Appendix G
Mechanical Plant Costs and NPV

Dillon Consulting Limited
Cape Dorset Sewage Options
File: 031943-1000

Option #1 - Mechanical Treatment Plant
Capital and Operating Costs

	Perma / FWS	Sanitherm -SBR		Notes
Capital Cost:				
Original Bid	$1,877,300	$835,676		
REDUCE: Adjusted Tankage	-$67,500.00			
REDUCE: Delete 1 Digester	-$129,850.00			
ADD: Elevated Walkways		$40,000.00		
ADD: Extra Blowers (~)		$15,000.00		
Total SBR Cost	**$1,679,950**	**$890,676**		
Building Footprint (m2)	530	580		
Building Envelope Cost per m^2	$3,000	$3,000		
Building Envelope Cost	$1,590,000	$1,740,000		
Foundation Volume @ 200 mm thick	106	116		
Foundation Cost @ $2000 / m3	$212,000	$232,000		
Building Mechanical / Electrical	$960,000	$1,200,000.000		Mech / Electrical Costs Based on Pang RBC + 20%
Nunavut Power Line (800 m @ $100 /m)	$80,000	$80,000		Includes Installation of SBR Plant
Total Building	**$2,842,000**	**$3,252,000**		
Total Plant and Building	**$4,521,950**	**$4,142,676**		
Engineering @ 10%	$452,195	$414,268		
Contingency @ 25%	$1,130,488	$1,035,669		
GRAND TOTAL	**$6,104,633**	**$5,592,613**		
O + M Cost @ Design Flow (8% of Capital)	$361,756	$331,414		

Note:
Costs do not include any Environmental Assessments and Permitting, Sealift, and Taxes

NPV ANALYSIS

	Perma / FWS	SBR	
Construction Year	$6,104,632.50	$5,592,612.60	
1	$218,161	$199,863	Operating Cost @ 156 m3/day
2	$223,763	$204,995	
3	$229,818	$210,543	
4	$235,720	$215,949	
5	$241,873	$221,586	
6	$248,077	$227,270	
7	$255,382	$233,962	
8	$262,544	$240,523	
9	$268,917	$246,362	
10	$275,772	$252,642	
11	$282,250	$258,577	
12	$288,780	$264,559	
13	$296,242	$271,395	
14	$303,101	$277,679	
15	$311,134	$285,038	
16	$319,243	$292,467	
17	$327,422	$299,960	
18	$339,914	$311,404	
19	$350,835	$321,409	
20	$361,756	$331,414	Operating Cost @ 265 m3/day
NPV @ 2%	**$10,638,182**	**$9,745,914**	
NPV @ 4%	**$9,810,469**	**$8,987,625**	
NPV @ 8%	**$8,699,817**	**$7,970,128**	

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Mechanical Plant Operating and Maint. Cost Worksheet

Background: US EPA has published O + M costs for an SBR with a daily flow of 378 m3/day. The capital cost of the plant was $1,104,500 in 1999 US $$.

Source: US EPA Wastewater Technology Fact Sheet,
Wetlands: Subsurface Flow, Table 6, Cost Comparison
SF Wetland and Conventional Wastewater Treatment

	Raw EPA O + M data			
	Daily Flow	378		m3/day
	Annual Flow	137970		m3
	Annual O + M	$106,600		1999 US $$
	Plant Cost	$1,104,500		1999 US $$
(1)	**O + M as % of Plant Cost**	**9.7%**		
	per m3	$0.77		1999 US $$

	Adjust EPA Data for Cape Dorset:			
	Daily Flow	265		m3/day
	Annual Flow	96725		m3
	Annual O+ M @ $0.77 per m3	$74,733		1999 US $$
	Say 50% of Cost is Power	$37,366		1999 US $$
	NU Power Cost / US Power Cost	3.5		
	Adjusted Power Cost	$130,782.41		1999 US $$
	Total Adjusted Cost	$168,148.81		1999 US $$
	Inflation @ 2 %/yr (1999-2005)	$185,650		
	Convert to CDN $$	$278,474.81		
(2)	As Percentage of Capital Cost	6.16%		Perma
	per m3	$2.88		CDN $$

Take Average of (1) and (2) **7.9%** **say 8%**

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Cape Dorset Sewage Options
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Mechanical Plant Operating and Maint Costs
Based on 8.0% of Capital Cost.
Cost is scaled at flows less than peak flow

Perma SBR

Year	Population	Daily Sewage (m3)	Annual Sewage (m3)	O + M Unit Rate ($$/m3)	O + M Cost ($$)
2004	1327	156	56,897.00	3.74	$212,797
2005	1354	160	58,331.00	3.74	$218,161
2006	1382	164	59,829.00	3.74	$223,763
2007	1412	168	61,448.00	3.74	$229,818
2008	1441	173	63,026.00	3.74	$235,720
2009	1471	177	64,671.00	3.74	$241,873
2010	1501	182	66,330.00	3.74	$248,077
2011	1536	187	68,283.00	3.74	$255,382
2012	1570	192	70,198.00	3.74	$262,544
2013	1600	197	71,902.00	3.74	$268,917
2014	1632	202	73,735.00	3.74	$275,772
2015	1662	207	75,467.00	3.74	$282,250
2016	1692	212	77,213.00	3.74	$288,780
2017	1726	217	79,208.00	3.74	$296,242
2018	1757	222	81,042.00	3.74	$303,101
2019	1793	228	83,190.00	3.74	$311,134
2020	1829	234	85,358.00	3.74	$319,243
2021	1873	240	87,545.00	3.74	$327,422
2022	1919	249	90,885.00	3.74	$339,914
2023	1965	257	93,805.00	3.74	$350,835
2024	**2012**	**265**	**96,725.00**	**3.74**	**$361,756**
				Average	**$278,738**

Sanitherm SBR

Year	Population	Daily Sewage (m3)	Annual Sewage (m3)	O + M Unit Rate ($$/m3)	O + M Cost ($$)
2004	1327	156	56,897.00	3.43	$194,949
2005	1354	160	58,331.00	3.43	$199,863
2006	1382	164	59,829.00	3.43	$204,995
2007	1412	168	61,448.00	3.43	$210,543
2008	1441	173	63,026.00	3.43	$215,949
2009	1471	177	64,671.00	3.43	$221,586
2010	1501	182	66,330.00	3.43	$227,270
2011	1536	187	68,283.00	3.43	$233,962
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2014	1632	202	73,735.00	3.43	$252,642
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2016	1692	212	77,213.00	3.43	$264,559
2017	1726	217	79,208.00	3.43	$271,395
2018	1757	222	81,042.00	3.43	$277,679
2019	1793	228	83,190.00	3.43	$285,038
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2021	1873	240	87,545.00	3.43	$299,960
2022	1919	249	90,885.00	3.43	$311,404
2023	1965	257	93,805.00	3.43	$321,409
2024	**2012**	**265**	**96,725.00**	**3.43**	**$331,414**
				Average	**$255,359**

Appendix H
SBR Mechanical Plant Operating Cost Data

Cost and Performance Evaluation of BNR Processes

Gerald W. Foess, Paul Steinbrecher, Kenneth Williams, and George S. Garrett

The use of biological nutrient removal (BNR) processes is expected to increase in Florida because of growing concerns about the effects of nitrogen and phosphorus on the stimulation of undesirable aquatic growth in surface waters and the potential adverse health effects of nitrates in groundwater.

In the Florida Keys, degradation and eutrophication of canal and nearshore waters led Monroe County to require all new and expanding wastewater treatment facilities to meet Advanced Wastewater Treatment (AWT) or Best Available Technology (BAT). However, the county lacked the information it needed to determine what discharge limitations could reasonably be imposed under these requirements, given the large number (nearly 300) of wastewater treatment plants with small flows and limited operational oversight. Experience had demonstrated that DEP AWT limits of 3 mg/L for nitrogen and 1 mg/L for phosphorus could be achieved by large plants, but there was no assurance or expectation that such stringent limits could be achieved by small plants. Additionally, no specific BAT standards existed.

A study was commissioned by Monroe County, with support and financial assistance from DEP, to determine BAT effluent limitations for treatment plants with permitted design capacities in the range of 2,000 to 100,000 gpd. The summary provided in this article includes a review and ranking of BNR technologies and proprietary equipment on the market with respect to costs, performance, and other factors. Information was derived from equipment suppliers, DEP and EPA databases, technical literature, and visits to operating facilities.

Small-Flow Nutrient Removal Facilities in the U. S.

Table 1 contains a nationwide list of full-scale facilities in the 2,000 to 100,000 gpd range that are designed to meet total nitrogen or phosphorus limits, as derived from DEP and EPA databases and input from 85 equipment suppliers. The most common phosphorus limit is 1.0 mg/L, ranging from 0.1 to 2.0. The most common nitrogen limit is 10 mg/L, ranging from 3 to 14. Florida has imposed the most stringent nitrogen limits on plants in this size range.

TABLE 1. U.S. WWTPs WITH NUTRIENT REMOVAL PROCESSES CAPACITY ≤ 0.1 MGD

Location	*P Removal*	*N Removal*
Arkansas	—	1
Arizona	—	1
California	—	1
Colorado	10	3
Connecticut	—	1
Florida	8	16
Indiana	3	—
Maryland	2	1
Massachusetts	—	2
Michigan	4	5
Minnesota	15	—
New Jersey	8	4
New Mexico	—	3
New York	5	12
Pennsylvania	—	11
TOTAL	55	61

Sources: U. S. EPA Permit Compliance System; FDEP WAFR database; Equipment Suppliers

Site Visits

Nutrient removal systems in the size range of 2,000 to 100,000 gpd are almost universally furnished as pre-engineered, factory- or field-assembled package systems. Approximately 25 systems available on the market were evaluated, followed by visits to 17 operating treatment plants in Florida, New York, New Jersey, and Massachusetts. The plants represented diverse technologies and covered a spectrum of sizes within the range of interest. Information was gathered on plant performance, actual operation and maintenance costs, actual capital costs, and the level of operator staffing. The collected information was subsequently used in the evaluation of alternative systems.

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Nutrient Removal Systems Evaluated

The following biological nitrogen removal systems, which were considered representative of the diverse technologies on the market and applicable to small treatment systems, were selected and evaluated.

1. MLE (2-Stage) Continuous-Flow Suspended-Growth Process
2. 4-Stage Continuous-Flow Suspended-Growth Process
3. 3-Stage Continuous-Flow Suspended-Growth Process
4. 4-Stage Sequencing Batch Reactor (SBR) Suspended-Growth Process

TABLE 2. SELECTED NUTRIENT REMOVAL SYSTEMS

System Description	*Representative Suppliers*	*Achievable Effluent Quality BOD/TSS/TN/P[1] (mg/L)*
1. MLE Process – continuous-flow suspended-growth process with an initial anoxic stage followed by an aerobic stage	Smith and Loveless U. S. Filter/Davco Aeration Industries Zenon Environmental The McNeil Company	10/10/10/2 (5/5/10/1 with filtration)
2. Four-Stage Process – continuous-flow suspended-growth process with alternating anoxic/aerobic/ anoxic/aerobic stages	Smith and Loveless U. S. Filter/Davco Zenon Environmental The McNeil Company	10/10/6/2 (5/5/6/1 with filtration)
3. Three-Stage Process – continuous-flow suspended-growth process with alternating aerobic/anoxic/aerobic stages	Smith and Loveless U. S. Filter/Davco Zenon Environmental The McNeil Company	10/10/6/2 (5/5/6/1 with filtration)
4. SBR Suspended-Growth Process – batch process sequenced to simulate the four-stage process	Aqua-Aerobics Purestream, Inc U. S. Filter/Jet Tech Babcock International Fluidyne	10/10/8/2 (5/5/8/1 with filtration)
5. Intermittent-Cycle Process – modified SBR process with continuous influent flow but batch, four-stage, treatment process	Schreiber Corporation Austgen-Biojet Cromaglass Corporation AES	10/10/8/2 (5/5/8/1 with filtration)
6. MLE and Deep-Bed Filtration Process – Alternate 1 followed by attached-growth denitrification filter	U. S. Filter/Davco Purestream, Inc. Aeration Industries	10/5/6/1 (process includes filtration)
7. Submerged Biofilter Process – continuous-flow or intermittent-cycle process using one or more submerged media biofilters with sequential anoxic/aerobic stages	Tetra Technologies, Inc. WWSI Smith and Loveless	20/20/12/2 (5/5/12/1 with filtration)
8. RBC Process – continuous-flow process using RBCs with sequential anoxic/aerobic stages	CMS Group WWSI	20/20/12/2 5/5/12/1 (with filtration)
9. Conventional Secondary Treatment – continuous-flow activated sludge process (no enhanced nutrient removal; included for basis of comparison)	Smith and Loveless U. S. Filter/Davco Aeration Industries Zenon Environmental The McNeil Company	10/10/X/X 5/5/X/X (with filtration)

5. 4-Stage Intermittent-Cycle Suspended-Growth Process
6. MLE Process followed by Deep Bed Filtration Process
7. Submerged Biofilter Process
8. Rotating Biological Contactor (RBC) Process

In each case, the recommended method of phosphorus removal was chemical precipitation. In addition, effluent polishing filtration would be provided in each system, except System 6, which already incorporates the deep bed filtration process for nitrogen removal.

Table 2 presents a description of each system, representative equipment suppliers, and estimated achievable effluent quality. Also included for comparison is a conventional secondary treatment plant (System 9).

Two of the systems identified above (Systems 1 and 6) were determined to be potentially applicable for retrofitting nitrogen removal to existing WWTPs, and evaluated separately. These were identified as (1) System 1R—MLE (2-Stage) Continuous-Flow Suspended-Growth Process, and (2) System 2R—Deep Bed Filtration Process.

The MLE process (System 1R) can be retrofitted to an existing plant by adding an anoxic basin upstream of the existing plant, redirecting the influent flow to this basin, and adding recirculation pumping from the existing aeration basin to the new anoxic basin. Alternatively, an anoxic zone could be created within the existing aeration basin by adding a baffle wall, but that would reduce the capacity of the plant. New chemical feed facilities for phosphorus removal could also be added.

In System 2R, a deep-bed filter would be added downstream of the existing package plant, replacing any existing filtration facilities. New pumping facilities to pump secondary effluent to the deep bed filter would be required, as well as methanol feed facilities and chemical feed facilities for phosphorus removal.

Performance Comparison

As indicated in Table 2, all of the systems are generally considered capable of meeting effluent BOD and TSS concentrations similar to large plants. Achievable effluent nitrogen concentrations range from 6 to 12 mg/L, with the 4-stage and 3-stage processes and the deep-bed filtration process (Systems 2, 3, and 6, respectively) being the most effective. Chemical phosphorus removal in all of the alternative systems is expected to achieve effluent limits of 2 mg/L without filtration and 1 mg/L with filtration.

Achievable permit limits for the MLE retrofit system (System 1R) were considered comparable to the corresponding new-plant MLE system (System 1). Achievable permit limits for the deep-bed filtration retrofit system (System 2R) were also estimated to be similar to those for the corresponding new-plant system (System 6), but with a somewhat lesser N removal capability because the retrofit system did not incorporate an MLE process.

As a result of this performance assessment, DEP provided to Monroe County the following BAT limitations (annual average basis) applicable to new and expanding facilities with permitted design capacities of less than 100,000 gpd (source: DEP correspondence to Monroe County Commissioners dated May 12, 1998):

CBOD	10 mg/L
TSS	10 mg/L
N	10 mg/L
P	1 mg/L

Cost Comparison

Tables 3 and 4 compare costs for the nine new-plant and two retrofit alternatives, respectively, for five different treatment capacities. The cost summary includes the estimated construction cost, annual O&M cost, uniform annual cost, and unit cost ($/1,000 gallons). Uniform annual costs were determined using an interest rate of 6 percent for a 20-year period. The unit cost was determined by dividing the uniform annual cost by the number of 1,000 gallons of wastewater treated per year, at 80 percent capacity utilization.

Construction costs for the new-plant alternatives include all required facilities for a new plant on a new site. Filtration was included for all of the systems except the base case secondary treatment system. In general, the conventional suspended-growth nutrient removal technologies have the lowest construction costs for capacities exceeding approximately 10,000 gpd. The attached-growth processes construction costs are competitive at the smallest system sizes of 4,000 and 10,000 gpd. A generally poor correlation exists between the construction cost of alternatives and nitrogen removal performance.

TABLE 3. COSTS OF NUTRIENT REMOVAL SYSTEMS – NEW PLANTS

Cape Dorset ~70,000 gpd

System	Treatment Facility Design Capacity 4,000 (gpd)	10,000 (gpd)	25,000 (gpd)	50,000 (gpd)	100,000 (gpd)
1 **MLE**					
Construction Cost, $	$ 261,000	$ 311,000	$ 422,000	$ 601,000	$ 874,000
Annual O&M Cost, $/yr	$ 30,400	$ 35,500	$ 49,400	$ 66,600	$ 100,100
Uniform Annual Cost, $/yr	$ 53,200	$ 62,600	$ 86,200	$ 119,000	$ 176,300
Unit Cost, $/1,000 gal	$ 61.8	$ 29.1	$ 16.0	$ 11.1	$ 8.2
2 **Four-Stage**					
Construction Cost, $	$ 336,000	$ 368,000	$ 475,000	$ 666,000	$ 968,000
Annual O&M Cost, $/yr	$ 52,500	$ 57,600	$ 73,800	$ 95,900	$ 132,300
Uniform Annual Cost, $/yr	$ 81,800	$ 89,700	$ 115,200	$ 154,000	$ 216,700
Unit Cost, $/1,000 gal	$ 95.0	$ 41.7	$ 21.4	$ 14.3	$ 10.1
3 **Three-Stage**					
Construction Cost, $	$ 291,000	$ 333,000	$ 441,000	$ 627,000	$ 913,000
Annual O&M Cost, $/yr	$ 35,900	$ 41,900	$ 56,400	$ 76,200	$ 115,900
Uniform Annual Cost, $/yr	$ 61,300	$ 70,900	$ 94,800	$ 130,900	$ 195,500
Unit Cost, $/1,000 gal	$ 71.2	$ 32.9	$ 17.6	$ 12.2	$ 9.1
4 **SBR**					
Construction Cost, $	$ 336,000	$ 381,000	$ 482,000	$ 697,000	$ 966,000
Annual O&M Cost, $/yr	$ 28,000	$ 34,100	$ 49,100	$ 67,600	$ 100,000
Uniform Annual Cost, $/yr	$ 57,300	$ 67,300	$ 91,100	$ 128,400	$ 184,200
Unit Cost, $/1,000 gal	$ 66.5	$ 31.3	$ 16.9	$ 11.9	$ 8.6
5 **Intermittent Cycle**					
Construction Cost, $	$ 229,000	$ 374,000	$ 584,000	$ 861,000	$ 1,026,000
Annual O&M Cost, $/yr	$ 28,000	$ 34,100	$ 49,100	$ 67,600	$ 100,000
Uniform Annual Cost, $/yr	$ 48,000	$ 66,700	$ 100,000	$ 142,700	$ 189,400
Unit Cost, $/1,000 gal	$ 55.7	$ 31.0	$ 18.6	$ 13.3	$ 8.8
6 **MLE + Deep Bed Filtration**					
Construction Cost, $	$ 308,000	$ 368,000	$ 486,000	$ 664,000	$ 958,000
Annual O&M Cost, $/yr	$ 36,900	$ 42,700	$ 58,100	$ 75,900	$ 111,400
Uniform Annual Cost, $/yr	$ 63,800	$ 74,800	$ 100,500	$ 133,800	$ 194,900
Unit Cost, $/1,000 gal	$ 74.1	$ 34.7	$ 18.7	$ 12.4	$ 9.1
7 **Submerged Biofilters**					
Construction Cost, $	$ 247,000	$ 296,000	$ 450,000	$ 847,000	See Note (1)
Annual O&M Cost, $/yr	$ 19,500	$ 24,400	$ 41,100	$ 60,400	See Note (1)
Uniform Annual Cost, $/yr	$ 41,000	$ 50,200	$ 80,300	$ 134,200	See Note (1)
Unit Cost, $/1,000 gal	$ 47.6	$ 23.3	$ 14.9	$ 12.5	See Note (1)
8 **RBCs**					
Construction Cost, $	$ 263,000	$ 342,000	$ 527,000	$ 868,000	$ 1,092,000
Annual O&M Cost, $/yr	$ 20,400	$ 25,900	$ 43,400	$ 61,500	$ 89,400
Uniform Annual Cost, $/yr	$ 43,300	$ 55,700	$ 89,300	$ 137,200	$ 184,600
Unit Cost, $/1,000 gal	$ 50.3	$ 25.9	$ 16.6	$ 12.7	$ 8.6
9 **Baseline – Secondary Treatment**					
Construction Cost, $	$ 183,000	$ 223,000	$ 303,000	$ 461,000	$ 671,000
Annual O&M Cost, $/yr	$ 22,000	$ 26,500	$ 39,200	$ 52,100	$ 78,000
Uniform Annual Cost, $/yr	$ 37,900	$ 45,900	$ 65,600	$ 92,300	$ 136,500
Unit Cost, $/1,000 gal	$ 44.0	$ 21.3	$ 12.2	$ 8.6	$ 6.3

Note: (1) Exceeded manufacturer's sizes

TABLE 4. COST SUMMARY FOR RETROFIT SYSTEMS

System	System Design Capacity 4,000 (gpd)	10,000 (gpd)	25,000 (gpd)	50,000 (gpd)	100,000 (gpd)
R1 Anoxic Tank for MLE Upgrade					
Construction Cost, $	21,000	24,000	39,000	57,000	80,000
Annual O&M Cost, $/yr	12,100	12,600	13,400	18,700	21,100
Uniform Annual Cost, $/yr	13,900	14,700	16,800	23,700	28,100
Present Worth, $	159,800	168,500	192,700	271,500	322,000
Unit Cost, $/1,000 gal	16.1	6.8	3.1	2.2	1.3
R2 Deep Bed Denitrification Filter					
Construction Cost, $	109,000	121,000	147,000	163,000	213,000
Annual O&M Cost, $/yr	17,600	18,200	20,300	24,800	28,600
Uniform Annual Cost, $/yr	27,100	28,700	33,100	39,000	47,200
Present Worth, $	310,900	329,800	379,800	447,500	541,000
Unit Cost, $/1,000 gal	31.5	13.3	6.1	3.6	2.2

For the retrofit alternatives, only the new facilities needed for nitrogen and phosphorus removal are included. Although the deep bed denitrification filter retrofit alternative provides somewhat better nitrogen removal percentage than the MLE retrofit alternative, it is approximately two to four times more costly, depending on capacity.

O&M costs were developed by individually considering operations labor, electricity, maintenance and repairs materials and labor, solids handling and disposal, administration labor, laboratory analytical requirements, and chemical costs. For the retrofit alternatives, only the increase in these costs associated with the addition of nitrogen and phosphorus removal facilities was estimated. Assumptions were as follows:

- Operations labor - labor at $36/hour (includes overhead), with minimum staffing per F.A.C. 62-699.310
- Electricity - $0.10/kW-hr
- Maintenance and repairs materials and labor - 3 percent of capital costs/year
- Solids handling and disposal - liquid haul at $0.17/gal
- Administrative - 5 percent of the sum of the operations labor, electricity, and maintenance and repairs costs
- Laboratory - commercial rates applied to required monitoring parameters in F.A.C.62-0699.310
- Chemical costs - alum for P removal at $1.80/lb; Symclosene (chlorine) at $2.50/lb; methanol at $0.15/lb

For the new-plant alternatives, the data show that the two attached-growth processes (Systems 7 and 8) have the lowest O&M costs, which was due to lower costs for electricity, solids handling, and laboratory analyses. These processes are also simpler to operate than suspended-growth processes. O&M costs are highest for the four-stage (System 2) and deep-bed filtration (System 6) systems because they are the most complex to operate and maintain. For the same reason, the deep-bed retrofit alternative (System 2R) has higher estimated O&M costs than the MLE retrofit system (System 1R).

On a unit cost basis, the nutrient removal systems with filtration included are approximately 20 to 40% more costly than a conventional secondary treatment system without filtration. For the two lowest new-plant capacities analyzed (4,000 and 10,000 gpd), the attached-growth processes (Systems 7 and 8) appear to have clear life-cycle and unit cost advantages over the other nutrient removal technologies. These alternatives are followed by the intermittent-cycle, MLE, and SBR systems (Systems 5, 1, and 4) in a middle cost range. The highest cost systems in this flow range are the four-stage (System 2) and denitrification filter (System 6) systems. As plant capacity increases to approximately 25,000 gpd or greater, the total cost advantage of the attached-growth systems begins to disappear. The four-stage continuous-flow process (System 2) is consistently more costly than all other technologies across all facility sizes.

For the retrofit alternatives, the annual and unit cost: operating a denitrification filter are nearly twice those retrofitting and operating an MLE system.

Ranking

Weighted rankings for the seven new treatment pla alternatives and the two plant retrofit alternatives were pı pared using five criteria that considered both cost and no cost factors associated with the ownership, operation, aı performance of small-flow nutrient removal treatment plan The criteria evaluated were unit cost, nitrogen removal pe formance, process control flexibility, ease of operation, ar land requirements. For each criterion, a relative score of (less favorable) to 5 (very favorable) was assigned to eac alternative. The raw scores for each criterion were the multiplied by a weighting factor to amplify the rankings (more important criteria relative to those of less important criteri The results are summarized in Tables 5 and 6 for the new-plant an retrofit systems, respectively.

For the new-plant alternatives, the three-stage system (Systen 3) was ranked the most favorable based on its moderate costs process control flexibility, and ease of operation. The MLE an deep-bed filtration systems (Systems 1 and 6, respectively) wer ranked second and third, respectively. The SBR and intermittent cycle systems (Systems 4 and 5, respectively) were ranked in a tie for fourth. The four-stage system (System 2) was ranked fifth, while the attached-growth systems (Systems 7 and 8) were ranked in a tie for sixth.

Among the two retrofit alternatives, the MLE system (System 1R) had the best ranking, primarily due to more favorable unit costs and ease of operation. ■

TABLE 5. RANKING OF NUTRIENT REMOVAL ALTERNATIVES FOR NEW WWTPs

No.	System Alternative	Unit Cost	Nitrogen Removal	Process Control Flexibility	Ease of Operation	Land Required	Raw Score	Weighted Score	Ranking
	Weighting Factor	30%	30%	15%	15%	10%		100%	
1	MLE	4	4	3	3	3	17	3.6	2
2	Four-stage	1	5	5	2	3	16	3.2	5
3	Three-stage	3	5	4	3	3	18	3.8	1
4	SBR	3	4	3	3	4	17	3.4	4 (tie)
5	Intermittent Cycle	3	4	3	3	4	17	3.4	4 (tie)
6	MLE + Deep Bed Filtration	2	5	5	2	3	17	3.5	3
7	Submerged Biofilters	3	2	2	4	5	16	2.9	6 (tie)
8	RBC	3	2	2	4	5	16	2.9	6 (tie)
	Total Possible Points						25	5	

Note: Scores: 1 (Less Favorable) to 5 (More Favorable)

TABLE 6. RANKING OF RETROFIT NUTRIENT REMOVAL ALTERNATIVES

No.	System Alternative	Unit Cost	Nitrogen Removal	Process Control Flexibility	Ease of Operation	Land Required	Raw Score	Weighted Score	Ranking
	Weighting Factor	30%	30%	15%	15%	10%		100%	
1	Anoxic Tank, MLE Upgrade	4	4	3	3	3	17	3.6	1
2	Deep-Bed Benite Filter	2	4	3	2	4	15	3.0	2
	Total Possible Points						25	5	

Note: Scores: 1 (Less Favorable) to 5 (More Favorable)

Strategies For Procurement of a 6.0 MGD Wastewater Treatment Facility

Harold E. Schmidt, Jr., J. Richard Voorhees, Jon D. Fox, and Peter A. Korelich

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In 1980 New Smyrna Beach constructed a 4.0 MGD pure oxygen high-rate activated sludge wastewater treatment plant that discharged to the Indian River Lagoon system. To comply with House Bill 3247, *the Indian River Lagoon Act*, in 1991 the city upgraded the plant to provide advanced secondary treatment and a public access reclaimed water system. Additional expansions were necessitated by population growth in the service area.

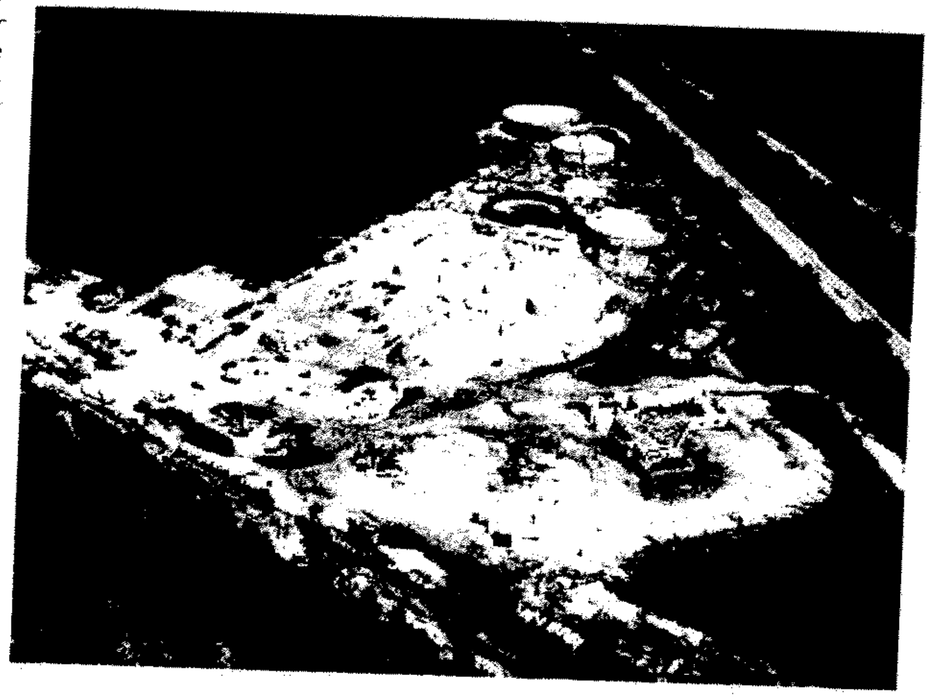
Alternative methods of process optimization to upgrade the existing facilities included pilot testing various configurations to reduce nitrogen and phosphorus. Because of site constraints and process equipment optimization to meet the effluent criteria required by the regulatory agencies, the city decided to make various improvements to the wastewater transmission system and to construct a new 6.0 MGD treatment facility. The deadline to have the new facility on line was June 30, 1999, per an imposed Consent Order.

The improvements to the wastewater transmission system consisted of permitting and design of two wastewater pump stations, with pumping capacities of 3.0 and 15 MGD, and various improvements to existing stations. The city's engineering staff provided in-house design for 95,200 linear feet of 12-, 24-, and 30-inch diameter pipelines for raw wastewater, reclaimed water, and potable water transmission mains.

Development of the new facility consisted of site selection, ecological assessments, and resolution of various site zoning issues. Engineering service included permitting and design of a pretreatment structure, a five-stage biological nutrient removal wastewater treatment system, secondary clarifiers, continuous backwash deep bed filters, and high-level disinfection. The nutrient removal system consisting of fermentation, first anoxic, aeration, second anoxic, and reaeration basins.

The design was to provide advanced levels of treatment because of the effluent requirements for wet weather discharge into the Indian River Lagoon system and Class I reliability requirements. Also included was a Class B sludge stabilization facility consisting of sludge holding, sludge thickening, and lime stabilization.

The reclaimed water reuse system consisted of a 6.0-million-gallon substandard effluent storage tank, a 2.0-million-gallon reclaimed water storage tank, and high service pumping. The reclaimed water high service pumping facilities consisted of five vertical turbine pumps ranging in capacities from 450 to 2,000 gpm. Ancillary facilities included a new administration building, a laboratory for both wastewater and potable water, motor control centers, and other miscellaneous facilities.



The overall wastewater management program was funded using a combination of methods. It included funds from the city's mandated facility surcharges and renewal and replacement accounts), utility system revenue bonds, the State Revolving Fund, and a grant from the St. Johns River Water Management District.

Objectives

The success of a wastewater management design depends on development of a thorough and coordinated set of engineering drawings and specifications, selection of equipment, choice of contractor, and owner's commitment to proper operation. A project still may not meet all expectations because of hidden problems that enter into the project as contractors prepare the bids. Our goal was to develop a format that prevented poor quality or misapplied equipment from being included in the project, while maintaining a high level of competition between the equipment manufacturers and suppliers.

The method of procurement itself can become an impediment to a successful project. The conventional open format commonly used in the bidding of wastewater management systems generally encourages selection of only the lowest priced materials, methods of construction, and equipment. Problems sometimes develop and extend through construction and operation. For example, when the term "or equal" is added to a well-written specification, it may become vague to the reader. During the bidding process, the contractor will receive many quotes from many suppliers of the equipment named in the specifications and/or interpreted as an "equal" to the specified equipment, and thus must select the lowest priced equipment or package to be selected for the project. Therefore, little consideration is given to the equipment that best meets the requirements of the project. Most important, needs of the owner, who must operate and maintain the facilities, are ignored. Based on information from the U.S. Accounting Office, one of the most signifi-