Moyock Central Sewer District Master Plan

Final Report

Currituck County, NC

October 2008

ARCADIS
Infrastructure, environment, buildings

Moyock Centralized Sewer Master Plan

Currituck County, NC

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Currituck County

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FIGURES

TABLES

ARCADIS

1. Introduction

Moyock Township represents one of the most densely populated areas in Currituck County. The increasing population has brought new businesses to the Moyock area, many of which currently rely on septic systems that are reported by NC DENR Department of Health to have a high failure rate. The Moyock area is characterized by soils with limited infiltration capacity and high groundwater tables, both of which hinder effective wastewater treatment and disposal. Coordinated and consolidated wastewater management in Currituck County, particularly in the Moyock service area, would allow for the County to plan for and accommodate additional growth while protecting and enhancing the County's water resources.

Currituck County has commissioned ARCADIS to determine the optimal means of providing central wastewater collection and treatment services to Moyock. This report summarizes ARCADIS' findings from the Moyock Centralized Sewer evaluation, presents the Moyock service area and current and future wastewater flow projections, identifies wastewater treatment alternatives, and also presents conceptual-level cost opinions for the recommended alternative. The cost opinion includes costs for primary wastewater collection and transmission system infrastructure, including regional pump stations, force mains, and a wastewater treatment facility. For this evaluation, it was assumed that ancillary infrastructure would be constructed by private entities or in separate public projects. Ancillary infrastructure that may be constructed by private entities includes new neighborhood wastewater transmission systems installed by the developer, or public projects to install sewer collection systems in areas having poorly performing septic systems.

This report also assists the County in evaluating alternatives for sewer rates and impact fees, and presents a 15 year financing plan for the recommended alternative.

2. Service Area Development and Wastewater Flow Projections

2.1 Service Area Development

In May 2008, ARCADIS met with Currituck County staff to outline the general service area boundaries and identify wastewater service needs within the service area, such as areas of environmental concern and proposed developments. Figure 1 illustrates the proposed service area for the Moyock Sewer District. The Moyock Sewer Service Area is based on the County's 2006 Land Use Plan which classifies areas as Full Service, Limited Service, Rural, or Conservation Areas. These classifications are intended to encourage development while maintaining the character of historic

Currituck County. The Proposed Service Area for the Moyock Sewer District incorporates the

- Full service areas
- Limited service areas
- Some areas designated as Rural which currently have proposed developments.

The service area does not include any conservation areas. The proposed range of service is from the Virginia/North Carolina state line south to the High Cotton Subdivision in Moyock.

The four land use classifications are defined in detail below:

Full Service Areas are those intended to host a broad range of infrastructure and services to encourage both residential and commercial development. Residential users are planned to include 2 or more units per acre and nonresidential uses include clusters of businesses serving both the immediate and more extensive market territories. Services in the areas include centralized water along with central wastewater treatment and disposal.

Limited Services areas provide primarily for residential development at low densities. Residences in these areas usually employ wells and private septic tanks, but limited municipal services such as fire protection, emergency services, and community water may be available along with centralized sewage collection and treatment systems. Base development density is 1 unit per acre but depends upon service facilities in place or planned.

Rural areas are intended to provide for agriculture, forestry, and other uses traditionally associated with a rural area. The rural class is a broad class of the several general land classes and constitutes the second largest land area on the Currituck County Land Classification Map. Preferred uses include very low-density dispersed development associated directly with forestry, agriculture, or other similar uses. Population densities are generally very low and development density is typically no more than 1 unit per 3 acres. In addition, any development in rural areas would be served by individual on-site water and septic.

Conservation area is defined as lands set aside to provide long-term management and protection of significant, limited, or irreplaceable areas. These areas are preserved

through limited development and through the exclusion of infrastructure and other community services. Areas included are Areas of Environmental Concern as defined in 15A NCAC 7H (e.g. coastal wetlands, estuarine and coastal shorelines, estuarine waters, public trust waters, etc.), freshwater wetland areas under the jurisdiction of the US Army Corps of Engineers' 404 Wetlands Permit Program, certain critical wildlife habitat areas as designated by the State Natural Heritage Program, and other environmentally significant coastal lands. Due to the low-lying nature of much of Currituck County, and the prevalence of wetlands, conservation areas are the most extensive of the four land classes.

The Moyock Sewer District is intended to primarily serve existing and new commercial customers along the NC 168 corridor and proposed residential developments. There are, however, exceptions where existing residential users will be permitted to connect to the central sewer. Residents allowed to hook on are those immediately adjacent to NC 168, and customers of the existing Newtown Sanitary District, a failing low pressure pipe (LPP) subsurface disposal system. All other existing residential developments (Quail Run, Ranchland, Camelia Acres, etc.) will be served by a future service area expansion. The Eagle Creek subdivision was not included in the service area, despite its "full service" classification, since it currently has central wastewater service.

The Moyock Commons Sanitary District is shown within the proposed Moyock Service Area, even though it too has central wastewater service. The district serves the Moyock Commons shopping center only. The County intends to incorporate the Moyock Commons Sanitary District into the new Moyock Sewer District.

2.2 Existing Wastewater Infrastructure

Most of the wastewater generated in Moyock is currently treated by on-site treatment systems (septic systems). There are, however, several existing sewer systems in the Moyock Area which serve private developments or commercial areas. Those systems are listed below.

- Moyock Commons Sewer District: 40,000 gpd extended aeration package plant with stet infiltration pond disposal. This system is currently permitted as low rate, but would be considered "high-rate" under the new 2T rule. This system currently serves an existing shopping center, with daily flows reported to be approximately 10,000 gpd. The plant was replaced in its entirety in November 2006 and the system faces no compliance issues.

The Moyock Commons WWTP will continue to operate during Phase 1. Eventually, the Moyock Commons Sanitary District will be incorporated in the new Moyock Sanitary District.

The Moyock Commons WWTP site is severely spatially limited which greatly reduces the possibility of major expansions to treatment and/or disposal.

- Newtown Sewer District: Septic tank effluent pump (STEP) wastewater collection system with a 15,000 gpd LPP subsurface soil treatment and dispersal system. This system currently serves an existing residential community, with flow reported to be around 10,000 gpd.

  The STEP-LPP system at Newtown is a land-intensive, low-technology methodology for wastewater management that does not provide a high level of treatment sufficient for larger flow rates. Additionally, it appears that the treatment capabilities of the soil treatment unit may be limited, as down gradient monitoring wells around the LPP system periodically exceed groundwater standards for nitrate-nitrogen. Any expansion of the design flow for this system would require advanced pretreatment. The Newtown site is 8 acres and disposal capacity may be quite limited.

  ARCADIS evaluated the Newtown Sewer District for renovation and expansion possibilities, and four options were addressed in a memo to the County, dated January 14, 2008. The memo included the following:

  Option 1. Upgrade existing pumps and controls for 15,000 gallon per day system. This option would involve decommissioning the existing tanks, pumps and controls and installing a new 15,000-gallon septic/surge tank, 15,000-gallon pump tank, four (4) 10 hp Myers WHV4 pumps (same as existing pumps but with larger motor and impeller to deliver more flow), timer-based, alternating quadruplex dosing control system and associated pipes, valves, fittings, etc. If option 1 is to be used in conjunction with Options 3 or 4 (adding pretreatment) upfront or in the foreseeable future, then an additional 5,000-gallon pump tank ("final dosing tank") and a standard float-based duplex pumping system would also be included to avoid having to relocate pumps and controls after the addition of pretreatment.

  Option 2. Upgrade existing pumps and controls for future 30,000 gallon per day system. This option would involve decommissioning the existing tanks, pumps and controls and installing a new 30,000-gallon septic/surge

tank, 30,000-gallon pump tank, four (4) 10 hp Myers WHV4 pumps (same as existing pumps but with larger motor and impeller to deliver more flow), timer-based, alternating quadruplex dosing control system and associated pipes, valves, fittings, etc. If option 2 is to be used in conjunction with Options 3 or 4 (adding pretreatment) upfront or in the foreseeable future, then an additional 5,000-gallon pump tank ("final dosing tank") and a standard float-based duplex pumping system would also be included to avoid having to relocate pumps and controls after the addition of pretreatment.

Option 3. Add 15,000 gallon per day pretreatment system with nitrogen removal. This option would involve adding a 15,000-gpd pretreatment system to meet an effluent total nitrogen (TN) limit of 10 mg/l (the groundwater standard). This would essentially "solve" the nitrogen problem at the site for the County, insomuch as any future groundwater excedences could not be attributed to the wastewater system, although existing excedences could remain an issue and may require remediation or investigation to determine the source of the nitrogen with certainty. This option would be conducted either in conjunction with or following Options 1 or 2 above.

Option 4. Add 30,000 gallon per day pretreatment system with nitrogen removal. As in Option 3, this option would involve adding a 30,000-gpd pretreatment system to meet an effluent total nitrogen (TN) limit of 10 mg/l (the groundwater standard), with the considerations listed above. This option would also allow for a rerating of the system to double its design flow to 30,000 gallons per day without having to expand or modify the low pressure pipe drainfields. This option additionally includes a subcontract for the additional soil/site evaluation work necessary to justify the flow increase. This option would be conducted either in conjunction with or following Option 2 above.

Budgetary costs were estimated for each of the four options and are shown below.

Table 1. Newtown Expansion Cost Opinions

Option 1	No future pretreatment	$125,000
Option 2	With future pretreatment	$180,000
Option 3	After Options 1 or 2 have been implemented	$325,000
Option 4	After Option 2 has been implemented	$910,000

Following the Newtown evaluation, the County opted to abandon the system and incorporate the Newtown Sanitary District into the new Moyock centralized system.

- Eagle Creek Subdivision: Vacuum collection system with a 300,000 gpd denitrification plant to serve 400-home residential development. Re-claimed water is disposed of via irrigation on the Eagle Creek Golf Course. The system currently treats approximately 60,000 gpd.

  The owner of the Eagle Creek Subdivision is not interested in accepting and treating wastewater from off-site locations at this time, nor is he willing to dispose of additional wastewater effluent on the golf course.

2.3 Wastewater Flow Projection Analysis

Flow projections within the Moyock service area were estimated using existing and potential development. Prior to flow projection analysis, the Moyock service area was sub-divided into 19 collection areas as shown on Figure 2. These areas include proposed residential and commercial developments, undeveloped parcels (classified as full service or limited service), and existing subdivisions and commercial properties (currently relying on septic systems).

2.3.1 Existing Development

Existing developments, with the exception of the Newtown Sanitary District, will not be served by Phase I of the Moyock Sewer System. As mentioned previously, the system will initially serve only existing commercial, existing residential, and proposed residential/commercial development, and existing residential along NC 168. Future phases will expand wastewater collection to areas such as Ranchland, Quail Run, and Camellia Acres (see Figure 2).

Flow projections for existing developments were estimated by multiplying the developable acreage of each site by a wastewater flow rate. It was assumed that 65% of the total area had been developed and that the other 35% was set aside for roadways, open space, etc. A wastewater flow rate of 360 gpd was used based on the wastewater design flow rates provided in the NCAC 2T Rules (15A NCAC 02T .0114(b)). That flow rate was applied on a per acre basis (360 gpd/acre), given the size of existing residential lots.

Moyock has approximately 85 existing commercial water customers. Although commitments from existing customers have not been obtained, it was assumed that 75% are expected to connect to central sewer once available. The largest consumers in Moyock are listed in Table 2, below. Water demands in 2007 averaged approximately 28,000 gpd. Wastewater flows were estimated to be approximately 85% of water demands.

Table 2. Largest Existing Commercial Customers in Moyock

Customer Name	Estimated Average Daily Wastewater Flow[1] (gpd)
BORDER STATION	5,526
LGI ENERGY SOLUTIONS INC	2,053
SOUTHLAND TRADE CORP.	1,707
MOYOCK PRO-WASH	1,626
SOUTHLAND TRADE CORP.	1,576
EL POTRILLO MEXICAN RESTAURANT	1,058
LSD LAND COMPANY LLC	995
FOOD LION LLC	916
ANDY'S CHEESESTEAKS	807
LU, FA N	763
MOYOCK UNITED METHODIST CHURCH	570
AFFORDABLE CARE INC.	558

1. Wastewater flows estimated based on water billing records.

2.3.2 Future Development

All undeveloped parcels within the proposed service area were considered developable, and future wastewater flows were determined using acreage and land classification. Total area was calculated for each of the undeveloped sub-divided sections, and 65% of the area was considered developable, similar to the method described in section 2.3.1. It was assumed that each area would be developed with 80% residential and 20% commercial occupancy. A wastewater unit flow rate, in gallons per day per acre (gpd/acre) was applied to each collection area to yield a respective wastewater flow.

The flow rates and assumptions utilized during the flow development phase are described below.

1. Commercial = 880 gpd/acre. "Design daily flow rates for proposed non-residential developments where the types of use and occupancy are not known shall be designed for a minimum of 880 gallons per acre or the applicant shall specify an anticipated flow based upon anticipated or potential uses." (15A NCAC 02T .0114(d)).

2. Residential (Full Service) = 900 gpd/acre. Currituck County's 2006 Land Use Plan states that full service base development density is 2 units per acre, but may be increased to 4 units per acre depending on services available and impacts to the surrounding area. Assuming 2.5 bedrooms per unit, and a wastewater flow rate of 120 gpd/bedroom, total average day flows may range from 600 to 1,200 gpd/acre. The mean of 900 gpd/acre was used.

3. Limited Service/Low Density = 375 gpd/acre. Currituck County's 2006 Land Use Plan states that limited service/low density base development density is 1 unit per acre, but may be increased to 1.5 units per acre depending on services available and impacts to the surrounding area. Assuming 2.5 bedrooms per unit, and a wastewater flow rate of 120 gpd/bedroom, total average day flows may range from 300 to 450 gpd/acre. The mean of 375 gpd/acre was used.

For each proposed development, wastewater flow estimates were obtained from the respective developer or designer, or from Currituck County staff. Build-out flows were provided for Currituck Reserve, High Cotton Towne Center, Shingle Landing, and other commercial and residential developments located on the US Hwy 168 corridor. At the time this report was published, the developer of Shingle Landing had decided to proceed with on-site wastewater management and indicated that the development may not join the Moyock Sewer District.

Table 3 provides the estimated average day wastewater flow service for build-out of the Moyock central sewer system. Flows from the Newtown Sanitary District have been incorporated since this system currently experiences high nitrates and improvements to Newtown were not considered cost-effective. Build-out flow, not including other existing residential areas, is expected to reach approximately 2.3 mgd.

Table 3. Moyock Sewer Estimated Flows

Area ID	Development	Total Area (acre)	Estimated Developable Area (acre)[1]	Residential Wastewater Flow (gpd)	Commercial Wastewater Flow (gpd)	Estimated Buildout Wastewater Flow (gpd)
1	Currituck Reserve	468	468	287,760	47,500	352,023
2	High Cotton Towne Center	13	8	0	51,589	51,589
3	Northridge & Southridge	133	86	190,000	35,000	225,000
4	Shingle Landing	46	30	31,680	1,740	33,420
5	Moyock Commons SD	50	32.3	NA	28,417	40,000
6	Low Density Development	287	187	69,944	NA	69,944
7	Low Density Development	223	145	54,432	NA	54,432
10	Commercial	196	127	NA	111,923	111,923
11	Future Commercial/Residential	330	215	154,501	37,767	192,268
12	Future Commercial/Residential	119	77	55,725	13,622	69,346
13	Future Commercial/Residential	220	143	103,105	25,203	128,309
14	Future Commercial/Residential	1,591	1,035	744,817	182,066	926,884
15	Commercial	95	62		54,197	54,197
16	Newtown Sanitary District - Residential	83	54	15,000	NA	15,000
	Total Estimated Flow (excluding existing residential areas)	3,854	2,669	1,706,964	589,025	**2,324,335**
8	Existing Residential - Ranchland	463	301	108,384	NA	108,384
9	Existing Residential - Quail Run	254	165	59,464	NA	59,464
17	Existing Residential - Old South Landing	38	25	8,876	NA	8,876
18	Existing Residential - Juniper Ridge	69	45	16,141	NA	16,141
19	Existing Residential - North Point	109	71	25,396	NA	25,396
	Total Estimated Flow (including existing residential area)	4,787	3,275	1,925,225	589,025	**2,542,596**

1. Estimated Developable Area assumes that 35% of Total Area is set aside for roadways, open space, etc.; unless specified differently by developer.

2.3.3 Moyock Sewer Phasing

Projected flows for Phase 1 of the Moyock Centralized Sewer System are provided in Tables 4 and 5. Phasing information was collected for the proposed commercial and residential planned units developments (PUDs) for build-out of Phase I, and Year 1 flows. Table 4 presents the initial plans of the PUDs listed and assumes that the Moyock Commons WWTP remains in service during the initial phases of the Moyock Centralized Sewer System.

It was assumed that 75% of the existing commercial properties located along US Hwy 168 would connect to central sewer, with one-third of the connections being made in the first year. The number of existing customers willing to connect to the Moyock Sewer System is not known. It is recommended that the County gauge interest by issuing a letter to existing customers and requesting that interested parties respond, so that a better accounting of existing customers can be available for planning.

A reserve capacity of 26,000 gpd was included for future commercial development. Flows during year 1 are estimated to be approximately 51,750 gpd, and are expected to reach 200,000 gpd at the end of Phase I.

Table 4. Moyock Sewer Flow Demands for Phase 1

Use	Proposed Phase I Build-out Flow (gpd)	Estimated 1st Year Flow (gpd)
Existing Commercial	15,000[1]	5,000
Newtown Sanitary District	12,000	10,000
Reserve Capacity	26,000	
SUBTOTAL	***53,000***	***21,000***
High Cotton Towne Center	52,000	13,000
Currituck Reserve	95,000	23,750
PUD SUBTOTAL	***147,000***	***36,750***
Total Proposed Flows	**200,000**	**51,750**

[1]Assumes 75% of existing commercial businesses connect to Moyock Sewer System

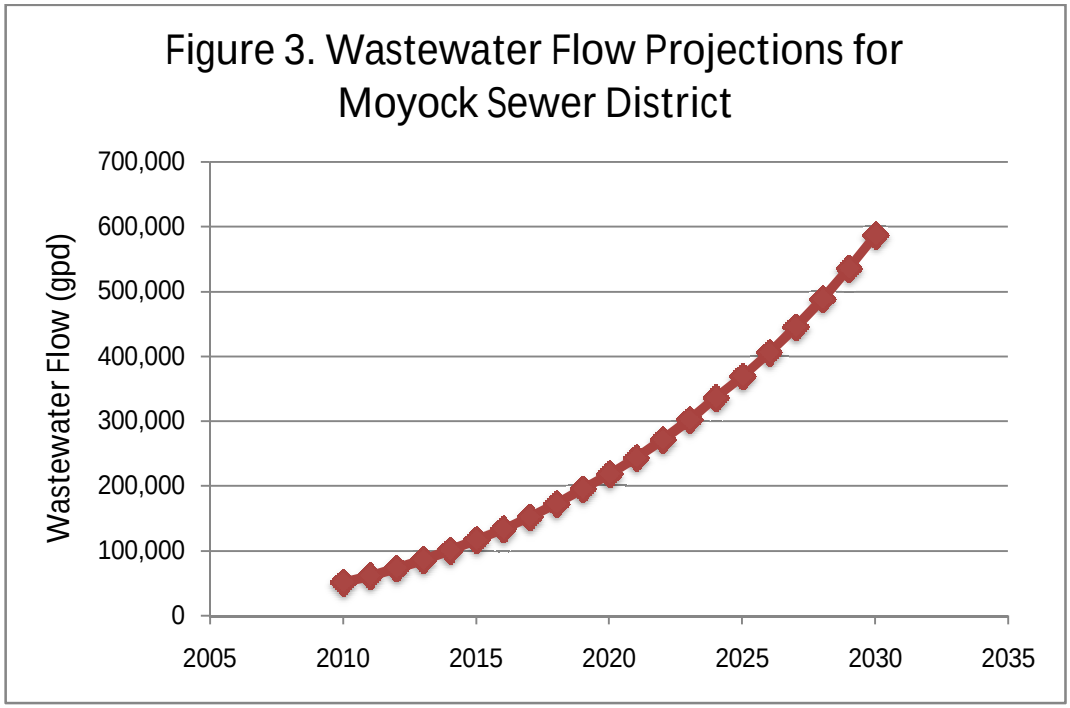
The Currituck County Planning Department provided historical growth data and expected growth percentages for the County in its entirety through 2025. From years 2010 to 2015, the county is expected to grow at a rate of approximately 10% per year. Growth percentages from 2015 to 2020 are expected to be approximately 9%, and approximately 8% from 2020 to 2025. Central sewer service is expected to attract

additional commercial development; therefore, a slightly higher growth rate was applied to the Moyock area.

Wastewater flows are projected to increase from 51,750 gpd in 2010 to approximately 587,200 gpd by 2030. According to the projections, the Phase 1 build-out will occur around year 2019 (see Table 5 and Figure 3).

Table 5. Moyock Sewer District Wastewater Flow Projections

Year	Total Flow (gpd)	Annual Increase in Flow (gpd)	ERCs (at 250 gpd)	Annual Increase in ERCs per Year
2010	51,750		207	207
2011	62,100	10,350	248	41
2012	73,600	11,500	295	46
2013	86,600	13,000	346	52
2014	101,100	14,500	404	58
2015	117,300	16,200	469	65
2016	134,000	16,700	536	67
2017	152,500	18,500	610	74
2018	173,000	20,500	692	82
2019	195,800	22,800	783	91
2020	218,800	23,000	875	92
2021	244,100	25,300	977	101
2022	272,000	27,900	1,088	111
2023	302,600	30,600	1,210	122
2024	336,300	33,700	1,345	135
2025	369,600	33,300	1,479	133
2026	406,000	36,400	1,624	145
2027	445,600	39,600	1,782	158
2028	488,800	43,200	1,955	173
2029	535,900	47,100	2,144	188
2030	587,200	51,300	2,349	205



3. Evaluation of Wastewater Collection Alternatives for the Moyock Sewer Service Area

Several collection system alternatives were evaluated for the Moyock Sewer District including gravity, pressure, and vacuum systems. Each option is discussed below. Cost estimates including capital costs and O&M costs are included at the end of Section 3.

3.1 Gravity Collection

Conventional wastewater collection systems (gravity systems) transport sewage through a buried piping network installed on a slope to facilitate gravity drainage. The systems are generally reliable and consume no power, allowing for low-cost conveyance to a central treatment facility. However, flat topography and high groundwater levels, both present in Moyock, significantly increase installation costs by requiring dewatering, and either deep excavations and/or a significant number of lift stations. Manholes and other sewer appurtenances add substantial costs to gravity systems.

Operation and maintenance costs of gravity systems are typically low compared to other collection systems; however, shallow groundwater (in Moyock) could lead to significant infiltration and inflow, depending upon the design and specifications used for pipe installation, manhole waterproofing, etc. Infiltration and inflow (I/I) can result in higher wastewater flows, particularly peak flows, to the treatment facility, which could have a negative effect on plant operations and increased treatment costs. Therefore, an area-wide gravity collection system throughout Moyock is not viewed as the most desirable option and is not recommended. It may be possible, however, to have centralized gravity systems within developments and then pump into a common force main along NC 168.

3.2 Pressure System Collection

Pressure systems offer several advantages over gravity systems. They do not require pipe slope, allowing the pipe to be installed with shallower excavations, and typically have limited groundwater influence due to infiltration and inflow. Consequently, pipe installation costs are minimized, and treatment costs are reduced as less sewage is conveyed to the wastewater facility. Pipe diameters used with pressure systems are generally smaller than gravity pipes, and are constructed of PVC, and thus, initial capital costs for pressure system can be lower than gravity systems.

Pressure systems rely on pumps to convey sewage to a common force main, allowing piping to follow the topography and also greatly reducing the possibility of infiltration and inflow. Pressure systems are classified as either septic tank effluent pump (STEP) systems, or grinder pump systems. STEP systems simply pump effluent from a septic tank into a force main, while a grinder pump system pulverizes sewage entering a wetwell and pumps it to a force main. It is possible that a hybrid of the two systems could be used in Moyock, given the fact that some existing residents and businesses have septic tanks.

The lower capital costs of pressure systems are tempered by the associated installation and O&M costs for wetwell pumps and major pump stations. A wetwell with grinder or effluent pump is installed at every one or two connections (home or business), requiring an excavation and an electrical service to the pump. Additionally, the installation and maintenance of pumps presents problems of access to private property, unless each is located in the right-of-way. Easements from each customer would have to be obtained for service requirements.

Operation and maintenance of pressure systems can often be time consuming for operations personnel, as pumps will routinely clog with sewage causing pump failure.

It is estimated that grinder pumps in a typical residential collection system are replaced every 10 years on average. Major pump stations, used to direct flow towards the wastewater facility, will need major repair or replacement after approximately 15-20 years of service.

3.3 Vacuum System Collection

Vacuum systems are the third alternative for the Moyock sewage collection system. Vacuum systems utilize suction to draw sewage to regional vacuum stations which then pump to a central force main. The regional vacuum lines are sized similarly to those of a pressure system (smaller than a comparable gravity system), and are installed at a shallow depth of approximately 3-5 feet. The small pipe size and shallow excavation results in low installation costs and limited infiltration and inflow of groundwater. Vacuum system piping also follow the topography of the land to an extent, making them well suited for areas such Moyock. These systems have limited ability to transport wastewater uphill and do not perform well in hilly environments.

Vacuum systems require that a series of vacuum pits be installed either in the right-of-way adjacent to a customer, or on a customer's property. These pits do not require electricity, as the vacuum valves contained inside are pneumatically operated. Electricity is only required at the vacuum stations to power blowers (vacuum pumps) and sewage pumps. The pits receive sewage via gravity from up to four users. The pneumatic valve opens once the pit is full and the wastewater plug enters the main. The initial force of the vacuum taking up the sewage is usually enough to break up any solids in the wastewater. If blockage occurs or maintenance is required, repairs are generally easy and exposure to sewage can be avoided.

Vacuum valves need to be rebuilt typically every 5-7 years to ensure a proper seal is maintained and vacuum pressure is not lost. Rebuilding a valve consists of replacing seals, O-rings, and lubricating valve shafts which takes minimal effort. If regular maintenance is not performed, a line may develop a leak which can affect the entire vacuum system. It is important that staff be well trained and that vacuum pumps at the central station are checked and gauge readings are taken daily. If a leak should occur, vacuum in the system will drop and sections of the system can be isolated to repair piping or valves. With a well monitored system, vacuum maintenance can be an easier alternative than caring for individual grinder stations, and a much cheaper option as well.

Infiltration and inflow in vacuum systems is nearly non-existent. It is not the result of superior fittings or gaskets, but rather the functionality of the system. A system that is

not airtight will quickly be noticed as vacuum readings drop. Damaged piping, open valves, etc. can be isolated and infiltration can therefore be limited. If pipe failure or breakage should occur, sewage spill and contamination to surrounding areas is highly unlikely. This cannot be said for pressure or gravity systems. Vacuum piping from valve pits is laid in a saw-tooth pattern and slopes slightly towards the vacuum station, ensuring a proper vacuum at both ends of the line. The lack of pressure on the line, and saw-tooth pattern does not allow for major sewage spills.

Vacuum collection systems are vendor designed. Vacuum system design does not follow standard engineering practices for hydraulics, but rather are designed based on empirical data. A conceptual system layout has been provided by AIRVAC, Inc. and is shown on Figure 4.

3.4 Collection System Summary

Cost opinions have been calculated for each collection system alternative. For each option, the proposed Currituck Reserve layout was used to estimate the amount of infrastructure required for new developments (i.e. piping, pump stations, etc.). A cost per acre was then calculated and applied to all undeveloped tracts. Vacuum collection system costs are estimated to have significantly lower costs compared to gravity and pressure systems and is the recommended option for the Moyock Sewer District.

Table 6. Collection System Cost Comparison

Collection System	Build-out Costs	Annual O&M Costs[1]
Gravity	$96,000,000	$253,000
Pressure	$85,000,000	$572,000
Vacuum	$24,500,000	$374,000

[1]Annual O&M costs represent finances to be applied following the first year of operation. It should be assumed that O&M costs will increase approximately 3% annually.

4. Evaluation of Wastewater Disposal Alternatives

4.1 High Rate Infiltration

Rapid infiltration is a method of effluent disposal that requires much less land than conventional land application systems. Rapid infiltration systems involve the application of highly treated wastewater effluent into shallow basins constructed in deep and permeable deposits of highly porous soils. High rate infiltration systems are typically classified by the presence of groundwater lowering devices (i.e. well pumps,

ditches, etc.) which artificially lower the head in an infiltration pond, allowing a higher rate of disposal.

Roanoke (Ro) soils dominate north Currituck County and most of the Moyock area, as shown in Figure 5. Roanoke is classified as a poorly drained soil with a loamy surface layer and a loamy or clayey subsoil, making it poorly suited for high rate disposal. The only two soils in Moyock which are likely to allow subsurface disposal (without groundwater lowering devices) are Bojac (BoA) and State (StA) soils, both of which are present in small pockets only. Bojac is a well-drained loamy sand and State soils consist of fine loamy sand. Borings in Moyock have suggested that excavating the "overburden" from Roanoke-laden areas may uncover more permeable sandy soils, better suited for high rate wastewater disposal. Therefore, additional excavation may be required at many of the possible disposal locations in Moyock.

In non-coastal areas (which Moyock is considered by DWQ), high rate infiltration is defined as an application rate that exceeds 1.50 inches of wastewater effluent per week (0.134 gallons per day per square foot). In North Carolina, there are 34 existing rapid infiltration systems, located primarily in coastal counties. Currituck County currently owns two high rate infiltrations systems; one which serves the Moyock Commons Sanitary District, and another at the Ocean Sands WWTP. The Ocean Sands system is allowed to dispose of wastewater in excess of 1.75 inches of wastewater effluent per week due to its "coastal area" classification. The Ocean Sands WWTP applies treated effluent at a loading rate of 7.65 gpd/ft^2, whereas the Moyock Commons WWTP disposes approximately 0.7 gpd/ft^2. Infiltration rates are typically less than those at the Ocean Sands WWTP and must be determined by a licensed soil scientist. Site selection requires analysis of soil depth, permeability, and depth to groundwater. Higher infiltration rates and reduced buffer requirements can be obtained by treating to reuse quality. Table 7 shows the effluent quality requirements for high rate infiltration systems, as well as other common wastewater disposal practices.

4.2 Low Rate Infiltration

Low rate infiltration systems typically utilize a lower surface overflow or loading rate than high-rate infiltration ponds. Low-rate infiltration ponds do not have groundwater dewatering for hydraulic control. Given land values in Moyock and the large land requirements for this disposal alternative, low-rate infiltration is not considered a viable option.

4.3 Land Application via Spray Irrigation

Land application via spray irrigation is a method for effluent disposal used for small municipal wastewater systems which have limited treatment. Generally, only limited secondary treatment is provided prior to irrigation and thus, does not facilitate other options for effluent disposal, such as reuse, or high rate infiltration. Additionally, land application systems do not maximize the value and service of the property due in part to the large buffer areas that are required. Research suggests that land application of secondary treated effluent may reduce the porosity of soil (i.e. clogging), and reduce the infiltration rate over time (Clanton and Slack, 1987). More land may therefore be required to dispose of the same quantity of effluent as the system ages. Given land costs in Moyock and the large land requirements for this disposal alternative, land application via spray irrigation is not considered a viable option.

4.4 Reuse

Reuse quality treatment requires high level secondary treatment with tertiary filtration to meet reuse effluent quality standards (shown in Table 7). Reuse quality treatment allows for greater utilization of spray irrigation acreage and the potential for other effluent disposal alternatives. Conventional land application of wastewater requires secondary treatment only. Therefore, buffer requirements and land area required for conventional land application is significantly greater than those required for reuse applications. Table 8 details the land buffer requirements for application of secondary treated wastewater via spray systems, reuse quality effluent, and high rate infiltration effluent, per NC Administrative Code.

Production of reuse quality effluent also allows a variety of potential disposal options which are not allowed with secondary treated effluent. These options include:

- Irrigation of golf courses, residential lawns, parks and school grounds
- Irrigation of crops not for human consumption
- High Rate Infiltration

Reuse application rates are typically equivalent to those of low rate infiltration systems and must be determined by a licensed soil scientist. Site selection requires analysis of soil depth, permeability, and depth to groundwater. Reuse is not considered a viable option for disposal of Phase I flows given the intense land requirements. Reuse should, however, be considered for disposal prior to future wastewater expansions. The County could mandate that new residential and/or commercial developments include purple pipe systems to each user.

4.5 Surface Water (Direct) Discharge

Direct discharge of wastewater to surface waters in Currituck County is not a viable option. Obtaining a NPDES permit for direct discharge of treated wastewater to the Currituck Sound is not considered feasible due to concerns over toxicity of introducing freshwater into saltwater, nutrient loading into receiving waters, coliform contamination of public beaches or nursery areas, and other water quality concerns. Wastewater disposal options for the Currituck County mainland area are limited to non-discharge alternatives such as land application via spray irrigation, water reuse, high rate infiltration, and low rate infiltration.

4.6 Disposal Alternatives Summary

High rate infiltration is the recommended disposal method for the Moyock Sewer District. Wastewater should be treated to a reuse quality and should meet total nitrogen and total phosphorus levels of 7 mg/L and 3 mg/L, respectively, in order to meet setbacks shown in Table 8. Reduced setbacks will result in lower land costs for disposal, and provide greater flexibility in disposal options.

Table 7. Effluent Quality Requirements for Various Wastewater Disposal Techniques

Water Quality Parameter	Spray Irrigation Systems	Reuse	High Rate Infiltration (Per 2T Rules)	High Rate Infiltration (Alternative Design Criteria[2])
	Monthly Average Concentrations			
BOD_5	$\leq$ 30 mg/L	$\leq$ 10 mg/L	$\leq$ 10 mg/L	$\leq$ 10 mg/L ($\leq$ 15 mg/L [3])
TSS	$\leq$ 30 mg/L	$\leq$ 5 mg/L	$\leq$ 15 mg/L	$\leq$ 5 mg/L ($\leq$ 10mg/L [3])
NH_3	$\leq$ 15 mg/L	$\leq$ 4 mg/L	$\leq$ 4 mg/L	$\leq$ 4 mg/L ($\leq$ 6 mg/L [3])
Fecal Coliforms	$\leq$ 200 colonies /100 mL	$\leq$ 14 colonies /100 mL	$\leq$ 14 colonies /100 mL	$\leq$ 14 colonies/100 mL ($\leq$ 25 colonies/100 mL [3])
NO_3	NA	NA	$\leq$ 10 mg/L	$\leq$ 10 mg/L
Turbidity	NA	10 ntu	NA	NA (10 NTU [3])
Total Nitrogen	NA	NA	$\leq$ 7 mg/L[1]	$\leq$ 7 mg/L[1]

[1] Setback requirements are reduced for high rate infiltration ponds if TN is $\leq$ 7mg/L

[2] Alternative Design Criteria per DWQ memo dated October 27, 2006

[3] Daily maximum requirements

Table 8. Setback Requirements for Wastewater Disposal Techniques

Setback from:	Spray Irrigation Systems*	Reuse	High Rate Infiltration
Habitable residence	400 ft.	None required	400 ft.
Surface water	100 ft.	100 ft. from class SA 25 ft. from non-class SA	100 ft.**
Groundwater Lowering Ditches	100 ft.	NA	100 ft.**
Any property line	150 ft.	None required	200 ft.**
Any well with exception of monitoring wells	100 ft.	100 ft.	100 ft.

* Assumes Spray Irrigation with secondary treated wastewater.
** Reduced setbacks are allowed as long as treatment units are designed to meet Total Nitrogen of 7 mg/L and Total Phosphorus of 3 mg/L effluent limit.

5. Infiltration Pond Disposal Options

Options for disposal of treated wastewater effluent for the Moyock Sewer District were evaluated. Only options that were estimated to have a capacity of at least 400,000 gpd (Phase 2) were considered and presented below. Disposal capacity is critical to wastewater management. We recommend that the County secure disposal capacity through the Phase 2 wastewater needs such that land availability and costs does not become a limiting factor on sewer system expansion. As development continues in the Moyock area, land costs will continue to increase and development plans may make cost-effective land acquisition for wastewater management a significant challenge. To this end, the County should continue to consider options for expanding disposal capacity in consideration of growth in wastewater demands.

Cost opinions for each disposal option are included in Section 5.6.

5.1 Disposal Alternative 1

Alternative 1 consists of disposal on two sites; a 27.7-acre parcel (Site A as shown on Figure 6) located to the southwest of the Moyock Commons WWTP site, and a 52-acre site (Site B) located approximately 1.6 miles southwest of NC 168, down Puddin Ridge Road. Site A and the Moyock Commons WWTP site are separated by an irrigation ditch which runs the length of the property and serves as a groundwater lowering ditch for the Moyock Commons high rate infiltration ponds. One-third of the parcel is

currently used for farming while the remaining two-thirds are still densely wooded. Surface soils at Site A consist of Roanoke soils (Ro); no soil borings have been taken to confirm soil profiles. The permitted loading rate of the Moyock Commons infiltration ponds is 0.7 gpd/sf. Given the proximity of Site A to Moyock Commons, it was assumed that the disposal rate would be similar, so disposal capacity has been estimated at approximately 200,000 gpd, which would account for all of the proposed Phase I flows. Excavation of infiltration ponds and groundwater lowering ditches would be required, as would approximately 2.5 miles of piping to convey wastewater effluent from the treatment facility (located on Site E). Construction of ponds, groundwater lowering ditches, and piping are accounted for in the cost opinions.

Site B is 52 acres and is contained within a much larger, 440-acre tract currently being used for agriculture. The southwest corner of the parcel was chosen as an alternative disposal location due its surface soils and topographic relief. Site B is almost entirely composed of Bojac soils, which as mentioned in Section 4.1, is one of two options for efficient subsurface disposal (without groundwater lowering devices). Not only are surface soils well suited for wastewater disposal at Site B, but an 8-foot relief next to the property would allow for natural drainage towards a large irrigation ditch. Disposal rates on Site B have been estimated at 300,000 gpd. The site would require infiltration ponds to be constructed and would require approximately 4.8 miles of pipe for conveyance of treated effluent.

The total cost opinion for this option is $4,965,000. Given the estimated land purchase costs, excavation costs, and associated piping for sites A and B, it is not recommend that the County pursue this option.

5.2 Disposal Alternative 2

Alternative 2 includes disposal at Site D (shown on Figure 6) only. Site D is a 48-acre active sand borrow pit operated by the Moyock Sand Company and is located 0.25 miles from NC 168. This site has an estimated disposal capacity of 525,000 gpd. Currently, the sand pit is approximately 30 feet deep and will continue to be mined for an additional 18 months, or until early 2010. Site D is located in close proximity to the proposed WWTP site; therefore, minimal piping would be required to carry effluent to the disposal location. A limited amount of excavation would be required (in comparison to other sites).

The sand pit located on Site D has a clay layer applied to its walls which reduces groundwater intrusion. The layer measures approximately 5 feet thick at the top of the

pit and an estimated 30 feet thick at the bottom. This layer would need to be removed prior to converting Site D to an infiltration pond. Additional site grading and groundwater lowering ditches would also be required.

The owner of Site D has recently indicated that a planned lake-front community is in the conceptual design phase for the property. The owner has indicated that the purchase price for this parcel is approximately $2,000,000 . The total cost opinion for this option is $2,739,000; therefore, it is not recommended that the County pursue disposal opportunities at Site D at this time. If the planned residential development proves to be unsuccessful, the County should revisit negotiations in order to acquire future disposal capacity.

5.3 Disposal Alternative 3

The owner of Site D also owns Sites E, F and G. Alternative 3 consists of effluent disposal on all three sites. Site E is 25.6 acres and is adjacent to the proposed Currituck Reserve development (Site H). Site F is 15.4 acres and is located 0.4 miles southeast of Site D. Site G is 12.9 acres and borders the southwest side of Site F. Each site is dominated by Roanoke soils; however, it is believed that underlying soils are primarily sand, given their close proximity to the sand pit on Site D. Based on this assumption, estimated disposal capacities are 360,000 gpd, 150,000 gpd, and 150,000 gpd for Sites E, F and G, respectively.

Only minor excavation has been performed on any of the Alternative 3 locations. Small drainage ponds have been constructed on Sites E and F, to which water is pumped and conveyed from the neighboring sand pit. These ponds could be excavated further and used for infiltration of current and future wastewater effluent.

The owner of Sites E, F, and G has indicated that each parcel is available for $20,000 per acre, and that (infiltration pond) excavation of the sites could be performed by the property owner at no cost to the County. It is assumed that the property owner would not excavate the groundwater lowering ditches, so costs have been incorporated for additional excavation and final grading work.

The total cost opinion for this option is $1,848,000. Alternative 3 is a viable option for the County and should be considered.

5.4 Disposal Alternative 4

Alternative 4 consists of disposal at sites E and H. These sites have an estimated total disposal capacity of approximately 430,000 gpd. MSA, P.C. is currently conducting in-depth hydrogeological testing on Site H to determine actual disposal capacity. Disposal on Site E is estimated at 360,000 gpd, as discussed in Alternative 3.

Site H is located adjacent to Site E, and is part of the proposed Currituck Reserve development. Site H is 14.2 acres, and was offered to the County free of charge for wastewater disposal, or as a WWTP site. There is an existing storage pond on site, limiting the amount of additional excavation required for use as an infiltration pond. Excavation and construction of groundwater lowering ditches would be required, however, to achieve the estimated loading rate. The total cost opinion for Alternative 4 is $1,222,000.

Disposal Alternative 4 is a viable option, and is the recommended alternative for the County to pursue for the following reasons:

1. Costs are significantly lower than alternatives 1, 2, 3, or 5.

2. Wastewater disposal and treatment infrastructure would be centrally located in the service area, reducing collection system costs.

3. Currituck Reserve will deed Site H to the District at no cost, and the owner of Site E has offered to handle bulk excavation of infiltration ponds at no additional cost.

Together, the offer is very attractive and should be strongly considered for Phase I of the Moyock Sewer District. Sites F, G, C or D may all be considered for future disposal, given their close proximity to Sites E and H.

5.5 Disposal Alternative 5

Alternative 5 includes effluent disposal on sites C and D. Site D is described in detail as part of Alternative 2. Site C is a 51-acre, abandoned sand pit which borders Site D to the west. Like much of Moyock, Roanoke soils dominate the surface at Site C; however, sand was excavated to a depth of approximately 35 feet below grade. It is uncertain whether clay was applied to line the walls of the sand pit, but it is currently

filled with water and resembles a large reservoir. The estimated disposal capacity of Site C is approximately 970,000 gpd.

Site C would be an excellent location for disposal of Phase I flows and future flows. A limited amount of excavation would be required for infiltration purposes, and very little piping needed, assuming that the WWTP was located on Site D.

Owners of Site C have indicated that they are not interested in selling the property at this time. As mentioned earlier, the owner of Site D will accept no less than $2M for his tract. Therefore, the acquisition of Sites C and D does not seem feasible. Total cost opinion for this option is $4,873,000. The County should pursue this option at a later date, prior to future wastewater expansions, to determine whether the owners of sites C or D are willing to sell.

5.6 Disposal Capacity Summary

The disposal alternatives and rates described in Sections 5.1 thru 5.5 are summarized in Table 9. All effluent disposal rates are preliminary estimates, and ARCADIS does not recommend that the County proceed with any land acquisitions prior to thorough hydrogeological testing.

The following assumptions were made in order to estimate the disposal rates at each site.

- Hydraulic conductivity of 30 ft/day
- Aquifer thickness of 25 feet
- Hydraulic head in the pond is 3 feet greater than the hydraulic head in groundwater lowering ditch
- Ditches and ponds fully penetrate the aquifer

Costs estimates include land acquisition, where applicable, and excavation costs of high rate infiltration ponds and groundwater lowering ditches.

Table 9. Summary of Disposal Options

Alternative	Acreage	Preliminary Estimate of Disposal Rates (gpd)[1]	Opinion of Probable Cost[2]	Unit Cost ($/gal)
1	79.7	500,000	$4,965,000	$9.93
2	48	525,000	$2,739,000	$5.22
3	53.9	660,000	$1,848,000	$2.80
4	38.1	430,000	$1,222,000	$2.84
5	41.1	1,495,000	$4,873,000	$3.26

[1] Disposal rates are preliminary estimates and should be confirmed with hydrogeologcal testing and modeling.
[2] Cost opinions include engineering, permitting, and contingency.

6. Wastewater Infrastructure for Moyock Central Sewer

6.1 Wastewater Treatment and Disposal – Phase I

The planned Phase I capacity of the Moyock WWTP is 200,000 gpd. Disposal Alternative 4 represents the most cost-effective option for the County, and disposal via high rate infiltration ponds should be located on sites E and H. It is expected that disposal capacity of the two sites will accommodate the wastewater disposal needs beyond Phase I. Hydrogeological investigations are currently being undertaken by MSA and confirmation of the disposal capacity of Sites E and H is expected by mid October 2008.

A conceptual site plan for the Moyock WWTP is shown in Figure 7. The layout includes a 200,000 gpd WWTP (Phase I), and space for a 5-day upset storage pond. The conceptual layout provides space for future phases of the wastewater treatment facility to expand to the estimated build-out flow of 2.3 MGD. The 5-day upset storage pond is sized for approximately 4.1 MG, which is sized for a WWTP capacity up to 800,000 gpd. Additional upset storage and disposal capacity will be required to meet the projected buildout needs of the Moyock Sewer District.

Several wastewater treatment alternatives were considered for use in Moyock. It is important that the selected treatment method produce a reuse quality effluent (see Table 7) in order to meet the effluent quality goals. The effluent quality goals were set in order to achieve reduced setbacks between infiltration ponds and surface waters (to reduce land requirements), and to provide the opportunity for water reuse. Water reclamation could become an important component to wastewater management in

Moyock in the future. Disposal of treated effluent will be a significant challenge as growth in wastewater flows in the Moyock area continues. Distributed disposal of treated effluent among various sites may be necessary as the system approaches buildout (approximately 2.3 mgd). The County should continue to see cost-effective options for the use of reclaimed water.

The selected alternative, based on treatment capabilities and capital costs is the Biologically Engineered Single Sludge Treatment (BESST) system manufactured by Purestream ES, LLC. The BESST system utilizes a pre-anoxic single sludge activated sludge process which uses the natural carbon source present in wastewater to denitrify without the use of methanol or other carbon sources. A step by step treatment process is described below.

- Raw water enters the anoxic zone and is mixed with nitrified RAS from a sludge blanket clarifier. Submersible mixers in the anoxic zone maintain a homogenous and promote efficient denitrification.

- Mixed liquor flows to the aeration zone where fine bubble diffusers provide oxygen for nitrification and BOD_5 reduction.

- Aerated mixed liquor enters the bottom of the separation compartment where solids and effluent are separated by a sludge blanket clarifier. Solids rise into the fluidized bed filter and effluent is passed through. Particles are trapped by the blanket and heavy solids drop to the bottom of the clarifier.

- Solids are returned to the anoxic zone via airlift or mechanical pump typically at a rate of four times the average daily flow.

Based on recommendations from Purestream, and data from existing WWTPs, the BESST treatment system is expected to meet the effluent quality goals assuming medium-strength residential wastewater. Typical influent characteristics include:

- BOD ≅ 190 mg/L
- TSS ≅ 210 mg/L
- TKN ≅ 40 mg/L
- NH_4-N ≅ 25 mg/L
- NO_3-N ≅ 0 mg/L
- Total Phosphorus ≅ 7 mg/L
- Alkalinity ≅ 200mg/L (As $CaCO_3$)

Several concerns with the BESST system include limited process control and operational flexibility of the treatment system. The limitation could lead to system upsets during variable flow regimes or limit treatment efficiency. Also, the sludge blanket in the sludge blanket type clarifiers can be difficult to manage and control. Some WWTPs utility flocculants or polymers to weigh down the sludge blanket to prevent upsets.

6.2 Wastewater Treatment and Disposal – Phase 2

Based on the growth projections, the Phase 2 expansion may be required by 2018. An expansion of the Moyock WWTP to 400,000 gpd is recommended. The existing pond located on Site H should be improved for use as a high-rate infiltration pond and groundwater lowering ditches around the pond should be constructed.

6.3 Wastewater Collection – Phase I

In Section 3, vacuum collection system was shown as the most cost-effective option for the Moyock Centralized Sewer System at buildout. However, the initial costs of the wastewater collection alternatives differ. Whereas vacuum collection systems have lower costs in the long-term, the initial costs to provide the "backbone" collection system along US Hwy 168 could not be supported by the limited number of wastewater connections projected in the early stages of sewer development. Additional discussion on sewer rates and fees are presented in Section 7.

The recommended collection infrastructure for Phase 1 of the Moyock Sewer District is shown in Figure 7 and includes:

- One 14" force main from Site E to US Hwy 168/Guinea Mill Road.
- One 6" force main along US Hwy 168 south to the High Cotton Towne Center.

- One 12" force main from US Hwy 168/Guinea Mill Road to Sawyertown Road.

- One 8" force main from Sawyertown Road to Newtown Road.

The force main will provide service to the existing Newtown Sanitary District, the existing Moyock Commons Sanitary District, Currituck Reserve, High Cotton Towne Center, and potential customers along US Hwy 168.

New customers outside of the Newtown Sanitary District, the Moyock Commons Sanitary District, or one of the proposed Planned Unit Developments would need to install grinder pumping stations in order to convey wastewater flows into the force main.

Due to the limited number of connections expected during Phase I, small pressure grinder systems are suggested to connect residential and commercial users to the system. As interest grows for connections beyond the NC 168 corridor, the County should consider implementing a mandatory vacuum collection system policy for all new developments. This would provide some uniformity to the system and would significantly reduce O&M costs.

6.4 Wastewater Collection – Phase 2

During Phase 2, it is recommended that the initial stages of a vacuum collection system be constructed including the trunk vacuum collection mains along US Hwy 168. This will eliminate the need for further use of grinder pump stations. Construction of Vacuum Pump Stations No. 1, 2, and 5 are recommended during Phase 2. One 8" force mains would be extended along US Hwy 168 from Newtown Road north to Inventors Road.

6.5 Existing and Planned Capital Costs

Table 10 shows the planned capital projects for Phases 1 and 2. This plan provides for the minimum facilities necessary to provide for the collection, transmission, treatment and disposal of all wastewater from the service area for the initial phases of this project. Additional collection system projects anticipated in this initial period as well as later years will be entirely dependent on the progress of development in the service area and will have to be funded by Impact Fees.

TABLE 10. Recommended Capital Improvements: Phases 1 and 2

Project Type- Description	Fiscal Year Scheduled for Construction	Project Cost Opinion[1]
Phase 1		
0.2 mgd Wastewater Treatment Plant	2010	$3,586,800
High-Rate Infiltration Disposal on Site E	2010	$960,750
Force Main along US Hwy 168	2010	$1,908,690
Subtotal Capital Projects – Phase 1		**$6,456,240**
Phase 2		
0.2 mgd Wastewater Treatment Plant	2018-2020	$3,722,200
High-Rate Infiltration Disposal on Site H	2018-2020	$387,700
Vacuum Station #1	2018-2020	$877,400`
Vacuum Station # 2	2018-2020	$922,000
Vacuum Station # 5	2018-2020	$924,400
Vacuum Collection Mains	2018-2020	$2,791,700
Subtotal Capital Projects – Phase 2		**$9,625,400**

[1] Cost opinions have been escalated from 2008 dollars to midpoint of construction at 3% per year.

7. Financing Plan

The first step in the preparation of the financing plan is to identify the revenue requirements in order to provide the sewer service to the increased population base anticipated for the Moyock Sewer District. The next objective is to evaluate a rate and fee structure for sewer service that is consistent with the County's goals and objectives and focuses on a fair and equitable methodology for allocation of costs to provide service to existing and future sewer customers in this area. This plan is to focus on a financing period of 15 years. The conclusions of the financing plan will be based on the use of a cash flow analysis to support the pricing of utility services with a

segregation of costs and revenues identified as growth-related capital costs, the cost of operating the water and sewer systems and for non-growth capital costs.

7.1 Assumptions Used In the Rate Evaluation

In order to project future revenue requirements, as well as revenues to be derived from water and sewer rates, several assumptions were made regarding economic conditions and growth as follows:

1. Treatment plant costs were based on the use of the BESST system by Purestream ES, LLC.

2. The Newtown Sanitary District and the Moyock Commons Sanitary District will be eliminated and combined into the new Moyock Sewer District.

3. Rates for the Newtown Sanitary District will be increased from the current rate of $20 per month per residential connection to $50 per month per residential connection over a 5 year period. Rates for commercial customers will be increased to match the rate for the Moyock Sewer District over a 5 –year period.

4. Rates for the Moyock Commons Sanitary District will be reduced from the current rate to match the rates for the Moyock Sewer District over a 5 –year period.

5. Construction costs have been escalated by 5% per year to the date they are expected to be constructed.

6. Plant expansions will be timed so that construction will be completed when the demand equals 80% of the current plant capacity.

7. No grants will be obtained.

8. The interest rate on new financing will be 5% assumed for the 2010 borrowing needs, and 5.0% for all subsequent events with each issue being financed over a 15 year period with a 2.0% cost of issuance.

9. Estimated average household consumption allowance - 250 gallons per day per Equivalent Residential Connection (ERC).

10. O&M reserve – 90 days of operating budget minimum.

11. Repair and Replacement Fund has already been included in the estimates for operation and maintenance of the collection system and pumping stations for the recommended alternative. The amount recommended to be set aside for the Treatment and Disposal Facilities amounts to 2.5% of the capital costs of the facilities per year which assumes a 40 year life of the facilities.

12. Rate of inflation used for monthly service charges (user rates), Impact Fees, and operation and maintenance costs was assumed to be 3% per year.

7.2 Existing Debt

Currituck County owns and operates two existing sewer utility systems in the service area known as the Newton Service District and the Moyock Commons Service District, which are operated as self-supporting entities. These existing systems will be merged with the proposed Moyock Sanitary District.

The Moyock Commons Sewer District currently has one outstanding loan payment to the County General Fund. The loan from the General Fund initiated in 2007 was $181,367 to be paid over 6 years at a 4% interest rate with an annual payment of $34,598 through FY 2013. The annual debt service payment and remaining term for this loan has been included in the calculations for the total expenses for the County. These requirements are summarized in the following Table No. 11.

The Newtown Sewer Service District has recently obtained a $100,000 Rural Center Grant which requires the District to match these funds to complete anticipated improvements to the system. The transfer of $100,000 from the General Fund has taken place but the funding from the Rural Center has not been received. If this project moves forward, the Newtown Sewer District will be responsible for the repayment of the $100,000 to the General Fund of the County. This possible debt has not been accounted for in this analysis pending a decision to proceed with the project and a schedule to be agreed to for repayment of the loan from the General Fund of the County.

7.3 Existing and Planned Capital Costs

Table 10 shows the year scheduled and funding requirements for the various projects in Phases 1 and 2. The financial analysis assumes that developers will pay the full Impact

Fee at the time the developer requests wastewater capacity to be reserved. It is also assumed that developers are responsible for the wastewater collection infrastructure within their particular development.

Impact Fees collected for the Phase 1 facilities have been determined and subtracted from the Phase I capital cost to determine the amount to be financed by the County. For the Phase 1 facilities, the amount to be financed in 2010 is $1,091,895.

Due to the significant yearly cash outlays required for the projects, we have assumed that all projects scheduled in this report will be funded by the issuance of debt. There will likely be additional minor projects which will be funded from cash on hand or cash derived from operations that have not been included in this analysis. To the extent that the County can pay for relatively small projects in size or there is cash on hand from prior years, additional long term debt will be avoided thus avoiding interest expenses.

7.4 Operating and Maintenance Costs

Operation and maintenance costs of the Moyock sewer system projected for Phases 1 and 2 include the costs of daily operations such items as administration, billing, engineering, operations, and maintenance. The actual O&M costs of other similar facilities were used as the basis for projecting future O&M expenses. Additional costs were added when significant additions were made to the sewer utility systems, both in plant operation costs and miles of line work associated with the sewer lines. The costs were calculated based on 2008 costs and then escalated at 3% annually to keep pace with inflation. The estimated O&M Costs for all facilities for the period of this study is shown in Table 13.

7.5 Proposed Reserves

Good management practices dictate that cash reserves be accumulated to provide for contingencies and unplanned major expenses. We recommend the establishment of two types of reserves for the County's sewer system: an operating reserve and a repair and replacement reserve fund.

An operating reserve is important to provide funds for unplanned minor repairs and other significant cash outlays encountered in the course of operation of a system. We have recommended that the County establish and maintain a minimum operating reserve equal to 90 days operating expenses for the sewer utilities.

This fund is to provide the money necessary to pay for unexpected major repairs and planned replacement or rehabilitation of equipment or machinery. The reserve amount recommended to be funded for Currituck County is $85,000 per year for the treatment and disposal facilities as an annual contribution to the reserve.

7.6 Sewer Rates and Fees

The County provided ARCADIS with desired user rates and impact fees, and ARCADIS evaluated the desired rates to determine if they adequately cover the total estimated costs of providing wastewater service. Once the desired rates were evaluated and determined to be insufficient to support future costs of services, other rate alternatives were identified and/or planned capital improvements were adjusted.

Based on the rate and fee analysis to support the planned capital improvements, the recommended rates and fees are shown in Table 15. Monthly service charges were set to approximately 1.5 times water consumption charges.

TABLE 15. Recommended Rate and Fees

Water Consumption/Month (in gallons)	Residential	Commercial**
0 – 2000	Base Rate ($20.00)	Base Rate ($20.00)
Up to 5,000	$7.00/1,000 gallons	$7.00/1,000 gallons
Up to 10,000	$8.25/1,000 gallons	$8.25/1,000 gallons
Over 10,000	$9.50/1,000 gallons	$9.50/1,000 gallons
Impact Fees	$7,500 per ERC	

The rate evaluation assumed a minimum Monthly Sewer Service Charge for a usage of 6,000 gallons per month at $70 per month and increased 3% per year. Impact Fees for sewer service were set at a minimum of $7,500 for both residential and commercial customers and increased at a rate of 3% per year. Table 14 shows a cashflow projection for the Moyock Sewer Fund including revenues from the user fees and impact fees discussed above as well as annual O&M expenses and annual debt service payments.

These rates and fees are based on that Currituck County will fund the capital cost of the force main separately. If the capital cost of the force main is included in the rate

evaluation, then impact fees need to increase to $10,000 per ERC to ensure rates and fees cover the future costs of sewer services.

7.7 Additional Recommendations

It is extremely important for the County to adopt an appropriate ordinance that outlines in detail the Rules and Regulations it will be operating under as well as the necessary rates and charges applicable to each residence. Impact Fees for large users of the system need to be defined as to how they are calculated as well as the Availability Charges, Service Charges and any other charges applicable to the operation of the utility. This would also address the policy the County intends to follow regarding the need to connect the existing residences and commercial operations located in the proposed service area.

8. Summary

A summary of the recommended Phase 1 sewer infrastructure improvements for the proposed Moyock Centralized Sewer District are presented below. A capital improvements plan is shown in Table 10. A project schedule is also attached (Figure 9).

- The County should proceed with creation of the Moyock Sewer District as shown on Figure 1, and implement ordinances requiring all new customers to connect to the Moyock Sewer District. The creation of additional wastewater systems in the Moyock area may affect the economies of scale associated of the centralized system.

- The County should proceed with acquisition of Site E and negotiate with the property owner to handle bulk excavation of the upset storage pond, and infiltration ponds at no additional cost. It is assumed that the property owner would not agree to be responsible for excavation of the groundwater lowering ditches, or final grading and site stabilization. Negotiations with the property owner should also include force main easements across Sites F and G owned by the same property owner.

- Re-combine Site E and Site H into one property, so the District has ownership over the entire site.

- Establish Rules and Regulations for the Moyock Sewer District that will set forth the methodology for calculation of Impact Fees and Service Charges.

- The District should develop Construction Standards and Details for wastewater collection infrastructure to prescribe the type and quality of collection systems, vacuum stations, and pump stations constructed by others that may be allowed to connect to the Moyock Central Sewer System. This should also address the responsibility of maintaining the system and inspection of facilities during construction to ensure compliance with the standards.

- The existing pond located on the adjacent Currituck Reserve property could be improved for use in Phase 2.

- Proceed with design and construction of a 200,000-gpd WWTP train using the BESST technology on Site E.

- Negotiate a force main easement with the property owner of the parcel to the south of Site E. The existing right-of-way across this parcel is no longer needed if access to Site E is provided through the Currituck Reserve development.

- Construct one 14" force main from Site E to US Hwy 168/Guinea Mill Road. Construct one 6" force main along US Hwy 168 south to the High Cotton Towne Center. From US Hwy 168/Guinea Mill Road, construct one 12" force main along US Hwy 168 north to Sawyertown Road. Construct one 8" force main along US Hwy 168 north to Newtown Road. The force main route is shown on Figure 8.

- Construction of a 350-gpm pump station at Newtown Road to allow the existing LPP system to be abandoned.

- Moyock Sewer District should review its financial status annually since the actual growth in new connections has a major impact on financial status. Adjustments to its schedule of rates and charges should be reviewed annually.

TABLE 11: Estimated Operating Expenses and Debt Service - Wastewater System

OPERATIONAL YEAR		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
FISCAL YEAR	FY 10	FY 11	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17	FY 18	FY 19	FY 20	FY 21	FY 22	FY 23	FY 24	FY 25
ANNUAL OPERATING EXPENSES																
O & M New Plant and Facilities	$0	$163,753	$183,149	$204,774	$229,101	$256,538	$285,784	$318,626	$355,574	$394,732	$647,342	$704,650	$768,452	$839,559	$918,890	$1,001,829
O & M Existing Facilities	$81,306	$83,745	$86,258	$88,845	$91,511	$94,256	$97,084	$99,996	$102,996	$106,086	$109,268	$112,547	$115,923	$119,401	$122,983	$126,672
SUBTOTAL OPERATION EXPENSES	$81,306	$247,498	$269,407	$293,619	$320,612	$350,794	$382,868	$418,623	$458,570	$500,818	$756,610	$817,196	$884,375	$958,960	$1,041,873	$1,128,501
EXISTING AND NEW DEBT																
Total Existing Debt (Moyock Commons)	$34,598	$34,598	$34,598	$34,598	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Debt Service Expense for New Projects	$0	$107,296	$107,296	$107,296	$107,296	$107,296	$107,296	$107,296	$107,296	$107,296	$954,879	$954,879	$954,879	$954,879	$954,879	$954,879
SUBTOTAL EXISTING AND NEW DEBT	$34,598	$141,894	$141,894	$141,894	$107,296	$107,296	$107,296	$107,296	$107,296	$107,296	$954,879	$954,879	$954,879	$954,879	$954,879	$954,879
TOTAL EXPENSE	$115,904	$389,392	$411,301	$435,513	$427,908	$458,090	$490,164	$525,919	$565,866	$608,114	$1,711,489	$1,772,075	$1,839,253	$1,913,838	$1,996,752	$2,083,379

TABLE 12: Project Capital Costs - Fiscal Year 2010 - 2025

INFRASTRUCTURE	FY SCHEDULED	FY 08 Construction	FY '08 Total Costs	ESCALATED COSTS	AMOUNT TO BE FINANCED	NOTES
PHASE 1						
Wastewater Treatment Plant - Phase 1 - 0.2 MGD	2010	$ 2,800,000	$3,416,000	$3,586,800	$3,586,800	
Wastewater Disposal - Recommended Alternative	2010	$750,000	$915,000	$960,750	$960,750	
Force Main along Rt. 168	2010	$1,490,000	$1,817,800	$1,908,690	$ 954,345	County to fund force main separately
SUBTOTAL CAPITAL PROJECTS		**$5,040,000**	**$6,148,800**	**$6,456,240**	**$5,501,895**	
TOTAL DEVELOPER TAP FEE					**$4,410,000**	
AMOUNT TO BE FINANCED - PHASE 1					**$1,091,895**	
PHASE 2						
Wastewater Treatment Plant - Phase 2 - 0.4 MGD	2020	$ 2,400,000	$2,928,000	$3,722,200	$3,722,200	
Phase 2 Recommended Alternative	2020	$250,000	$305,000	$387,700	$387,700	
Vacuum Station #1	2020	$565,700	$690,154	$877,400	$877,400	
Vacuum Station #2	2020	$594,500	$725,290	$922,000	$922,000	
Vacuum Station # 5	2020	$596,000	$727,120	$924,400	$924,400	
Vacuum Collection System	2020	$1,800,000	$2,196,000	$2,791,700	$2,791,700	
SUBTOTAL CAPITAL PROJECTS		**$ 2,650,000**	**$3,233,000**	**$9,625,400**	**$9,625,400**	
TOTAL DEVELOPER TAP FEE					**$1,000,000**	
AMOUNT TO BE FINANCED - PHASE 2					**$8,625,400**	

NOTES
1. These project costs have been escalated in price by 3% per year to the date they are expected to be needed and assume a reasonable growth model for development.
2. Developers are expected to pay 100% of the collection system costs for their subdivisions.
3. Assumes $1,000,000 is collected upfront from developers of future PUD prior to construction of Phase 2.

DEVELOPER TAP FEES (PHASE 1)

Planned Development	Phase 1 Capacity	ERCs	Share of	Impact Fee per ERC	Impact Fee
Currituck Reserve	95,000	380	0	$ 7,500	$ 2,850,000
High Cotton Towne Center	52,000	208	0	$ 7,500	$ 1,560,000
				TOTAL TAP FEES FOR PUDs (PHASE 1)	**$ 4,410,000**

TABLE 13: Proposed Operation and Maintenance Costs - Sewer System

OPERATIONAL YEAR		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
FISCAL YEAR	FY 10	FY 11	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17	FY 18	FY 19	FY 20	FY 21	FY 22	FY 23	FY 24	FY 25
NEW FACILITIES																
Construct WWTP 0.2 MGD		$97,158	$112,081	$129,297	$149,157	$172,068	$196,725	$224,916	$257,146	$293,995	$333,097	$377,398	$427,592	$484,462	$548,896	$616,245
Phase 1 Disposal Facilities		$6,000	$6,180	$6,365	$6,556	$6,753	$6,956	$7,164	$7,379	$7,601	$7,829	$8,063	$8,305	$8,555	$8,811	$9,076
Force Main Along Route 168		$11,140	$11,474	$11,818	$12,173	$12,538	$12,914	$13,302	$13,701	$14,112	$14,535	$14,971	$15,420	$15,883	$16,359	$16,850
High Cotton Pump Station		$15,000	$15,450	$15,914	$16,391	$16,883	$17,389	$17,911	$18,448	$19,002	$19,572	$20,159	$20,764	$21,386	$22,028	$22,689
Currituck Reserve Pump Stations (2)		$15,000	$15,450	$15,914	$16,391	$16,883	$17,389	$17,911	$18,448	$19,002	$19,572	$20,159	$20,764	$21,386	$22,028	$22,689
Grinder Pump Stations		$4,000	$6,592	$9,064	$11,536	$14,008	$16,480	$18,952	$21,424	$21,424	$21,424	$21,424	$21,424	$21,424	$21,424	$21,424
Newtown District Pump Station	$15,000	$15,450	$15,914	$16,391	$16,883	$17,389	$17,911	$18,448	$19,002	$19,572	$20,159	$20,764	$21,386	$22,028	$22,689	$23,370
Vacuum Station # 1 and Collection System											$61,283	$64,347	$67,564	$70,942	$74,489	$78,214
Vacuum Station # 2 and Collection System											$73,647	$77,329	$81,195	$85,255	$89,518	$93,994
Vacuum Station # 5 and Collection System											$76,200	$80,010	$84,011	$88,211	$92,622	$97,253
TOTAL O&M NEW PLANT AND FACILITIES	**$15,000**	**$163,753**	**$183,149**	**$204,774**	**$229,101**	**$256,538**	**$285,784**	**$318,626**	**$355,574**	**$394,732**	**$647,342**	**$704,650**	**$768,452**	**$839,559**	**$918,890**	**$1,001,829**
EXISTING FACILITIES																
Moyock Commons Sewer District (Esc. Financial Rpt.)	$81,306	$83,745	$86,258	$88,845	$91,511	$94,256	$97,084	$99,996	$102,996	$106,086	$109,268	$112,547	$115,923	$119,401	$122,983	$126,672
TOTAL O&M EXISTING FACILITIES	**$81,306**	**$83,745**	**$86,258**	**$88,845**	**$91,511**	**$94,256**	**$97,084**	**$99,996**	**$102,996**	**$106,086**	**$109,268**	**$112,547**	**$115,923**	**$119,401**	**$122,983**	**$126,672**
TOTAL ANNUAL O&M	**$96,306**	**$247,498**	**$269,407**	**$293,619**	**$320,612**	**$350,794**	**$382,868**	**$418,623**	**$458,570**	**$500,818**	**$756,610**	**$817,196**	**$884,375**	**$958,960**	**$1,041,873**	**$1,128,501**

TABLE 14: Cash Flow Projection

	OPERATIONAL YEAR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	FISCAL YEAR	FY 11	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17	FY 18	FY 19	FY 20	FY 21	FY 22	FY 23	FY 24	FY 25
	RESIDENTAIL SEWER RATE AND SALES INFORMATION															
1	Moyock SD Monthly Service Charge	$70.00	$72.10	$74.26	$76.49	$78.79	$81.15	$83.58	$86.09	$88.67	$91.33	$94.07	$96.90	$99.80	$102.80	$105.88
2	Moyock Commons SD Monthly Service Charge	$132.00	$135.96	$140.04	$144.24	$148.57	$153.02	$157.61	$162.34	$167.21	$172.23	$177.40	$182.72	$188.20	$193.85	$199.66
3	Newtown SD Monthly Service Charge	$26.00	$32.00	$38.00	$44.00	$50.00	$51.50	$53.05	$54.64	$56.28	$57.96	$59.70	$61.49	$63.34	$65.24	$67.20
4	Projected Total Connections (ERC)	40	248	294	346	404	469	536	610	692	783	875	976	1,087	1,209	1,344
5	New Connections subject to Tap Fee	36	16	16	16	19	20	22	25	27	28	30	57	122	135	133
6	PUD Connections (paid Tap Fee upfront)	172	30	36	42	45	47	52	58	64	64	71	54			
7	Tap Fee	$7,500	$7,725	$7,957	$8,195	$8,441	$8,695	$8,955	$9,224	$9,501	$9,786	$10,079	$10,382	$10,693	$11,014	$11,344
	ANNUAL REVENUES															
8	Annual Service Charge Revenue from Moyock Commons SD	$63,360	$65,261	$67,219	$69,235	$71,312	$73,452	$75,655	$77,925	$80,263	$82,670	$85,151	$87,705	$90,336	$93,046	$95,838
9	Annual Service Charge Revenue from Newtown SD	$12,480	$15,360	$18,240	$21,120	$24,000	$24,720	$25,462	$26,225	$27,012	$27,823	$28,657	$29,517	$30,402	$31,315	$32,254
10	Annual Service Charge Revenue from Moyock Central SD	($43,680)	$134,971	$180,222	$233,158	$294,983	$367,085	$444,985	$534,807	$638,282	$757,390	$884,006	$1,028,239	$1,192,024	$1,378,280	$1,591,156
11	Moyock Commons SD Tax Revenue	$37,000	$37,000	$37,000	$37,000	$37,000	$37,000	$37,000	$37,000	$37,000	$37,000	$37,000	$37,000	$37,000	$37,000	$37,000
12	Tap Fee (New connections)	$270,000	$123,600	$127,308	$131,127	$164,491	$173,944	$198,870	$227,368	$259,950	$270,183	$306,117	$591,760	$1,304,571	$1,486,890	$1,508,808
13	Newtown SD Rural Center Grant and County Match	$200,000	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
14	County's Contribution to Force Main	$954,345	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
13	**TOTAL REVENUES**	**$1,493,505**	**$376,192**	**$429,988**	**$491,641**	**$591,787**	**$676,201**	**$781,972**	**$903,326**	**$1,042,507**	**$1,175,066**	**$1,340,931**	**$1,774,221**	**$2,654,334**	**$3,026,531**	**$3,265,056**
	ANNUAL OPERATION EXPENSES															
14	O & M New Plant and Facilities	$163,753	$183,149	$204,774	$229,101	$256,538	$285,784	$318,626	$355,574	$394,732	$647,342	$704,650	$768,452	$839,559	$918,890	$1,001,829
15	O & M Existing Facilities	$83,745	$86,258	$88,845	$91,511	$94,256	$97,084	$99,996	$102,996	$106,086	$109,268	$112,547	$115,923	$119,401	$122,983	$126,672
16	Reserve for Equipment Replacement	$85,000	$87,550	$90,177	$92,882	$95,668	$98,538	$101,494	$104,539	$107,675	$110,906	$114,233	$117,660	$121,190	$124,825	$128,570
17	CIP Projects	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
18	**SUBTOTAL OPERATION EXPENSES**	**$332,498**	**$356,957**	**$383,796**	**$413,493**	**$446,463**	**$481,406**	**$520,117**	**$563,109**	**$608,494**	**$867,516**	**$931,429**	**$1,002,034**	**$1,080,149**	**$1,166,698**	**$1,257,071**
	EXISTING AND NEW DEBT															
19	Total Existing Debt	$34,598	$34,598	$34,598	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
20	Plus Debt Service Expense for New Projects	$107,296	$107,296	$107,296	$107,296	$107,296	$107,296	$107,296	$107,296	$107,296	$954,879	$954,879	$954,879	$954,879	$954,879	$954,879
21	Other Capital Projects (Grinder Pump Stations)	$40,000	$24,000	$24,000	$24,000	$24,000	$24,000	$24,000	$24,000	$0	$0	$0	$0	$0	$0	$0
22	**SUBTOTAL EXISTING AND NEW DEBT**	**$181,894**	**$165,894**	**$165,894**	**$131,296**	**$131,296**	**$131,296**	**$131,296**	**$131,296**	**$107,296**	**$954,879**	**$954,879**	**$954,879**	**$954,879**	**$954,879**	**$954,879**
23	**TOTAL EXPENSE**	**$514,392**	**$522,851**	**$549,690**	**$544,789**	**$577,759**	**$612,702**	**$651,413**	**$694,405**	**$715,790**	**$1,822,395**	**$1,886,308**	**$1,956,913**	**$2,035,028**	**$2,121,577**	**$2,211,950**
24	**Net Profit/Loss**	**$979,113**	**($146,659)**	**($119,701)**	**($53,149)**	**$14,028**	**$63,499**	**$130,559**	**$208,921**	**$326,717**	**($647,328)**	**($545,377)**	**($182,692)**	**$619,306**	**$904,954**	**$1,053,106**
25	**Accumulated Cash Flow Balance**	**$979,113**	**$832,454**	**$712,753**	**$659,604**	**$673,632**	**$737,132**	**$867,691**	**$1,076,611**	**$1,403,329**	**$756,000**	**$210,624**	**$27,931**	**$647,237**	**$1,552,191**	**$2,605,297**
28	Number of Days Operating Reserve	695	581	473	442	426	439	486	566	716	151	41	5	116	267	430

Assumptions

1. Service Charge rates increase at a rate of 3% per year
2. Tap Fee increases at 3% per year
3. Reserve for equipment replacement is already included in O&M costs for P.S. and Vacuum Lines.
4. Interest on Bond issues was assumed to be 5% for 15 years, and 2% issuance cost.
5. Assumes Impact Fee for PUDs is charged up front for Phase 1.
6. Developers will be required to install collection systems within their project boundaries.