OYSTER DEPURATION FACILITY: ECONOMIC ASSESSMENT

Bureau of Business Research
University of Southern Mississippi
Hattiesburg, Mississippi 39401

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OYSTER DEPURATION FACILITY: ECONOMIC ASSESSMENT

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by
D. C. Williams, Jr., Ph.D.
David J. Etzold, DBA
Edward Nissan, Ph.D.

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PREFACE

This work is a result of research sponsored by NOAA Office of Sea Grant, Department of Commerce, under grant number NA79AA-D-0049. The project is the third phase of research initially authorized by the Mississippi-Alabama Sea Grant Consortium in 1977 to study the feasibility of an oyster depuration facility. The first phase, conducted by Dr. Edwin W. Cake, Jr., Dr. David W. Cook, and Mr. William J. Demoran at the Mississippi Gulf Coast Research Laboratory, investigated environmental, legal, and management aspects. The second phase, an engineering assessment, was conducted in 1978 by Dr. Marvin T. Bond and Mr. Dennis D. Truax of Mississippi State University. The purpose of this project is to assess the economic feasibility of an oyster depuration facility based upon the engineering specification developed in Phase II and supplementary information.

The authors wish to acknowledge the importance of inputs from Phase I and Phase II to this analysis and the cooperation of the principal investigators of both Phase I and Phase II during this study. Without those inputs, this project would have been impossible. The authors also wish to acknowledge the assistance of Albert E. Schamber, graduate assistant, for his contribution to this analysis. Any errors in this analysis are, of course, the responsibility of the authors.

OYSTER DEPURATION FACILITY: ECONOMIC ASSESSMENT

INTRODUCTION

Oysters do not have the mobility characteristics of fish, shrimp, or crabs. They attach themselves to some object and grow within a shell. Thus, they are immobile and are affected by the water and other environmental characteristics of the location. If the water where oysters grow becomes polluted, the oysters are susceptible to becoming polluted and unsafe for human consumption [12].

The problem of condemning large areas of oyster grounds by governmental authorities due to pollution has a long and persistant history. As far back as 1911, Phelps [10] alluded to this important question and gave suggestions to overcome such pollution. In 1961, approximately 550 acres (223 ha) of oyster bottom near Pascagoula, Mississippi, were closed to harvesting. The Biloxi Bay oyster reef containing approximately 900 acres (365 ha) of highly productive reefs was closed in 1967. Other areas along the Mississippi-Alabama Gulf Coast were also closed.

Oyster production in Mississippi has averaged about 33,000 barrels (132,000 bu = 4,651 m^3) annually since 1970. Oyster biologists estimate that the sustainable yield of reefs presently closed in Mississippi is about 100,000 barrels (400,000 bu -- 14,095 m^3) per year. At $30.00 per barrel ($7.50/bu), this represents about $3 million of renewable resources being lost annually. A similar situation exists in Alabama, although the value of oysters in closed waters is considerably less.

Before oysters from polluted waters may be utilized, they must be cleaned. The U.S. Food and Drug Administration recognizes two cleansing methods. One is relaying, which involves harvesting the oysters and transplanting them into approved water for at least 14 days. The other method is by the use of a depuration facility located on shore. It involves a process of self-cleansing in which water purified by ozonation or ultraviolet irradiation flows through tanks containing the oysters. The depuration process requires about 48 to 72 hours. Bacteriological testing is required to confirm that depuration has been completed.

Experimental depuration methodology has proven successful under the prevailing Gulf Coast environmental conditions [6]. Commercial depuration of oysters and other shellfish has been used successfully in Great Britain and other European countries for many years, and commercial clam depuration facilities are currently in operation in the United States, especially in Maine, Massachusetts, and New Jersey. However, there are no known commercial oyster depuration facilities operating in the United States at this time.

Some personal observations were made by a member of the research team of oyster depuration facilities in selected European countries. Visits included two plants in West Mersea, Essex, England, where one plant uses natural sea water and another uses artificial sea water. Visits were also undertaken to some clam depuration plants in Conway, North Wales [1, 13, and 14]. A brief description of the operations of those facilities is given in the Appendix.

The Mississippi-Alabama Sea Grant Consortium authorized research in 1977 regarding the feasibility of oyster depuration in the Mississippi-Alabama area. A study of the environmental, legal, and management aspects, the first phase was conducted by Dr. Edwin W. Cake, Jr., Dr. David W. Cook, and Mr. William J. Demoran at the Mississippi Gulf Coast Research Laboratory [3]. The results indicate that no insurmountable problems are anticipated. The second phase, the Engineering Assessments, was conducted in 1978 by Dr. Marvin T. Bond and Mr. Dennis D. Truax of Mississippi State University through Mississippi-Alabama Sea Grant Consortium funding [2]. A 96 bushel (3.4 m^3) capacity depuration plant was designed that could be used as an open and/or closed system with ozonation as the water purification method [2]. Also, a small pilot system was constructed and operated to test certain features of depuration. The engineering design suggested provided the basis for this study. The reports of the first two phases [2 & 3] give a detailed background and literature review of the overall problem.

Objective and Procedure

The objective of this phase of the research was to conduct an economic assessment of the oyster depuration facility designed in Phase II. It is noteworthy that because of the stage of design and consideration, this analysis was intended as a first approximation rather than a precise estimate. The estimated cost of the facility was based upon the design and specifications developed in Phase II [2].

Manufacturers of the materials and equipment specified were contacted to obtain cost estimates for the plant and equipment. Also, building systems manuals were consulted, including McKee [8], Means [11], Moselle [9], and Engelsman [4]. Some estimates were verified and/or obtained from local builders. Operating costs estimates were based upon operation and maintenance data provided by equipment manufacturers (to the extent possible) and upon personal estimates. The prevailing utility and wage rates were used. Cost of oysters for depuration and the market value of depurated oysters were based upon conversations and information obtained from people involved in the oyster industry and local officials.

Research in Phase II indicated that treatment of process water would probably depend upon the characteristics of the water source and whether or not ozone or ultraviolet treatment for depuration was used. Equipment needed and specifications for ultraviolet treatment were not provided in the reports of Phase II because this was not within the scope of the project. However, information was provided by Dr. Edwin Cake, Jr., one of the principal investigators of Phase I. The cost of ultraviolet treatment in the depuration process was based upon that information. Specifications and design for water treatment prior to entering or upon leaving the system, if needed, were not provided and, thus, were not included in the cost estimates.

All of the cost and revenue estimates, both present and projected, are based upon 1978-1979 prices. No adjustments were made for inflation in projections.

The analysis of estimated costs and revenues provides an indication of the economic feasibility of depurating oysters with the facility as designed. To give a comparison, a brief overview of cleansing polluted oysters by relaying is included. These estimates are based upon an update of data estimated by Etzold [5] and information on costs of relaying oysters to a private lease provided by a firm involved in such an operation.

DEPURATION FACILITY ANALYSIS

The facility under analysis would have a capacity of 96 bushels (3.4 m^3- 24 bbl) of oysters. It consists of eight tanks which would accommodate four trays holding three bushels each for a total of 96 bushels. For details and specifications of the building and equipment design, see the reports of Phase II [2].

It is assumed that it would take three days* for depuration and that the facility would be operated in such a manner that the depuration of one-third of the capacity would be completed and the oysters replaced each day. Such an operation should minimize labor requirements.

In this study the initial installation costs, yearly operating costs and projected revenues were estimated. The estimates do not include several items because of insufficient specifications and information. The effect of inflation has been ignored. However, it is felt that these factors do not adversely affect this analysis nor conclusions.

Items which are not included are:

1. Property taxes. (Taxes would depend upon the location of the facility.)

2. Water for the system. (The source and equipment necessary to supply the water were not specified and could vary depending upon facility site.)

3. Payroll taxes and fringe benefits.

4. Permits and licenses.

5. Insurance.

6. Cost of office machines.

7. Bacteriological testing and equipment.

8. Water treatment prior to entering or upon leaving the system. (If water comes from a well, no treatment should be needed prior to entering the system. If it were surface water, treatment needed could range from none to extensive, depending upon the water quality. If ozone were used in the process, no further treatment of the water should be needed upon leaving the system, with the possible exception of a minimum amount of chlorination or ozonation. The generators specified have sufficient capacity to provide such treatment. No additional treatment should be needed where ultraviolet light is used and the facility is operated as an open system. However, if it were operated as a closed system, it is expected that some treatment would be needed relative to Kjeldahl nitrogen and, over a prolonged period of time, organic content may reach the level that would require reduction in BOD.)

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*The time frame used was established by Dr. Edwin Cake, Jr.

9. Water treatment for total Kjeldahl nitrogen (TKN). (Indications are that TKN would build up if ultraviolet treatment were used in a closed facility. Additional research is needed to determine the treatment needed.)

The facility could be operated as an open or closed system, and ozone or ultraviolet treatment of the water for depuration could be used. The initial cost of the facility and equipment for each of these alternatives is itemized in Table 1. The initial cost estimates range from $137,000 for the facility operated as an open system using the ultraviolet water treatment method to $210,000 for the facility operated as a closed system using the ozone treatment. The system using ozone to treat the water would cost approximately $61,000 more than if the ultraviolet method were used. The difference in cost for the closed system would be approximately $7,000 greater than for an open system.

Preliminary findings indicate that a buildup of TKN may be anticipated if ultraviolet light were used with the closed system [2]. The TKN represents a combination of organic and ammonia nitrogen. If such a buildup occurs, additional treatment of the water would be needed for the facility operated as a closed system using ultraviolet light. Additional research is needed to determine the additional treatment needs. It should be noted that the cost of any additional treatment is not included in this analysis. Some design changes would be possible if only ultraviolet light were to be used. For example, schedule 40 PVC pipe could be used instead of schedule 80 which would reduce the initial facility cost about $8,600.

A schedule of annual costs of operation is itemized in Table 2. Electrical consumption is based on a charge of 5.5¢ per KWH. It is assumed that the labor force would consist of a supervisor, three laborers, and one secretary. It is also assumed that the laborers would be needed only during the oyster depuration period. The salaries are $12,000 per year

TABLE 1

SCHEDULE OF ESTIMATED INITIAL COSTS

	Closed Ozone System	Open Ozone System	Closed Ultraviolet System	Open Ultraviolet System
Land	$ 18,000	$ 18,000	$ 18,000	$ 18,000
Land Preparation	5,000	5,000	5,000	5,000
Metal Building	15,500	15,500	15,500	15,500
Office	18,000	18,000	18,000	18,000
Cooler Door & Inst.	1,582	1,582	1,582	1,582
O_3 Recovery Chamber[1]	1,700	1,700	--	--
O_3 Main Treatment Chamber	1,700	1,700	--	--
Aeration Chamber	1,700	1,700	--	--
Optional Tanks	700	700	700	700
Depuration Tanks	6,000	6,000	6,000	6,000
Slanture Clarifier	10,000	10,000	10,000	10,000
Pump	360	360	360	360
12000 Gal. Reservoir	4,000	--	4,000	--
Crane	725	725	725	725
Platform Trucks (2 @ 475)	950	950	950	950
P/C Plastic Pipes & Fittings	17,200	17,200	17,200	17,200
2-Ton Air Conditioning Unit	1,520	1,520	1,520	1,520
Air Compressor	3,067	3,067	3,067	3,067
Oyster Trays	140	140	140	140
Dome Diffuser	1,620	1,620	--	--
O_3 Generators & Air Prep. Units	58,000	58,000	--	--
Portable Mixer	560	560	560	560
Horizontal Pumps	8,976[2]	6,732[3]	8,976[2]	6,732[3]
Verticle Pumps	6,276	6,276	6,276	6,276
Horizontal Pumps	2,358	2,358	2,358	2,358
Ultraviolet Water Ster. & Mon.	--	--	4,000	4,000
Installation:				
Pipes	1,600	1,600	1,600	1,600
Motor	1,500	1,500	1,500	1,500
Tanks & Equipment	2,000	2,000	2,000	2,000
Misc.	500	500	500	500
Subtotal	$191,234	$184,990	$130,514	$124,270
Contingency (10%)	19,123	18,499	13,051	12,427
Estimated Initial Cost	$210,357	$203,489	$143,565	$136,697

[1] O_3 = Ozone

[2] 4 Pumps @ \$2,244 = \$8,976

[3] 3 Pumps @ \$2,244 = \$6,732

TABLE 2

ESTIMATED ANNUAL OPERATING COSTS*

	Closed Ozone System	Open Ozone System	Closed Ultraviolet System	Open Ultraviolet System
Cost of Oysters	$ 45,864	$ 45,864	$ 45,864	$ 45,864
Electrical Consumption:				
a. Machinery	13,811	12,735	7,349	6,274
b. General	1,205	1,205	1,205	1,205
Salaries:				
a. Supervisor	12,000	12,000	12,000	12,000
b. Secretary	7,200	7,200	7,200	7,200
c. General Workers	20,311	20,311	20,311	20,311
Maintenance Costs	1,000	1,000	1,000	1,000
Telephone Expense	600	600	600	600
Water & Sewage	180	180	180	180
Total Operating Costs	$102,171	$101,095	$ 95,709	$ 94,634
Cost per bushel, excluding cost of oysters	$6.45	$6.32	$5.71	$5.58

*It should be noted that these cost data are variable costs only and do not include the costs of the facility and equipment which are an important part of total cost. As noted in the text, the cost of microbiolgoical testing and other items are included.

for supervision, $600 per month for secretary and minimum wages ($3.10 per hr.) for the other workers. The cost of oysters is based on $21.00 per barrel or $5.25 per bushel dredged, culled and delivered to the plant. Over a 273-day operating season (Sept. 1 - May 31) with a capacity of 96 bushels, and an operating cycle of three days, the seasonal capacity is 8,736 ($96 \times \frac{273 \text{ days}}{3 \text{ days}} = 8{,}736$) bushels. At the cost of $5.25 per bushel the cost of oysters necessary to supply the facility for the season amounts to $45,864 or ($5.25 x 8,736). The annual operating costs range from $94,634 for the open ultraviolet system to $102,171 for the closed ozone system.

Sale of the depurated oysters would be the source of revenue. As noted earlier, the facility would have a capacity to depurate 8,736 bushels of oysters during the oyster season. It was assumed that the expected mortality would be 3 percent and a market price of $30.00 per barrel ($7.50 per bu.). Thus, the estimated revenue would be 8,474 bushels at $7.50 per bushel which would equal $63,555.

There are several factors which could result in a shut-down of the system, such as mechanical breakdown, unavailability of oysters, power outages, etc. The estimated revenue figure does not take into account any time for shutdown. Some shutdown will occur, but at this time it is impossible to estimate the shutdown time. The loss of revenue for these shutdowns would be approximately $233 per day ($63,555 ÷ 273 days = $232.80).

To determine the economic feasibility of the four alternative systems (closed ozone system, open ozone system, closed ultraviolet system, and open ultraviolet system), the present worth equivalent annual cost method was used. Exhibit 1 shows the computation for the present worth equivalent annual cost method at interest rates of 10 percent and 12 percent.

EXHIBIT 1-A

PRESENT WORTH - EQUIVALENT ANNUAL COST

Initial Installed Cost	$210,357	**Closed Ozone System**
Operating Costs per Year	$102,171	Symbols:
Expected Serviceable Life	20 years	PW_C = Present worth of costs
Salvage Value	$ 39,750	PW_I = Present worth of income
Interest Rates	10% and 12%	AE_C = Annual equivalent of PW_C
		AE_I = Annual equivalent of PW_I

10%	Value ($)	(x)	Present Worth ($)
Installment Costs	210,357	1.0	210,357
20 Years Operating Costs	102,171	8.513564	869,839.34
Salvage Value	39,750	.148644	5,908.60

Present Worth:

PW_C = $210,357 + 869,839.34 - 5,908.60 = $1,074,288.20

PW_I = $63,555 x 8.513564 = $541,079.56

Annual Equivalent:

AE_C = $1,074,288.30 x .117460 = $126,185.89

AE_I = $ 541,079.56 x .117460 = $ 63,555.21

$AE_I < AE_C$ Therefore, Project is not feasible.

12%	Value ($)	(x)	Present Worth ($)
Installment Costs	210,357	1.0	210,357
20 Years Operating Costs	102,171	7.469444	763,160.56
Salvage Value	39,750	.103667	4,120.76

Present Worth:

PW_C = $210,357 + 763,160.56 - 4,120.76 = $969,396.80

PW_I = $63,555 x 7.469444 = $474,720.51

Annual Equivalent:

AE_C = $969,396.80 x .133879 = $129,781.87

AE_I = $474,720.51 x .133879 = $ 63,555.11

$AE_I < AE_C$ Therefore, Project is not feasible.

EXHIBIT 1-B

PRESENT WORTH - EQUIVALENT ANNUAL COST

Initial Installed Cost	$203,489	Open Ozone System
Operating Cost per Year	$101,096	Symbols:
Expected Serviceable Life	20 years	PW_C = Present worth of costs
Salvage Value	$ 39,750	PW_I = Present worth of income
Interest Rates	10% and 12%	AE_C = Annual equivalent of PW_C
		AE_I = Annual equivalent of PW_I

10%	Value ($)	(x)	Present Worth ($)
Installment Costs	203,489	1.0	203,489
20 Years Operating Costs	101,096	8.513564	860,867.26
Salvage Value	39,750	.148644	5,908.60

Present Worth:

PW_C = $203,489 + 860,687.26 - 5,908.60 = $1,058,267.60

PW_I = $ 63,555 x 8.513564 = $541,079.56

Annual Equivalent

AE_C = $1,058,267.60 x .117460 = $124,304.11

AE_I = $ 541,079.56 x .117460 = $ 63,555.21

$AE_I < AE_C$ Therefore,
Project is not feasible.

12%	Value ($)	(x)	Present Worth ($)
Installment Costs	203,489	1.0	203,489
20 Years Operating Costs	101,096	7.469444	755,130.91
Salvage Value	39,750	.103667	4,120.76

Present Worth:

PW_C = $203,489 + 755,130.91 = 4,120.76 = $954,499.15

PW_I = $ 63,555 x 7.469444 = $474,720.51

Annual Equivalent:

AE_C = $954,499.15 x .133879 = $127,787.39

AE_I = $474,720.51 x .133879 = $ 63,555.11

$AE_I < AE_C$ Therefore,
Project is not feasible.

EXHIBIT 1-C

PRESENT WORTH - EQUIVALENT ANNUAL COST

Closed Ultraviolet System

Initial Installed Cost	$143,565
Operating Costs per Year	$ 95,709
Expected Serviceable Life	20 years
Salvage Value	$ 39,750
Interest Rates	10% and 12%

Symbols:

PW_C = Present worth of costs

PW_I = Present worth of income

AE_C = Annual equivalent of PW_C

AE_I = Annual equivalent of PW_I

10%	Value ($)	(x)	Present Worth ($)
Installment Costs	143,565	1.0	143,565
20 Years Operating Costs	95,709	8.513564	814,824.69
Salvage Value	39,750	.148644	5,908.60

Present Worth:

PW_C = $143,565 + 814,824.69 - 5,908.60 = $952,481.09

PW_I = $ 63,555 x 8.513564 = $541,079.56

Annual Equivalent:

AE_C = $952,481.09 x .117460 = $111,878.42 $AE_I < AE_C$ Therefore,

AE_I = $541,079.56 x .117460 = $ 63,555.21 Project is not feasible.

12%	Value ($)	(x)	Present Worth ($)
Installment Costs	143,565	1.0	143,565
20 Years Operating Costs	95,709	7.469444	714,893.01
Salvage Value	39,740	.103667	4,120.76

Present Worth:

PW_C = $143,565 + 714,893.01 - 4,120.76 = $854,337.25

PW_I = $ 63,555 x 7.469444 = $474,720.51

Annual Equivalent:

AE_C = $854,337.25 x .133879 = $114,377.81 $AE_I < AE_C$ Therefore,

AE_I = $474,720.51 x .133879 = $ 63,555.11 Project is not feasible.

EXHIBIT 1-D

PRESENT WORTH - EQUIVALENT ANNUAL COST

Initial Installed Cost	$136,697	
Operating Costs per Year	$ 94,634	
Expected Serviceable Life	20 years	
Salvage Value	$ 39,750	
Interest Rates	10% and 12%	

Open Ultraviolet System

Symbols:

PW_C = Present worth of costs

PW_I = Present worth of income

AE_C = Annual equivalent of PW_C

AE_I = Annual equivalent of PW_I

10%	Value ($)	(x)	Present Worth ($)
Installment Costs	136,697	1.0	136,697
20 Years Operating Costs	94,634	8.513564	805,672.61
Salvage Value	39,750	.148644	5,908.60

Present Worth:

PW_C = $136,697 + 805,672.61 - 5,908.60 = $936,461.01

PW_I = $ 63,555 x 8.513564 = $541,079.56

Annual Equivalent:

AE_C = $936,461.01 x .117460 = $109,996.71

AE_I = $541,079.56 x .117460 = $ 63,555.21

$AE_I < AE_C$ Therefore Project is not feasible.

12%	Value ($)	(x)	Present Worth ($)
Installment Costs	136,697	1.0	136,697
20 Years Operating Costs	94,634	7.469444	706,863.36
Salvage Value	39,750	.103667	4,120.76

Present Worth:

PW_C = $136,697 + 706,863.36 - 4,120.76 = $839,439.60

PW_I = $ 63,555 x 7.469444 = $474,720.51

Annual Equivalent:

AE_C = $839,438.60 x .133879 = $112,383.33

AE_I = $474,720.51 x .133879 = $ 63,555.11

$AE_I < AE_C$ Therefore Project is not feasible.

Using this method the present worth of cost, PW_c, and present worth of income, PW_I, were calculated and then converted into an annual equivalent income, AE_I, and cost, AE_c. If the annual cost of operation, AE_c, is less than annual income, AE_I, the project is economically feasible. The project is not feasible when cost of operation is greater than revenue received. (If $AE_c > AE_I$, project not feasible.)

Information obtained from manufacturers of the equipment and materials indicates that the useful life would be approximately 20 years. The salvage value includes the land at the initial cost and the estimated salvage value of the building.

The present worth and the annual equivalent costs and income would depend upon the interest rate. The actual interest rate used may depend upon whether it were financed by a government unit or private enterprise, and the prevailing interest rates at the time of financing. Thus, two interest rates were used for illustrative purposes, 10 percent and 12 percent. The annual benefit-cost ratios for each system is shown below at the 10 percent and 12 percent interest rates:

	Ozone		Ultraviolet	
	Closed	Open	Closed	Open
	10 Percent Interest Rate			
$\frac{AE_I}{AE_c}$	$\frac{\$63{,}555}{\$126{,}186} = 0.50$	$\frac{\$63{,}555}{\$124{,}304} = 0.51$	$\frac{\$63{,}555}{\$111{,}878} = 0.57$	$\frac{\$63{,}555}{\$109{,}997} = 0.58$
	12 Percent Interest Rate			
$\frac{AE_I}{AE_c}$	$\frac{\$63{,}555}{\$129{,}782} = 0.49$	$\frac{\$63{,}555}{\$127{,}787} = 0.50$	$\frac{\$63{,}555}{\$114{,}378} = 0.56$	$\frac{\$63{,}555}{\$112{,}383} = 0.57$

The benefit-cost ratio at 10 percent interest rate ranges from 0.50 for the closed ozone system to 0.58 for the open ultraviolet system. At 12 percent interest, the benefit-cost ratio ranges from 0.49 for the closed ozone system to 0.57 for the open ultraviolet system. It should be noted that the difference between the benefit-cost ratios at different interest rates is not linear.

The annual operation cost and the annual equivalent of installation cost per bushel, exclusive of the cost of oysters, are summarized below using an interest rate of 10 percent:

Annual Depuration Cost Per Bushel
of Oysters With the Cost of Oysters Excluded

	Ozone		Ultraviolet	
	Closed	Open	Closed	Open
		10 Percent Interest Rate		
Annual Operating Cost	$ 6.45	$ 6.32	$ 5.71	$ 5.58
Annual Equivalent of Facility Cost	2.83	2.74	1.93	1.84
Total	$ 9.28	$ 9.06	$ 7.64	$ 7.42

The operating cost (not including the cost of oysters) per bushel to depurate oysters with the system would range from $5.58 for the open ultraviolet system to $6.45 for the closed ozone system. The cost per bushel including the cost of the facility and operation cost (not including the cost of oysters) would range from $7.42 for the open ultraviolet system to $9.28 for the closed ozone system.

The calculations indicate that the facility as designed is not econmically feasible at present prices. The annual loss would range from about $46,442 with the open ultraviolet system to $62,631 with the closed ozone system at 10 percent interest. It may be recalled that shutdown time and other factors were assumed to be the same for each system. If practice proved otherwise, these differences would not be the same.

Although the analysis indicates that the facility would not be economically feasible as designed, it does not necessarily follow that alternative designs would not be feasible. For example, there may be economies of scale. Also, different specifications may result in different costs. Schedule 80 PVC pipe was specified because the facility was designed so that the water could be treated by ozone. If ozone is used, the pipe would have to be threaded, which requires schedule 80. However, a discussion with the engineer indicated that if only ultraviolet treatment were to be used, schedule 40 PVC pipe could be used. That would reduce the cost. If schedule 40 were used instead of schedule 80, the initial cost of the same amount of pipe would be cut approximately one-half. This would reduce the initial cost about $8,600. At 10 percent interest the annual equivalent would be $1,010. At 12 percent interest; the annual equivalent would be $1,151.

As indicated in the appendix, a less sophisticated design could perhaps reduce the costs. However, it was beyond the scope of this study and the amount of funding to analyze alternative designs.

OYSTER RELAYING

Oyster relaying may be accomplished by alternative schemes. One is where a state agency transplants the oysters and the cleansed oysters are harvested by private interests. Another is where the entire operation is conducted by private business.

Combined State-Private Relaying

In 1975, Etzold [5] estimated the cost of transplanting oysters from polluted to non-polluted waters by a state agency for harvest by oyster tongers. The estimated annual operating cost to the State at that time for transplanting the oysters was $1.30 per barrel. The estimated annual total cost with the vessel included was $1.56 per barrel. These costs are for total volume transferred. The Mississippi Marine Conservation Commission transplanted some oysters in 1977. The cost of dredging the oysters from polluted waters and putting them overboard in approved waters was $1.06 per barrel (total volume). Part of the difference between the cost experienced by the Commission and the estimate by Etzold appears to be difference in cost factors included in the computation. For example, the estimates by Etzold were for long term averages. Included were engine overhaul, painting, etc., which would not be required for an operation of just one year. Thus, the estimates by Etzold were assumed to be an acceptable base for this analysis. Those data were updated by either the consumer price index or the durable goods price index. The changes in the indexes from 1975 to 1978 are as follows:

Year	CPI	Durable Goods
1975	161.3	165.8
1978	195.3	188.1
% Change	21.2	13.5

The updated estimated costs to transport the oysters are shown in Exhibit 2. The updated costs of harvesting the transplanted oysters by tongers are shown in Exhibit 3. These data indicate that it would cost the State approximately $1.86 per barrel (total volume) at present to transplant the oysters. The recovery rate was about 30 percent, i.e., about 30 barrels of oysters were recovered for each 100 barrels of total volume transferred. Part of the total volume dredged and transferred was shells which account for part of the difference between volume of oysters harvested and the total volume transferred from polluted waters. Thus, the transplanting cost per barrel of oysters harvested would be about $6.14 per barrel ($1.86 x 3.3 = $6.14). At four bushels per barrel, the cost per bushel would be $1.54 ($6.14 ÷ 4 = $1.54). The estimated cost to the tongers for harvesting the transplanted oysters would be about $5.20 per barrel or $1.30 per bushel ($5.20 ÷ 4 = $1.30). The sum of these two costs is

EXHIBIT 2

COST TO STATE FOR TRANSPLANTING OYSTERS

	A	x	B	=	C
Vessel	$ 8,000		1.135		$ 9,080
Interest	4,400				4,400
Operation & Maintenance	58,500		1.212		70,902
Haul Out, Scrape, Paint	1,500		1.212		1,818
Engine Overhaul	400		1.212		485
Miscellaneous	2,000		1.212		2,424
Total Estimated Annual Costs					$89,109

Cost per barrel $= \frac{\$89,100}{48,000 \text{ bbl.}} = \$1.86$

Note: The data in Column A are from David J. Etzold, Estimated Annual Costs for the Oyster Transplanting Project, Mississippi Marine Conservation Commission, August 1975, Bureau of Business Research, University of Southern Mississippi. Data in Column B are the price adjustment factors.

EXHIBIT 3

COST TO OYSTER TONGERS TO HARVEST TRANSPLANTED OYSTERS

	A	x	B	=	C
Boat	$ 40		1.135		$ 45
Motor	450		1.135		510
Equipment	100		1.212		121
Fuel, etc.	1,500		1.212		1,818
Total Estimated Annual Costs					$2,494

$2,500 x 100 Tongers = $250,000

Cost per barrel = $250,000 / 48,000 bbl

Total cost per barrel of transplanted oysters

Transplant	=	$1.86
Harvest	=	5.20
Total		$7.06

Note: The data in Column A are from David J. Etzold, Estimated Annual Costs for the Oyster Transplanting Project, Mississippi Marine Conservation Commission, August 1975, Bureau of Business Research, University of Southern Mississippi. Data in Column B are the price adjustment factors.

$11.34 ($6.14 + $5.20 = $11.34) per barrel or $2.84 per bushel ($11.34 ÷ 4 = $2.84). It should be noted that these data do not include administrative costs to the State. They also do not include any charge for labor and management for tonging the transplanted oysters. At a market price of $7.50 per bushel ($30.00 per bbl), returns to labor and management for oyster tongers would be $6.20 per bushel ($7.50 - $1.30 = $6.20). This, of course, excludes all costs of transplanting the oysters.

Private Relaying

In 1977, the Mississippi legislature authorized leasing water bottoms by private interests for oyster culture. The number of leases and area leased to date are limited. Thus, data on the costs of such operations are somewhat preliminary and limited. The following analysis is based upon information supplied by a firm with a lease after one season.

The cost to have oysters dredged from polluted waters and placed on the lease was $3.00 per barrel (total volume). Most of the transplanted oysters were harvested after 15 days. Recovery was about 30 percent of the total volume. About 70 percent of one batch left on the bottom for six months was recovered. The 30 percent recovery rate is the same as reported from the transplanting operations by the Mississippi Marine Conservation Commission. Some people expect that the long term recovery rate would increase. Part of the unrecovered oysters would be subject to recovery at a later harvest. As reefs develop, the unrecovered oysters would reproduce. New seed oysters (spat) would set upon the shell material thereby increasing the reef's long-term potential.

At a short-term recovery rate of 30 percent (total volume), the per barrel cost of transplanting recovered oysters would be about 3.3 times the cost per barrel (total volume) or $9.90 per barrel ($3.00 x 3.3). The cost to harvest the oysters from the lease was $15.00 per barrel. Thus, the cost per barrel to transplant and recover the oysters from the private lease was $24.90. At four bushels per barrel the cost would be $6.23 per bushel. It should be noted that these costs do not include any cost for obtaining the lease, etc. It includes only (1) the contract cost of having the oysters dredged from the polluted waters and put overboard at the lease and (2) the price paid to have the oysters harvested from the lease. At a market price of $7.50 per bushel ($30.00 per bbl) there would be $1.27 per bushel to go toward the cost of capital, management, and any other cost and profit.

Some indication of the cost of a lease is provided in a prospectus prepared by the Mississippi-Alabama Sea Grant Advisory Service [7]. The current law allows each individual to lease up to 100 acres (40.5 ha) of water bottoms. The prospectus indicates that the cost of a lease would probably vary relatively little with the size of the lease and a leasee would probably lease the full allotment of 100 acres (40.5 ha). Some of the cost data shown in the prospectus are as follows:

Lease application expenses	$	100.00
Yearly lease payment (100 acres)		100.00 to 500.00
Survey fee		500.00 to 1,500.00
Annual Patroling expense		2,000.00

These data are shown to point out that all costs and income from the various options shown in this analysis must be included for a direct comparison between each method. Since all the data are not available for each method, comparisons should be made with caution and discretion.

SUMMARY

This is the third phase of research to study the feasibility of oyster depuration along the Mississippi-Alabama coastal area. Phases I and II included legal, environmental, management, and engineering assessments. The purpose of this study was to estimate the economic feasibility of the facility designed in Phase II.

The engineering design was for a facility with a capacity of 96 bushels. It was designed to be operated as a closed and/or open system with ozone treatment of the water for the depuration process. Supplemental information was obtained for ultraviolet water treatment.

Costs and revenue were based upon estimates supplied by manufacturers of materials and equipment specified, published cost guides, local contractors, industry personnel, public officials and, when necessary, personal estimates. Costs and revenues were based upon 1978-79 prices.

The initial cost estimates range from $137,000 for the facility operated as an open system using ultraviolet water treatment to $210,000 operated as a closed system using the ozone treatment. Annual operating cost would range from about $95,000 to $102,000 depending upon the method of operation. Operating at full capacity, the facility could depurate 8,736 bushels of oysters during the oyster season. With an expected 3 percent mortality and a market price of $7.50 per bushel, revenue would be $63,555 per year. Data were not available to estimate the amount of time that the facility would likely be shutdown during the season. The loss in revenue per day would be approximately $233.

In order to analyze the costs and revenue on a comparable basis, the present worth equivalent annual cost method was used. The estimated annual benefits at full capacity would be $63,555. At a 10 percent interest rate the annual cost for the open ultraviolet system would be $109,997 which yield a benefit-cost ratio of 0.58. The annual cost would range up to $126.186 for the closed ozone system and would yield a benefit-cost ratio of 0.50.

Relaying is also an acceptable method of cleansing oysters. It was estimated that it would cost the State about $1.54 per bushel (excluding administrative costs) to transplant oysters, and tongers about $1.30 per bushel to tong the transplanted oysters. At $7.50 per bushel, returns to labor and management for oyster tongers would be about $6.20 per bushel. This return, of course, excludes all costs of transplanting the oysters.

An alternate cleansing method would be relaying by private interests. Based upon one seasons' operation by one commercial firm, the cost of transplanting would be about $2.48 per bushel. The cost to harvest the transplanted oysters from a lease would be about $3.25 per bushel. At a market price of $7.50 per bushel, there would be about $1.27 per bushel to go toward the cost of capital (including the cost of a lease), management, any other cost, and profit.

At current prices and interest at 10 percent or 12 percent, the depuration facility as designed is not economically feasible as noted above. It does not necessarily mean, however, that an alternative design and/or size would not be feasible.

APPENDIX

SHELLFISH PURIFICATION IN THE UNITED KINGDOM

Several shellfish depuration facilities were examined during the period of December, 1978, and January, 1979, in Wales and England.*

The plant in Wales was constructed in 1913 as an outdoor government facility and is used to depurate blue mussels (mylitus edulis). The process water comes from the Conway Estuary, and chlorine powder is used as a disinfectant. The operation of the facility is a cooperative effort between the government operator and the fishermen [13].

Two small private commercial oyster depuration plants were observed in operation at West Mersea, Essex, England. Both facilities were used to depurate European flat oysters (ostrea edulis).

The first plant was located principally outdoors and utilized a Weir system, with sea water. The plant has been in use since the late 1950s, with little or no maintenance required. The owner stated the present day costs would approximate $3,000.00. Labor costs were estimated at $210/week. Ultraviolet light is used as a disinfectant.

The other plant was located in a small garage type structure, and also uses ultraviolet light. It utilizes a cascade/tray system and uses artificial sea water [14]. The facility was built in 1975 at a cost of $2,000, and has an expected ten-year life [9]. A part-time labor cost is

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estimated at \$30/week, with chemical costs of \$7.00/fill.

There are approximately 20 commercial plants in England utilizing ultraviolet light, and most are small local operations. Inspection is by the Ministry of Agriculture, Fisheries and Food, with no cost to the owner.

The referenced documents give further insight into the details of plant construction and operation. Appendix Table 1 provides additional data supplied by the owner of the facilities.

APPENDIX TABLE 1

COMPARISONS OF WEIR AND CASCADE/TRAY SYSTEMS

Item	Weir System	Cascade/Tray System
1. Type of Shellfish	European Flat Oyster	European Flat Oyster
2. Volume of Shellfish handled at one time	10,000* oysters every 36 hours	2,000* oysters every 36 hours
3. Source of Process Water	Sea Water	Drinking Water (with artificial sea salts)
4. Depuration Time	36 hours	36 hours
5. Prime use of Shellfish	On the half-shell	On the half-shell
6. Expected functional life of facility	In operation for last 20 years	10 years
7. Cost of facility	$3,000 - present day costs	$2,000 - 1975 costs
8. Tank Material	Concrete	Racks are alloy. Trays are plastic.
9. Labor costs	$120/week	$30/week
10. Inspection Costs	Free - by health authorities	Free - by health authorities
11. Water costs	--	$0.50/1,000 gallons
12. Cost of Chemicals (artificial sea salt)	--	$7.00/fill
13. Maintenance costs	$100/year	Negligible

Note: Costs are quoted, and no attempt was made to verify them. Costs were in British Pounds and were converted to dollars by multiplying by two (2). Land costs are not included.

*210 oysters equals one Mississippi, USA, bushel.

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