3. Alternative Analysis

3.1 Alternatives Considered

A total of six (6) alternatives were identified for consideration through discussions with the City, the County and DNREC. These alternatives are briefly described as follows:

Alternative 1: No Action: Treated effluent continues to be discharged into the Rehoboth Bay.

Alternative 2: Nutrient Trading: Treated effluent continues to be discharged into the Rehoboth Bay. The plant offsets effluent nutrient loads by purchasing credits from non-point sources in the Rehoboth Bay watershed. The consent order finalized in December 2002 would only allow credit offsetting if no other options were technically or economically feasible.

Alternative 3: Land Application: Treated effluent is sprayed on agricultural land to irrigate crops and provide nutrients as required for crop uptake. The effluent, with nutrients not taken up by the crops, percolates through the soil to the groundwater. Several variations of this alternative were evaluated including:

Alt. 3A: Treated effluent from Rehoboth Beach is sent to a new facility built for the sole use of the RBWWTP.

Alt. 3B: The RBWWTP is shut down and all raw wastewater is sent to the Wolfe Neck Regional Wastewater Facility (WNRWF) with excess flow treated at the Inland Bays Regional Wastewater Facility (IBRWF).

Alt. 3C: The RBWWTP is shut down and all raw wastewater is sent to the WNRWF with excess flow treated by a Private Wastewater Provider (PWWP).

Alt. 3D: The RBWWTP remains in service and treated effluent is sent to the WNRWF for disposal via spray irrigation, with excess flow sent to the IBRWF.

Alt. 3E: The RBWWTP remains in service and treated effluent is sent to the WNRWF for disposal via spray irrigation, with excess flow sent to a PWWP.

Alternative 4: Rapid Infiltration Beds: Treated effluent is flooded on to sand beds allowing the water to percolate down into the groundwater. The basins are typically flooded and then allowed to dry and rest for a period of time. A minimal amount of additional treatment is achieved through filtration, but the treatment level is much less than provided by spray irrigation,

Alternative 5: Ground Water Injection: Treated effluent is injected into the groundwater. Two variations of this alternative were evaluated including:

Alt. 5A: Treated effluent is injected into a shallow well in an area where the groundwater is contaminated.

Alt. 5B: Treated effluent is injected through a deep well into an aquifer that is confined below the drinking water aquifers.

Alternative 6: Ocean Outfall: Treated effluent is discharged through an outfall and diffuser into the ocean at a depth and distance from the shore that allows adequate mixing with the sea water such that all water quality criteria and public health standards are achieved.

Individual treatment alternatives, such as incinerating toilets, were not investigated. All residents and other users in the RBWWTP service area would have to agree to have all of their existing toilets replaced with incinerating toilets, which is not considered feasible. Additionally, such toilets do not provide treatment or disposal of other sources of domestic wastewater, such as sink drains, shower drains, dishwashers, or clothing washers.

The use of constructed wetlands to enhance treatment as a component in the overall RBWWTP disposal project was considered. As discussed in Section 2.4.2 of this report, the RBWWTP is currently meeting and achieving higher levels of treatment than required by the State under its current discharge permit, and although minor upgrades are anticipated to be needed to extend the useful life of the plant, major changes to improve performance of the treatment process are not needed, and there are no plans to replace the existing RBWWTP. However, constructed wetlands can bring environmental enhancements to the overall system, which are evaluated for the RBWWTP below.

It should be noted that constructed wetlands are not proposed as a means of eliminating the discharge of treated effluent. The use of constructed wetlands may change the volume of effluent to be disposed of through evapotranspiration, percolation, and precipitation. However, there will still be a significant volume of effluent to dispose of, which is the focus of this EIS.

Wetland plants create an environment that supports a wide range of physical, chemical, and microbial processes. These processes separately and in combination remove total suspended solids, reduce the influent BOD, transform nitrogen species, provide storage for metals, cycle phosphorus, and attenuate organisms of public health significance.

Constructed wetlands are artificial wastewater treatment systems consisting of shallow (usually less than 3 feet deep) ponds or channels which have been planted with aquatic plants, and which rely upon natural microbial, biological, physical, and chemical processes to treat wastewater. The use of constructed wetlands for wastewater treatment in the US dates back to the 1970's, and their use has continued to increase. According to the US Environmental Protection Agency. North American Wetlands for Water Quality Treatment Database (NADB) version 2 produced in 2000, in the US and Canada there are now at least 245 locations that use constructed wetlands for wastewater treatment, and there are likely considerably more today (USEPA 2000).

Constructed wetlands are typically an appropriate technology for areas where inexpensive land is generally available and skilled labor is generally less available, as these systems require a large amount of land, but have low operations and maintenance requirements.

Wetlands are one component of a larger treatment system and are typically used to treat primary or secondary effluent and can also be used as a final enhancement or polishing step. There is no consensus on the optimal design of wetland systems. Data related to wetland design, operation, and performance exists, but is variable with respect to quality. Table 3-1A below presents a comparison of constructed wetland effluent quality data to current RBWWTP effluent quality.

Table 3-1A Comparison of Constructed Wetland Effluent Quality with RBWWTP Effluent Quality

	Quality of Constructed Wetlands Effluent (1)			RBWWTP Existing Effluent Quality
	min	mean	max	
BOD (mg/L)	1.2	15	69	2.8
TSS (mg/L)	1.1	15	40	5.4
TN (mg/L)	0.85	4	9.8	6.2
TP (mg/L)	0.09	2	4.2	0.3

Notes:

1. Reference Table 4.1 Summary of performance data and loadings for TADB (Technology Assessment Database) systems, (USEPA 1999).

As can be seen from Table 3-1A, the current RBWWTP effluent quality exceeds that of the mean effluent quality for constructed wetlands for all but total nitrogen. The ability of constructed wetlands to remove high levels of nitrogen is unproven. Harvesting of wetland plants removes less than 20% of influent nitrogen (Reed, Crites and Middlebrooks 1995). This leaves nitrification and denitrification as the primary removal mechanism. To achieve this, sufficient open water areas would need to be incorporated to allow for aerobic zones in the dominantly anaerobic wetland, which will increase the area needed for the constructed wetland. Based on literature data, with an effective and specifically designed constructed wetland added to the treatment train, total nitrogen levels could be reduced another 50% to 3.1 mg/L (USEPA 1999).

In addition to the comparisons made in Table 3-1A, constructed wetlands are also associated with the removal of heavy metals from wastewater effluent. Metals removed from the effluent are bound to solids and settle from the water column and can be buried in the wetland sediments. If sediments are disturbed, the potential exists for the chemically reduced and sequestered metals to be oxidized and dissolve, thus becoming biologically mobile again. Metals are also incorporated into biomass via primary production processes occurring in wetlands. Metals are taken up via the roots and distributed throughout the plant. The extent of uptake and distribution within the plant depends on the metal species and plant type (USEPA 2000).

For persistent metals, wetland sinks may become sources if not properly constructed and managed. The extent to which wetlands retain contaminants such as metals is an important unknown factor, as are the conditions under which wetlands may release stored contaminants. Bioaccumulation and biotoxicity in treatment wetlands is not clearly documented nor understood (USEPA 1999). Thus, the ability of a constructed wetland to reduce metals on a long-term basis is unknown and should not be relied upon.

Constructed wetlands function in the environment in many of the same ways as a natural wetland. Depending on the system design, constructed wetlands can provide ample habitat for wildlife, including birds and aquatic species. They can also be designed to provide public access including walking and biking trails, public education, and wildlife viewing. Constructed wetlands are generally viewed as favorable by the public in comparison to other forms of wastewater treatment.

The RBWWTP currently produces a high quality effluent. In the discussion of treatment one potential benefit was additional nitrogen removal in the effluent. An estimate of the area needed for a constructed wetland based on additional nitrogen removal was made. The area estimate was based on an areal loading rate of 2 kg/ha-day (USEPA 1999), and includes an additional land for required buffers, set back and site constraints. The estimated area is 110 acres. This is a planning level estimate, and actual acres needed could be much higher. For example, a constructed wetland for the town of Arcata, California was designed to treat an annual average flow of 2.3 MGD (comparative to the 2.5 MGD average design flow of RBWWTP), and included 154 acres of freshwater and saltwater marshes, tidal mudflats and grasslands, on a 307 acre property (Suutari 2007). The current RBWWTP is on less than 10 acres of land, thus additional land would be needed to construct the wetland. The purchase of land contiguous to the ocean is not possible and thus the wetlands discharge would be directed to the Inland Bays (if suitable land in proximity to the wastewater treatment plant could be identified and purchased).

Table 3-1B Summary of Advantages and Disadvantages of Constructed Wetlands for RBWWTP

Advantages	Disadvantages
Can provide habitat for fish, birds, and other wildlife.	Lack of available land (would require 110 acres or more).
Can provide recreation opportunities, such as bird watching, photography, and education.	Existing RBWWTP produces effluent quality better than most constructed wetlands systems.
Can be built to fit harmoniously into the landscape and provide aesthetic and landscape enhancement.	No consensus on the optimal design of wetland systems, thus long-term performance is difficult to rely on.
Can potentially reduce nitrogen and metals in the RBWWTP effluent.	Ability of wetlands to reduce metals in effluent over the long-term uncertain.
Typically low operations costs.	Addition of constructed wetlands would result in minimal improvement in effluent quality for a significant investment in land and infrastructure.
Are an environmentally-sensitive approach to wastewater treatment that is often viewed with favor by the general public.	Will result in continued discharge of nitrogen into the inland bays.

Refer to Table 3-1B for a summary of advantages and disadvantages of constructed wetlands for RBWWTP. While constructed wetlands have many benefits to the environment, they would not improve the effluent quality to a point that would change the analysis of the disposal alternatives. Constructed wetlands do not provide the new method of disposal needed by the RBWWTP to address the consent decree, and thus are not a feasible alternative.

3.1.1 Alternative 1: No Action

3.1.1.1 Description of Alternative

The City continues to operate the RBWWTP as currently configured, which will result in the continued discharge of treated effluent directly into the Lewes-Rehoboth Canal that empties directly into Rehoboth Bay.

3.1.1.2 Environmental Impact

The RBWWTP currently meets the annual waste load limit of the National Pollutant Discharge Elimination System (NPDES) permit. However, the continued discharge of treated effluent is not in compliance with the consent order imposed by DNREC to enforce the requirements of the TMDL. The TMDL developed by the Watershed Assessment Section, Division of Water Resources, DNREC, identified over enrichment by nitrogen and phosphorus as the cause for the Inland Bays not meeting their established water quality criteria. The symptoms of over enrichment include excessive macroalgae growth, phytoplankton blooms, large diurnal swings in dissolved oxygen, loss of submerged aquatic vegetation, and fish kills (DNREC 1998). Thus, the Bays are currently listed as water quality impaired and are not recommended for swimming or fishing use. According to the water quality model developed by DNREC, the water quality of the Bays would improve with the removal of other sources of discharge but would be unable to make the maximum recovery required by DNREC unless the point sources are eliminated.

3.1.1.3 Cost

The direct cost of taking no-action would be minimal since no capital investment would be required, and the operating costs would remain constant. However, the consent order finalized in December 2002 and made a part of the NPDES permit established a firm date of December 31, 2014 for discharge to be eliminated from the Lewes-Rehoboth Canal. If no-action is taken, legal action would likely be taken by DNREC against the City of Rehoboth Beach. Thus, this alternative could result in significant legal fees and fines.

3.1.2 Alternative 2: Nutrient Trading

3.1.2.1 Description of Alternative

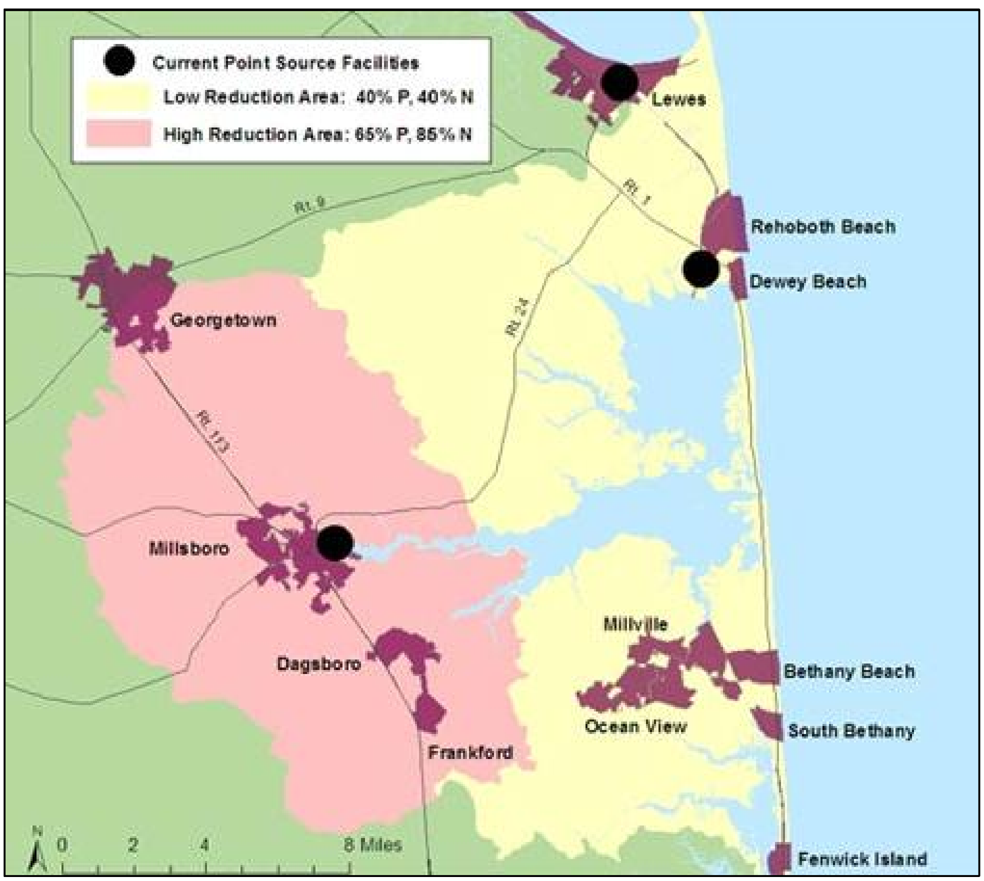
Nutrient trading would allow the RBWWTP to continue to discharge nutrients into the Lewes-Rehoboth Canal while meeting the terms of the consent order. Under a nutrient trading program, a cap is placed on the total amount of nitrogen and phosphorus that can be discharged into a body of water. Users within a watershed may then buy and sell the ability to discharge nutrients with each other. Thus, if one party wishes to exceed their allocated amount of nutrient loading, they may purchase nutrient credits from another party, who agrees to reduce their nutrient loading. The RBWWTP has the option to participate in such a program, as outlined by DNREC in the *Regulations Governing the Pollution Control Strategy for the Indian River, Indian River Bay, Rehoboth Bay and Little Assawoman Bay Watersheds* (DNREC 2008a):

Subject to approval by the Department, point sources may choose to engage in water quality trading on a case-by-case basis in accordance with the following:

1. Trades must occur within the same watershed … as the point source discharge is located.
2. Trades must involve a trading ratio of at least 2:1 between nonpoint sources and point sources.
3. The nutrient load reduction involved in the trade must constitute reductions that occur beyond the baseline or the point or nonpoint source nutrient reductions required under the TMDL and this Pollution Control Strategy.

All trading would have to occur between sources within the Inland Bays sub-basin, as presented in Figure 3-1. Trading would not be possible with any point sources within the sub-basin, since they too must eliminate all nutrient discharge per the TMDL. Non-point sources within the sub-basin may continue to discharge nutrients, but they must reduce nitrogen loading by 40-85% and phosphorus loading by 40-65%. Trading would only be possible with non-point sources that have reduced their loading in excessive of these mandated baseline reductions. Additionally, the consent order finalized in December 2002 would only allow credit offsetting if no other options were possible.

Figure 3-1 Inland Bay Sub-basin (DNREC 2008a)



3.1.2.2 Environmental Impact

While nitrogen and phosphorus would still be discharged into the Inland Bay sub-basin by the RBWWTP, the total amount of loading within the basin would decrease. As required by the Pollution Control Strategy Regulation (DNREC 2008a), trading with a non-point source must be at a 2:1 trading ratio. The non-point sources would have to reduce twice as much nutrient loading as the plant is discharging. The requirement for a 2:1 trading ratio is based on uncertainties in the actual amount of nutrients removed by different types of non-point source strategy employed and by the difficulties associated with maintaining these types of improvements. Credits are based on daily nutrient loads, so a nitrogen or phosphorus credit is equivalent to a continuous discharge of one (1) lb/day of the relevant nutrient. The required amount of nitrogen and phosphorus credits are shown in Table 3-1 and are based on the current RBWWTP performance and future projected flows.

Table 3-1 Nutrient Trading Requirements

Nutrient	Measured Concentration (mg/L)	Daily Load (lbs/day)			
		Current Annual Flow (1)		Future Annual Average Flow (2)	
		Actual	Credits Required	Actual	Credits Required
Nitrogen	6.2	46.9	94	130.1	261
Phosphorus	0.3	3.2	7	7.3	15

Notes:

1. Performance data based on January 2007 – July 2010. Annual average flow for reported period was 1.1 MGD.
2. Anticipated Annual average flow is 2.5 MGD.
3. Loading determined by average of daily loading, which varies according to daily flow and concentration.

3.1.2.3 Cost

With nutrient trading, no capital improvements would be required at the RBWWTP, and direct operating costs would not be affected. However, when operating at design capacity, the City would be required to annually purchase 261 nitrogen credits and 15 phosphorus credits from local non-point sources. Since credit trading is a market based system, the cost of nutrient credits is both hard to predict and highly volatile. The cost of nutrient credits can be estimated from the cost of implementing additional Best Management Practices (BMPs) on agricultural land, as presented in Table 3-2.

Table 3-2 Cost of implementing additional BMPs on agricultural land (DNREC 2008a)

	$/lb Nitrogen	$/lb Phosphorus
Cover Crops	$2.81	$890
Grass Filter Strips / Wildlife Habitats	$12.00	$524
Grass Buffers / Grass Filter Strips	$6.05	$157
Forested Buffers/Riparian Buffers	$4.25	$128
Wetland Restoration	$6.80	$204
Water Control Structures	$1.69	n/a
Manure Relocation	$2.32	$22
Average	$5	$321
Estimated Annual Cost per Credit	$1,825	$117,165

As presented in Table 3-3, based on an average cost of $5/ lb of nitrogen and $321/lb of phosphorus, the necessary reduction in nutrients would cost non-point sources a total of approximately $2.23 million a year. The actual cost will likely be significantly higher since the TMDL has already required significant reduction from the non-point sources. In addition, if future legislation further reduces the amount of allowed non-point nutrient loading, the available nutrient credits for purchase would decrease and potentially vanish.

Table 3-3 Cost of nutrient trading option

Nutrient	Cost per credit	Current Annual Average Load (1)		Anticipated Annual Average Load (2)	
		Credits Required	Annual Cost	Credits Required	Annual Cost
Nitrogen	$1,825	93.8	$171,000	260.2	$475,000
Phosphorus	$117,165	6.4	$750,000	14.6	$1,757,000
		Total Cost:	$921,000	Total Cost:	$2,232,000

Notes:

1. Performance data based on January 2007 – July 2010. Annual average flow for reported period was 1.1 MGD.
2. Anticipated Annual average flow is 2.5 MGD.

3.1.3 Alternative 3: Land Application

There are five (5) land application alternatives. One alternative is based on a system dedicated to Rehoboth Beach in which the land is owned or leased by the city. The other four (4) alternatives involve sending either raw or treated wastewater to other treatment plants in the area. These alternatives are as follow:

3.1.3.1 Description of Alternative

Land application involves the spray of treated wastewater effluent over a vegetated site at agronomic rates appropriate for irrigating the crop. It is considered a form of beneficial reuse since the practice involves the indirect recycle of water. This process accomplishes several objectives including irrigation of the crop, additional wastewater treatment and disposal of the effluent through nutrient uptake by the crop and filtration through the soil column, and recycling to the groundwater.

The additional treatment provided by the land application system is limited, but in the case of the RBWWTP, the effluent is already treated to a very high level. Typically, conventional secondary effluent would be acceptable for land application at restricted public access sites. This would require an effluent BOD and TSS of 30 mg/L. The RBWWTP currently produces an effluent with less than 15 mg/L BOD and TSS. The RBWWTP also removes a significant amount of nitrogen and phosphorus through biological and physical/chemical processes. A typical secondary wastewater treatment plant discharges approximately 20-25 mg/L TN and 4-6 mg/L TP. The RBWWTP currently discharges approximately 6.2 mg/L TN and 0.3 mg/L TP.

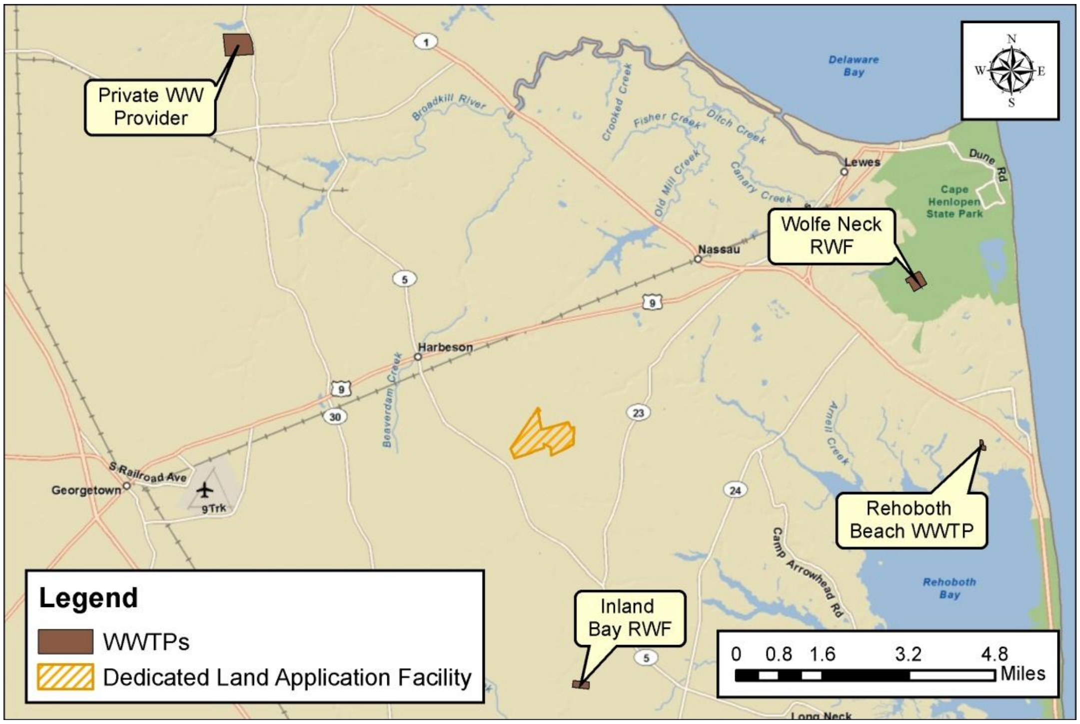
- **Alternative 3A:** The land application system designed for the sole use by RBWWTP would include a spray irrigation system, a pump station and an effluent flow conveyance system. A lagoon for onsite storage at the land application facility would also be required, since effluent is continuously discharged from the plant but not continuously land applied. In addition, under all alternatives where the RBWWTP remains in service, an effluent pump station would be required at the RBWWTP to provide the hydraulic head necessary to pump effluent to the land application site.

The other four land application alternatives involve sending either raw or treated wastewater to other treatment plants in the area. These alternatives are as follow:

- **Alternative 3B:** The RBWWTP is shut down and all raw wastewater is sent to the WNRWF with excess flow treated at the IBRWF.
- **Alternative 3C:** The RBWWTP is shut down and all raw wastewater is sent to the WNRWF with excess flow treated by a PWWP.
- **Alternative 3D:** The RBWWTP remains in service and treated effluent is sent to the WNRWF for disposal via spray irrigation, with excess flow sent to the IBRWF.
- **Alternative 3E:** The RBWWTP remains in service and treated effluent is sent to the WNRWF for disposal via spray irrigation, with excess flow sent to a PWWP.

All spray irrigation alternatives would require the construction of a new pump station at the RBWWTP to convey the treated or raw wastewater to the appropriate site. The location of the local treatment plants is presented in Figure 3-2.

Figure 3-2 Local Wastewater Treatment Plants



3.1.3.2 Environmental Impact

Land application has been practiced successfully in Delaware for over 25 years with no adverse effect on the fields, crops or groundwater. Additionally, the land used for spray irrigation would be protected from further development and remain a vegetated, pervious area.

There are a number of restrictions placed on the agricultural use of the land for the protection of human health. The growing of vegetables and the grazing of animals are prohibited on land that is actively used for land application (DNREC 1999). The concern is for the potential transfer of pathogens and parasitic organisms. Once land application has ceased, then:

- Grazing by animals other than dairy cows may be resumed after one month
- Grazing by dairy cows may be resumed after one year
- Vegetables may be grown after 18 months

The primary health related concern is in regards to the potential for either direct or indirect contact with pathogenic organisms contained in the effluent wastewater. This could potentially occur either by direct contact with effluent that has collected in ponds on the site in runoff from the site, or from contact with aerosols. This risk is essentially nonexistent since the effluent is disinfected prior to application on the field. Epidemiological studies have demonstrated that aerosols pose no increased health concern to the public

(See Section 9.6.2.2 for more information). There are several regulatory requirements regarding site buffers and level of disinfection that are intended to protect the public from these potential health risks. These regulations are contained in the DNREC document entitled "Guidance and Regulations Governing the Land Treatment of Wastes" (DNREC 1999). The regulations ensure a high level of wastewater treatment and restrict the uses of the land based on the level of treatment achieved. Site conditions, such as soil type and slope, must also be met, and buffers are required between the spray field and residential area, streams and wells. Typical secondary treated wastewater is required to maintain a 100 to 150 foot buffer. Design standards for land application systems prohibit the application of treated effluent at rates that will exceed the hydraulic capacity of the soils. Thus, runoff from the site should not be a concern if managed properly.

The treated effluent will percolate through the soil and into the shallow aquifer. As it passes through the soil and the roots of the crops, additional treatment of the effluent is achieved. The nitrate concentration in the percolate must not exceed the state drinking water standard of 10 mg/L (State of Delaware Department of Health & Social Services 2003). The RBWWTP operates a biological nutrient removal process in which ammonia is oxidized to nitrates and some of the resulting nitrates are removed as nitrogen gas through the process of denitrification. The effluent of the RBWWTP is typically 6 mg/L Total Nitrogen of which approximately 4 to 5 mg/L is in the form of nitrate. However, from an agronomic point of view, the discharge of nitrified wastewater, in which most of the ammonia has been oxidized to nitrate, is not preferred. The maximum uptake of nitrogen by plant growth is achieved when the nitrogen is in the form of ammonia or organic nitrogen. Nitrate is soluble and thus not retained by soil particles and tends to move with the groundwater.

Use of land application for effluent disposal to the ground water will ultimately result in the discharge to surface water bodies in the watershed. Land application is essentially not a farming operation. The treated effluent must be discharged throughout the year despite the fact that farming is a seasonal operation. During the winter there would be little or no additional uptake of nitrogen by crops. As the effluent passes through the soil and into the shallow aquifer, some minimal amount of additional treatment is achieved. Phosphorus can attenuate to some degree in the subsurface, but significant phosphorus plumes have been identified down gradient of wastewater discharge locations. Nitrogen is generally considered to be conservative in the subsurface environment and the nitrogen discharged from RBWWTP would ultimately end up in surface water via the groundwater pathway. Higher levels of treatment can mitigate the impacts of nutrients on surface water but would not completely eliminate the nutrients. Therefore, under a strict interpretation of the terms of the TMDL, the use of spray irrigation in the watershed would not be permittable.

Another concern in regards to the soils is the addition of salts that can accumulate over time. High concentrations of salts can cause injury to the crops. High concentrations of sodium relative to calcium and magnesium can reduce the permeability of the soil by the dispersion of clay materials. This ratio is expressed as the Sodium Absorption Ratio (SAR), which will reduce hydraulic conductivity in most soils if it is greater than 15. This is typically not a concern with a land application program that is properly managed. Municipal wastewater typically has SAR's of 5 or less, indicating that effluent from the RBWWTP will not impact hydraulic conductivity. (DNREC 1999).

3.1.3.3 Cost

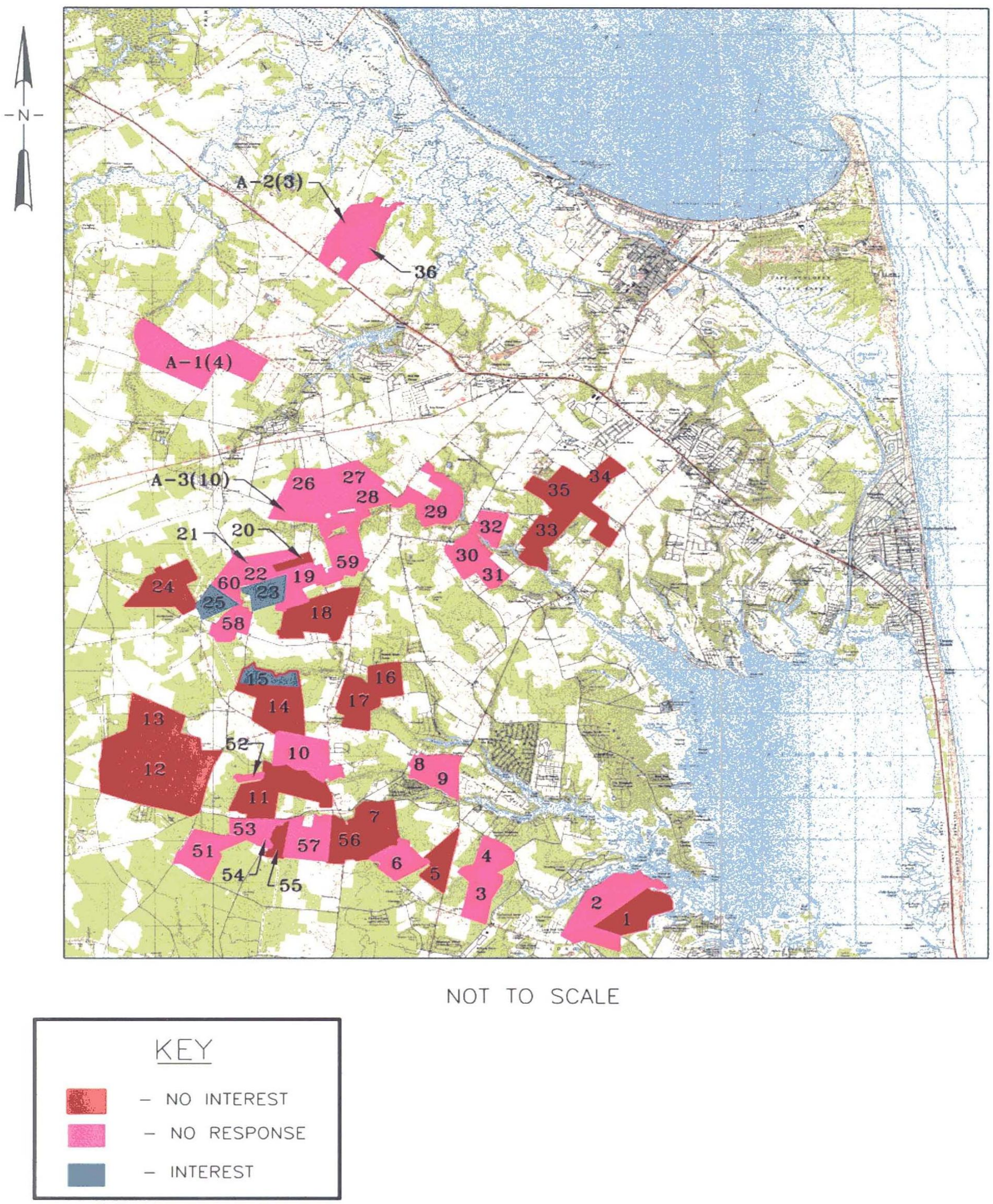
3.1.3.3.1 Alternative 3A: Dedicated Spray Irrigation Facility

Because of the restrictions outlined in Section 3.1.3.2, it is unlikely that any farm owners, even those owning land in the Agricultural Lands Preservation Program, would be willing to switch to irrigation by disinfected effluent, as this would prohibit them from growing produce or raising livestock for human consumption. Thus, for this alternative, the City would need to purchase or lease land specifically for the purpose of spray irrigation.

The site selected for the preliminary layout of the spray irrigation system was based on the single property owner that indicated tentative interest in selling his property to the City. However the size of this property is inadequate for a spray irrigation system and adjacent lands are not available to the City for purchase. Even if land was available to implement spray irrigation that met the current effluent disposal needs of the RBWWTP, any future increases in flow would require additional land to be found. An extensive land search utilized the services of a professional realtor over a period of several years but was not successful in identifying even a single landowner willing to sell their property to the City for the purpose of spraying treated effluent. Letters were sent to all the property owners within a reasonable distance of the RBWWTP (approximately 15 miles) soliciting interest. This effort was followed up by an expanded search with phone contact and an additional letter. The search was then again expanded to include lands that are preserved for agricultural use by the Delaware Agricultural Lands Preservation Act. The Agricultural Lands Preservation Foundation was established by the State of Delaware to create incentives to agricultural land owners to preserve their land for farming and not sell to developers. The law does not allow the application of treated effluent on lands preserved by the Agricultural Land Preservation Act, but the last several years there have been initiatives in the legislature to remove these restrictions. The owners of three (3) different groups of properties protected by the Agricultural Land Preservation Act were contacted, but none expressed an interest in allowing spray irrigation. At one point during the land search, a good faith effort was made by the City to purchase a tract of land. The tract of land would have been too small to meet the needs of a spray irritation facility, but the objective was to initiate a program of land acquisition with the hope that others would be willing to sell after the initial purchase was made. However, the purchase offer was declined, and no further acquisition could be identified. A search for leasable land was also conducted and was also not successful.

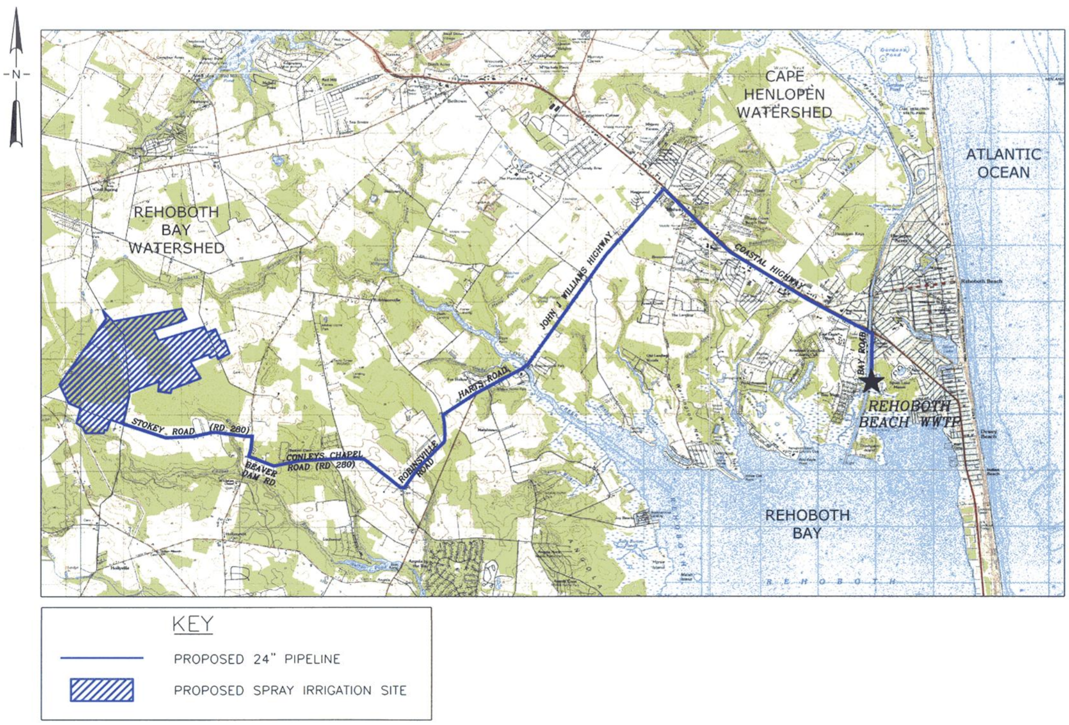
A summary of the land search effort is presented in (Appendix C) and further detail is available in the "Rehoboth Beach Wastewater Treatment Plant Effluent Disposal Study" (Stearns & Wheler 2005). A map showing the properties contacted and the results is presented in Figure 3-3.

Figure 3-3 Sussex County Land Availability (Stearns & Wheler 2005)



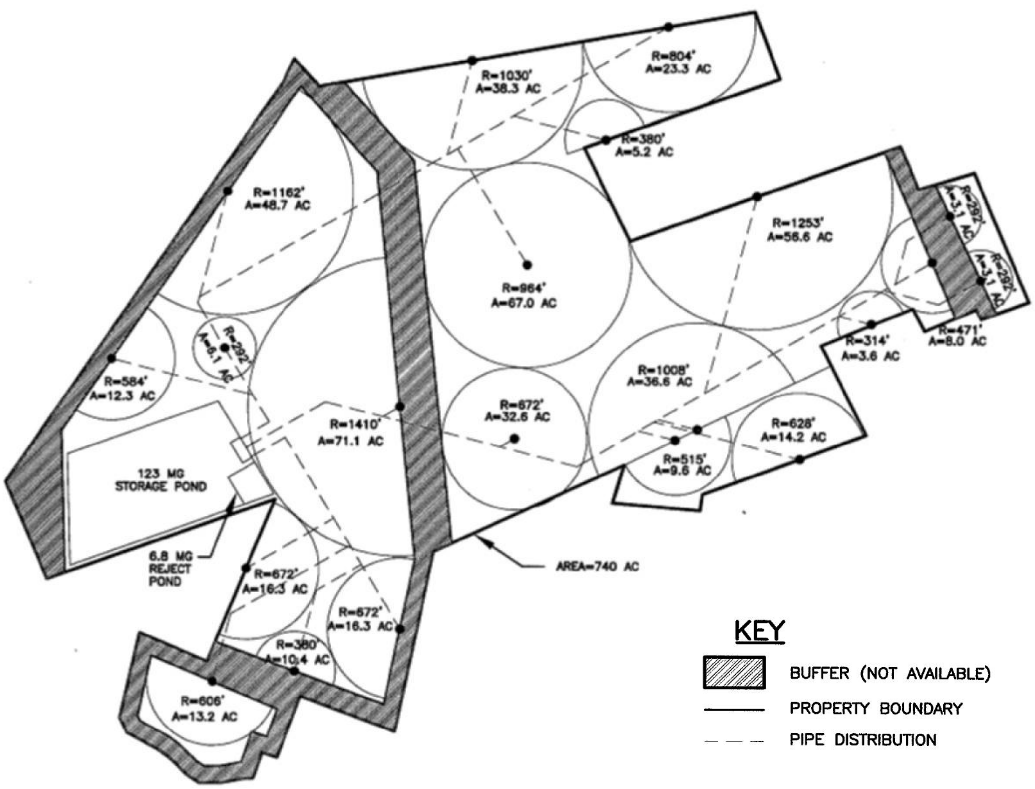
For a dedicated effluent spraying operation to be feasible, it is necessary to acquire adjacent properties. If the spray fields are too spread out geographically, the piping to distribute the effluent and the management of the operation becomes impractical and excessively expensive. However, for the purpose of developing cost estimates for this alternative, it was assumed that the City could acquire the properties identified in Figure 3-4 for construction of an effluent spray irrigation system. The land purchase cost estimate was based on the total acreage required.

Figure 3-4 Proposed Spray Irrigation Field Location



The dedicated spray irrigation facility design, as shown in Figure 3-5, is the basis of the cost estimate presented. The design is based on 123 MG of storage volume and a design hydraulic loading rate of 2.1 inches per week on the irrigation fields. To achieve this design, the storage lagoon will require 47 acres and the spray fields will require 496 acres, resulting in a total area of 740 acres required for purchase.

Figure 3-5 Proposed Spray Irrigation Field Site Plan



An engineering estimate of probable construction cost for spray irrigation is presented in Table 3-4.

Table 3-4 Estimate of Probable Construction Cost for the RBWWTP Spray Irrigation System Alternative

Description	Cost
RBWWTP Effluent Pump Station	$1,000,000
Force Main to Lagoon (Holding Pond)	$15,500,000
Spray Irrigation System	$16,400,000
Land Purchase Price[(1)]	$18,500,000
Construction Cost (Year 2005 Dollars)[(2)]	$51,400,000
Engineering, Construction Inspection, Administration, Legal and Financial Expenses @ 30%	$9,900,000
Total Project Cost (Year 2005 Dollars)	$61,300,000

Description	Cost
Total Project Cost (Year 2009 Dollars) (3)	$69,000,000

Notes:

1. Land price estimate based on 740 acres @ $25,000 per acre.
2. Cost includes 30 % contingency.
3. At 3.0% inflation rate.

3.1.3.3.2 Alternative 3B: Sending Raw Wastewater to WNRWF with Excess Flow Sent to the IBRWF

Under this alternative, the RBWWTP would be shut down, and all raw wastewater would be sent to the WNRWF with excess flow treated at the IBRWF. This alternative will require the construction of a new Rehoboth Beach raw wastewater pump station, a force main to convey the flows from the pump station to the WNRWF, upgraded headworks facilities at the WNRWF, a new Wolfe Neck transfer pump station, and a new force main to the IBRWF. Expanded treatment and disposal facilities will have to be constructed at the IBRWF to handle additional flow. This alternative would be implemented in cooperation with Sussex County, which would own and operate the WNRWF and IDRWF land application facilities for their own treatment needs. Table 3-5 presents the estimated cost based on a tentative cost sharing agreement with the County.

Table 3-5 Alternative 3B Capital Cost Summary

Description	Total Estimated Capital Cost[1] (Year 2009 Dollars)	Estimated Cost for RB Service Area [2] (Year 2009 Dollars)
RBSTP Pumping Station	$3,000,000	$3,000,000
30" PVC Force Main to WNRWF	$3,120,000	$3,120,000
WNRWF Headworks Upgrades	$1,530,000	$550,000
WNRWF to IBRWF Transfer Pumping Station	$2,490,000	$1,350,000
24" PVC Force Main to IBRWF	$13,030,000	$7,070,000
IBRWF Phase 2 Upgrades	$20,600,000	$20,600,000
IBRWF Phase 3 Upgrades	$12,700,000	$6,770,000
IBRWF Phase 4 Upgrades	$18,850,000	$0
Land/Easements	$11,250,000	$11,250,000
10% Contingency	$7,530,000	$4,250,000
Engineering/Administration	$18,230,000	$10,280,000
Total Project Cost	$112,320,000	$68,250,000

Notes:

1. Total Estimated Capital Cost includes total construction cost, including cost Sussex County is responsible for.
2. Cost for RB Service Area includes cost for Sussex County residents in Dewey Beach, Henlopen Acres, and North Shores.

3.1.3.3.3 Alternative 3C: Sending Raw Wastewater to WNRWF with Excess Flow Sent to a PWWP

Under this alternative, the RBWWTP would be shut down and all raw wastewater would be sent to the WNRWF with excess flow treated by a PWWP. This alternative will require the construction of a new Rehoboth Beach raw wastewater pump station, a force main to convey the flows from the pump station to the WNRWF, upgraded headworks facilities at the WNRWF, a new Wolfe Neck transfer pump station, and a new force main to the PWWP. Expanded treatment and disposal facilities will have to be constructed at the PWWP facility to handle additional flow. The cost of partnering with a PWWP was estimated based on the approach proposed by Artesian Resources to pump excess wastewater to the Artesian Northern Sussex Regional Water Recharge Facility (ANSWRF). This approach was developed as a result of a Request for Proposals issued by the City in which the City solicited proposals from private utilities to accept either raw wastewater or treated effluent from the RBWWTP for disposal via land application.

This alternative also requires cooperation with Sussex County and thus the cost of required facility upgrades and the cost of the private utility would be shared between the City and the County. The estimated costs are presented in Table 3-6.

Table 3-6 Alternative 3C Capital Cost Summary

Description	Total Estimated Capital Cost[1] (Year 2009 Dollars)	Estimated Cost for RB Service Area[2] (Year 2009 Dollars)
RBSTP Pumping Station	$3,000,000	$3,000,000
30" PVC Force Main to WNRWF	$3,120,000	$3,120,000
WNRWF Headworks Upgrades	$1,530,000	$550,000
WNRWF to ANSWERF Transfer Pumping Station	$2,490,000	$1,350,000
IBRWF Phase 2 Upgrades	$10,910,000	$0
24" PVC Force Main to ANSRWF	$15,700,000	$8,530,000
ANSWRF Treatment Capacity	$48,410,000	$26,310,000
Land/Easements	$500,000	$270,000
Contingency	$3,720,000	$1,680,000
Engineering & Administration	$10,630,000	$4,800,000

Description	Total Estimated Capital Cost[1] (Year 2009 Dollars)	Estimated Cost for RB Service Area[2] (Year 2009 Dollars)
Total Project Cost	$100,010,000	$49,600,000

Notes:

1. Total Estimated Capital Cost includes total construction cost, including cost Sussex County is responsible for.
2. Cost for RB Service Area includes cost for Sussex County residents in Dewey Beach, Henlopen Acres, and North Shores.

3.1.3.3.4 Alternative 3D: Sending Treated Effluent to WNRWF with Excess Flow Sent to the IBRWF

This alternative will require the construction of a new Rehoboth Beach pump station (RBPS), a force main to convey the flows from the RBPS to the WNRWF, a new Wolfe Neck transfer pump station, and a new force main to the IBRWF. Expanded treatment and disposal facilities will have to be constructed at the IBRWF. Table 3-7 summarizes the capital costs for Alternatives 2D.

Table 3-7 Alternative 3D Capital Cost Summary

Description	Total Estimated Capital Cost[1] (Year 2009 Dollars)	Estimated Cost for RB Service Area[2] (Year 2009 Dollars)
RBSTP Pumping Station	$900,000	$900,000
30" PVC Force Main to WNRWF	$3,500,000	$3,500,000
RBWWTP Improvements	$2,930,000	$2,930,000
WNRWF Headworks Upgrades	$1,300,000	$0
WNRWF to IBRWF Transfer Pumping Station	$2,270,000	$950,000
24" PVC Force Main to IBRWF	$13,030,000	$5,430,000
IBRWF Phase 2 Upgrades	$20,600,000	$18,190,000
IBRWF Phase 3 Upgrades	$12,700,000	$0
IBRWF Phase 4 Upgrades	$10,660,000	$0
Land/Easements	$11,250,000	$11,250,000
Contingency	$6,930,000	$3,340,000
Engineering/Administration	$16,460,000	$7,750,000
Total Project Cost	$102,500,000	$54,200,000

Notes:

1. Total Estimated Capital Cost includes total construction cost, including cost Sussex County is responsible for.
2. Cost for RB Service Area includes cost for Sussex County residents in Dewey Beach, Henlopen Acres, and North Shores.

3.1.3.3.5 Alternative 3E: Cost of Sending Treated Effluent to WNRWF with Excess Flow Sent to a PWWP

This alternative will require the construction of a new Rehoboth Beach pump station (RBPS), a force main to convey the flows from the RBPS to the WNRWF, a new Wolfe Neck transfer pump station, and a new force main to a PWWP. Expanded treatment and disposal facilities will have to be constructed at a PWWP facility. The cost of partnering with a PWWP was estimated based on an approach, suggested by Artesian Resources, to pump excess wastewater to the Artesian Northern Sussex Regional Water Recharge Facility (ANSWRF). Table 3-8 summarize the capital costs for Alternatives 3E.

Table 3-8 Alternative 3E Capital Cost Summary

Description	Total Estimated Capital Cost[1] (Year 2009 Dollars)	Estimated Cost for RB Service Area[2] (Year 2009 Dollars)
RBSTP Pumping Station	$900,000	$900,000
30" PVC Force Main to WNRWF	$3,500,000	$3,500,000
RBWWTP Improvements	$2,930,000	$2,930,000
WNRWF Headworks Upgrades	$1,300,000	$0
WNRWF to ANSWERF Transfer Pumping Station	$2,270,000	$950,000
IBRWF Phase 2 Upgrades	$10,910,000	$0
24" PVC Force Main to ANSRWF	$15,700,000	$6,550,000
ANSWRF Treatment Capacity	$38,580,000	$16,090,000
Land/Easements	$500,000	$210,000
Contingency	$3,950,000	$1,650,000
Engineering & Administration	$10,470,000	$4,140,000
Total Project Cost	$91,000,000	$36,900,000

Notes:

1. Total Estimated Capital Cost includes total construction cost, including cost Sussex County is responsible for.
2. Cost for RB Service Area includes cost for Sussex County residents in Dewey Beach, Henlopen Acres, and North Shore.

3.1.4 Alternative 4: Rapid Infiltration Beds

3.1.4.1 Description of Alternative

Rapid infiltration involves the percolation of treated effluent into the ground water through a soil bed at a fairly high rate. The basins are typically flooded and then allowed to dry and rest for a period of time. Thus the rapid infiltration beds (RIBs) rotate in and out of service. The soil that provides the bed for percolation of the effluent is typically either sand or the natural soils on the site. A minimal amount of additional treatment is achieved through filtration, but the treatment level is much less than provided by spray irrigation, which involves effluent application rates that are much lower and the use of crops to take up nutrients. Filtration through the soil may remove some minor amount of BOD and solids. A very minor amount of nitrogen, present as organic nitrogen in particulate form, may be removed but soluble organic nitrogen, ammonia and oxidized nitrogen (nitrate) which are soluble, will pass through to the ground water. Ammonia can be oxidized to nitrate through the process of nitrification by bacteria present in the soil, if a sufficient amount of oxygen is present. However, this results in increased levels of nitrate with the potential to violate groundwater standards. A layout plan of the RBWWTP, with RIBs for effluent disposal, is shown in Figure 3-6.

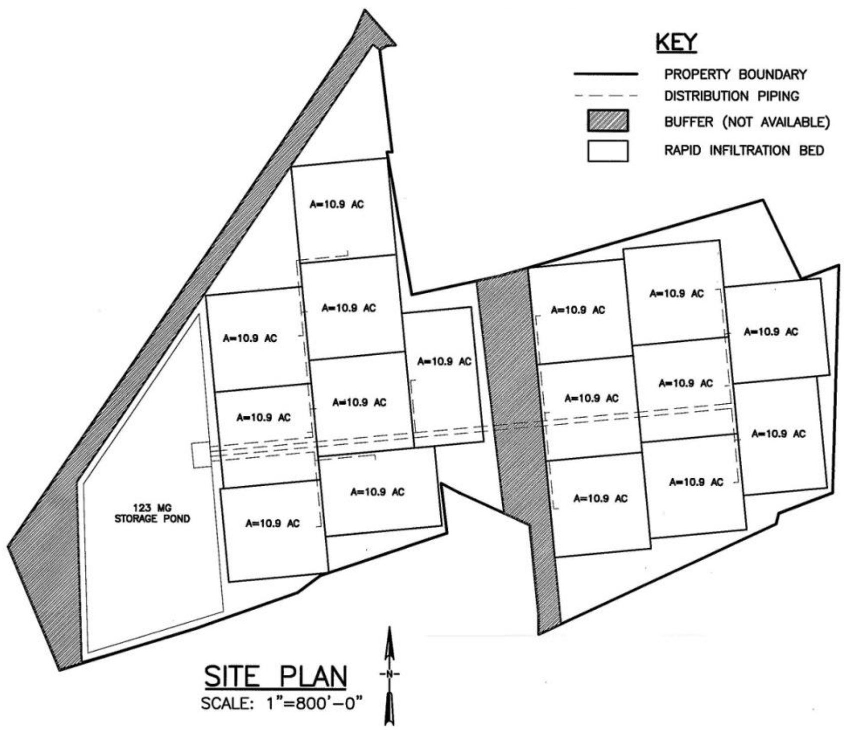
Figure 3-6 Proposed Rapid Infiltration Bed Location

As shown in Figure 3-3, the land search identified only one site with limited acreage as a possible site for either land application or RIBs. The property, referred to as the Glatfelter property, is located approximately 11.5 miles from the RBWWTP and would require an effluent pump station and extensive piping to deliver the effluent to the site. In addition, this alternative would require obtaining several adjacent properties in order to accommodate a RIB system. The City was not able to purchase or lease the property. However, in order to provide a realistic basis for comparison of costs, it was assumed that the RIBs would be constructed at this site.

As with the spray irrigation alternative, a holding pond sized for 123 million gallons (MG) of storage and flow equalization would be required with the RIB system.

The RIB facility design proposed in the "2005 Effluent Disposal Study" (Stearns & Wheler 2005), as shown in Figure 3-7, is the basis of the cost estimate presented. The design is based on 123 MG of storage volume and a design application rate of 0.6 gallons per day per square foot (gpd/sf) based on the soil characteristics of the site. This design will require 16 beds, each approximately 10.9 acres, and a 47 acre storage lagoon, resulting in a total facility area of 300 acres.

Figure 3-7 Proposed Rapid Infiltration Bed Site Plan



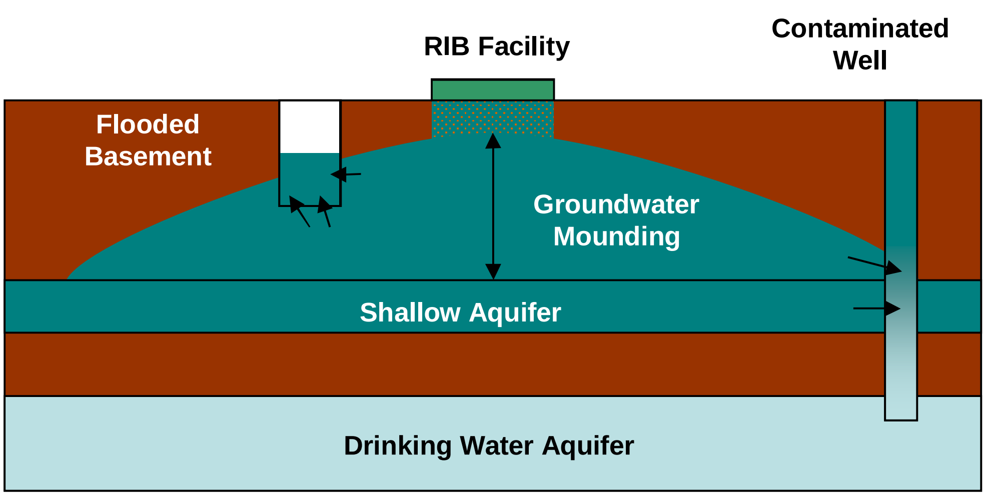
3.1.4.2 Environmental Impact

The rapid infiltration site would have to be closed to the public, to eliminate direct contact with effluent and the risk associated with flooded ponds. The effluent is not sprayed; therefore, there is little risk of aerosols presenting a health hazard to the public. The other source of potential adverse heath affects is through ground water contamination. The treated effluent will continue to be disinfected, and thus, the risk of introducing pathogens to the groundwater is minimized. However, disinfection does not remove all bacteria and viruses. Some additional removal of solids and associated bacteria will be achieved as the water passes through the RIBs and through the soils.

Use of RIBs for effluent disposal to the ground water will ultimately result in the discharge to surface water bodies in the watershed. The treated effluent will percolate through the soil and into the shallow aquifer. As the effluent passes through the soil, some minimal amount of additional treatment is achieved. Phosphorus can attenuate to some degree in the subsurface, but significant phosphorus plumes have been identified down gradient of wastewater discharge locations. Nitrogen is generally considered to be conservative in the subsurface environment and the nitrogen discharged from the RBWWTP would ultimately end up in surface water via the groundwater pathway. The RBWWTP provides a higher degree of treatment than is normally provided for RIBs. The standard level of treatment required is to meet secondary treatment requirements. The RBWWTP provides tertiary treatment, which removes additional solids, provides biological nitrogen removal and achieves chemical phosphorus removal. The nitrate concentration in the percolate must not exceed the state drinking water standard of 10 mg/L. The effluent of the RBWWTP is typically 6 mg/L Total Nitrogen of which approximately 4 to 5 mg/L is in the form of nitrate. There are no metals or hazardous waste in the RBWWTP effluent. Higher levels of treatment can mitigate the impacts of nutrients on surface water but would not completely eliminate the nutrients. Therefore, under the terms of the TMDL, the use of RIBs in the watershed would not be permittable.

The use of RIBs presents the risk of groundwater mounding in the vicinity of the ponds. Groundwater at the proposed RIB site is found at a depth of approximately 10 feet based on data from wells in the area. The potential increase in the groundwater elevation was modeled using the Hantaxis Model based on what was known about the existing water table gradient and the type of soils at the proposed site (Stearns & Wheler 2005). The model found that a mound of approximately 9.0 feet has the potential to form if 2.3 MGD is applied over a 90 acre area. The effect of groundwater mounding can be seen in Figure 3-8. The increased hydrostatic head caused by the RIB facility could potentially drive the injected effluent into the basements of residences in the area or into nearby wells, affecting the water quality. Approximately 205 wells are located in the area of the proposed RIB site.

Figure 3-8 Groundwater Mounding



Historically, RIB facilities on the east coast have regularly encountered severe issues that result in decreased capacity, ground or surface water contamination, or complete facility shut down. On the east coast, RIBs serve only as a method of effluent disposal, but in more arid regions RIBs provide crucial groundwater recharge and typically have a known customer that pumps the water back out of the aquifer.

Permitting of an RIB requires the accurate mapping of the hydrogeology of the region so that the directional flow of groundwater is completely understood. This requires a significant upfront investment that is not practical since any discharge to the groundwater in the watershed will most likely flow to surface waters that discharge to the Inland Bays. This would be in violation of the consent order, which prohibits the discharge of nutrients to the Inland Bays.

A study completed by the Delaware Geological Survey (Türkmen, et al. 2008) concluded that the discharge of poorly treated wastewater to RIBs creates a potential risk to groundwater due to nutrient and pathogen contamination. The Columbian aquifer is quite shallow and thus particularly at risk.

There are additional risks of failure with regard to RIBs. The Hammonton Land Application Facility in Hammonton, NJ is currently operating at a third of its design capacity because of lower than expected infiltration rates (Reilly, et al. 2006). RIBs in Bethany Bay, DE and Southwood Acres, MA, have been completely abandoned because the effluent would not infiltrate. Many RIBs that are still hydraulically functioning, such as those in Solomon's Island, MD and Winslow Township in Sicklerville, NJ, require significant maintenance work to remain in operation (Andres 2010). The Solomons Island WWTP was required to undergo a significant upgrade in order to continue RIB discharging because the ammonia discharged to the groundwater was becoming nitrified and contaminating the groundwater with high levels of nitrates (Andres 2010).

3.1.4.3 Cost

A summary of the engineering estimate of probable construction cost for the RIB is presented in Table 3-9.

Table 3-9 Estimate of Probable Construction Cost for the RBWWTP Rapid Infiltration Bed Alternative

Description	Cost
RBWWTP Effluent Pump Station	$1,000,000
Force Main to Holding Pond	$15,500,000
Rapid Infiltration Bed System	$18,900,000
Land Purchase Price(1)	$7,350,000
Construction Cost (Year 2005 Dollars)(2)	$42,750,000
Engineering, Construction Inspection, Administration, Legal and Financial Expenses @ 30%	$10,600,000
Total Project Cost (Year 2005 Dollars)	$53,350,000
Total Project Cost (Year 2009 Dollars) (3)	$60,000,000

Notes:

1. Land price estimate based on 296 acres @ $25,000 per acre.

2. Cost includes 30 % contingency. No contingency for land prices.

3. At 3.0% inflation rate

3.1.5 Alternative 5: Ground Water Injection

Underground injection is referred to as the disposal of wastewater below ground by pumping or gravity flow to an aquifer. A well is defined as any bored, drilled or driven shaft or dry hole that is deeper than it is wide. There are five (5) classes of wells regulated by the Environmental Protection Agency (EPA) and DNREC; however, there are basically two types of underground injection systems that could potentially be used to dispose of the treated effluent from the RBWWTP. These are Shallow Well Injection (Class V) and Deep Well Injection (Class I).

Two (2) potential locations for the well field would be the RBWWTP and Thompson Island as shown on Figure 3-9. The Thompson Island site is a nature preserve and is considered in this report only for the purpose of developing a cost estimate. The Thompson Island Nature Preserve has significant historical, cultural, and ecological resources that require protection. It is recognized that it is very unlikely that approval to build on the site could be obtained.

Figure 3-9 Potential Well Injection Sites

SCALE: 1"=1000'-0"

3.1.5.1 Alternative 5A: Shallow Wells

3.1.5.1.1 Description of Alternative

Shallow wells would typically include any system that injects treated wastewater into a shallow aquifer either by pumping into the aquifer or by infiltration. This type of well system is regulated as a Class V well. With shallow injection wells, the aquifer is not confined and the injected wastewater effluent is free to migrate as determined by the pressure gradients. The greatest concern with this type of disposal system is the protection of all Underground Source of Drinking Water (USDW) aquifers, and there are two (2) situations under which this type of well may be permittable: either the treated effluent must meet safe drinking water standards or the shallow aquifer must already be contaminated to the point where it would no longer be considered as a potential source of drinking water. The latter situation could possibly exist in coastal areas where salt water has intruded into the shallow drinking water aquifer; however, there are no existing sites in the watershed that have salt water contamination at the concentration required to make the aquifer eligible for effluent disposal. Furthermore, there is no intent on the part of DNREC to consider the declassification of a USDW aquifer to allow its use for effluent disposal.

Treatment of the effluent to a level that would comply with drinking water standards is technically feasible. However, it would be very expensive, and there are currently no water supply issues that would favor this alternative. Delaware Geological Survey has indicated that the drinking water aquifers in the Delaware area provide a plentiful supply of drinking water (Talley and Andres 1987).

3.1.5.1.2 Environmental Impact

The land disturbance resulting from the construction of an individual well is minimal, and the impacts are primarily related to construction and are thus temporary. However, a much larger area is impacted because of the number of wells that could potentially be required. The physical facilities must be protected from access by the public. The site could still be available to the public, but the individual well sites would have to be fenced. The permanent impacts, other than site access, are minimal because the well sites have a low profile and present very little aesthetic impacts.

Shallow well injection could potentially impact drinking water sources because effluent injection would be into a superficial aquifer. However, by definition, injection would be either into an already contaminated aquifer (which is not the case with Rehoboth Beach) or the injected wastewater would have to meet drinking water quality standards. Although technically feasible, it is not proposed to treat the effluent to that level because of the capital and operating cost required and issues associated with public perception of pumping into a drinking water aquifer.

Drinking water regulations limit the amount of nitrates to less than 10 mg/L. Even if the effluent was treated to drinking water standards, the effluent would still contain some forms of nitrogen and most likely contain as much as 6 mg/L Total Nitrogen. At the proposed injection site, groundwater recharges the Lewes and Rehoboth Canal or flows directly to the Rehoboth Bay. This is despite the probable subregional flow toward the coast because the canal and bay are immediately adjacent to the proposed injection site. Thus, any nutrients in the treated effluent would reach the Inland Bays, which violates the requirements of the TMDL.

There is a potential benefit associated with shallow well injection if the site is properly located. A shallow well injection system could provide a buffer against salt water intrusion if the wells are located such that the net flow of groundwater is forced toward the ocean. However, property in the vicinity with the required hydrogeologic characteristics is not available along the coast. All such property is either private residencies or state-owned park land.

There is a potential for public health issues with underground injection but not due to routine operations. The regulations imposed on this type of disposal technology are stringent and have been shown to adequately protect public health when properly implemented. However, in the event of a failure of the treatment process or redundant protection systems, there is a potential to contaminate a potential drinking water source. Water quality monitoring would detect this event and the injection well would be taken offline and an emergency response plan (as required by permit) would be initiated.

3.1.5.1.3 Cost

For the effluent to meet drinking water standards, the RBWWTP would have to be expanded to provide additional treatment. A reverse osmosis system, such as that used in desalination plants, would be required for removal of total dissolved solids and viruses. The cost would be approximately $17.5 million in 2009 dollars. See (Appendix D) for a detailed cost estimate. There are currently no water supply issues that would favor this alternative. Delaware Geological Survey (DGS) has indicated that the drinking water aquifers in the Delaware area provide a plentiful supply of drinking water (Talley and Andres 1987).

3.1.5.2 Alternative 5B: Deep Wells

3.1.5.2.1 Description of Alternative

Deep Wells are wells that inject waste below the lowermost geological formation containing an existing or potential drinking water aquifer defined in the Underground Injection Control program as an USDW. A USDW is an aquifer that is presently used for drinking water, has the potential to be used for drinking water or has a total dissolved solids (TDS) concentration less than 10,000 mg/L. Deep wells inject into aquifers below USDWs and are regulated as Class I wells. A confining geologic layer must be present between the USDW and the contaminated aquifer to protect the USDW from potential contamination. The porosity and permeability in the injection zone must be sufficient to prevent excessive pressure buildup in the aquifer. The depth of Class I wells varies but can be as deep as 12,000 feet or more.

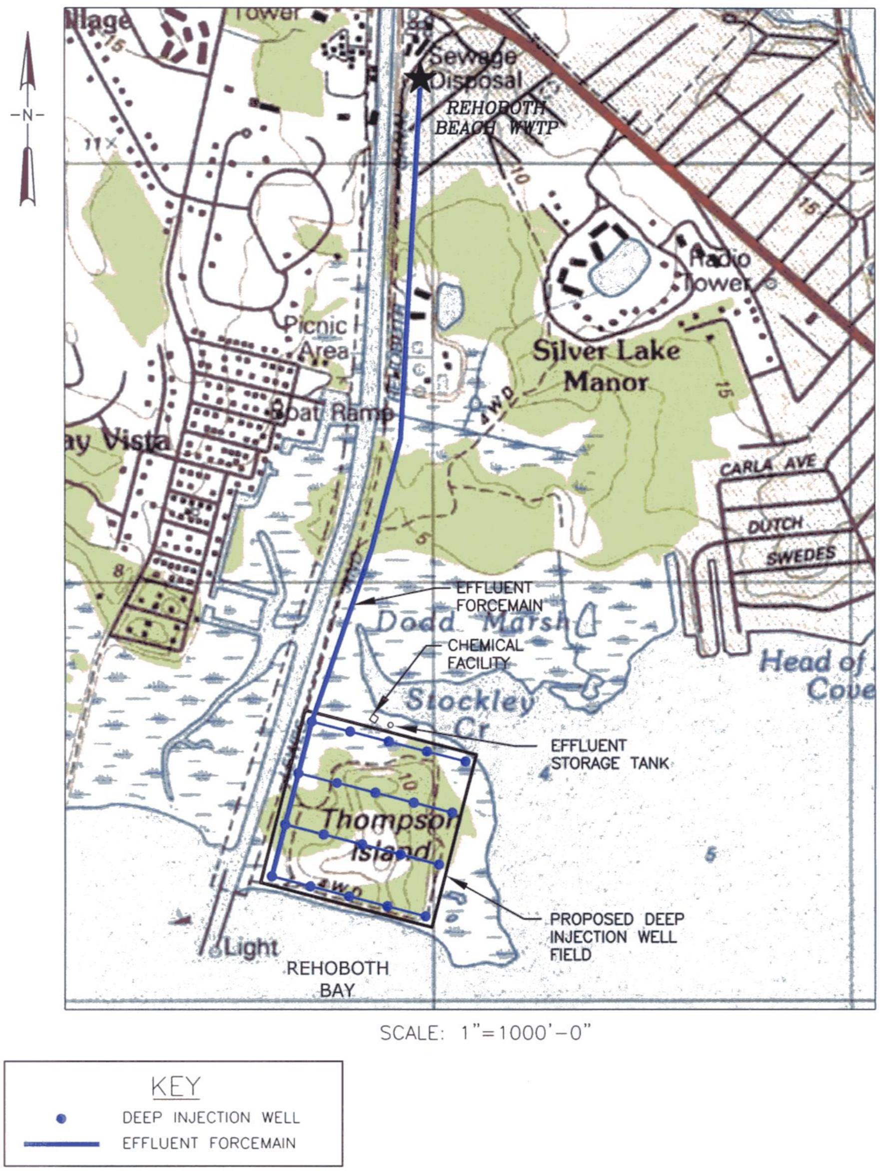
Drilling logs to the depth required to definitively evaluate this option are limited. However, some limited information available from the DGS and the Maryland Geological Survey (MGS) allowed a very preliminary assessment of its potential. Based on the limited available information, the Cheswold and Waste Gate Formations are two possible formations for deep well injection (Stearns & Wheler 2005).

The Cheswold formation is approximately 900 feet deep. It is believed that the level of salinity in the aquifer is in the range of several hundred mg/L, which is not nearly enough to disqualify it as a USDW. Thus it was dismissed from further consideration.

The Waste Gate Formation was identified when the US Department of Energy drilled in the area in a search for oil heavy formations. The confined aquifer is approximately 5,000 feet deep and is believed to contain salinities of approximately 42,000 mg/L. This aquifer was carried forward for consideration despite the fact that the potential to actually use such an injection field for this purpose was very tenuous.

As proposed in the 2005 “Rehoboth Beach Wastewater Treatment Plant Effluent Disposal Study” (Stearns & Wheler 2005), the evaluation of underground injection as an effluent disposal alternative will be based upon using deep wells (Class I) located on the Thompson Island property, to drill into the deep Waste Gate Formation. The locations of the proposed wells are shown in Figure 3-10.

Figure 3-10 Proposed Deep Well Injection Site Plan



3.1.5.2.2 Environmental Impact

In 1989, the EPA studied the comparative risk associated with a number of treatment technologies including deep well injection and concluded that deep well injection was one of the most desirable alternatives in terms of risk (USEPA 1989). Further studies (USEPA 2001) also concluded that the probability of failure has been demonstrated to be low. The existing permitting, testing, construction and monitoring requirements provide adequate protection.

Deep well injection would directly impact groundwater, but the aquifer effected would not be a potential source of drinking water and the groundwater would be completely isolated from any potential sources of drinking water. Deep well injection has little or no potential to impact surface waters since the effluent would be injected beneath a confining layer that prevents movement vertically to the surface. Thus, compliance with TMDL requirements prohibiting the discharge of nutrients to the Inland Bays is assured.

This method of effluent disposal does not recharge the drinking water aquifer. However, the DGS has indicated that there is an abundant supply of water in the drinking water aquifers and that recharge to protect the supply is not a concern (Talley and Andres 1987). Additionally, the current method of wastewater disposal, as a point source discharge to the canal, does not recharge the groundwater.

Despite best efforts to isolate a well and to seal the well casing to prevent migration from a formation below to the aquifer above, it is not possible to absolutely guarantee that there will never be any cross contamination. However, continuous monitoring of the well operation should detect the possibility of contamination at which time a response plan for closing the well would be implemented.

3.1.5.2.3 Cost

One major hurdle in proceeding with deep well injection is the risk associated with the permitting and design process. Developing the test well to obtain the information required to proceed with design and permitting is costly. This money would have to be invested with no guarantee that the project will ultimately be technically feasible or permitted by DNREC.

The technical feasibility of this alternative is doubtful because of the unknowns associated with the subsurface geology of the Waste Gate Formation. The stratigraphy of this formation is very complex with beds of sand lying within clay layers. Adequate capacity for disposal relies on a sufficient length of well screen for discharge into the sand layers. This is an unknown that can vary greatly depending on location and which cannot be determined until expensive pilot wells are drilled. Also, capacity relies on soil transmissivity which is an unknown until a pilot well is drilled.

The estimated capital cost for the required improvements at the RBWWTP and for the underground injection wells and appurtenances are shown in Table 3-10.

Table 3-10 Deep Injection Well Probable Construction Cost Estimate

Description	Cost
RBWWTP - Effluent Filters	$2,680,000
RBWWTP – Effluent Pump Station	$1,000,000

Description	Cost
Chlorination System	$30,000
Force Main to Well Field	$1,090,000
6,000 ft Deep Injection Well (20 wells @ $4,000,000)	$80,000,000
Well Field Pipe Manifold	$760,000
Description	**Cost**
Well Redevelopment	$410,000
Land Purchase Price[(1)]	$1,050,000
Construction Cost (Year 2005 Dollars)[(2)]	$87,020,000
Engineering, Construction Inspection, Administration, Legal and Financial Expenses @ 30%	$25,800,000
Total Project Cost (2005 Dollars)	$112,800,000
Total Project Cost (2009 Dollars) [(3)]	$127,000,000

Notes:

1. Land price estimate based on 42 acres @ $25,000 per acre.
2. Cost includes 30% contingency. No contingency on land purchase.

The estimated costs for the deep well injection system are extremely high. There are a number of reasons for this in addition to the anticipated depth of the wells. In the absence of good design data, which could only be obtained by drilling expensive pilot wells, several fairly conservative design criteria were set regarding the length of the injection zone and the injection rate. Also, this alternative must include a method to periodically clean the well screens by backwashing the well with chemicals. The chemical backwash waste would be pumped back from the well and returned to the RBWWTP for treatment. Most significant, however, is the cost of the drilling operation. Experience with typical municipal drinking water wells is not applicable because of the difference in well depths. The technology to install the deep wells is similar to that used in the oil drilling industry, and there are few contractors on the east coast capable of performing this work.

3.1.6 Alternative 6: Ocean Outfall

3.1.6.1 Description of Alternative

This method of effluent disposal is based on the discharge of the highly treated effluent wastewater into the ocean at a distance offshore and at a depth where the potential public health and environmental impacts are minimized or proven to be negligible. The system would be designed such that the initial dilution and dispersion of the treated effluent will achieve compliance with all water quality regulations and public health standards. Ocean outfalls have been used for many years, both locally and around the world, as a means to dispose of treated wastewater with an excellent record of protecting environmental resources and protecting public health. Public health is protected in several ways, including:

- **Advanced Treatment:** A very high level of treatment is provided prior to discharge. It is anticipated that the same level of treatment provided by the South Coastal Regional Wastewater Facility, which discharges treated effluent through an ocean outfall off South Bethany in Delaware, will be required for the RBWWTP. The anticipated discharge permit, summarized in Table 3-11, would require effluent filtration be provided to remove additional organics and nutrients and, as is the case with the existing system, a very high level of disinfection would be required.
- **Initial Dilution:** The effluent is discharged through specially designed diffusers that promote the mixing and dilution of the treated effluent with the seawater. A very significant degree of dilution is achieved.
- **Farfield Dilution:** After the initial mixing of the effluent plume with the seawater, the plume continues to mix and dissipate as it travels. The location of the diffuser is such that, even under the worst case operating conditions, the plume is so dilute that public health requirements are met and exceeded before the plume has any possibility of reaching the beach. In fact, in most cases, public health requirements are met at the initial zone of dilution.

Table 3-11 Anticipated NPDES Permit Limits for Ocean Discharge

Parameter	Permit Requirement	Unit	Basis
BOD_5	15	mg/L	Daily Average
TSS	15	mg/L	Daily Average
pH	6.0 – 9.0		

Several alternative locations for the ocean outfall were considered in previous studies. The locations were based on some earlier work that will be referred to as the LaCato Project (George, Miles & Buhr 1977). This project was comprised of a series of studies and reports that were completed in the 1970s in an effort to evaluate alternatives for the treatment and disposal of wastewater from a new proposed service area, the John M. LeCato Sanitary and Water District.

The results of dilution studies performed for the LaCato Project suggested that an ocean outfall located 6,000 feet offshore from the City of Rehoboth Beach would provide adequate dilution.

In order to determine if greater distance from shore provided any discernible benefits, locations 9,000 feet and 12,000 feet offshore were also considered by the City in the “2005 Effluent Disposal Study”. A regional alternative located about four (4) miles north of the other three (3) potential locations was evaluated in the 2005 report as well, but this location is no longer practical as the City and County have rejected regional solutions to effluent disposal.

The locations of the alternative ocean outfall sites considered are shown in Figure 3-11 and are described in Table 3-12

Figure 3-11 Outfall Locations Considered in Lawler, Matusky & Skelly Engineers Model

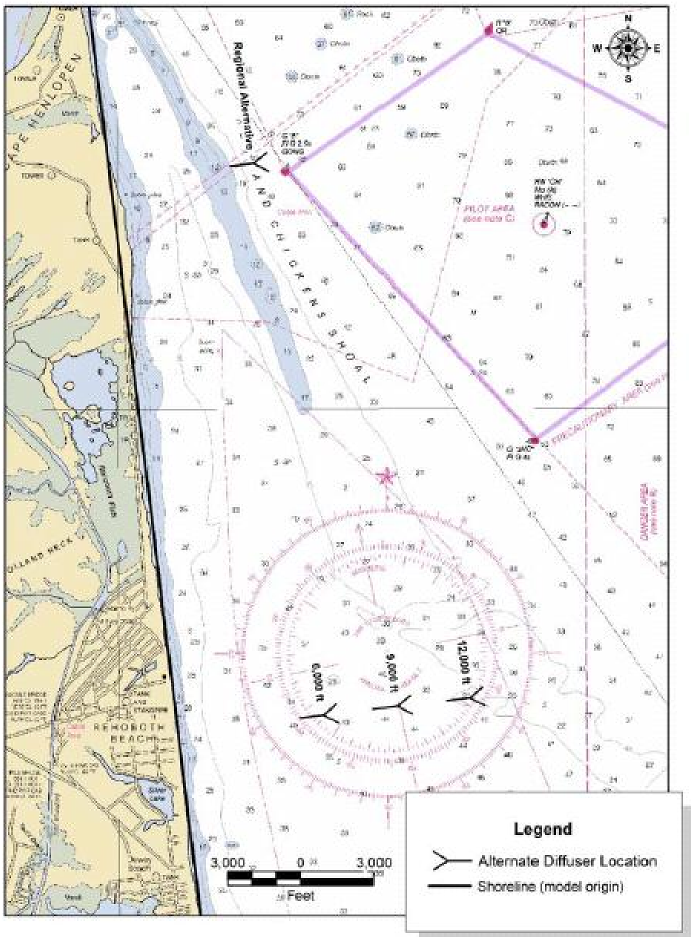


Table 3-12 Approximate Outfall Locations Considered in Lawler, Matusky & Skelly Engineers Model (Stearns & Wheler 2005)

Location	Coordinates
Rehoboth Beach – 6,000 ft offshore	75° 3.3' W 38° 42.9' N
Rehoboth Beach – 9,000 ft offshore	75° 2.6' W 38° 43.0' N
Rehoboth Beach – 12,000 ft offshore	75° 2.0' W 38° 43.1' N

Extensive current and dilution modeling was performed for the 2005 Effluent Disposal Study by Lawler, Matusky & Skelly Engineers and is included in (Appendix E). The results of the model are summarized in Table 3-13 (Stearns & Wheler 2005). The results indicate that the 100:1 dilution is achieved in less than 500 feet and in slightly more than five minutes. The time and distance to the 100:1 dilution was essentially the same at all locations, and thus, there would no benefit gained by the additional construction cost and operating cost imposed by extending the outfall. While the extended outfall provides a greater distance between the shore and the diffuser for far-field dilution to continue, the distance is not required in light of the very effective mixing achieved at the 6,000 foot location. Also, extending the outfall further would, at some point, require construction in the Hen and Chicken Shoals, which would potentially have an adverse environmental impact.

Table 3-13 Rehoboth Beach - Distance and Time to Achieve 100:1 Dilution (Stearns & Wheler 2005)

Scenario	Downcurrent distance to 100:1 dilution (feet)	Time to 100:1 dilution (minutes)
6,000 ft offshore	415	5.4
9,000 ft offshore	432	5.4
12,000 ft offshore	420	5.3

3.1.6.2 Environmental Impact

The discussion of environmental issues that follows is based on studies completed for other projects that were related by geographic proximity or are similar in terms of the type of construction proposed and on discussions with Federal and State regulatory agencies.

The most critical issue regarding water quality is to maintain compliance with the water quality criteria that is designated by EPA and DNREC to protect aquatic and human health. The standards are specified in the State of Delaware Surface Water Quality Standards as amended July 11, 2004 (DNREC 2004). Delaware's 2002 305(b) report indicates that all assessed coastal waters fully support both swimming and aquatic life (DNREC 2002).

The Surface Water Quality Standards also impose limits for pollutants that have been identified as potential carcinogens. Rehoboth Beach effluent was collected on three separate days during Summer 2010 and tested for priority pollutants. A copy of the results are included in (Appendix F). No metals were found in concentrations exceeding the specified limit. The RBWWTP is currently in compliance with all criteria at its existing discharge location.

The effluent from the RBWWTP will be a highly treated effluent with advanced treatment processes in place to remove nutrients and additional solids and to provide a very high degree of disinfection. The discharge permit that is anticipated will apply even higher standards and require a greater degree of solids removal from the effluent than is required for conventional secondary treatment. This is based on the discharge permit currently applied to the South Coastal WWTP, which discharges treated effluent through an ocean outfall located in the vicinity of Bethany Beach. In order to more reliably achieve compliance with this standard, the City plans on replacing the microscreen system at the RBWWTP with new effluent filters. The existing microscreens are an older technology that is difficult to maintain. New filter systems are available that provide better performance and are more reliable. The RBWWTP currently utilizes a chlorine disinfection system to comply with a very stringent bacterial standard that is based on the protection of swimmers for primary contact recreation and for shellfish resources. The current discharge permit standard for the plant is 10 colonies per 100 ml enterococcus and the treatment plant routinely produces an effluent with either no enterococcus or levels of 1 to 2 colonies per 100 ml. Thus, even without the dilution provided by the diffuser, the effluent complies with the applicable bacterial standard for primary contact recreational marine waters.

However, the assessment of potential impacts should reasonably consider a worst-case scenario. As described previously, the ambient conditions considered by the dilution model already has a worst case scenario built into its assumptions since the current vectors used are the vectors, which have the greatest onshore component during the summer season. The worst case scenario that could possibly be experienced at the RBWWTP would be a failure of both the normal power and the emergency backup power. If this were to happen, the efficiency of the biological treatment processes would be greatly reduced since blowers providing air to the process would not be operable. The treatment plant would essentially function as a primary plant in which the aeration basins and clarifiers become settling basins. In this case, the effluent characteristics that would be expected are equivalent to primary effluent. It should be noted, however, that this worst case scenario is impossible because in the event of a power failure, the influent pumps pumping raw wastewater to the treatment plant and the effluent pumps required to discharge the effluent through the ocean outfall would not be operable, and thus, there would be no effluent. The disinfection system is provided with backup systems for reliability but even if they were inoperable, a manual system for metering chlorine into the effluent could be utilized. Thus, under the worst case scenario, backup treatment systems and initial and farfield mixing of the effluent would protect public health.

The water quality standards to protect aquatic life focus on the prevention of acute and chronic toxicity. Concentration limits are placed on a number of metals, organic compounds and inorganic compounds. The compounds are not suspected to be present in the RBWWTP effluent. The wastewater treated at the plant is almost entirely domestic with some light commercial wastes such as from restaurants. One exception is chlorine, which is used for disinfection. However, a dechlorination system is in-place at the treatment plant that effectively removes all of the chlorine prior to discharge. The scan of priority pollutants in the RBWWTP effluent that was completed as part of the NPDES permit renewal confirm that there are no hazardous chemicals in the effluent (see (Appendix F).

The NPDES permit for the RBWWTP requires the plant to conduct a chronic biomonitoring test on their effluent annually. The test procedures are outlined in the "Short-term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Marine and Estuarine Organisms" (USEPA 2002b). The treatment plant has never failed a toxicity test and there is no reason to suspect that they would be at risk to fail a biomonitoring test.

Other potential environmental impacts include effects on the physical environment and on biological organisms. These include short term impacts during construction and long term impacts as a result of the continued operation of the outfall. These impacts and methods to mitigate them are discussed in detail in Chapters 7 through 9.

3.1.6.3 Cost

The ocean outfall alternative includes the construction of a pump station at RBWWTP, a forcemain to convey treated effluent to the outfall, the outfall pipe, and the outfall diffuser. The RBWWTP already provides a high level of treatment, which include advanced treatment for nutrient removal that complies with the anticipated discharge permit. However, in order to improve the reliability of the existing RBWWTP, improvements to the plant are planned. These improvements include new motor controls, emergency power generation, and more efficient effluent filters, followed by an effluent pumping system. The effluent pump station will provide the hydraulic head required to pump the flow through the ocean outfall pipe and diffuser. The proposed alignment of the outfall is detailed in Chapter 4. The method of construction continues to be evaluated but will include a combination of horizontal directional drilling (HDD) and open cut trench excavation. The HDD method of construction, while potentially more expensive, minimizes the potential environmental impacts. The cost analysis contained in this section allows for both types of construction.

A summary of the engineering estimates from three construction firms for the probable construction cost consisting of the ocean outfall (only from the dune parking lot to the outfall location) is presented in Table 3-14. The average from the different firms was used to estimate the total construction cost of the Ocean Outfall Alternative, which is presented in Table 3-15.

Table 3-14 Summary of Estimated Capital Costs – Ocean Outfall (Year 2009 Dollars)

Cost Component	Stearns & Wheler	Weeks Marine	WorleyParsons
Subtotal	$19,900,000	$11,700,000	$12,720,000
Contingency (15%)	$2,990,000	$1,760,000	$1,910,000
Total	$22,900,000	$13,500,000	$14,600,000
Average	$ 17,000,000		

Table 3-15 Estimate of Probable Construction Cost for the RBWWTP Ocean Outfall Alternative

Component	Estimated Cost (Year 2009 Dollars)
RBWWTP Pumping Station	$990,000[1]
Rehoboth Treatment Upgrades	$3,330,000[1]
Rehoboth FM to Ocean Outfall	$2,820,000[1]
Rehoboth Ocean Outfall	$17,000,000[1,2]
Subtotal	$24,200,000
Engineering & Administration	$5,320,000

Component	Estimated Cost (Year 2009 Dollars)
Permitting (5%) Ocean Outfall Only	$850,000
Total Project Cost	$30,370,000

Notes:

1. Costs include contingencies.
2. Cost based on average of estimates from previous studies

3.2 Comparison of Alternatives

In this section, the relative merits of each alternate method of effluent disposal for the City of Rehoboth are presented in order to identify the most technically feasible, environmentally acceptable and cost-efficient alternative. The technical issues, environmental impacts and costs associated with each alternative were provided in Sections 3.1.1 to 3.1.6 of this report.

Table 3-16 presents a summary of this discussion and the resulting conclusions regarding the suitability of each alternative. Table 3-17 compares the alternatives on the basis of other more subjective issues. Table 3-18 provides a summary of the estimated annual user rates for the residents of the City of Rehoboth Beach for the alternatives determined to be technically feasible. These include land application in cooperation with Sussex County and an ocean outfall dedicated to the City. For more information on estimated user charges, see Section 9.6.2 of this report and (Appendix B).

The subjective analysis indicates a generally favorable rating for the ocean outfall alternative compared to the other alternatives. During the completion of the various studies since 1998 when the City was notified that an alternative discharge would be required, there has been an extensive effort to provide information to the public regarding the various alternatives. The outreach has been in the form of workshops, newspaper articles, presentations to various organizations and public hearings. These efforts have allowed an informal consensus to be reached by the City and the citizens with the result that the ocean outfall is the preferred alternative. While there do exist certain groups, such as the Delaware chapter of the Surfrider Foundation, that oppose the ocean outfall alternative, most citizens of Rehoboth Beach are in favor of this alternative because the cost per user is low, and it provides an independence for the City not attainable with the alternatives that require cooperation with the county and/or a private utility.

Table 3-16 Summary of Alternatives

Alternative	Advantages	Disadvantages
1. No Action	No capital investment required Operating costs remain constant	Water quality of Rehoboth Bay would continue to deteriorate Violates consent order, resulting in significant legal fees and fines

Alternative	Advantages	Disadvantages
	Conclusion: Does not meet TMDL established by DNREC and would result in legal action being taken against the City.	
2. Nutrient Trading	No capital investment required Net reduction in Inland Bay Sub-basin nutrient loading	Not a long term solution Significantly increases annual operating costs Non-point sources have already been required to significantly reduce loading according to the TMDL Highly dependent on available of non-point sources in the future Difficult to maintain
	Conclusion: Infeasible due to lack of available nutrient credits within the Inland Bay Sub-basin.	
3. Land Application	Well established and accepted practice in Delaware Recharges groundwater Preserves agricultural use of land	Lack of available land High cost of property Significant effluent wastewater storage volume required Use of existing WNRWF spray irrigation facilities would require coordination with Sussex County including capital improvements to County WWTPs Potential to continue discharge of nitrogen into Inland Bay via groundwater City essentially operating two treatment facilities
	Conclusion: Land not available. Alternative possible only if cooperation with County at significantly higher cost. City and County rejected regional solution.	
4. Rapid Infiltration Beds	Proven technique for effluent disposal Recharges groundwater Relatively low impact in terms of amount of land required and cost Easy to operate Relatively inexpensive	Potential to contribute nutrients to Inland Bays through groundwater migration and contact with surface water Potential for local mounding of groundwater Lack of available land Use would prevent public access to land

Alternative	Advantages	Disadvantages
	Conclusion: Land not available and significant environmental concerns including ground water mounding and nutrient transport to Inland Bays.	
5A. Shallow Well Injection	Significantly less land requirements Recharge groundwater	Nutrient transport ultimately into Inland Bays Complex operations High level of pretreatment required (drinking water standards) Periodic maintenance required (acid cleaning) Unknown aquifer hydraulic capacity Significant risk of mounding based on RIB data Potential increase of nitrates in groundwater No salt water intrusion aquifers available Pilot borings required to characterize well and aquifer
	Conclusion: No appropriate aquifer available and would result in nutrient transport to Inland Bays through groundwater.	
5B. Deep Well Injection	Significantly less land requirement No potential for ultimate discharge to surface water Primary drinking water standards not required	Complex operations High level of pretreatment required including filtration and chlorination Periodic maintenance required Unknown subsurface below 900 ft Unknown aquifer hydraulic capacity Pilot borings required to characterize well and aquifer No qualified local contractor No groundwater recharge High Risk
	Conclusion: Excessive risk and cost.	
6. Ocean Outfall	Minimal operational requirements Minimal maintenance requirements No potential nutrient transport into Bay	Public acceptance by certain groups may be difficult Permitting issues

Alternative	Advantages	Disadvantages
		No groundwater recharge
	Conclusion: Most practical solution considering the availability of land and the protection of groundwater and water quality of the Inland Bays. Also, this alternative has the lowest impact on estimated user charges and greatest acceptance by citizens of Rehoboth Beach.	

Table 3-17 Comparison of Alternatives

Issue	No Action (1)	Nutrient Trading (2)	New Land Application Facility (3A)	Land Application at Existing Facilities (3B/3C/ 3D/3E)	RIB (4)	Underground Injection		Ocean Outfall (6)
						Shallow (5A)	Deep (5B)	
Public Acceptance	-	+	+	+	0	-	-	-
Environmental Impacts	-	0	+	+	-	-	0	0
Nutrient Loading to Inland Bays	-	+	0	0	-	-	+	+
Permitting Issues	-	0	+	+	-	-	-	0
Reliability	0	-	0	0	0	-	-	+
Operability	+	-	0	0	+	-	-	+
Construct-ability	+	+	0	0	+	-	-	0
Long Term Solution	-	-	0	0	-	0	0	+
Groundwater Recharge	-	-	+	+	+	+	-	-
Land Requirement	+	+	-	0	-	0	0	+
Risk	-	0	+	+	0	-	-	+
Cost	0	0	0	0	0	0	-	+
Summary								
+	3	4	5	5	3	1	1	7
0	2	4	6	7	4	3	3	3
-	7	4	1	0	5	8	8	2

Notes:

2. A (+) indicates that, in regards to the particular issue the alternative is generally considered to be positive or beneficial.
3. A (0) indicates a neutral response.
4. A (-) indicates that the alternative is negative or detrimental with regards to the issue.
5. Indicates an issue, which essentially eliminates the alternative from further consideration.

Table 3-18 Summary of Estimated User Charges (Stearns & Wheler 2009)

Alternative	No.	Description	Estimated Annual User Charge
No Action	1	No Action (Current User Rate)	$ 326
Land Application	3B	Raw wastewater to County	$ 1,160
	3C	Raw wastewater to County/Private	$ 1,430
	3D	Treated wastewater to County	$ 1,010
	3E	Treated wastewater to County/Private	$ 1,420
		Land Application Average	$ 1,255
Ocean Outfall	6	Dedicated City outfall	$ 635