Recommended Filter Area (ft^2)
= 1458.3 / 430.4 ft^2
= 3.39 gpm/ft^2 (8.28 m/hr) at Avg. Flow

Maximum Flow Conditions:

Maximum Hydraulic Loading
= Max. Design Flow (gpm) / Recommended Filter Area (ft^2)
= 1826.4 / 430.4 ft^2
= 4.24 gpm/ft^2 (10.38 m/hr) at Max. Flow

Solids Loading:

Solids Loading Rate
= (lbs TSS/day at max flow and max TSS loading) / Recommended Filter Area (ft^2)
= 329 lbs/day / 430.4 ft^2
= 0.76 lbs. TSS /day/ft^2 (3.73 kg. TSS/day/m^2)

The above recommendation is based upon the provision to maintain a satisfactory hydraulic surface loading at 50% of the Maximum Design Flow with (1) unit out of service. The resultant hydraulic loading rate at 50% of the Maximum Design Flow is: 4.2 gpm / ft^2 = (10.4 m/hr)

AquaSBR

Influent Valves

2 Influent Valve(s) will be provided as follows:

- 12 inch diameter Milliken 601 electrically operated eccentric plug valve(s) with 125# flanged end connection, ASTM A-126 Class B cast iron body with welded in nickel seat, EPDM coated ductile iron plug, assembled and tested with an Auma, 115 VAC, 60 hertz, single phase open/close service electric actuator. Valve actuator includes compartment heater.

Mixers

2 AquaDDM Direct Drive Mixer(s) will be provided as follows:

- 40 HP Aqua-Aerobic Systems Endura Series Model FSS DDM Mixer(s).

Mixer Mooring

2 Mixer Cable Mooring System(s) consisting of:

- #4 AWG-four conductor electrical service cable(s).
- Aerial support tie(s).
- Electrical cable strain relief grip(s), 2 eye, wire mesh.
- 304 stainless steel cable.
- Maintenance mooring cable loop(s).
- Stainless steel mooring spring(s).
- Stainless steel anchors.

Decanters

2 Decanter assembly(ies) consisting of:

- 10x9 decanter(s) with fiberglass float, 304 stainless steel weir, galvanized restrained mooring frame, and painted steel power section with #14-10 conductor power cable.
- Decant pipe(s).
- 4" schedule 40 galvanized steel mooring post.
- 16 inch electrically operated butterfly valve(s) with actuator.

Transfer Pumps/Valves

2 Submersible Pump Assembly(ies) consisting of the following items:

- 5 HP Submersible Pump(s) with painted cast iron pump housing, discharge elbow, and multi-conductor electrical cable.
- Upper guide bar bracket(s).
- 6" Manual plug valve(s).
- 6 inch diameter swing check valve.
- 304 stainless steel guide bar(s).

Retrievable Fine Bubble Diffusers

20 Retrievable Fine Bubble Diffuser Assembly(ies) consisting of:

- 25 diffuser tubes consisting of two flexible EPDM porous membrane sheaths mounted on a rigid support pipe with 304 stainless steel band clamps.
- 304 stainless steel manifold weldment.
- 304 stainless steel leveling angles.
- 304 stainless steel leveling studs.
- Galvanized vertical support beam.
- Galvanized vertical air column assembly.
- Galvanized upper vertical beam and pulley assembly.
- Galvanized top support bracket.
- 3" EPDM flexible air line with stainless steel quick disconnect end fittings.
- Galvanized threaded flange.

- 3" manual isolation butterfly valve with cast iron body, EPDM seat, aluminum bronze disk and one-piece steel shaft.
- Quick disconnect cam lock adapter.
- 304 stainless steel adhesive anchors.
- Brace angles.

1 Diffuser Electric Winch(es) will be provided as follows:

- Portable electric winch.

Positive Displacement Blowers

3 Positive Displacement Blower Package(s), with each package consisting of:

- Positive Displacement Blower Package with common base, V-belt drive, enclosed drive guard, pressure gauge, pressure relief valve, and vibration pads.
- Stainless steel anchors.
- 125 HP motor with slide base.
- Blower startup by the blower packager is included.
- Inlet filter and inlet silencer.
- Discharge silencer, check valve, manual butterfly isolation valve, and flexible discharge connector.

3 Modular Blower Sound Enclosure(s) consisting of:

- Blower acoustical enclosure(s).

Air Valves

2 Air Control Valve(s) will be provided as follows:

- 10 inch electrically operated butterfly valve(s) with actuator.

Level Sensor Assemblies

2 Pressure Transducer Assembly(ies) each consisting of:

- Pressure transducer(s).
- Mounting bracket weldment(s).
- Transducer mounting pipe weldment(s).

2 Level Sensor Assembly(ies) will be provided as follows:

- Float switch(es).
- Float switch mounting bracket(s).
- Stainless steel anchors.

Instrumentation

2 Dissolved Oxygen Assembly(ies) consisting of:

- DO probe(s).

2 Process Controller(s) consisting of:

- Controller and display module(s).

AquaSBR: Post-Equalization

Transfer Pumps/Valves

3 Submersible pump assembly(ies) consisting of the following items:

- 10 HP Submersible Pump(s) with painted cast iron pump housing, discharge elbow, and multi-conductor electrical cable.
- 6" Manual plug valve(s).
- 6 inch diameter swing check valve.
- Upper guide bar bracket(s).
- 304 stainless steel guide bar(s).
- Stainless steel lifting chain(s).

Fixed Coarse Bubble Diffusers

1 Fixed Coarse Bubble Diffuser Assembly(ies) consisting of:

- 304 stainless steel drop pipe(s).
- 304 stainless stee manifold(s) with connection to drop pipe and air distribution header(s).
- Minimum 3" diameter 304 stainless steel air distributor(s).
- 304 stainless steel piping supports with vertical supports, clamps, adjusting mechanism and anchor bolts.
- Coarse bubble diffuser assemblies.s, adjusting mechanism and anchor bolts.
- Coarse bubble diffuser assemblies.

Positive Displacement Blowers

1 Positive Displacement Blower Package(s), with each package consisting of:

- Positive Displacement Blower Package with common base, V-belt drive, enclosed drive guard, pressure gauge, pressure relief valve, and vibration pads.
- Stainless steel anchors.
- 15 HP motor with slide base.
- Inlet filter and inlet silencer.
- Discharge silencer, check valve, manual butterfly isolation valve, and flexible discharge connector.

1 Modular Blower Sound Enclosure(s) consisting of:

- Blower acoustical enclosure(s).

Level Sensor Assemblies

1 Pressure Transducer Assembly(ies) each consisting of:

- Pressure transducer(s).
- Mounting bracket weldment(s).
- Transducer mounting pipe weldment(s).

1 Level Sensor Assembly(ies) will be provided as follows:

- Float switch(es).
- Float switch mounting bracket(s).
- Stainless steel anchors.

AquaSBR: Aerobic Digester

Mixers

1 AquaDDM Direct Drive Mixer(s) will be provided as follows:

- 40 HP Aqua-Aerobic Systems Endura Series Model FSS DDM Mixer(s).

Mixer Mooring

1 Mixer Restrained Mooring Assembly(ies) consisting of:

- Galvanized steel restrained mooring frame(s).
- #4 AWG-four conductor electrical service cable(s).
- Fiberglass electrical cable float(s) filled with closed cell polyurethane foam, complete with cable tie wraps.
- Electrical cable strain relief grip(s), 2 eye, wire mesh.
- 6" Schedule 40 galvanized steel restrained mooring post(s) with base plate.

Supernatant Withdrawal

1 Floating Weir Assembly(ies) consisting of:

- 8x7 Aqua-Aerobics floating weir(s) with fiberglass float, 304 stainless steel weir, galvanized restrained mooring frame, and painted steel base plate.
- Decant pipe(s).
- 4" schedule 40 galvanized restrained mooring post(s) with base plate.
- Manual plug valve(s).

Transfer Pumps/Valves

1 Submersible Pump Assembly(ies) consisting of the following items:

- 5 HP Submersible Pump(s) with painted cast iron pump housing, discharge elbow, and multi-conductor electrical cable.
- Upper guide bar bracket(s).
- 6" Manual plug valve(s).
- 6 inch diameter swing check valve.
- 304 stainless steel guide bar(s).

Retrievable Coarse Bubble Diffusers

4 Retrievable Coarse Bubble 10 Tube Diffuser Assembly(ies) consisting of:

- 316 L stainless steel wide band coarse bubble diffusers with Schedule 80 3/4" NPT male pipe thread connection with integral hex head nut.
- Galvanized manifold assembly.
- Galvanized vertical support beam.
- Galvanized upper vertical beam and pulley assembly with manual winch.
- Galvanized top support bracket.
- 3" EPDM flexible air line with stainless steel quick disconnect end fittings.
- Galvanized threaded flange.
- 3" manual isolation butterfly valve with cast iron body, EPDM seat, aluminum bronze disk and one-piece steel shaft.
- Quick disconnect cam lock adapter.
- 304 stainless steel adhesive anchors.

Positive Displacement Blowers

1 Positive Displacement Blower Package(s), with each package consisting of:

- Positive Displacement Blower Package with common base, V-belt drive, enclosed drive guard, pressure gauge, pressure relief valve, and vibration pads.
- Stainless steel anchors.
- 100 HP motor with slide base.
- Blower startup by the blower packager is included.
- Inlet filter and inlet silencer.
- Discharge silencer, check valve, manual butterfly isolation valve, and flexible discharge connector.

1 Modular Blower Sound Enclosure(s) consisting of:

- Blower acoustical enclosure(s).

Controls

Controls wo/Starters

1 Controls Package(s) will be provided as follows:

- NEMA 12 panel enclosure suitable for indoor installation and constructed of painted steel.
- Fuse(s) and fuse block(s).
- Compactlogix Processor.
- Operator interface(s).
- Remote access Ethernet modem(s).

Cloth Media Filters

AquaDisk Tanks/Basins

2 AquaDisk Model # ADFSP-54x4E-PC Package Filter Painted Steel Tank(s) consisting of:

- 4 Disk painted steel tank(s).
- 3" ball valve(s).

AquaDisk Centertube Assemblies

2 Centertube(s) consisting of:

- 304 stainless steel centertube weldment(s).
- Centertube driven sprocket(s).
- Dual wheel assembly(ies).

- Rider wheel bracket assembly(ies).
- Effluent seal plate weldment.
- Centertube bearing kit(s).
- Effluent centertube lip seal(s).
- Pile cloth media and non-corrosive support frame assemblies.
- Disk segment 304 stainless steel support rods.
- Media sealing gaskets.

2 Cloth set(s) will have the following feature:

- Cloth will be OptiFiber PES-14.

AquaDisk Drive Assemblies

2 Drive System(s) consisting of:

- Gearbox with motor.
- Drive sprocket(s).
- Drive chain(s) with pins.
- Stationary drive bracket weldment(s).
- Adjustable drive bracket weldment(s).
- Chain guard weldment(s).
- Warning label(s).

AquaDisk Backwash/Sludge Assemblies

2 Backwash System(s) consisting of:

- Backwash shoe assemblies.
- Backwash shoe support weldment(s).
- 1 1/2" flexible hose.
- Stainless steel backwash shoe springs.
- Hose clamps.

2 Backwash/Solids Waste Pump(s) consisting of:

- Backwash/waste pump(s).
- Stainless steel anchors.
- 0 to 15 psi pressure gauge(s).
- 0 to 30 inches mercury vacuum gauge(s).
- Throttling gate valve(s).
- 2" bronze 3 way ball valve(s).

AquaDisk Instrumentation

2 Pressure Transmitter(s) consisting of:

- Level transmitter(s).

2 Float Switch(es) consisting of:

- Float switch(es).

2 Vacuum Transmitter(s) consisting of:

- Vacuum transmitter(s).

AquaDisk Valves

2 Set(s) of Backwash Valves consisting of:

- 2" full port, three piece, stainless steel body ball valve(s), grooved end connections with single phase electric actuator(s). Valve / actuator combination shall be TCI / RCI (RCI, a division of Rotork).
- 2" flexible hose.
- Victaulic coupler(s).

2 Solids Waste Valve(s) consisting of:

- 2" full port, three piece, stainless steel body ball valve(s), grooved end connections with single phase electric actuator(s). Valve / actuator combination shall be TCI / RCI (RCI, a division of Rotork).
- 2" flexible hose.

- Victaulic coupler(s).

AquaDisk Controls w/Starters

2 Conduit Installation(s) consisting of:

- PVC conduit and fittings.

2 Control Panel(s) consisting of:

- NEMA 4X fiberglass enclosure(s).
- Circuit breaker with handle.
- Transformer(s).
- Fuses and fuse blocks.
- Line filter(s).
- GFI convenience outlet(s).
- Control relay(s).
- Selector switch(es).
- Indicating pilot light(s).
- Compactlogix Processor.
- Power supply(s).
- Input card(s)
- Output card(s).
- Analog input card(s).
- Ethernet switch(es).
- Operator interface(s).
- Power supply(ies).
- Motor starter(s).
- Terminal blocks.
- UL label(s).

Appendix 7: Aqua-Aerobic Systems Company Profile and Capabilities

COMPANY PROFILE AND CAPABILITIES

AQUA-AEROBIC SYSTEMS, INC.
A Metawater Company

GENERAL INFORMATION

ABOUT OUR COMPANY

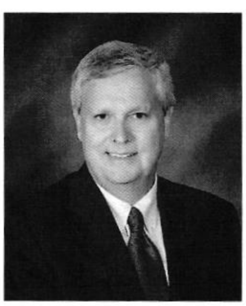
Aqua-Aerobic Systems is an applied engineering company specializing in adaptive water management solutions including aeration/mixing, biological processes, cloth media filtration, membranes, oxidation/disinfection and process control. Since 1969, the company has served the water and wastewater industry by providing both municipal and industrial customers around the world with advanced technologies and treatment solutions that easily adapt to changing demands. From enhanced nutrient removal to primary filtration, ultra low phosphorus removal or water reuse, Aqua-Aerobic has proven solutions that offer the lowest cost of ownership with life-time customer service.

MISSION

Make a Good Company a Great One!

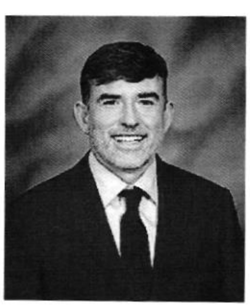
STRATEGIC INTENT

To build Aqua-Aerobic Systems, Inc. into a global technology leader that provides water treatment solutions for aeration/mixing, biological processes, filtration, disinfection, and aftermarket sales and services. To grow our company through technological leadership and partnerships with our customers. To uphold the values that have been the key to the success of Aqua-Aerobic Systems, Inc.



Peter G. Baumann, MBA
President & CEO

Kevin L. Heasley, EIT
Vice President, Operations



James Horton
Vice President, Process Group

Scott R. Willis
Vice President & Chief Financial Officer

FACILITY / TEST FACILITY

125,000 square feet office and manufacturing (25% office space and 75% manufacturing space)

250,000 gallon (950 m^3) test tank
55,000 gallon (209 m^3) test tank

RESEARCH & TECHNOLOGY CENTER

Located at the Rock River Water Reclamation District, this on-site research facility allows Aqua-Aerobic to conduct extensive research and testing on new products and process concepts.

REPRESENTATION

150 Sales Representatives in the US, Canada, Mexico and throughout the world. Most are graduate engineers and have design capabilities.

MARKETS

85% United States, Canada, Virgin Islands
15% International

INSTALLATIONS

More than 10,000 installations worldwide

ENGINEERING & TECHNICAL EXPERTISE

Aqua-Aerobic Systems, Inc. has a full staff of process, mechanical and electrical engineers, product managers, R&D staff, customer service and field service specialists.

Total Employees	200 (Office and Manufacturing)
Administration	9 Technical Managers & Officers
Process Group	1 Vice President 1 Director of Product Management
Cloth Media Filtration	1 Product Manager 1 Process Engineer
Biological Processes	3 Product Managers 2 Senior Process Engineers
Oxidation & Disinfection	1 Process Engineer
Domestic Sales	5 Regional Managers
International Sales	1 International Business Director
Industrial Sales	1 Industrial Business Director
Applications Engineering	1 Manager 1 Supervisor 6 Project Applications Engineers 9 Applications Engineers
Equipment & Services Group	1 Manager
Aeration & Mixing	2 Support Personnel
Customer Service/ Field Service	1 Director 1 Manager 13 Employee Outside Service Providers 16 Authorized Service Providers 3 Inside Personnel
Aftermarket Service	1 Director 7 Support Personnel
Operations	1 Vice President
Manufacturing	1 Manager 13 Shop Employees
Project Management	1 Director 1 Senior Project Manager 3 Project Managers
Research & Development	1 Director 1 Manager 6 Degreed Engineers/Support Personnel
Engineering	1 Director 4 Managers 1 Supervisor 38 Degreed Engineers/Support Personnel

FINANCIAL INFORMATION

Aqua-Aerobic Systems, Inc. is a well financed company with sales approaching $100 Million. Aqua-Aerobic Systems, Inc. also has extensive bonding capabilities.

Primary Banking	BMO Harris Bank, Rockford, Illinois
Auditors	RSM McGladrey, Rockford, Illinois

COMPANY HISTORY

In 1919, Rockford, Illinois was a rapidly growing riverfront community. Race Street, in the center of town, was home to Solem Machine Company, a respected manufacturer of woodworking equipment. As the city grew and thrived, so did the company. In 1958, larger facilities were needed and the company moved to 6306 N. Alpine Road.

In 1964, a group of investors, including Aqua-Aerobic Systems, Inc. President, John D. Brubaker (retired), purchased this well established manufacturing firm. With an eye toward the future, these investors considered the changing market needs and began expanding the product line. Soon after, the company was positioned to meet the demands of a new and growing environmental industry. In 1969, Solem Machine Company purchased Aqua-Aerobic Systems and began manufacturing its own line of surface aerators, the Aqua-Jet®. The Aqua-Jet® aerator quickly revolutionized the aerator industry, which led to the company phasing out its other product lines and shifting its focus exclusively to wastewater treatment. In 1976, that commitment resulted in Solem Machine Company's decision to legally adopt the name Aqua-Aerobic Systems, Inc.

In 1989, an additional 35,000 square feet of office and manufacturing space was constructed to accommodate the company's rapid growth. Due to increased requests for Aqua's technical seminars and an increase in local business due to growth of the Chicago suburbs, Aqua-Aerobic once again expanded its facilities. In April 2005, another 25,000 square feet was added to the existing building for new, state-of-the-art seminar facilities, more meeting areas, a formal lunchroom, and new offices. The exterior of the new building is environmentally friendly, utilizing glass to promote natural heat and lighting. The existing building was renovated and included conversion of 4,800 square feet of office space into manufacturing space. Existing office areas were also remodeled to coincide with the interior of the new building. Construction was complete in Spring 2006 and included space for company growth. The new high-tech facilities allow Aqua-Aerobic to accommodate larger seminar audiences and to provide remote webcasts.

In 2016, Aqua-Aerobic Systems merged with Metawater Co., Ltd., (Tokyo, Japan) an international company and leading supplier of advanced water and wastewater solutions. Currently, Aqua-Aerobic employs approximately 200 persons in manufacturing, engineering, sales/marketing and administration. The company's product line includes: surface aerators, diffused aeration systems, surface spray coolers, direct-drive mixers, batch reactor systems, cloth media filters, sand media filters, membrane systems, control panels, and process management control systems.

The company's dedication to research and development ensure the availability of products to meet unique applications and changing requirements. Aqua-Aerobic has gained recognition for quality products. Our commitment to environmental preservation and product integrity ensures continued success well into the 21st century.

TRADEMARKS & PRODUCT LINE

PATENTS

Aqua-Aerobic Systems, Inc. holds 45 patents for processes and equipment used in wastewater treatment systems.

PRODUCTS AND SYSTEMS

TYPICAL INDUSTRIES SERVED

- Pulp & Paper
- Food/Dairy
- Beverage
- Chemical
- Petroleum/Petrochemical
- Textile
- Energy/Utility
- Pharmaceutical

Aeration & Mixing

Aqua-Jet® Surface Mechanical Aerator
Aqua-Jet II® Contained Flow Aerator
AquaDDM® Direct-drive Mixer
ThermoFlo® Surface Spray Cooler
Endura® Series Limited Maintenance Product
OxyMix® Pure Oxygen Mixer
OxyStar® Aspirating Aerator
Fold-a-Float® Self-deploying Segmented Float
SAF-T Float® Safe Accessible Float Technology

Biological Processes

TurboStar™ Directional Mixer
Aqua MixAir® Aeration System
AquaCAM-D® Combination Aerator/Mixer/Decanter
AquaSBR® Sequencing Batch Reactor
AquaNereda® Aerobic Granular Sludge Technology
Aqua MSBR® Modified Sequencing Batch Reactor
AquaPASS® Phased Activated Sludge System
AquaEnsure® Ballast Decanter
Aqua EnduraTube® Fine-bubble Tube Diffuser
Aqua EnduraDisc® Fine-bubble Disc Diffuser
Aqua CB-24® Coarse-bubble Diffuser

Filtration

AquaDisk® Cloth Media Filter
AquaDiamond® Cloth Media Filter
AquaDrum® Cloth Media Filter
Aqua MiniDisk® Cloth Media Filter
Aqua MegaDisk® Cloth Media Filter
AquaPrime® Cloth Media Filter
AquaStorm® Cloth Media Filter
OptiComb® Backwash System
OptiFiber® Cloth Filtration Media
OptiFiber PES-13® Cloth Filtration Media
OptiFiber PA2-12® Cloth Filtration Media
OptiFiber PES-14® Cloth Filtration Media

Filtration (continued)

OptiFiber PF-14® Cloth Filtration Media
OptiFiber UFS-9™ Cloth Filtration Media
AquaABF® Automatic Backwash Filter

Membranes

AquaPRS™ PFAS Removal System
Aqua MultiBore® P-Series Polymeric Membrane System
Aqua MultiBore® C-Series Ceramic Membrane System
AquaMB Process® Multiple-Barrier Membrane System
Aqua-Aerobic® MBR Membrane Bioreactor System

Disinfection

Aqua ElectrOzone® F-Series Ozone Generator

Controls and Monitoring

IntelliPro® Monitoring and Control System

COMMUNITY INVOLVEMENT

Aqua-Aerobic Systems takes pride in its donations to over 100 organizations.

MEMBERSHIPS

American Membrane Technology Association (AMTA)
American Society for Quality
American Water Works Association (AWWA)
Business for the Bay
Illinois Chamber of Commerce
Illinois Manufacturers' Association
International Association on Water Quality (IAWQ)
International Desalination Association (IDA)
International Ozone Association (IOA)
National Association of Manufacturers
National Association of Clean Water Agencies
Technical Association of Pulp & Paper Industry (TAPPI)
Water Environment Federation (WEF)
Water & Wastewater Equipment Manufacturers Association (WWEMA)
WateReuse Association
Water Design-Build Council

RECOGNITIONS

Northern Illinois Business Hall of Fame
Exporter Continuing Excellence Award
Manufacturer of the Year Award from Rockford Chamber of Commerce
Special Congressional Recognition
WWEMA Diamond Award
Outstanding Corporation Award from the City of Rockford
Innovative Technology Award from WEF - 2008, 2011
Export Achievement Certificate from the U.S. Dept. of Commerce
Confluence Partnership Honors - Aqua-Rock Business Development Project (2018)

TRAINING AND EDUCATION

Structured training seminars are conducted by Aqua-Aerobic personnel monthly, May through September. More than 30 Consulting Engineers, Plant Operators, and Municipal Officials typically attend these training seminars each month to learn about Aqua-Aerobic equipment and systems. Aqua-Aerobic Systems' engineering staff attends company sponsored seminars and workshops relating to the wastewater industry.

OFFICERS

Peter Baumann, MBA
President & CEO
M.S. degree in Business Administration, B.S. degree in Engineering/University of Wisconsin - Milwaukee. Experience in wastewater since 1976, including 20 years at Envirex Corp.

Kevin L. Heasley, E.I.T.
Vice President, Operations
B.S. degree in Structural Design & Construction Technology/Penn State University, Harrisburg, EIT/State of Pennsylvania. Experience in large underground piping systems and wastewater since 1984.

James Horton
Vice President, Process Group
M.S. degree in Civil Engineering/Queensland University of Technology, Australia. B.S. degree in Chemical / Environmental Engineering/University of Queensland, Australia. Domestic and International experience in wastewater engineering since 1996 including positions with consulting engineer and specialty wastewater contractor.

Scott Willis
Vice President & Chief Financial Officer
M.S. degree in Business Administration and B.S. degree in Accounting/Northern Illinois University, DeKalb, IL AAS degree in Business/Rock Valley College, Rockford, IL.

ADMINISTRATIVE MANAGERS

Pamela Appino, P.H.R.
Director of Human Resources
B.S. degree in Administration of Criminal Justice/Bradley University, Peoria, IL. P.H.R. Certification from HR Certification Institute. Human Resources experience since 1991.

PROCESS GROUP

James Horton
Vice President, Process Group
M.S. degree in Civil Engineering/Queensland University of Technology, Australia. B.S. degree in Chemical / Environmental Engineering/University of Queensland, Australia. Domestic and International experience in wastewater engineering since 1996 including positions with consulting engineer and specialty wastewater contractor.

PRODUCT MANAGEMENT

Mark Hughes, P.E.
Director of Product Management
M.S. degree in Environmental and Water Resources Engineering/The University of Texas - Austin. B.S. degree in Civil Engineering/University of Iowa, Iowa City, IA. Experience in water/wastewater industry since 2008.

John Dyson
Product Manager - AquaPrime® / AquaStorm®
B.S. degree in Chemistry/Longwood College, Farmville, VA. Experience in water/wastewater industry since 1991.

Kristy Chycota
Process Engineer - Filtration
B.S. degree in Paper Engineering - Environmental Processes/Western Michigan University, Kalamazoo, MI. 2 years experience in Product Management at Englewood and 4 years at Beloit Corporation as a process engineer. Experience in water/wastewater industry since 2019.

Manuel de los Santos
Product Manager - Biological Processes
M.S. degree in Sanitary and Environmental Engineering/Universidad de Cantabria, Spain. B.S. degree in Civil Engineering/Universidad Nacional Pedro Henriquez Ureña, Santo Domingo, DR. Experience in water/wastewater industry since 2000.

Dave Lamphere
Product Manager-Membranes
Bachelor's Degree in Mechanical Engineering and an executive MBA from Rochester Institute of Technology (R.I.T). Experience in water/wastewater industry since 2005.

Dave Holland
Senior Process Engineer
A.A.S. degree in Technical writing/Rock Valley College, Rockford, IL. Experience in water/wastewater industry since 1979.

Joe Tardio
Product Manager - AquaNereda®
M.S. degree in Environmental & Waste Management/ Stony Brook University, Stony Brook, NY. B.A. degree in Biological Sciences & Chemistry/University of Delaware, Newark, DE. Experience in water/wastewater industry since 2006.

Brett Quimby
Senior Process Engineer - AquaNereda®
B.A. degree in Japanese Language and Literature/ University of Wisconsin, Madison, WI. Experience in water/wastewater industry since 2016.

Paula Dorn
Process Engineer
M.S. degree in Environmental Engineering, B.S. degree in Civil Engineering/University of Illinois, Urbana-Champaign, IL.Experience in water/wastewater industry since 2018.

MARKETING

Cheryl Kunz
Director of Marketing
B.A. degree in Business Management/Ashford University, Clinton, IA. Experience in water/wastewater industry and marketing since 1989.

APPLICATION ENGINEERING

Tamera Knapp
Application Engineering Manager
B.S. degree in Environmental Engineering/Michigan Technological University. B.S. degree in Environmental Liberal Arts/Northland College, Ashland, WI. Experience in water/wastewater industry since 2004.

Angelica Davila, E.I.T.
Application Engineering Supervisor
B.S. degree in Environmental Engineering/University of Central Florida. Experience in water/wastewater industry since 2013.

APPLICATION ENGINEERING (continued)

Tatiana Mazzei
Senior Project Application Engineer
M.S. degree in Engineering and minor in Production Engineering/University of Wisconsin-Milwaukee, WI. B.S. degree in Chemical Engineering/Universidad Metropolitana, Caracas, Venezuela Experience in water/wastewater industry since 2007.

Thea Davis
Project Application Engineer
B.S. degree in Chemical Engineering and M.S. degree in Chemical Engineering/Illinois Institute of Technology, Chicago, IL. Water Innovation Research Intern at Current Innovation. Experience in water/wastewater industry since 2019.

Rungrod Jittawattanarat, Ph.D.
Project Application Engineer
Ph.D. degree in Civil Engineering/Polytechic Institute of New York University. M.S. degree in Water and Wastewater Engineering/ Asia Institute of Technology, Thailand. B.S. degree in Environmental Engineering/ Chiang-Mai University,Thailand. Experience in water/ wastewater industry since 1990.

Harrison DeBruler
Project Application Engineer
B.S. degree in Mechanical Engineering/University of Alabama, Tuscaloosa, AL. Experience in water/ wastewater industry since 2021.

Nicholas Fortsas
Project Application Engineer
B.S. degree in Chemical Engineering/University of Illinois at Urbana-Champaign, Champaign, IL. Experience in water/wastewater industry since 2019.

Vedansh Gupta
Project Application Engineer
B.S. degree in Chemical Engineering/Malaviya National Institute of Technology, Jaipur, India. M.S. in Civil & Environmental Engineering/ University of Utah, Salt Lake City, UT. Experience in water/wastewater industry since 2018.

Yusuke Saito
Application Engineer
M.S. degree in Mechanical Engineering/Yokohama University, Japan. Experience in water/wastewater industry since 2018.

Xu Ye, E.I.T.
Application Engineer
M.S. degree in Environmental Engineering/University of Wisconsin, Madison, WI. B.S. degree in Chemistry/ Texas A&M University, College Station, TX. Experience in water/wastewater industry since 2016.

Mitchell McMahon
Ozone Application Engineer
B.A. degree in Mechanical Engineering/Northern Illinois University. Experience in water/wastewater industry since 2022.

Bryce Hatfield
Application Engineer
B.S. in Chemical Engineering at Rose-Hulman Institute of Technology. Experience in water/wastewater industry since 2022.

Takuya Sakomoto
Application Engineer
M.S. degree in Civil Engineering/Tottori University, Japan. Experience in water/wastewater industry since 2020.

Brian Huyge
Application Engineer
B.S. degree in Chemical Engineering/Rose-Hulman Institute of Technology. Experience in water/wastewater industry since 2023.

Natalie Watson
Application Engineer
B.S. degree in Chemical Engineering/University of Minnesota-Duluth. Experience in water/wastewater industry since 2023.

Kenta Cojerian
Application Engineer
B.S. degree in Chemical Engineering/University of Wisconsin-Madison. Experience in water/wastewater industry since 2023.

Nick Schiavo
Application Engineer
B.S. degree in Chemical Engineering/Michigan Technological University. Experience in water/ wastewater industry since 2023.

REGIONAL MANAGERS

Scott Kelly
Regional Sales Manager, West
B.S. degree in Chemical Engineering and Petroleum Refining/Colorado School of Mines, Golden, CO. Experience in water/wastewater industry since 1991.

Tom Miles
Regional Sales Manager, Northeast
B.S. degree in Chemical Engineering/Penn State University, State College, PA. Experience in water/wastewater industry since 1986.

Paul Nelson
Regional Sales Manager, Southeast
B.S. degree in Business and Economics/Elmhurst College, Elmhurst, IL. Experience in water/wastewater industry since 1978.

Steve Stanish
Regional Sales Manager, Midwest
B.A. degree in Business Administration/Washington & Jefferson College, Washington, PA. Experience in water/wastewater industry since 1996.

Jeff McCormick
Director of Industrial Sales
B.S. degree in Chemical Engineering/Grove City College, Grove City, PA. Experience in water/wastewater industry since 1985.

Dave Fisher
Director of International Business
B.S. degree in Civil Engineering and M.B. in Business Administration/Brigham Young University. Experience in water/wastewater industry since 1991.

Tatiana Mazzei
Regional Manager - Latin America
M.S. degree in Engineering and minor in Production Engineering/University of Wisconsin-Milwaukee, WI. B.S. degree in Chemical Engineering/Universidad Metropolitana, Caracas, Venezuela. Experience in water/wastewater industry since 2007.

OPERATIONS GROUP

Kevin L. Heasley, E.I.T.
Vice President, Operations
B.S. degree in Structural Design & Construction Technology/Penn State University, Harrisburg, EIT/State of Pennsylvania. Experience in large underground piping systems and water/wastewater industry since 1984.

PROJECT MANAGEMENT

Blake Hoffmann
Director, Project Management
B.S. degree in Business Management and Marketing/Edgewood College, Madison, WI. B.S degree in Mechanical Engineering/University of Wisconsin-Platteville, WI. Experience in water/wastewater industry since 2018.

Shawn Butterfield
Project Manager
A.A.S. degree in Science Engineering (Electronic/Electrical Drafting)/Wisconsin School of Electronics (now Herzing University). Experience in water/wastewater industry since 2018.

Tom Fenton
Senior Project Manager
A.A.S. degree in Civil Engineering/Williamsport College, Williamsport, PA. Experience in Project Management (including Accounting, Field Service, and Manufacturing) since 1994.

Traci Kreitzman
Project Manager
Attended Marquette University. Experience in Supply Chain and New Product Development since 1998.

Glorianne Nimmer
Project Manager
Experience in water/wastewater industry since 2016.

Stephen Yalung
Project Manager
A.A.S. degree in Design and Drafting/Illinois Valley Community College, Oglesby, IL. Experience in water/wastewater industry since 2019.

Jeff Alaniz
Project Manager
B.S. degree in Business Management/Saint Leo University, FL.

Jim Evans
Project Manager
B.S. degree in Marketing/Illinois State University.
Experience in customer service since 1992.

RESEARCH & DEVELOPMENT

Terrence Reid, P.E.
Director of Research & Development
M.S. degree in Product Design and Development/ Northwestern University, Evanston, IL. B.S. degree in Civil & Environmental Engineering/University of Wisconsin-Madison, WI. Experience in water/wastewater industry since 1989.

Joe Campanaro
Senior R&D Engineer
M.S. degree in Environmental Engineering/New York University, New York, NY. B.S. degree in Biology/Stony Brook University, Stony Brook, NY.

Darryl Gravagno
Senior Research & Development Engineer
B.S. degree in Environmental Engineering/University of Wisonconsin, Platteville, WI. A.A.S. degree in Science, Rock Valley College, Rockford, IL. Experience in water/ wastewater industry since 2015.

Chris Kurshinsky
Research & Development Technical Systems Supervisor
Experience with product development since 1995. Engineering Supervisor R&C Test Lab from 2010-2017 and named as inventor of several patents. Experience as Technical Center Supervisor in the automotive industry 1995-2010. Experience in water/wastewater industry since 2017.

Christopher Roenger
Research & Development Specialist
B.S. degree in Chemical Engineering/Iowa State University, Ames, IA.

ENGINEERING

Robert Wiegand
Engineering Director
M.B.A. degree/University of Wisconsin-Madison.
B.S degree in Electrical Engineering Technology/ Bradley University, Peoria, IL. 10+ years experience in paper industry with Beloit Corp. Experience in water/ wastewater industry since 2000.

ELECTRICAL STANDARDS

Gerald Schneider, P.E.
Electrical Standards Supervisor
B.S. degree in Electrical Engineering/University of Wisconsin, Madison, WI. Experience in water/ wastewater industry since 1989.

Mike Hevey
Senior Electrical Engineer
A.A.S. degree in Electromechanical Technology/ Chippewa Valley Technical College, Eau Claire, WI. 16+ years electrical controls engineering experience including control system and software validation and design, development and implementation of systems incorporating PLC, HMI, SCADA, hardware design, power distribution and MCC specification.

Aaron Halloway
Senior Electrical Designer
B.A. degrees in Physics and Mathematics/University of Wisconsin-Whitewater. Experience in electrical design since 2017.

Junji Sakashita
Services & Electrical Engineer
Attended the Hiroshima Institute of Technology, Hiroshima, Japan. Experience in the wastewater treatment industry, specifically Ozone, since 2011 at Fuji Electric Corp. of America/Metawater USA.

ELECTRICAL CONTRACT

Gary Lightfoot
Electrical Engineering Manager
A.A.S. degree in Electrical Technology/Rock Valley College, Rockford, IL. Experience in Electrical Engineering since 1978.

Mondi Anderson
Controls Engineer
B.S. degree in Computer Science/Neumont University, Salt Lake City, UT.Experience in water/wastewater industry since 1998.

Brian Pass
Electrical Design Engineer
A.A.S. degree in Electrical/Electronic Drafting/Herzing Institute of Technology, Madison, WI. Experience in water/wastewater industry since 2000.

ELECTRICAL STANDARDS (continued)

Kent Campbell
Electrical Engineer
Degree in Engineering Electronic Technician/Radio College of Canada (RCC), Toronto, Calanda. Experience in water/wastewater industry since 2019.

Brad Christian
Electrical Engineer
A.A.S degree Robotics/ Automation Technology, Indian Hills community College, Ottumwa, IA.

Bill Douglas
Electrical Designer
B.S. degree in Electrical Engineering/University of Wisconsin-Platteville. A.A.S. degree in Mathematics and Science/University of Wisconsin at Rock County. A.S. degree in Electronic/Electrical Drafting/Wisconsin School of Electronics. Experience in electrical engineering since 2003.

Chris Guntermann
Electrical Designer
Experience in wastewater/water industry since 2022.

Connor Johnson
Electrical Engineer
B.S. degree in Computer and Electrical Engineering/ University of Wisconsin-Stout. Experience in electrical engineering since 2022.

Dave Johnson
Senior Electrical Engineer
B.S. degree in Electrical Engineering/Milwaukee School of Engineering, Milwaukee, WI. Experience in water/ wastewater industry since 2000.

Jeff Johnson
Senior Electrical Designer
M.B.A. degree and B.S. degree in Electrical Engineering Technology/Northern Illinois University, DeKalb, IL. Experience in electrical engineering since 2003.

Deborah Lewis
Electrical Designer
Experience in water/wastewater industry since 2021.

Stephen Napadow
Electrical Designer
Experience in electrical design since 2003. Experience in water/wastewater industry since 2023.

Edi Schardl
Electrical Engineer
B.A. degree in Business Administration/SFB Rapperswil, Switzerland. B.S. degree in Electrical Engineering/ Juventus Engineering School Zürich, Switzerlad. Experience in programming and engineering since 1985.

Jeremy Try
Senior Electrical Engineer
B.S. degree in Electrical Engineering/Southern Illinois University, Carbondale, IL. A.A.S. degree in Engineering/ Rock Valley College, Rockford, IL. Experience in engineering since 1983.

MECHANICAL STANDARDS

David Smith
Mechanical Engineering Manager
B.S. degree in Mechanical Engineering/University of Wisconsin-Madison. Experience in wastewater since 2000. Experience in mechanical design engineering and development since 1986, including 4 years at Beloit Corporation. Received patents for tissue machine equipment.

Devon Bockhop
Mechanical Designer
A.A.S. degree in Drafting and Design/Morrison Institute of Technology, Morrison, IL. Experience in water/ wastewater industry since 2019.

Noah Dellamater
Mechanical Engineer
B.S. degree in Mechanical Engineering/Olivet Nazarene University, Bourbonnais, IL. Experience in water/ wastewater industry since 2019.

Michael McCormick
Senior Mechanical Engineer
B.S. degree in Mechanical Engineering/University of Wisconsin-Madison, WI. Experience in water/wastewater industry since 2010.

Mike Schmitz
Principal Engineer
B.S. degree in Mechanical Engineering/University of Wisconsin, Milwaukee, WI. Experience in water/ wastewater industry since 2008.

MECHANICAL STANDARDS (continued)

Brant Uppenkamp
Mechanical Designer
A.A.S. degree in Mechanical Design/Blackhawk Technical College. A.A.S. degree in Architectural Design/ Milwaukee Area Technical College. Experience in water/ wastewater industry since 2012.

MECHANICAL CONTRACT

Dan Durdan
Manager, Contract Engineering & Estimating
A.A.S. degree in Mechanical Engineering/IL Valley Community College, Oglesby, IL. Experience in water/ wastewater industry since 2005.

Tim Austin
Senior Mechanical Designer
A.A.S. degree in Computer Aided Mechanical Design/ Rock Valley College, Rockford, IL. Experience in design engineering since 1997.

Beth Bahr
Mechanical Designer
A.A.S. degree in Mechanical Engineering/Blackhawk Technical College, Janesville, WI. Experience in water/ wastewater industry since 2001.

Chris Carlson
Design Engineer
A.A.S degree in Engineering Technology-Design and Drafting/Morrison Institute of Technology, Morrison, IL. Experience in water/wastewater industry since 2007.

Scott Howarth
Senior Mechanical Designer
A.A.S. degree in Mechanical Drafting/Morrison Institute of Technology, Morrison, IL. Drafting experience since 2002.

Troy Lieb
Mechanical Designer
A.A.S. degrees in Mechanical Engineering Technology and Mechanical Design/Highland Community College, Freeport, IL. Experience in mechanical design since 2006.

Matthew Martineau
Mechanical Designer
M.S. degree in Engineering Technology/Purdue University, West Lafayette, IN. B.S. degree in Applied Manufacturing Technology/Northern Illinois University, DeKalb, IL. A.A.S. degree in Manufacturing Engineering Technology/Rock Valley College, Rockford, IL. A.O.S. degree in Computer-Aided Drafting/Hamilton Technical College, Davenport, IA. Experience in mechanical design since 2007. Experience in water/wastewater industry since 2022.

Joseph Massari
Design Engineer
A.A.S. degree in Machine Design Technology/Rock Valley College, Rockford, IL. Mechanical and design experience since 1979. Experience in water/wastewater industry since 2002.

Jeff McGee
Mechanical Designer
A.A.S. degree in Computer-Aided Design Technology/ Rock Valley College, Rockford, IL. Experience in mechanical design since 1987.

Alex Neisewander
Mechanical Designer
Experience in mechanical design since 2017. Experience in water/wastewater industry since 2023.

Joe Wakefield
Mechanical Designer
B.S. degree in Mechanical Engineering/Michigan Technological University, Houghton, MI. Experience in mechanical design since 1993.

Ray Watkins
Mechanical Designer
A.A.S. degrees for Mechanical Design and Industrial Design Technician/Blackhawk Technical College, Janesville, WI. Experience in mechanical design since 2005.

Bryce Worley
Mechanical Designer
Attended ITT Tech-online. Attended Morrison Institute of Technology, Morrison, IL. Experience in water/ wastewater industry since 2021.

ESTIMATING

Ali Groen
Cost Estimating Supervisor
A.A.S. degree in Construction Technology/Morrison Institute of Technology, Morrison, IL. Experience in water/wastewater industry since 2008.

Zach Dal Pra
Design Analyst
B.S. degree in Mechanical Engineering/Michigan Technological University, Houghton, MI. Experience in water/wastewater industry since 2023.

Todd Riding
Design Analyst
A.A.S. degree in Engineering Drafting and Design Technology/Utah Valley University, Orem, UT. Experience in water/wastewater industry since 2021.

Scott Tripp
Senior Design Analyst
Experience in Engineering since 1989. Experience in water/wastewater industry since 1995.

EQUIPMENT AND SERVICES GROUP

AERATION & MIXING

Loryn Martin
Product Manager - Aeration & Mixing Technologies
M.B.A. degree in Business Administration/University of Phoenix, Phoenix, AZ. B.A. degree in Communication with emphasis on Public Speaking/ Loyola University, Chicago, IL. A.A.S. degree/Rock Valley College, Rockford, IL. Experience in water/wastewater industry since 2013.

Zachery Swanson
Application Engineer
B.S. degree in Mechanical Engineering/Northern Illinois University, DeKalb, IL. Experience in water/wastewater industry since 2023.

CUSTOMER SERVICE

Stephanie Duchow
Director of Customer Service
A.S. degree of Rock Valley College. Experience in aftermarket and manufacturing customer service since 2014 including parts, service, repairs and retrofits.

Tyrone Pratt
Customer Service Manager
B.S. degree in Marketing/Southern Illinois University, Carbondale, IL. Experience in Field Service / Journeyman Electrician for industrial, commercial and residential since 1987.

Evan Price
Customer Service Process Specialist
M.S. degree and B.S. degree in Biological Systems Engineering/University of Wisconsin-Madison, WI. Experience in water/wastewater industry since 2018.

Michael Spragg
Technical Support Specialist
Experience with submarine maintenance for 20 years in the Navy. Experience as a Field Service Engineer for 13 years. Experience in water/wastewater industry since 2019.

John Mizik
Technical Support Specialist
Experience in water/wastewater industry since 2007.

Dean Woyak
Customer Service Process Specialist
B.S. degree in Water Resources/University of Wisconsin-Stevens Point. Experience in water/wastewater industry since 1994.

FIELD SERVICE

Curt Larson
Senior Field Service Specialist
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Benjamin Morton
Senior Field Service Specialist
PA DEP Wastewater Certificate. Experience in water/wastewater industry since 1998.

Tom Mowery
Senior Field Service Specialist
Experience in water/wastewater industry since 1996.

John Edelen
Field Service Specialist
B.S. degree in Science & Business Administration/University of Central Florida, Orlando, FL. Experience in Field Service since 1998.

FIELD SERVICE (continued)

Kacey King-McRae
Field Service Specialist
B.S. degree in Chemistry/Columbia College, Columbia, SC. Class 1 VA Wastewater License. 5.5 years Process Analyst at Alex Renew Enterprises. 1.5 years Operations Specialist at Arlington Water Pollution Control.Experience in water/wastewater industry since 2014.

Tony Smith
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Mike Rushing
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Edward Sanchez
Field Service Specialist
Certified in Mechanical Technology. Experience in field service since 2000.

Anthony Hart
Field Service Specialist
Cerfitied in Industrial Electrical. Experience in field service since 2019.

Aridane Rodriguez
Field Service Specialist
A.A.S. degrees in Graphic Design and Industrial Controls and Robotics/Dunwoody College of Technology. Experience in field service since 2018.

Camilo Rodriguez
Field Service Specialist
A.S. degree in Specialized Technology, Maintenance Electricity and Construction Technology/Triangle Tech Bethlehem, PA. Expereince in field service since 2018.

Jackson Blacketer
Field Service Specialist
A.A.S. degree in Instrumentation and Computerized Control Systems/Texas State Technical College, Waco, TX. Experience in electronics technology since 2015.

Jeff Wheaton III
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Christopher White
Field Service Specialist
Experience in water/wastewater industry since 2020.

Ohta Watson
Field Service Engineer
Kasukabe Technical High School Electricity Department, Japan. Experience in water/wastewater industry since 2010.

Raymond Ayala
Field Service Specialist
A.S. degree in Electronics. Experience in mechanical and electronic repair since 2003.

AFTERMARKET SERVICES

Paul Klebs
Director, Aftermarket Sales
B.S. degree in Chemistry/University of Wisconsin-Madison, WI. Graduate coursework in Environmental Studies/University of Wisconsin-Green Bay, WI. Certified operator in the state of Wisconsin. Experience in water/ wastewater industry since 1992.

Tim Lamont
Senior Aftermarket Sales Representative
B.S. degree in Geology/University of Illinois, Urbana-Champagin, IL. Experience in Sales and Customer Service since 2000. 5 years experience with retail and manufacturing in the electrical industry.

Michaela Villarreal
Senior Aftermarket Sales Representative
B.A. degree in Business Administration from Ashford University. Experience in Sales and Customer Service since 2010. Experience in Water and Wastewater Sales and Customer Service since 2018.

Denise Boehm
Aftermarket Sales Representative
Experience in Customer Service in HVAC, packaging and processing equipment and wastewater since 2000.

AFTERMARKET SERVICES (continued)

Jeff Ogle
Aftermarket External Sales Representative
B.S. degree from Western Illinois University, M.B.A. degree from Keller Graduate School of Management. Experience in water treatment industry, including operations, sales and management since 1991.

Leann Torrisi
Administration Assistant for Aftermarket Sales
Experience in administrative assistance since 2004.

Denise Uchacz
Aftermarket Sales Representative
Associates in Arts degree. Experience in water/wastewater industry since 2015 with previous experience in inside sales and customer service.

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Appendix 8: Questions to Evaluate Technology Selection for Lewes WWTF

QUESTIONS TO EVALUATE TECHNOLOGY SELECTION FOR LEWES WWTF

DESIGN PARAMETERS

Average Daily Flow: 1.75 mgd

Existing Site: 6 acres, MBR Process

Discharge: Lewes-Rehoboth Canal?

Influent: Primarily household

Parameter	Existing WWTF Performance [Sep '20 to Sep '21]			Permit Limit
	Min.	Ave.	Max.	
pH	7.1	**7.3**	7.5	6 - 9
Total Nitrogen (mg/L)	3.5	**5.6**	7.7	8 (daily av.)
Total Phosphorous (mg/L)	0.05	**0.59**	1.66	2 (daily av.)
Enterococcus (cfu/100 mL)	0.50	**0.89**	2.0	10 (daily av.); 104 (daily max)
Total Suspended Solids (TSS, mg/L)	0.25	**0.33**	0.40	15 (daily av.); 23 (daily max)
Biochemical Oxygen Demand (BOD, mg/L)	1.2	**1.2**	1.3	15 (daily av.); 23 (daily max)
Average Daily Flow (mgd)	0.39	**0.89**	1.69	-

QUESTIONS

Nereda Technology:

1. To meet or exceed these parameters consistently, what components besides the Nereda technology would be recommended?
2. Minimum space requirement / lot size - for full system
3. Lead time on design and build
4. Chemicals used – for full process train
5. ~~Number of operators to run the plant for all the above~~
6. Cost to build, including control systems and ancillary systems (e.g., headworks, polishing equipment, sludge dewatering)
7. Cost to operate
8. Headworks design (vs, e.g., for MBR system)
9. Number, configuration and size of tanks recommended
10. Disinfection system
11. Sludge management recommendations / options
12. Energy use
13. Loading of reactors: must we grow our own AGS? Pros and cons, is it more time consuming? Meeting permit limits in the interim period.
14. Polishing steps
15. Odour control

16. How many operators to run the full plant and how many need to be onsite versus remote? (Does the Delaware Code require more operators?)
17. Qualifications for operators
18. Training provided (vs assumed knowledge/qualifications) – and where and when
19. Other support provided
20. Resiliency to storms and to shock loading
21. Impact of saltwater intrusion into systems during high water events
22. What are the Alabama plant permit limits? Permit limits at other US Aqua-Nereda sites?
23. Utilization of existing equipment?

Advantages and disadvantages / compare to Sequencing Batch Reactor System for all the above

Questions for Sussex County:

24. Does Sussex County have the ability to take granular (i.e., Nereda) sludge?
25. What process technology do they intend to install at Wolfe Neck?
26. What are their current permit limits?
27. Update on how much of the leased property will remain off limits, or when they will know
28. Update on GHD study for ocean outfall