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A Cost Analysis of Offshore Mining Operations in the Greater New York Metropolitan Area

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Scope

This report was prepared as part of a New York State Sea Grant Project entitled, "The Impact of Offshore Sand and Gravel Mining on the Availability and Costs of Construction Minerals in the Greater New York Metropolitan Area (GNYMA)". This project concerns the economics of offshore mining of construction aggregates in the region. This report estimates the costs of offshore mining to determine its practicality in metropolitan area waters. In this paper:

1) the processes and technologies which could be used for offshore mining are described;

2) important factors to be considered in a cost analysis of offshore operations are identified;

3) capital and operating costs for offshore mining within the GNYMA, including: number, type, classification, size capacity, and equipment, are summarized; and

4) a prototypical capital investment of a new venture in offshore mining in the GNYMA was analyzed.

The data and information for this report came from a variety of sources: most important is the data used by the Army Corps of Engineers (ACOE) to evaluate dredging bids by private companies. Other cost material and support information, such as descriptions of processes and technologies, were compiled from the cited published and unpublished reports; personal communications with dredging and mining companies in particular Construction Aggregates, Inc. and McCormick Sand and Gravel; governmental agencies, professional consultants; and other researchers. Regular library channels were surveyed but only a few published reports on offshore operations were found to contain any cost information.

The data collected and summarized have been adjusted to reflect 1978 price levels. This adjustment was based on industry reviews [2] and the U.S. government's statistical reports on changes in equipment and labor costs [3].

This report is not all inclusive, but provides a cost base which must be modified to fit any particular offshore operation. However, we have tried to identify all relevent factors and give either representative data or estimates. These estimates are based upon the experience and judgement of those from industry and government involved in considering offshore mining.

Problem

Urbanization has created many problems, one of which is reduced available onshore sources of construction minerals [6]. Offshore aggregate mining may provide a partial solution [1].

The difficulties in providing construction minerals in urban areas have been noted by Cooper [5]. Available resources and demand do not match geographically. Many areas have abundant supplies while others are nearly exhausted. This is a product of multiple sociological, governmental and political factors, as well as the level of demand. Rapid urban and suburban growth have effectively prevented further extraction of onshore minerals. The content of current mineral deposits will seldon match consumer specifications.

Goodier [7] projects that present United States coastal area reserves will be depleted by 1988, based on current demand projections for major growth areas in this region.

The technology of offshore mining is more similar to dredging than to onshore mining. However, those companines involved in the dredging industry have little or no experience in the processing and distribution necessary for supplying construction aggregate. Therefore no one company has at present the ability to accurately estimate the risk involved in an offshore mining operation for these minerals.

A company evaluates risk in the determination of its required rate of return on an investment. The greater the risk, the higher the required return must be to attract investment.

Industry is also concerned about the lack of assurance that an offshore operation can be maintained for a long enough period to produce an adequate (if any) rate of return. For example, the fill mining permits issued by the NYS Office of General services are usually for one year. This policy is a definite restraint on the establishment of a long term offshore mining operation. In addition, an onshore mining operation may be required to adapt to changing government regulations or legal actions of environmental groups.

The use of any technology incurs some environmental hazard. Policy makers must establish a framework for offshore mining which incorporates mutually compatible levels of economic and environmental risks and returns.

A Brief Description of Current Technology

Current dredging technologies are diverse and their economic and environmental aspects vary significantly. There is no single best, or riskless, configuration of technology. In this section we have highlighted what we believe to be the most important aspects of the various technologies as they reflect on both the quantifiable and non-quantifiable costs of offshore mining.

Basically there are two types of extractive equipment: mechanical and hydraulic. Mechanical dredges usually lift material by a system of buckets, while hydraulic dredges pump the material directly into the dredge, into a secondary hauling barge, or through a pipeline.

The types of mechanical dredges are: ladder, dipper, buckets, dragline, clam shell, and orange peel. All mechanical dredges operate in the same basic fashion, the main difference between types is their capacity and the shape of the buckets or scoops used for excavation.

As an example, consider the ladder dredge, which incorporates a continuous chain of buckets moving in a circular fashion on a dredging ladder. One end of the ladder is permanently attached to the dredge and operates on a pivot which allows it to submerge and raise above water level. As the bucket chain revolves, material is dug or cut off the bottom by successive buckets, carried up the inclined ladder, and deposited onto an inclined conveyance chute. From the chute the dredged material slides onto a barge secured on the side of the dredge. The ladder dredge is customarily moved by as many as six cables which are attached to anchors.

Ladder dredges can dredge up to depths of 100 feet and the bucket speed can vary up to 30 buckets per minute. To date, the largest ladder dredges have a bucket capacity of 31.7 cu. feet with a 600 h.p. bucket drive and a 1300 h.p. total plan power. Their hourly production rate is approximately 1585 cu. yard/hr. This is equivalent ot that of a 27 inch pipeline dredge working on a short distance line, but the pipeline dredge would require twice the power.

Hydraulic dredges represent a more advanced technology and are more suitable for large offshore operations. In addition, they are presently used more in the United States.

The cutterhead pipeline dredge uses a variety of cutterhead drilling bits attached to the end of the dredge ladder, which bore the material loose and mix it with water. The mixture is pumped hydraulically to the surface and discharged through a stern connection. Dredged material can be pumped through floating pipelines to disposal sites.

Cutterhead pipeline dredges can economically handle large volumes. Equipped with the proper cutterhead, such dredges can mine materials from light silts to heavy rocks.

Other types of pipeline dredges are the plain suction and the dustpan dredge. The plain suction pipeline dredge is similar to the cutterhead dredge, but it does not incorporate a cutting device on the end of the suction ladder. Thus it is limited to silt and other soft materials. A suction ladder skims the seafloor and draws the material with its dilutitive water into the ladder and then into a stern connection. If necessary, the material's density may be adjusted by increasing or decreasing the water content. The material is then pumped through a discharge line to its point of destination. The dust-pan dredge is a modified version of the plain suction dredge. Its name is derived from the shape of its suction inlet which resembles a large dust pan ranging up to 45 feet in width and 1.5 feet in height. Soft sandy river beds are loosened by means of water jets and then drawn up by means of a vacuuming motion.

Any pipeline dredge, because of its trailing discharge line, will create a navigational hazard where vessel density is high. For this reason, several types of discharge line are currently available: floating line, supported on top of the water by pontoons; submerged line, used under the water; and short line, used to transport extracted material overland. These pipelines are normally constructed by steel modules, but manufacturers of pontoon and pipe-line modules have recently incorporated a new plastic formulation and molding technique which has the advantages of reduced cost, set up time and maintenance.

As a general practice, pipeline dredges should not be employed in dredging work in main navigational channels where a danger exists to the dredge or passing vessels, or in areas where unusually disruptive tidal currents are common.

Conventional pipelines dredges are limited to depths of approximately 60 feet. Specially designed ladders can extend their reach to 200 feet, but for most dredging operations, the cost of the additional capability is difficult to justify. Use of this special equipment also requires additional anchoring features in turbulent waters.

Pipeline dredges come in various sizes, the diameters of the pump discharge varing from 6 to 42 inches. Contractor-owned equipment in the United States today varies from 6 inch dredges with about 300 h.p. on the dredging pump to 42 inches dredges with over 10,000 h.p. The actual cutter horsepower ranges from 75 h.p. to 2500 h.p. depending on the size of the dredge. Production rates vary considerably among dredges of the same size.

One means of avoiding the navigational hazard of pipelines is to employ a hopper dredge. This type of dredge is a self propelled vessel with the capacity to carry extracted material in hopper bins. It has the capability to dredge while in motion and without the aid of moorings or anchors. As a result, the dredge is highly mobile and can operate with only slight interference to other vessels in the dredging area.

Once the material is suctioned intothe hopper bins, it can be separated from its dilutive water or left as is. The dredge operates until full, and proceeds to a disposal site where the material can be drawn from the hopper bins by an additional pump system. The material can then be transported by pipeline. This method facilitates the handling procedure and allows more production time for dredging operations.

Hopper dredges range in size from a hopper capacity of 300 cu. yards up to 11,700 cu. yards and can excavate material from as deep as 70 feet below the water surface. However, these dredges are not designed to excavate hard material, although they have been used for softrock and coral.

The most recently developed dredge is the sidecasting dredge and is distinguished from other hydraulic dredges by its large boom capacity, the boom can range up to 250 feet in length. All sidecasting dredges are self-propelled with a technology similar to hopper dredges. The incorporate suction drag arms to raise the material, and can discharge material to port or starboard through a discharge pipe that can range from 70 to 100 feet in length.

Sidecasting dredges are used for channel maintenance in locations where currents do not return a significant amount of the dredged material to the navigation channel. Because of its self propulsion and lack of anchoring devices, this type of vessel is used in channels which are exposed to open waters and in shallow offshore inlets. Production capacities are comparable to those of hopper dredges.

A precise comparison of the equipment was not possible because production rates depend a great deal upon the marine conditions of the site and the demand in the region. However Table 1 does present historical data from Corps of Engineers' data in the GNYMA.

Cost Analysis for Dredging Equipment

This approach enables one to calculate a return on investment for an operation. A cost structure was developed based upon Deming's assessment of hydraulic dredging costs [10], and from the Army Corps of Engineers' techniques for evaluating contract bids [23]. A simplified method for comparing total operation costs to total production was also developed. Profitability and productivity were used as measures of system performance, since these measures for those used by those onshore mining and dredging companies. They are also a direct function of operating costs, and can be stated in dollars per cubic yard of material.

The success of an offshore mining operation will be dependent on how well actual output and costs match estimates made prior to beginning the operations. Once data concerning a particular offshore operation have been developed, the productivity of the operation can be computed by comparing production levels

Table 1

AVERAGE PRODUCTION LEVELS VARIOUS TYPES OF DREDGE OPERATIONS

Type	Size	Capacity Per Hour
Dipper	6 yd.	35 (rock) to 150
Clamshell	12 yd.	510 (hd. clay-1140 soft)
	18 yd.	
"	12 yd.	495 (hd. clay-1140 soft)
	18 yd.	
"	4 yd.	135 (clay & silt - 250 silt)
	6 yd.	
Hydraulic	27 in.	800 hd. - 1500 soft clay
	16 in.	300
Clamshell	9 yd.	530 - 710
	14 yd.	
"	9 yd.	440 - 640
	15 yd.	
"	14 yd.	
	21 yd.	940 - 1110
"	9 yd.	1130 soft
	10 yd.	
Hydraulic	27 in.	1750 (sand) 8000 ft. line
Dipper	10 yd.	200 hd. with boulders
Clamshell	10 yd.	430 stiff clay
	8 yd.	340-450 sand & silt
	8 yd.	300-425 sand & silt
	6 yd.	210 stiff clay
Hydraulic	27 in.	1350 to 1700 sand
		6-8,000 ft. lines
"	12 in.	150 to 250
"	16 in.	200 - 300
"	12 in.	150 to 250
"	12 in.	150 to 250
"	12 in.	135 to 210
"	16 in.	200 to 300
"	16 in.	200 to 300
"	12 in.	100 to 250

to costs. Denning [10] proposed a method of marginal cost analysis using as the denominator an equivalence of all the inputs which determine total costs, and as numerator an adjusted production rate which reflects actual production time. The performance is measured by yardage removal per dollar expanded and is expressed as:

$$Y = \frac{R.T}{C}, \qquad (1)$$

where Y is the performance or productivity in cubic yards per dollar, R is the production rate in cubic yards per dredging minute, T is the ratio of effective dredging time to total rental time, and C is the cost per rental minute in dollars per minute.

To use this method, the time involved in various production operations must be estimated accurately. Equation (1) assumes the availability of an estimate of T. Plant costs are based on a yearly capital depreciation including the costs of subsequent additions and improvements to the original equipment.

As Bure [12] cautioned, the technological obsolescence of existing dredges required evaluation in terms of "competitive life" as opposed to "physical life". Generally accepted accounting principles, particularly the prohibition of revaluation and write up of assets, make it difficult to abstract the cost data needed for Denning's method. Another approach is to compute the following:

$$Y = \frac{C}{R}, \text{ where} \qquad (2)$$

Y is defined as before, R is measured in cubic yards per operating cycle, and C is costs per operating cycle. This method is based upon straight line depreciation of plant ownership and operating costs. Although possibly not detailed enough for budgeting this approach permits a simple and useful evaluation of performance.

Ease of adoption and conformance with accounting principles are two advantages of this method. In practice, while equipment and labor are not used directly on a 24 hour basis the equipment is committed and personnel are on payroll. Thus this method, unlike the first, can reflect the overhead of a dredging operation.

The preceding methods assume that production is a function of cost. Therefore using historical costs one should be able to estimate the costs of a particular project by determining the time required, distance from shore, and type of equipment to be used. In addition, such an analysis would need to consider any contingent costs which may occur in securing rights to perform such mining operations.

Costs for Operations in the Greater New York Metropolitan Area.

The summarized historical cost data contained in Tables 2 and 3 provide a basis for estimating the costs of offshore mining operations. These data were abstracted from contract bids received by the Army Corps of Engineers. The bid material used for this data base is considered representative of the average levels of cost and the various sizes and types of operations. The data include operational costs for both hydraulic and mechanical equipment.

These figures reflect only basic operating units and their applicable support equipment. The additional costs of pipeline and boosters must be added to these base figures. These figures do not include profit, overhead, processing and contingencies. The following adjustments have been made to the data:

1. All salary levels have been adjusted to reflect current levels as of the fourth quarter of 1978.
2. Taxes, insurance and employee benefits have been estimated to be 37% of the employee's gross salary.
3. All costs are computed to reflect a monthly operating cost. These costs are based on a 6 month operation with the costs spread over a 12 month period. This is done to allow for adverse weather conditions and other contingencies.
4. The costs of various hydraulic dredging units have been categorized by power capacity (H.P.) and according to pipeline diameters. Each category includes the minimum amount of support equipment which would normally be used with the particular unit.
5. All capital equipment has been adjusted to reflect a 1978 cost basis. Accordingly, depreciation will reflect 1978 levels of expense based on historical cost.
6. Interest expense on investment is assumed to be 6 percent.
7. The figures shown for pipeline costs reflect the monthly cost per foot of pipeline. Distance from shore and type of material mined will determine this variable expense.

Capital Investment Analysis

The profitability of a new offshore mining venture in the GNYMA, involving the purchase of completely new equipment, was considered. It was assumed that the offshore mining technology will be similar to that used in typical dredging operations. The only major differences are dredge size and the requirements of processing and distribution. Current replacement costs for equipment explicitly developed for offshore mining are used.

TABLE 2

MONTHLY SUMMARY OF OPERATING COSTS FOR BASIC HYDRAULIC DREDGES
BASED ON VARIOUS LEVELS OF LABOR, EQUIPMENT AND OPERATIONS OWNERSHIP
OPERATIONAL COSTS (6 MO./YR. OPERATIONS)

Monthly Costs	500 H.P. 10"	800 H.P. 12"	1200 H.P. 14"	1500 H.P. 16"	1800 H.P. 18"
Total Labor Cost	$64,935	$75,473	$120,690	$146,868	$155,813
Total Plant & Operation Cost	32,826	53,644	84,039	106,838	126,462
Total Booster Cost*	9,660	17,913	26,310	44,592	52,492
Total Monthly Cost	$107,421	$147,030	$231,039	$298,298	$334,767

Monthly Costs	2400 H.P. 20"	4000 H.P. 24"	5500 H.P. 27"	7000 H.P. 30"	8000 H.P. 32"
Total Labor Cost	$168,516	$207,370	$223,680	$251,346	$270,720
Total Plant & Operation Cost	149,967	199,503	246,635	292,180	319,796
Total Booster Cost*	63,439	113,774	124,503	145,345	145,345
Total Monthly Cost	$381,922	$520,647	$594,818	$688,871	$735,861

Monthly Costs	Representative Dipper Dredge	Representative Clamshell Dredge
Total Labor Cost	107,040	96,922
Total Plant & Operation Cost	221,070	192,950
Total Monthly Cost	328,110	289,872

**This is the cost of 1 booster suited to the particular size dredge which is usually required.

Table 3

OPERATION COSTS FOR BASIC HYDRAULIC DREDGING BASED ON VARIOUS TYPES OF PIPELINE AND AGGREGATE TYPES ESTIMATED PIPELINE COSTS FT./MO.

	Mud	Sand	Rock
500 H.P. 10"			
Floating Line	$ 2.44	2.90	3.23
Submerged Line	1.28	1.46	1.77
Shoreline	1.16	1.22	1.46
800 H.P. 12"			
Floating Line	2.50	3.05	3.36
Submerged Line	1.34	1.59	1.89
Shoreline	1.22	1.34	1.59
1200 H.P. 14"			
Floating Line	2.56	3.20	3.54
Submerged Line	1.46	1.77	2.20
Shoreline	1.28	1.40	1.83
1500 H.P. 16"			
Floating Line	2.68	3.34	3.66
Submerged Line	1.53	1.59	2.44
Shoreline	1.34	1.59	1.95
1800 H.P. 18"			
Floating Line	2.76	3.49	3.90
Submerged Line	1.65	2.20	2.68
Shoreline	1.40	1.71	2.07
2400 H.P. 20"			
Floating Line	2.93	3.64	4.15
Submerged Line	1.83	2.44	2.93
Shoreline	1.46	1.83	2.20
4000 H.P. 24"			
Floating Line	3.17	3.93	4.39
Submerged Line	2.26	2.93	3.48
Shoreline	1.40	1.95	2.38
5500 H.P. 27"			
Floating Line	3.42	4.15	4.64
Submerged Line	2.56	3.29	3.78
Shoreline	1.46	2.14	2.56

OPERATION COSTS FOR BASIC HYDRAULIC DREDGING BASED ON VARIOUS TYPES OF PIPELINE AND AGGREGATE TYPES ESTIMATED PIPELINE COSTS FT./MO.

	Mud	Sand	Rock
7000 H.P. 30"			
Floating Line	$ 3.66	4.37	4.92
Submerged Line	2.93	3.66	4.21
Shoreline	1.59	2.32	2.81
8000 H.P. 32"			
Floating Line	3.78	4.51	5.12
Submerged Line	3.17	3.90	4.51
Shoreline	1.83	2.44	3.05

A self-contained hopper dredge with onboard processing (that is, washing, grading, and blending) which transports its product to an onshore surge site was determined as one appropriate technology. In order to adequately study the economic potential of offshore mining for the region, all prospective mining sites should be considered. Here, in our work, the most costly operation (excluding environmental considerations) was selected as indicative of the economic viability of offshore mining in the area.

A 27" 5500 H.P. hydraulic mining vessel was assumed. It would operate in the East Bank area, approximately 15 miles off south shore Long Island. Survey data indicate the availability of sufficient marketable fine aggregate in the area and this type of dredge is considered appropriate to the location.

The profitability of the mining operation was evaluated with an equity level of 100 percent with, and without, a royalty charge of 5 percent, which is comparable to that now charged by New York State for fill mining.

A standard format for evaluating capital expenditures was used which involves determining positive and negative cash flow over the life of the asset; discounting the cash flows to reflect all amounts in the form of present values; and estimating the internal rate of retrun given the proposed expenditure. The internal rate of return method then permits determination if the interest rate that equates the present value of expected future cash outflows or receipts, to the initial cost outlay. For capital budgeting analysis the net after tax operating cash flows were discounted.

The particular investment alone was evaluated without any implied financing. An implied level of interest is included in the calculation of present value. Including interest payments would improperly overstate the amount of cash outflows. Thus the investment was evaluated at 100 percent equity.

The dredge can extract 1502 yd.^{3}/hr. Based upon industry data on the same type of dredge, the average monthly production time was assumed to be 420 hours with a 20% loss of material in the mining process, as above a six month operating period was assumed. This yielded an annual capacity of 4,543,000 tons per year.

An estimated selling price of $3.48 per ton at the surge was determined by averaging the onshore extraction costs in 1978 of all areas within a 15 mile radius of the proposed mining site. The result was an estimated net yearly sales of $15,810,000 for the first base year. Each additional year was adjusted to reflect a 10% increase in price which is currently comparative to average yearly price and cost increases. It was also assumed that an offshore mining operations of this size could sell all of its production due to a projected shortage in onshore supply.

The cost of material mined was obtained from the previously determined operating costs. In addition to these costs a $.80/ton charge was included to allow for on board material processing and unloading at the surge site. The estimated yearly cost of operations was then increased to reflect a 15% per year allowance for contingencies, yielding a cost of $11,408,000 per year.

In the analysis where no royalty rates were assumed, sales of general and administrative expenses were estimated at 12% of net sales. This estimate was based upon the experience of companies utilizing similar equipment. Where a 5% royalty rate was assumed it was included in the analysis by adjusting the 12% figure to 17%. Costs were also adjusted upward in increment of 10% per year.

Once the cash flows were determined for each year the internal rates of return were calculated. The internal rate of return with no royalty was 17.93%; with a 5% royalty, 13.36%.

Table 4

CAPITAL INVESTMENT ANALYSIS (27" - 5500 H.P. HYDRAULIC MINING UNIT)
ESTIMATED CASH FLOWS (100% EQUITY - NO ROYALTY
(IN THOUSANDS)

	Base Costs Yr. 1 1979 Yr. 1 Thousands	2	3	4	5	6	7	8	9	10
Est. Net Sales	$ 15810	17391	19130	21043	23147	25462	28008	30809	33890	32279
Cost of Material Mined	11408	12549	13804	15184	16702	18373	20210	22231	24454	26899
GROSS PROFIT	4402	4842	5326	5859	6445	7089	7798	8578	9436	10380
Sell, Gen, Admin. Expenses	1897	2087	2295	2525	2777	3055	3361	3697	4066	4473
NET INCOME BEFORE TAXES	2505	2755	3031	3334	3668	4034	4437	4881	5370	5907
Taxes (40%)	1002	1102	1212	1335	1467	1614	1775	1953	2148	2363
NET INCOME AFTER TAXES	1503	1653	1819	2001	2201	2420	2662	2928	3222	3544
Items Not Using Working Capital (Depreciation Exp)	100	110	121	133	146	161	177	195	214	236
FUND FLOW	$ 1603	1763	1940	2134	2347	2581	2839	3123	3436	3780

	11	12	13	14	15	16	17	18	19	20
Est. Net Sales	$ 41007	45108	49619	54580	60038	60042	72647	79911	87902	96693
Cost of Material Mined	29589	32548	35803	39384	43322	47654	52419	57611	63428	69770
GROSS PROFIT	11418	12560	13816	15196	16716	18388	20228	22250	24474	26923
Sell, Gen, Admin. Expenses	4920	5412	5954	6549	7204	7924	8717	9588	10547	11602
NET INCOME BEFORE TAXES	6498	7148	7862	8647	9512	10464	11511	21662	13927	15321
Taxes (40%)	2599	2859	3145	3459	3805	4186	4604	5065	5571	6128
NET INCOME AFTER TAXES	3899	4289	4717	5188	5707	6278	6907	7597	8356	9193
Items Not Using Working Capital (Depreciation Exp.)	259	285	314	345	380	418	460	505	556	612
FUND FLOW	$ 4158	4574	5031	5533	6087	6696	7667	8102	8912	9805

Table 5
CAPITAL INVESTMENT ANALYSIS (27" - 5500 H.P. HYDRAULIC MINING UNIT)
ESTIMATED CASH FLOWS (100% EQUITY - 5% ROYALTY)
(IN THOUSANDS)

	Base Costs Yr. 1 1979 Yr. 1 Thousands	2	3	4	5	6	7	8	9	10
Est. Net Sales	$ 15810	17391	19130	21043	23147	25462	28008	30809	33890	37279
Cost of Material Mined	11408	12549	13804	15184	16702	18373	20210	22231	24454	26899
GROSS PROFIT	4402	4842	5326	5859	6445	7089	7798	8578	9436	10380
Sell, Gen, Admin. Expenses	2688	2956	3252	3577	3936	4329	4762	5238	5762	6338
NET INCOME BEFORE TAXES	1714	1886	2074	2282	2509	2760	3036	3340	3674	4042
Taxes (40%)	686	755	830	913	1004	1105	1215	1337	1471	1618
NET INCOME AFTER TAXES	1028	1131	1244	1369	1505	1655	1821	2003	2203	2424
Items Not Using Working Capital (Depreciation Exp)	100	110	121	133	146	161	177	195	214	236
FUNDS FLOW	$ 1128	1241	1365	1502	1651	1816	1998	2198	2417	2660
	11	12	13	14	15	16	17	18	19	20
Est. Net Rev.	$ 41007	45108	49619	54580	60038	66042	72647	79911	87902	96693
Cost of Material Mined	29589	32548	35803	39384	43322	47654	52419	57661	63428	69770
GROSS PROFIT	11418	12560	13816	15196	16716	18388	20228	22250	24474	26923
Sell, Gen Admin. Exp.	6972	7669	8436	9280	10208	11228	12351	13586	14945	16440
NET INCOME BEFORE TAXES	4446	4891	5380	5917	6509	7160	7876	8664	9529	10483
Taxes (40%)	1179	1957	2153	2368	2605	2866	3152	3467	3814	4196
NET INCOME AFTER TAXES	2667	2934	3227	3549	3904	4294	4724	5197	5715	6287
Items Not Using Net Working Capital (Depreciation Exp)	259	285	314	345	380	418	460	505	556	612
FUND FLOW	$ 2926	3219	3541	3894	4284	4712	5184	5702	6271	6899

Conclusion

Determining the actual technological configuration to be used for specific offshore mining operations within the GNYMA will require further investigation. The amount and types of material available can only be determined by exploration of particular sites. One must consider the characteristics of the marine environment of the surrounding area to determine the procedures necessary to ensure little deleterious impact. If stringent requirements are set, alternate configurations for specific hydraulic or mechanical operations may have to be modified. Planning for these contingent events must recognize the possibility of increased costs.

For the greater New York region the investment in offshore mining is feasible. Both estimated internal rates of return for the prototype are within industry requirements.

It must be recognized that this analysis assumes the position of a private company seeking to mine the offshore region in the GNYMA. Therefore, it focuses on costs due solely to the operations of such a venture. The cost to the public of using these non-renewable resources was not included except in the royalty fee. If ongoing research on the effects of offshore mining on the marine environment does not discover any impacts so great that a "cost" cannot be computed, it is likely that an equitable agreement can be determined that will provide both adequate rate-of-return to the mining company and a fair price to the public for use of these resources.

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