United States Environmental Protection Agency

Technical Development Document for the Final Section 316(b) Phase III Rule

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Acronyms

a.k.a	also known as
AACE	American Association of Cost Engineers International
ADECA	Alabama Department of Economics and Community
AFB	aquatic filter barrier
AIF	actual intake flow
AKDFG	Alaska Department of Fish and Game
AKDNR	Alaska Department of Natural Resources
AOS	apparent opening size
ASCE	American Society of Civil Engineers
ASTM	American Society for Testing and Materials
BAFF	Bio-Acoustic Fish Fence
Bcf	billion cubic feet
BLS	Bureau of Labor Statistics
BPJ	best professional judgement
BPXA	BP Exploration, Inc.
BTA	best technology available
BTU	British thermal unit
C	Celsius
CalCOFI	California Cooperative Oceanic Fisheries Investigations
CEQ	Council of Environmental Quality
CFD	Computational Fluid Dynamics
CFR	Code of Federal Regulations
cfs	cubic feet per second
CGI	Conversion Gas Imports
cm	centimeter
CTR	cost to revenue
cu yd	cubic yard
CuNi	copper-nickel
CUR	capacity utilization rate
CWA	Clean Water Act
CWIS	cooling water intake structure
CWS	cooling water system
d	day
dB	decibel
dia	diameter
DIF	design intake flow
DOI	Department of the Interior
DTQ	Detailed Technical Questionnaire
DWPA	Deepwater Port Act of 1974
E	entrainment
EA	Economic Analysis
EA	Environmental Assessment
EBA	Economic Benefits Analysis
EIS	Environmental Impact Statement
ENR	Engineering News Record
EPA	Environmental Protection Agency
EPRI	Electric Power Research Institute
Eqn	equation

ETSU	Energy Technology Support Unit
F	Fahrenheit
FERC	Federal Energy Regulatory Commission
FGS	fish guidance system
FPL	Florida Power & Light
fps	feet per second
FR	Federal Register
ft	foot
GBS	gravity based structure
GCOM	gross compliance operations and maintenance
GIS	geographical information system
GOM	Gulf of Mexico
gpm	gallons per minute
HP	horsepower
hr	hour
Hz	hertz
I	impingement
I&E	impingement and entrainment
IADC	International Association of Drilling Contractors
ICR	information collection request
IFV	intermediate fluid vaporizers
IM	impingement mortality
IM&E	impingement mortality and entrainment
in.	inch
IPM	Integrated Planning Model
kW	kilowatt
kWh	kilowatt hour
l	liter
lb	pound
LMOGA	Louisiana Mid-Continent Oil and Gas Association
LNG	liquefied natural gas
m	meter
mg	milligram
MGD	million gallons per day
MIS	modular inclined screen
MLES	Marine/Aquatic Life Exclusion System
mm	millimeter
MM Btu/hr	million British thermal units
MMS	Mineral Management Service
MMTPA	million tons per year
MODU	mobile offshore drilling units
MPEH	Main Pass Energy Hub
MRIF	maximum reported intake flow
MSL	mean sea level
MTSA	Maritime Transportation Security Act of 2002
MW	megawatt
N/A	not applicable
NEPA	National Environmental Policy Act
NEST	Northeast Science and Technology
NOAA	National Oceanic and Atmospheric Administration
NODA	Notice of Data Availability
NOIA	National Oceans Industries Association

NOx	oxides of nitrogen
NPDES	National Pollutant Discharge Elimination System
NPP	nuclear power plant
NYDEC	New York Department of Environmental Conservation
O&G	oil and gas
O&M	operations and maintenance
OCS	outer continental shelf
OOC	Offshore Operators Committee
ORV	open rack vaporizer
OWR	Office of Water Resources
PCCP	prestressed concrete cylinder pipe
POA	percent open area
ppm	parts per million
psf	pounds per square foot
psi	pounds per square inch
psig	pounds per square inch gauge
PVC	polyvinyl chloride
re 1 mPa	at underwater reference pressure of 1 micro Pascal
s	second
SAV	submerged aquatic vegetation
SCV	submerged combustion vaporizers
SEAMAP	Southeast Area Monitoring and Assessment Program
SIC	Standard Industrial Classification
SPA	sound projector array
sq	square
SS	stainless steel
STL	submerged turret loading
STQ	short technical questionnaire
STV	shell and tube vaporizer
TBD	to be determined
TDD	Technical Development Document
TECC	total estimated capital costs
TVA	Tennessee Valley Authority
U.S.	United States
USC	United States Code
USCG	United States Coast Guard
USD	United States dollars
vs.	versus
WSPA	Western States Petroleum Association
yd	yard

Chapter 1: Summary of the Final Rule

1.0 APPLICABILITY OF THE FINAL RULE

This final action establishes requirements applicable to new offshore oil and gas extraction facilities. As discussed in the preamble, the Environmental Protection Agency (EPA) decided to continue to use case-by-case, best professional judgment (BPJ) permit conditions to implement Clean Water Act (CWA) section 316(b) at existing Phase III facilities.

This document summarizes EPA's analysis of engineering and compliance costs for the 316(b) Phase III final regulation for new offshore oil and gas extraction facilities and for the regulatory options that were considered for promulgation for Phase III existing facilities. Since EPA is not promulgating national section 316(b) requirements for existing Phase III facilities, there are no compliance costs for existing facilities from this action. However, EPA did estimate the costs for the regulatory options considered for existing facilities.

The final Phase III rule makes new offshore oil and gas extraction facilities subject to requirements similar to those under the final Phase I new facility regulation (40 Code of Federal Regulations (CFR) 125, Subpart I). Requirements for new offshore oil and gas extraction facilities are finalized in a new Subpart N. For the purposes of this final rule, new offshore oil and gas extraction facilities are those facilities that are subject to the Oil and Gas Extraction Point Source Category Effluent Guidelines (i.e., 435.10 Offshore Subcategory or 435.40 Coastal Subcategory) and meet the definition of "new offshore oil and gas extraction facility" in Subpart N, '125.133.

2.0 OVERVIEW OF THE FINAL REQUIREMENTS

The final rule establishes requirements for new offshore oil and gas extraction facilities that are similar to requirements established under the 316(b) Phase I rule for other new facilities. These requirements are summarized below.

Under Subpart N, new offshore oil and gas extraction facilities that withdraw more than 2 million gallons per day (MGD) must comply with the requirements in '122.21(r) and the requirements in '125.134. These requirements address fixed and non-fixed (mobile) facilities with and without sea chests. Under this rule, new offshore oil and gas extraction facilities that are fixed facilities and withdraw more than 2 MGD, and do not employ sea chests as cooling water intake structures, must comply with the requirements in '125.134(b)(2) through (8). The same facilities with sea chests must comply with all of the same requirements except '125.134(b)(5) addressing entrainment requirements. Mobile facilities that withdraw greater than 2 MGD must comply with requirements in '125.134(b)(2), (4), (6), (7), and (8). Requirements at '125.134(b) address intake flow velocity, proportional flow restrictions for facilities on tidal rivers or estuaries, specific impact concerns (e.g., threatened or endangered species, critical habitat, migratory or sport or commercial species), entrainment (where applicable), required information submission, monitoring, and recordkeeping.

Facilities also have the opportunity to request alternative requirements '125.135 and provide data to determine if compliance with the requirements would result in compliance costs wholly out of proportion to those EPA considered in establishing the requirement, or would result in significant adverse impacts on local water resources other than impingement or entrainment, or local energy markets.

3.0 ADDITIONAL REGULATORY DECISIONS MADE IN THE FINAL RULE

Existing Offshore Oil and Gas Extraction Facilities

Because the lowest co-proposed flow threshold option was 50 MGD, the proposed requirements would not apply to existing offshore oil and gas extraction facilities, as there are no existing offshore oil and gas extraction facilities with a design intake flow greater than 50 MGD. EPA did not propose to regulate existing offshore oil and gas extraction facilities, and decided not to establish national categorical requirements for them in the final Phase III rule. Instead, permit writers must impose impingement and/ or entrainment controls under Section 316(b) at existing offshore oil and gas extraction facilities on a case-by-case basis using their best professional judgment.

Liquefied Natural Gas Import Terminals

Based on information in EPA's rulemaking record, EPA identified only a few existing and new liquefied natural gas (LNG) import terminals that withdraw water for cooling purposes. Currently, only one existing offshore LNG import terminal meets the scope of the proposed Phase III rulemaking for existing facilities (e.g., existing facilities with design intake flows greater than 50 MGD, 25% or more of the water intake used for cooling purposes). As there is only one existing offshore LNG import terminal potentially within scope of the Phase III rulemaking, EPA determined that one facility did not justify a national categorical rulemaking. Consequently, EPA decided not to establish national categorical requirements for existing offshore LNG import terminals in the final Phase III rule. Based on information in EPA's rulemaking record, EPA identified 11 new offshore LNG import terminals may be built over the next decade. However, EPA estimates only three or four of these new offshore LNG import terminals will meet the scope of the proposed Phase III rulemaking for new facilities (e.g., new facilities with design intake flows greater than 2 MGD, 25% or more of the water intake used for cooling purposes). As there are only three or four new offshore LNG import terminal potentially within scope of the Phase III rulemaking, EPA determined that this limited number of facilities did not justify a national categorical rulemaking. Consequently, EPA decided not to establish national categorical requirements for new offshore LNG import terminals in the final Phase III rule. Instead of national categorical impingement and entrainment control requirements for existing and new offshore LNG import terminals, permit writers must impose impingement and/ or entrainment controls under Section 316(b) on cooling water intake structures at LNG import terminals on a case-by-case basis using their best professional judgment.

Seafood Processing Vessels

Because the lowest proposed flow threshold option for a national categorical rule was 50 MGD, the proposed requirements would not have applied to existing seafood processing vessels, as there are no known existing seafood processing vessels with a design intake flow greater than 50 MGD. Seafood processing vessels, like most offshore oil and gas extraction facilities, are mobile facilities. However, offshore oil and gas extraction facilities may remain stationary for several months to several years before relocating. During this time, aquatic habitats are formed in the vicinity of the facility. In contrast, seafood processing vessels do not remain stationary for any considerable period of time. Additional data available to the Agency indicate that given the relatively low cooling water flows used by seafood processing vessels, the propensity for reduced intake of fish or debris due to the vessel's speed in relation to the intake's orientation and intake velocity, and their highly mobile character (significantly more so than offshore oil and gas extraction facilities), these vessels are best assessed on case-by-case basis. Further, data available to the Agency has not clearly identified available technologies that would reduce entrainment for such vessels. EPA did not propose to regulate existing seafood processing vessels, and decided not to establish national categorical requirements for them in the final Phase III rule. For the same reasons as just mentioned, EPA also did not propose, and decided not to establish as part of today's final action, national categorical requirements for new seafood processing vessels either. Instead, permit writers must impose impingement and/ or entrainment controls under Section 316(b) at seafood processing vessels on a case-by-case basis using their best professional judgment.

Chapter 2: Description of the Industry

This section presents information characterizing all of the categories of facilities that EPA considered in developing this final rule, even if EPA did not ultimately issue national requirements for such facilities. EPA has generally categorized all of these industries into two groups: land-based facilities and offshore facilities. This chapter describes all industrial categories considered for the Phase III rulemaking.

I. LAND-BASED INDUSTRIES

This category includes existing electric generators not covered under the Phase II rule (those with a design intake flow (DIF) less than 50 MGD) and all existing manufacturers. This section describes these facilities, their source waterbodies, intakes, and intake technologies. Much of the data in this section is derived from the industry questionnaire data.

1.0 DESCRIPTION OF THE INDUSTRIES

In 1997, EPA estimated that over 400,000 facilities could potentially be subject to a cooling water intake regulation. Given the large number of facilities potentially subject to regulation, EPA decided to focus its data collection efforts on six industrial categories that, as a whole, are estimated to account for over 99 percent of all cooling water withdrawals. These six sectors are: Utility Steam Electric, Nonutility Steam Electric, Chemicals & Allied Products, Primary Metals Industries, Petroleum & Coal Products, and Paper & Allied Products.

EPA=s data collection efforts (via the 1998 industry questionnaire) focused on the electric generators (both utility and nonutility steam electric) and the four manufacturing industry groups that were identified as significant users of cooling water. These industries are shown below, as described by the Standard Industrial Classification (SIC) system.

Electric Services

This industry sector is classified under SIC Major Group 49. This major group includes establishments engaged in the generation, transmission, and/or distribution of electricity or gas or steam.

Chemical and Allied Products

This industry sector is classified under SIC Major Group 28. This major group includes establishments producing basic chemicals and establishments manufacturing products by predominantly chemical processes. Establishments classified in this major group manufacture three general classes of products: (1) basic chemicals, such as acids, alkalis, salts, and organic chemicals; (2) chemical products to be used in further manufacture, such as synthetic fibers, plastics materials, dry colors, and pigments; and (3) finished chemical products to be used for ultimate consumption, such as drugs, cosmetics, and soaps; or to be used as materials or supplies in other industries, such as paints, fertilizers, and explosives.

Primary Metals Industries

This industry sector is classified under SIC Major Group 33. This major group includes establishments engaged in smelting and refining ferrous and nonferrous metals from ore, pig, or scrap metals; in rolling, drawing, and alloying metals; in manufacturing castings and other basic metal products; and in manufacturing nails, spikes, and insulated wire and cable.

Paper and Allied Products

This industry sector is classified under SIC Major Group 26. This major group includes establishments primarily engaged in the manufacture of pulps from wood and other cellulose fibers, the manufacture of paper and paperboard, and the manufacture of paper and paperboard into converted products.

Petroleum and Coal Products

This industry sector is classified under SIC Major Group 29. This major group includes establishments primarily engaged in petroleum refining, manufacturing paving and roofing materials, and compounding lubricating oils and greases from purchased materials.

Other Industries

EPA sent industry questionnaires to individual facilities from a number of other industries outside of the five listed above and incorporated that data into the analysis for Phase III. In 2004, EPA also collected information on land-based liquefied natural gas (LNG) import terminals.

1.1 Estimated Numbers of Land-based Facilities in Scope of 316(b)

At proposal, EPA estimated that approximately 683 land-based Phase III facilities with a design intake flow greater than 2 MGD were potentially subject to regulation. These facilities combine to account for a design intake flow of over 40 billion gallons per day of cooling water from approximately 908 cooling water intake structures. See Exhibit 2-1 below. For comparison, the numbers of in-scope facilities for Phase I and Phase II are also included. The remaining exhibits in this section represent those land-based Phase III facilities with a design intake flow greater than 2 MGD.

Exhibit 2-1. Cooling Water Use in Surveyed Industries

	Estimated Number of Facilities	Estimated Design Intake Flow (MGD)
Phase I (new electric generators and manufacturers)	121 (over 20 years)	N/A
Phase II (existing electric generators >50 MGD)	554	367,752
Facility Considered for Regulation Under Phase III (existing electric generators <50 MGD and all existing manufacturers)	683	40,441
Existing electric generators <50 MGD	118	2,374
Existing manufacturers <50 MGD	410	7,931
Existing manufacturers >50 MGD	155	30,136

Source: Survey Data from Detailed Industry Questionnaire: Phase II Cooling Water Intake Structures (DCN 4-0016F-CBI).
Note: All values are weighted and include facilities identified as baseline closures.

Exhibit 2-2 shows the weighted distribution of manufacturers by industry type. See Chapter 5 for how EPA developed model facilities to specifically represent manufacturers for the first five industry types. These model facilities were weighted to develop national cost estimates that represent all manufacturers potentially subject to Phase III requirements.

Exhibit 2-2. Estimated Distribution of Manufacturing Facilities by Industry Group in Phase III

Industry Type	Estimated Number of Facilities	Percent
Chemical and Allied Products	188	30.23
Primary Metals	92	14.79
Paper and Allied Products	242	38.91
Petroleum and Coal Products	39	6.27

Food Products	41	6.59
Textiles	9	1.45
Other Manufacturing	8	1.29
Unknown Manufacturing	3	0.48
Total	622	100

1.2 Source Waterbodies

Existing facilities potentially subject to regulation under Phase III can be found on all waterbody types, but are predominantly located on freshwater rivers and streams. Exhibit 2-3 below illustrates the distribution of facilities by waterbody type. Intakes at Phase III existing facilities may be found on all five surface waterbody classifications. In this regard, intakes at Phase II facilities are identical to Phase III existing facilities.

Exhibit 2-3. Distribution of Source Waterbodies for Phase III Facilities

Source of Surface Water	Estimated Number of Facilities	Percent of Facilities
Freshwater River or Stream	496	72.6
Lake or Reservoir	60	8.8
Great Lakes	77	11.3
Estuary or Tidal River	39	5.7
Ocean	11	1.6
Total	683	100

Source: Survey Data from Detailed Industry Questionnaire: Phase II Cooling Water Intake Structures (DCN 4-0016F-CBI).
Note: All values are weighted and include those facilities identified as baseline closures.

1.3 Design Intake Flows

Exhibit 2-4 below illustrates the range of design intake flows in facilities potentially subject to regulation under Phase III. In this exhibit all of the existing facilities with a design intake flow greater than 50 MGD are manufacturing facilities, since power producers with a design intake flow of 50 MGD or greater are covered under Phase II.

Exhibit 2-4. Existing Phase III Facilities with a Design Intake Flow of 2 MGD or Greater

Design Intake Flow (MGD)	Estimated Number of Facilities	Percent of Number of Facilities	Cumulative Percent	Percent of Total Design Intake Flow
0 – 2*	0*	0*	0*	0*
2 - 5	83	12.2	12.2	0.6
5 - 10	84	12.3	24.5	1.5
10 - 15	74	10.8	35.3	2.3
15 - 25	104	15.2	50.5	5.1
25 - 50	183	26.8	77.3	16
50 - 100	82	12	89.3	14.2
> 100	73	10.7	100	60.3
Total	683	100		100

Source: Survey Data from Detailed Industry Questionnaire: Phase II Cooling Water Intake Structures (DCN 4-0016F-CBI).
* No facilities in the 0 – 2 MGD range were surveyed.
Note: All values are weighted and include those facilities identified as baseline closures.

See Exhibit 2-13 for a comparison of design intake flows at Phase II facilities. Phase III facilities exhibit a wide range of design intake flows similar to Phase II facilities. Exhibit 2-5 below illustrates the range of design intake flows by industry type.

Exhibit 2-5. Design Intake Flow by Industry Type

Industry Type	Estimated Number of Facilities	Total Design Intake Flow (MGD)	Percent of Total Design Intake Flow	Average Design Intake Flow (MGD)*
Utilities**	85	1,927	5	23
Nonutilities	36	482	1	16
Chemical and Allied Products	181	12,340	31	247
Primary Metals	89	8,870	22	240
Paper and Allied Products	225	11,904	30	127
Petroleum and Coal Products	39	3,259	8	112
Food Products	13	670	1	52
Textiles	<5	6	1	6
Other Manufacturing	14	983	2	98
Total	683	40,441	100	921

* Average based on surveyed facilities. May not be reflective of actual industry-wide average design intake flows.
Source: Survey Data from Detailed Industry Questionnaire: Phase II Cooling Water Intake Structures (DCN 4-0016F-CBI).
**Utilities < 50 MGD.
Note: All values are weighted and include facilities identified as baseline closures.

Exhibit 2-6 combines data from Exhibit 2-3 and 2-4 and provides summary-level data for all industry types.

Exhibit 2-6. Industry Overview

Design Intake Flow (MGD)	Estimated Number of Facilities	Total Design Intake Flow (MGD)	Percent of Total Design Intake Flow
2 - 20	290	2,612	6.5
20 - 50	238	7,693	19
> 50	155	30,136	74.5
Total	683	40,441	100

Source: Survey Data from Detailed Industry Questionnaire: Phase II Cooling Water Intake Structures (DCN 4-0016F-CBI).
Note: All values are weighted and include facilities identified as baseline closures.

1.4 Cooling Water System Configurations

Facilities potentially subject to regulation under Phase III employ a variety of cooling water system (CWS) types. Exhibit 2-7 shows the distribution of cooling water system configurations. Both Phase II and Phase III facilities employ once-through, recirculating, and recombination cooling water system configurations. The majority of intakes at both Phase II and Phase III facilities are once-through systems

Exhibit 2-7. Distribution of Cooling Water System Configurations

CWS Configuration	Estimated Number of CWS*	Percent of Total CWS	Estimated Number of CWS for Electric Generators	Percent of Total Electric Generator CWS	Estimated Number of CWS for Mfrs.	Percent of Total Mfr CWS	Percent of Phase II CWS
Once-through	436	49	32	25	404	53	76
Recirculating	285	32	93	72	192	25	14
Combination	92	10	3	2	89	12	9
Other	76	9	1	1	75	10	1
Total	889	100	129	100	760	100	100

* Some facilities have more than one cooling water system.
Source: Survey Data from Detailed Industry Questionnaire: Phase II Cooling Water Intake Structures (DCN 4-0016F-CBI).
Note: All values are weighted and include facilities identified as baseline closures.

Exhibit 2-8 illustrates the intake structure arrangements for facilities potentially subject to regulation under Phase III. The exhibit also shows all five types of intake arrangements are routinely used at both Phase II and Phase III facilities.

Exhibit 2-8. Distribution of Cooling Water Intake Structure Arrangements

Intake Arrangement	Estimated Number of Arrangements	Percent of Arrangements	Percent of Arrangements At Phase II Facilities*
Canal or Channel Intake	123	1	36
Bay or Cove Intake	49		10
Submerged Shoreline Intake	208	2	30
Surface Shoreline Intake	151	2	38
Submerged Offshore Intake	216	2	14

Note: The total number of facilities exceeds 683, since some facilities employ multiple intake arrangements.
Source: Survey Data from Detailed Industry Questionnaire: Phase II Cooling Water Intake Structures (DCN 4-0016F-CBI).
Note: All values are weighted and include facilities identified as baseline closures.
* Data from the proposed Phase II Technical Development Document (DCN 4-0004).

1.5 Design Through-Screen Velocities

Exhibit 2-9 below illustrates the wide range of design intake velocities at facilities covered by the proposed regulatory options presented in the proposed rule. Exhibit 2-9 shows a wide range of CWIS through-screen velocities are found at the intakes of both Phase II and Phase III facilities. The majority of intakes at both Phase II and Phase III facilities have a design through-screen velocity of 2 feet per second or lower. The mean through-screen intake velocities at Phase III facilities may be found in Exhibit 5-6.

Exhibit 2-9. Distribution of Cooling Water Intake Structure Design Through-Screen Velocities

Velocity (feet per second)	Estimated Number of CWIS	Percent of CWIS	Cumulative Percent	Percent of Phase II CWIS
0 - 0.5	156	31		9
0.5 - 1	112	22		23
1 - 2	112	22		38
2 - 3	71	14		23
3 - 5	26	5		4
5 - 7	11	2		1
> 7	19	4	1	2
Total	507	100		100

Note: The average design through-screen velocity for all surveyed cooling water intake structures (unweighted) is 1.67 feet per second. The median design through-screen velocity for all surveyed facilities is 0.92 feet per second.
Source: Survey Data from Detailed Industry Questionnaire: Phase II Cooling Water Intake Structures (DCN 4-0016F-CBI).
Note: All values are weighted and include those facilities identified as baseline closures.

1.6 Existing Intake Technologies

Many facilities potentially subject to regulation under Phase III have intake technologies already in place. Exhibit 2-10 illustrates the number of existing intake technologies. This table includes facilities with cooling towers that do not employ any intake technology to demonstrate the usage of flow reduction as a method to reduce impingement mortality and entrainment. All five intake technologies may be found on intakes at both Phase II and Phase III facilities. Cooling towers may be found on intakes at approximately one-fifth of both Phase II and Phase III facilities.

Exhibit 2-10. Distribution of Intake Technologies

Intake Technology Type	Estimated Number of Technologies	Percent of Technologies	Percent of Technologies at Phase II Facilities*
Bar Rack/Trash Rack	427	28	95
Screening Technologies	500	33	97
Passive Intake Technologies	233	15	5
Fish Diversion or Avoidance System	35	2	6
Fish Handling or Return System	33	2	32
No Intake Technologies	13	1	0
Cooling Tower	286	19	22

Note: The total number of technologies exceeds 683, since some facilities employ multiple intake technologies.
Source: Survey Data from Detailed Industry Questionnaire: Phase II Cooling Water Intake Structures (DCN 4-0016F-CBI).
Note: All values are weighted and include those facilities identified as baseline closures.
* Data from the proposed Phase II Technical Development Document (DCN 4-0004).

Exhibit 2-11 shows the percent of Phase III facilities that have technologies in-place that would meet the performance standards of the final Phase II rule.

Exhibit 2-11. Technologies Already In Place At Phase III Facilities By Industry

Industry	Percent of Phase II Facilities With A DIF > 50 MGD
Mining	ND
Food and Kindred	ND
Pulp and Paper	23
Chemicals	17
Petroleum	ND
Metals	23
Other	ND

ND = Not Disclosed, due to potential release of confidential business information

1.7 Operating Days per Year

In Phase II, generators with a capacity utilization rate (CUR) of less than 15 percent are not subject to entrainment requirements. As a corollary to this provision, EPA attempted to analyze the number of operating days for manufacturing facilities. At proposal, EPA considered setting a 60-day threshold for operating days per year, as 60 days is approximately 15 percent of one year. Exhibit 2-12 shows Phase II facilities are more likely to operate their intakes intermittently than Phase III facilities.

Exhibit 2-12. Distribution of Manufacturing Facilities by Number of Operating Days

Number of Operating Days (Equivalent Capacity Utilization Rate)	Percent of Facilities	Percent of Phase II Facilities
< 60 days (<15%)		
60 - 180 days (15-50%)		
> 180 days (>50%)		
Total		

Source: Survey Data from Detailed Industry Questionnaire: Phase II Cooling Water Intake Structures (DCN 4-0016F-CBI).
Note: All values are weighted and include those facilities identified as baseline closures.

1.8 Land-based Liquefied Natural Gas Import Terminals

Based on information in EPA's rulemaking record, there are five existing land-based liquefied natural gas (LNG) import terminals in the United States. These five LNG import terminals do not withdraw surface water for cooling purposes and EPA did not considered these facilities for 316(b) national categorical impingement and entrainment control standards in this rulemaking.

1.9 Design Intake Flow in Phase III Compared to Phase II

While the total volume of withdrawals is much greater in Phase II, EPA noted that there are a substantial number of facilities in both Phase II and Phase III with similar design intake flows. Exhibit 2-13 illustrates the number of facilities in each of the flow ranges.

Exhibit 2-13. Distribution of Design Intake Flow in Phase II and Phase III

DIF Range	Number of Phase III Facilities	Percent of Phase III Facilities	Number of Phase II Facilities	Percent of Phase II Facilities
2 – 50 MGD	547	77	0	0
50 – 100 MGD	84	12	54	10
100 – 200 MGD	44	6	88	16
> 200 MGD	33	5	412	74
Total	709	100	554	100

Source: Survey Data from Detailed Industry Questionnaire: Phase II Cooling Water Intake Structures (DCN 4-0016F-CBI).
Note: All values are weighted and include facilities identified as baseline closures.

2.0 PRELIMINARY ASSESSMENT OF COMPLIANCE

EPA considered all of the above data in deciding to continue to rely upon BPJ determinations to establish 316(b) requirements at Phase III existing facilities. Exhibit 2-14 below illustrates a synthesis of some of the pertinent data described above.

Exhibit 2-14. Technologies Already In Place at Facilities Potentially Regulated Under Phase III

Design Intake Flow (MGD) Threshold	Electric Generators		Manufacturers	
	% of Facilities With Technology Satisfying Phase II Requirements	% of Facilities With Closed-Cycle, Recirculating Cooling Systems	% of Facilities With Technology Satisfying Phase II or Requirements	% of Facilities With Closed-Cycle, Recirculating Cooling Systems
> 50	n/a	n/a	29	4
20 - 50	69	60	54	22
2 - 20	93	82	58	29
Total	82	72	48	20

Source: Survey Data from Detailed Industry Questionnaire: Phase II Cooling Water Intake Structures (DCN 4-0016F-CBI)
Note: All values are weighted and include those facilities identified as baseline closures.

II. OFFSHORE INDUSTRIES

EPA considered establishing national requirements for three additional industry groups that have been identified as potential large users of cooling water: offshore oil and gas extraction facilities, seafood processing vessels, and offshore LNG import terminals. An industry survey was developed in 2003 to collect data on offshore oil and gas extraction facilities and seafood processing vessels. EPA also collected technical and economic information on existing and new offshore LNG import terminals.

Under the final rule, only new offshore oil and gas extraction facilities are subject to 316(b) national categorical impingement and entrainment control standards. Existing offshore oil and gas extraction facilities are not subject to the national categorical requirements of the final rule. EPA's record shows that existing offshore oil and gas extraction facilities have design intake flows less than 50 MGD, therefore none would meet the scope and applicability requirements considered for the final regulation. Based on information in EPA's rulemaking record, EPA identified only one existing and three or four new offshore LNG import terminals that meet the scope of the proposed Phase III rulemaking for new and existing facilities. As there are only four or five offshore LNG import terminals potentially within scope of the Phase III rulemaking, EPA determined that this limited number of facilities did not justify a national categorical rulemaking. Consequently, EPA decided not to establish 316(b) national categorical impingement and entrainment control standards for offshore LNG import terminals. Instead of national categorical impingement and entrainment control requirements for existing and new offshore LNG import terminals, permit writers must impose impingement and/ or entrainment controls under Section 316(b) for cooling water intake structures at LNG import terminals on a case-by-case basis using their best professional judgment.

1.0 DESCRIPTION OF THE INDUSTRIES

After EPA proposed the Phase I rule for new facilities (65 FR 49060), the Agency received adverse comments from operators of mobile offshore and coastal drilling units concerning the limited information about their cooling water intakes, associated impingement and entrainment, costs of technologies, or achievability of the controls proposed by EPA. In the Phase I final rule, EPA committed to Apropose and take final action on regulations for new offshore oil and gas extraction facilities, as defined at 40 CFR 435.10 and 40 CFR 435.40, in the Phase III section 316(b) rule.@ EPA subsequently identified seafood processing vessels and offshore liquefied natural gas facilities as other potential large users of cooling water that may be subject to regulation under 316(b). Each of these industries is shown below, as described by the SIC system.

<u>Offshore Oil and Gas Extraction</u>
This industry sector is classified under SIC Major Group 13. This grouping is not to be confused with the EPA regulations at 40 CFR Part 435 with the same name. This major group includes establishments primarily engaged in: (1) producing crude petroleum and natural gas; (2) extracting oil from oil sands and oil shale; (3) producing natural gasoline and cycle condensate; and (4) producing gas and hydrocarbon liquids from coal at the mine site.

<u>Seafood Processing</u>
This industry sector is classified under SIC Major Group 09. This major group includes establishments primarily engaged in commercial fishing (including crabbing, lobstering, clamming, oystering, and the gathering of sponges and seaweed), and the operation of fish hatcheries and fish and game preserves, in commercial hunting and trapping, and in game propagation.

<u>Offshore Liquefied Natural Gas</u>
This industry sector is classified under SIC Major Group 49. This major group includes establishments engaged in the generation, transmission, and/or distribution of electricity or gas or steam. This industry sector is relatively new and currently includes a small number of facilities.

1.1 Estimated Numbers of Offshore Facilities Potentially Subject to Regulation

1.1.1 Existing Offshore Facilities

EPA estimated the number of existing facilities considered for regulation under Phase III in each of the three offshore industries listed above.

<u>Offshore Oil and Gas Extraction</u>
Using information from industry sources and other Federal agencies, EPA determined that there were approximately 2,929 offshore oil and gas extraction facilities potentially within the scope of the regulations (facilities withdrawing > 2 MGD, with at

least 25% of the water used for cooling purposes). Of these, 2,478 facilities are fixed facilities (i.e., fixed platforms) and were primarily located in the Gulf of Mexico, with some facilities also located in Alaska and along the Pacific coast. The remaining 451 facilities are mobile facilities (i.e., mobile offshore drilling units (MODU)), which can operate in or out of waters of the United States. Like the fixed platforms, the majority of MODUs operate in the Gulf of Mexico. All fixed platforms and MODUs are considered to be in scope of the regulation, as nearly all operate in Federal waters and are likely to meet the applicability requirements for 316(b).

Seafood Processing

Through existing databases and mailing lists, EPA determined that there were approximately 123 seafood processing vessels. Each of these vessels has been issued an NPDES permit and it was initially assumed that all vessels have a water intake of greater than 2 MGD and that at least 25% of the water withdrawn is for cooling purposes. EPA=s research indicated that vessels shorter than 100 feet in length were unlikely to withdraw more than 2 MGD.

Offshore LNG Import Terminals

Based on information in EPA's rulemaking record, there is currently only one existing offshore LNG import terminal in the United States.

1.1.2 New Offshore Facilities

Offshore Oil and Gas Extraction

Based on the rate of new projects in recent years, EPA projects that approximately 20 new offshore oil and gas extraction facilities will begin operations in the next 3 years.

Seafood Processing

Data available to the Agency indicate that given the relatively low cooling water flows used by seafood processing vessels, the propensity for reduced intake of fish or debris due to the vessel's speed in relation to the intake's orientation and intake velocity, and their highly mobile character, these vessels are best assessed on case-by-case basis. Further, data available to the Agency has not clearly identified available technologies that would reduce entrainment for such vessels. Therefore, these facilities were not expected to be regulated under the Phase III rule, and thus EPA did not estimate the number of projected new seafood processing vessels.

Offshore LNG Import Terminals

Based on information in EPA's rulemaking record, EPA identified eleven new offshore LNG import terminal that are currently proposed for development (see Table 4, DCN 9-3577). Additional new offshore LNG import terminal may also be proposed (see Figure 2, DCN 9-3577). Three or four of these facilities are designed to use water intakes that would withdraw more than 2 MGD and 25 percent or more of surface water intake for cooling purposes.

1.2 Offshore Facility Characteristics

EPA collected somewhat less information on the offshore industries and therefore will not present detailed tables as in the section above for land-based facilities. This section does, however, provide a summary of the offshore facility characteristics.

Offshore Oil and Gas Exploration Facilities

New offshore oil and gas extraction facilities include both fixed facilities (such as platforms) and mobile facilities (such as MODUs and barges). See chapter 3 for additional details on these facilities.

Seafood Processing Vessels

In developing technology cost modules, EPA assumed that a typical seafood processing vessel was 280 feet in length and primarily used sea chests as the cooling water intake structure (see Hatch Report for typical vessel sizes used to derive this model seafood processing vessel). Data available to EPA did not identify in-place intake technologies designed to reduce impingement mortality or entrainment, as most vessels have a simple screen or grate to screen trash and other debris. Simple screens and grates for debris control have wide mesh sizes, and would not likely provide reductions in impingement. EPA concluded no entrainment technologies were available for existing seafood processing vessels.

Data from respondents to the EPA Technical Survey for Seafood Processing Vessels indicate that the combined design intake flow from all the cooling water intakes in a vessel range from 3 MGD to 45 MGD. The total number of intakes per vessel withdrawing water for cooling purposes ranged from two to ten. These vessels had either a sea chest or simple pipe intake for withdrawing cooling water. As discussed in later in this document, EPA did not identify impingement and entrainment technologies demonstrated for these vessels and their intake configurations.

Offshore LNG Import Terminals

Based on information in EPA's rulemaking record, EPA identified only one existing and three or four new offshore LNG import terminals that meet the scope of the proposed Phase III rulemaking for new and existing facilities. See the following memorandum to the Phase III rulemaking record, "LNG Import Terminal Support Documentation for the 316(b) Phase III Final Technical Development Document," DCN 9-3577, for additional details on these facilities.

Chapter 3: Technology Cost Modules for Manufacturers

I. TECHNOLOGY COST MODULES FOR MANUFACTURERS

INTRODUCTION

This chapter presents the technology cost modules used by the Agency to develop compliance costs at model facilities considered for the proposed rule. Chapter 5 of this document describes the Agency's methodology for assigning particular cost modules to the model facilities considered.

The technology cost modules used in Phase III for manufacturers are the same as those used to determine the compliance costs for Phase II facilities. What the facility produces, manufactures, or what type of equipment the facility uses the cooling water for is not relevant to the performance requirements. EPA's survey data shows the types of intakes and the technologies available to address impingement and entrainment at Phase II facilities are identical to the intakes and technologies that may be appropriate for Phase III facilities and EPA has no data to show otherwise. However, EPA developed technology cost modules for offshore oil and gas extraction facilities, which are presented in Chapter 7.

Note that the cost modules presented in this chapter reference costs developed for year 2002 dollars, which were used to develop Phase II facility costs. However, all costs for Phase III facilities presented in the final rule reflect costs that were adjusted to year 2004 dollars.

1.0 SUBMERGED PASSIVE INTAKES

The modules described in this section involve submerged passive intakes and address both adding technologies to the inlet of existing submerged intakes and converting shoreline based intakes (e.g., shoreline intakes with traveling screens) to submerged offshore intakes with added passive inlet technologies. The passive inlet technologies that are considered include passive screens and velocity caps. All intakes relocated from shore-based to submerged offshore are assumed to employ either a velocity cap or passive screens. Costs for velocity caps are presented separately in section 3.0.

1.1 Relocated Shore-based Intake to Submerged Near-Shore and Offshore with Fine Mesh Passive Screens at Inlet

This section contains three subsections. The first two subsections respectively present documentation for passive screen technology selection and estimation parameters, and for development of capital costs for submerged passive intakes. This discussion includes: passive screen technology selection, selection of flow values, intake configurations, connecting walls, and connecting pipes. The second subsection discusses cost development for: screen construction materials, connecting walls, pipe manifolds, airburst systems, indirect costs, nuclear facilities, operations and maintenance (O&M) costs, construction-related downtime. The third subsection presents a discussion of the applicability of this technology cost module.

1.1.1 Selection/Derivation of Cost Input Values

<u>Passive Screen Technology Selection</u>

Passive screens come in one of three general configurations: flat panel, cylindrical, and cylindrical T-type. Only passive screens constructed of welded wedgewire were considered due to the improved performance of wedgewire with respect to debris removal and fish protection. After discussion with vendors concerning the attributes and prevalence of the various passive screen technology configurations, EPA selected the T-screen configuration as the most versatile with respect to a variety of local intake and waterbody attributes. The most important screen attribute was the requirement for screen placement. Both cylindrical and T-screens allow for placement of the screens extending into the waterbody, which allows for debris to be swept away from the screens once dislodged. T-screens produce greater flow per screen unit and thus were chosen because they are more practical in multi-screen installations.

Due to the potential for build-up and plugging by debris, passive screens are usually installed with an airburst backwash system. This system includes a compressor, an accumulator (also known as a receiver), controls, a distributor, and air piping that directs a burst of air into each screen. The airburst produces a rapid backflow through the screen; this air-induced turbulence dislodges accumulated debris, which then drifts away from the screen unit. Vendors claimed (although with minimal data) that only very stagnant water with a high debris load or very shallow water (<2 feet (ft) deep) would prevent use of this screen technology. Areas with low water velocities would simply require more frequent airburst backwashes, and few facilities are constrained by water depths as shallow as 2 feet.

While there are waterbodies with levels of debris low enough to preclude installation of an airburst system, EPA has chosen to include an airburst backwash system with each T-screen installation as a prudent precaution. The capital cost of the airburst backwash system is a substantial component, particularly in offshore applications, because of the need to install a separate air supply pipe from the shoreline to supply air to each screen or group of smaller screens. Thus, the assumption that airburst backwash systems are needed in all applications is considered as part of an overall cost approach that increases projected capital costs to the industry to develop a high-side cost estimate.

T-screens ranging in diameter from 2 feet (T24) to 8 feet (T96), in one-foot intervals, are used in the analysis. Costs provided are for two types of screens: one with a slot size of approximately 1.75 mm referred to as "fine mesh" and one with a slot size of 0.76 mm referred to as "very fine mesh." The design flow values used for each size screen correspond to wedgewire T-screens with a through-screen velocity of 0.5 feet per second. Exhibits 3-1 and 3-2 present design specifications for the fine mesh and very fine mesh wedgewire T-screens costed.

Exhibit 3-1. Fine Mesh Passive T-Screen Design Specifications

Fine Mesh Passive T-Screen Design Specifications

Screen Size	Capacity	Slot Size	Screen Length	Airburst Pipie Diameter	Screen Outlet Diameter	Screen Weight
	gpm	mm	Ft	Inches	Inches	Lbs
T24	2,500	1.75	6.3	2	18	375
T36	5,700	1.75	9.3	3	30	1,050
T48	10,000	1.75	13.3	4	36	1,600
T60	15,800	1.75	16.6	6	42	2,500
T72	22,700	1.75	19.8	8	48	4,300
T84	31,000	1.75	22.9	10	60	6,000
T96	40,750	1.75	26.4	12	72	NA

*Source: Johnson Screen - Brochure 2002 - High Capacity Screen at 50% Open Area

Exhibit 3-2. Very Fine Mesh Passive T-Screen Design Specifications

Very Fine Mesh Passive T-Screen Design Specifications

Screen Size	Capacity	Slot Size	Screen Length	Airburst Pipie Diameter	Screen Outlet Diameter	Screen Weight
	gpm	mm	Ft	Inches	Inches	Lbs
T24	1,680	0.76	6.3	2	18	375
T36	3,850	0.76	9.3	3	30	1,050
T48	6,750	0.76	13.3	4	36	1,600
T60	10,700	0.76	16.6	6	42	2,500
T72	15,300	0.76	19.8	8	48	4,300
T84	20,900	0.76	22.9	10	60	6,000
T96	27,500	0.76	26.4	12	72	NA

*Source: Johnson Screen - Brochure 2002 - High Capacity Screen at 33% Oper

Selection of Flow Values

The flow values used in the development of cost equations range from a design flow of 2,500 gallons per minute (gpm) (which is the design flow for the smallest screen (T24) for which costs were obtained) to a flow of 163,000 gpm (which is equivalent to the design flow of four T96 screens) for fine mesh screens and 1,680 gpm to 165,000 gpm (which is equivalent to the design flow of six T96 screens) for very fine mesh screens. The higher flow values were chosen because they were nearly equal to the flow in a 10-foot diameter pipe at a pipe velocity of just 4.6 feet per second. A 10-foot diameter pipe was chosen as the largest size for individual pipes because this size was within the range of sizes that are capable of being installed using the technology assumed in the cost module. In addition, the need to spread out the multiple screens across the bottom is facilitated by multiple pipes. One result of this decision is that for facilities with design flows significantly greater than 165,000 gpm, the total costs are based on dividing the intake into multiple units and summing the costs of each.

Intake Configuration

The scenarios evaluated in this analysis are based on retrofit construction in which the new passive screens are connected to the existing intake by newly installed pipes, while the existing intake pumps and pump wells remain intact and functional. The cost scenario also retains the existing screen wells and bays, since in most cases they are connected directly to the pump wells. Facilities may retain the existing traveling screens as a backup, but the retention of functioning traveling screens is not necessary. No operating costs are considered for the existing screens since they are not needed. Even if they are retained, there should be almost no debris to collect on their surfaces. Thus, they would only need to be operated on an infrequent basis to ensure they remain functional.

The new passive screens are placed along the bottom of the waterway in front of the existing intake and connected to the existing intake with pipes that are laid either directly on or buried below the streambed. The key components of the retrofit are: the transition connection to the existing intake, the connecting pipe or pipes (a.k.a. manifold or header), the passive screens or velocity cap located at the pipe inlet, and, if passive screens are used, the backwash system.

At most of the T-screen retrofit installations, particularly those requiring more than one screen, the installation of passive T-screens will likely require relocating the intake to a near-shore location or to a submerged location farther offshore, depending on the screen spacing, water depth, and other requirements. An exception would be smaller flow intakes where the screen could be connected directly to the front of the intake with a minimal pipe length (e.g., half screen diameter). Other considerations that may make locating farther offshore necessary or desirable include: the availability of cooler water, lower levels of debris, and fewer aquatic organisms for placements outside the littoral zone. As such, costs have been developed for a series of distances from the shoreline.

In retrofits where flow requirements do not increase, EPA has found existing pumps and pump wells can be, and have been, retained as part of the new system. The cost scenarios assume that the flow volumes do not increase. Thus, using existing pumps and pump wells is both feasible and economically prudent. There are, however, two concerns regarding the use of existing pumps and pump wells. One is the degree of additional head loss associated with the new pipes and screens. The second is the intake downtime needed to complete the installation and connection of the new passive screen system or velocity cap. The downtime considerations are discussed later in a separate section.

The additional head losses associated with the passive screen retrofit scenario described here include the frictional losses in the connecting pipes and the losses through the screen surface. If the new connecting pipe velocities are kept low (e.g., 5 feet per second is used in this analysis), then the head loss in the extension pipe should remain low enough to allow the existing pumps to function properly in most instances. For example, a 48-inch (in) diameter pipe at a flow of 28,000 gpm (average velocity of 4.96 feet per second) will have a head loss of 2.31 feet of water per 1,000-foot pipe length (Shaw and Loomis 1970). The new passive screens will contribute an additional 0.5 to 0.75 feet of water to this head loss, which will further increase when the screen is clogged by debris (Screen Services 2002). In fact, the rate at which this screen head loss increases due to debris build-up will dictate the frequency of use of the air backwash. Pump wells are generally equipped with alarms that warn of low water levels due to increased head loss through the intake. If the screen becomes plugged to the point where backwash fails to maintain the necessary water level in the pump well, the pump flow rate must be reduced. This reduction may result in a derating or shut down of the associated generating unit. Lower than normal surface water levels may exacerbate this problem.

In terms of required dimensions for installation, Exhibits 3-1 and 3-2 show screen length is just over three times the diameter and each screen requires a minimum clearance of one-half diameter on all sides except the ends. Thus, an 8-foot diameter screen will require a minimum water depth of 16 feet at the screen location (four feet above, four feet below, and eight feet for the screen itself). It is recommended that T-screens be oriented such that the long axis is parallel to the waterbody flow direction. T-screens can be arranged in an end-to-end configuration if necessary. However, using a greater separation above the minimum will facilitate dispersion of the released accumulated debris during screen backwashes.

In the retrofit scenario described here, screen size and number of screens are based on using a single screen with the screen size increasing with increasing design flows. When flow exceeds the capacity of a single T96 screen, multiple T96 screens are used. This retrofit scenario also assumes the selected screen location has a minimum water depth equal to or greater than the values shown in Exhibit 3-3.

Exhibit 3-3. Minimum Depth at Screen Location For Single Screen Scenario

Fine Mesh Flow	Very Fine Mesh Flow	Screen Size	Minimum Depth
2,500 gpm	1,680 gpm	T24	4 ft
5,700 gpm	3,850 gpm	T36	6 ft
10,000 gpm	6,750 gpm	T48	8 ft
15,800 gpm	10,700 gpm	T60	10 ft
22,700 gpm	15,300 gpm	T72	12 ft
31,000 gpm	20,900 gpm	T84	14 ft
40,750 gpm	27,500 gpm	T96	16 ft
>40,750 gpm	>27,500 gpm	Multiple T96	16 ft

In certain instances water depth or other considerations will require using a greater number of smaller diameter screens. For these cases the same size header pipe can be used, but the intake will require either more branched piping or multiple connections along the header pipe.

Connecting Wall

The retrofit of passive T-screen technology where the existing pump well and pumps are retained will require a means of connecting the new screen pipes to the pump well. Pump wells that are an integral part of shoreline intakes (often the case) will require installing a wall in front of the existing intake pump well or screen bays. This wall serves to block the existing intake opening and to connect the T-screen pipe(s) to the existing intake pump wells. In the proposed cost scenario, the T-screen pipe(s) can be attached directly to holes passing through the wall at the bottom.

Two different types of construction have been used in past retrofits or have been proposed in feasibility studies. In one, a wall constructed of steel plates is attached to and covers the front of each intake bay or pump well, such that one or more connecting pipes feed water into each screen bay or pump well individually. In this scenario, a single steel plate or several interlocking plates are affixed to the front of the screen bays by divers, and the T-screen pipe manifolds are then attached to flanged fittings welded at the bottom of the plate(s). For smaller flow intakes that require a single screen, this may be the best configuration since the screen can be attached directly to the front of the intake, minimizing the intrusion of the retrofit operation into the waterway.

In the second scenario, an interlocking sheet pile wall is installed in the waterbody directly in front of and running the length of the existing intake. Individual screen manifold pipe(s) are attached to holes cut in the bottom along the length of the sheet pile wall. In this case, a common plenum between the sheet pile wall and the existing intake runs the length of the intake. This configuration provides the best performance from an operational standpoint because it allows for flow balancing between the screen/pump bays and the individual manifold pipes. If there are no concerns with obstructing the waterway, the sheet pile wall can be placed far enough out so that the portion of the wall parallel to the intake can be installed first along with the pipes and screens that extend further offshore. In this case, the plenum ends are left open so that the intake can remain functional until the offshore construction is completed. At that point, the intake must shut down to install the final end portions of the wall, the air piping connection to the air supply, and make final connections of the manifold pipes. EPA is not aware of any existing retrofits where this construction technique has been used. However, it has been proposed in a feasibility study where a new, larger intake was to be constructed offshore (see discussion in Construction Downtime section).

Costs were developed for this module based on the second scenario described above. These costs are assumed equal or greater than costs for steel plate(s) affixed to the existing intake opening, and therefore inclusive of either approach. This assumption is based on the use of a greater amount of steel material for sheet piles (which is offset somewhat by the fabrication cost for the steel plates), the use of similarly sized heavy equipment (pile driver versus crane), and similar diver costs for constructing pipe connections and reinforcements in the sheet pile wall versus installing plates. Costs were developed for both freshwater environments and, with the inclusion a cost factor for coating the steel with a corrosion-resistant material, for saltwater environments.

<u>Connecting Pipes</u>

The design (length and configuration) of the connecting pipes (also referred to as pipe manifold or header) is partly dictated by intake flow and water depth. A review of the pipe diameter and design flow data submitted to EPA by facilities with submerged offshore intakes indicates intake pipe velocities at design flow were typically around 5 feet per second. Note that a minimum of 2.5 to 3 feet per second is recommended to prevent deposition of sediment and sand in the pipe (Metcalf & Eddy 1972). Also, calculations based on vendor data concerning screen attachment flange size and design flow data resulted in pipe velocities ranging from 3.2 to 4.5 feet per second for the nominal size pipe connection. EPA has elected to size the connecting pipes based on a typical design pipe velocity of 5 feet per second.

Even at 5 feet per second, the piping requirements are substantial. For example, if the existing intake has traveling screens with a high velocity (e.g., 2.5 feet per second through-screen velocity), then the cross-sectional area of the intake pipe needed to provide the same flow would be approximately one-third of the existing screen area (assuming existing screen open area is 68%). Given the above assumptions, an existing intake with a 10-foot wide traveling screen and a 20-foot water depth would require a 9.4-foot diameter pipe and be connected to at least four 8-foot diameter fine mesh T-screens (T96). The flow rate for this hypothetical intake screen would be 155,000 gpm.

For small volume flows (40,750 gpm or less for fine mesh–see Exhibit 3-3), T-screens (particularly those with a single screen unit) can be installed very close to the existing intake structure, and the upstream or downstream extensions of the screen should not be an issue. In the 10-foot wide by 20-foot deep traveling screen example above, each of the T96 screens required is 26 feet long. For this example, it is possible to place the four T96 screens directly in front of the existing intake connected to a single manifold extending 56 feet (i.e., 2*8+2*8+2*8+8) to the centerline of the last T-screen. This is based on a configuration where the manifold has multiple ports (four in this case) spaced along the top. However, this configuration will experience some flow imbalance between the screens. A better configuration would be a single pipe branching twice in a double "H" arrangement. In this case, the total pipe length would be 62 feet (i.e., 20+26+2*8). Therefore, a minimum pipe length of 66 feet (approximately 20 meters) was selected to cover the pipe installation costs for screens installed close to the intake.

Based on the above discussion, facilities with design flow values requiring multiple manifold pipes (i.e., design flow >163,000 gpm) will require the screens to extend even further out. In these cases, costs for a longer pipe size are appropriate. Using a longer pipe allows for individual screens to be spread out laterally and/or longitudinally. Longer pipes would also tend to provide access to deeper water where larger screens can be used. While using smaller screens allows for operations in shallower water, many more screens would be needed. This configuration covers a greater bottom area and requires more branching and longer, but smaller, pipes. Therefore, with the exception of the lower intake flow facilities, a length of connecting pipe longer than 66 feet (approximately 20 meters) is assumed to be required.

The next assumed pipe length is 410 feet (approximately 125 meters), based on the Phase I proposed rule cost estimates. A length of 125 meters was selected in Phase I costing as a reasonable estimate for extending intakes beyond the littoral zone. Additional lengths of 820 feet (approximately 250 meters) and 1640 feet (approximately 500 meters) were selected to cover the possible range of intake distances. The longest distance (1640 feet) is similar in magnitude to the intake distances reported for many of the facilities with offshore intakes located on large bodies of water, such as oceans and Great Lakes.

As described in Appendix A of the document Economic and Engineering Analyses of the Proposed Section 316(b) New Facility Rule, submerged intake pipes can be constructed in two ways. One construction uses steel that is concrete-lined and coated on the outside with epoxy and a concrete overcoat. The second construction uses prestressed concrete cylinder pipe (PCCP). Steel is generally used for lake applications; both steel and PCCP are used for riverine applications; PCCP is typically used in ocean applications. A review of the submerged pipe laying costs developed for the Phase I proposed rule showed that the costs of installing steel and PCCP pipe using the conventional method were similar, with steel being somewhat higher in cost. EPA has thus elected to use the Phase I cost methodology for conventional steel pipe as representative of the cost for both steel and concrete pipes installed in all waterbodies. The conventional pipe laying method was selected because it could be performed in front of an existing intake and was least affected by the limitations associated with local topography.

While other methods such as the bottom-pull or micro-tunneling methods could potentially be used, the bottom-pull method requires sufficient space for laying pipe onshore while the micro-tunneling method requires that a shaft be drilled near the shoreline, which may be difficult to perform in conjunction with an existing intake. The conventional steel pipe laying cost methodology and assumptions are described in detail in Appendix A of the document Economic and Engineering Analyses of the Proposed Section 316(b) New Facility Rule.

Exhibit 3-4. List of States with Freshwater Zebra Mussels as of 2001

List of States with Freshwater Zebra Mussels as of 2001	
State Name	**Abbreviation**
Alabama	AL
Connecticut	CT
Illinois	IL
Indiana	IN
Iowa	IA
Kentucky	KY
Louisiana	LA
Michigan	MI
Minnesota	MN
Mississippi	MS
Missouri	MO
New York	NY
Ohio	OH
Oklahoma	OK
Pennsylvania	PA
Tennessee	TN
Vermont	VT
West Virginia	WV

1.1.2 Capital Cost Development

Screen Material Construction and Costs

Costs were obtained for T-screens constructed of three different types of materials: 304 stainless steel (SS), 316 stainless steel, and copper-nickel (CuNi) alloy. In general, screens installed in freshwater are constructed of 304 stainless steel. However, where Zebra Mussels are present, CuNi alloys are often used because the leached copper tends to discourage screen biofouling with Zebra mussels. In corrosive environments such as brackish and saltwater, 316 stainless steel is often used. If the corrosive environment is harsh, particularly where oxygen levels are low, CuNi alloys are recommended. Since the T-screens are to be placed extending out into the waterway, such low oxygen environments are not expected.

Based on this information, EPA has chosen to base the cost estimates on utilizing screens made of 304 stainless steel for freshwater environments without Zebra Mussels, CuNi alloy for freshwater environments with the potential for Zebra Mussels, and 316 stainless steel for brackish and saltwater environments. Exhibit 3-4 provides a list of states that contain or are adjacent to waterbodies where Zebra Mussels are currently found. The cost for CuNi screens are applied to all freshwater environments located within these states. EPA notes that the screens comprise only a small portion of the total costs, particularly where the design of other components are the same, such as the proposed design scenarios for freshwater environments with Zebra Mussels versus those without.

Exhibit 3-5 presents the component and total installed costs for the three types of screens. A vendor indicated that the per screen costs will not change significantly between those with fine mesh and very fine mesh so the same screen costs are used for each. Installation and mobilization costs are based on vendor-provided cost estimates for velocity caps, which are comparable to those for T-screens. The individual installation cost per screen of $35,000 was reduced by 30% for multiple screen installations. Costs for steel fittings are also included. These costs are based on steel fitting costs developed for the new facility Phase I effort and are adjusted for a pipe velocity of 5 feet per second and converted to 2002 dollars. An additional 5% was added to the total installed screen costs to account for installation of intake protection and warning devices such as piles, dolphins, buoys, and warning signs.

Exhibit 3-5. T-Screen Equipment and Installation Costs

T-Screen Equipment and Installation Costs

Size	Number of Screens	Capacity	Total Screen Cost by Material			Air Burst Equipment	Screen Installation	Mobilization	Steel Fitting
		gpm	304SS	316SS	CuNi				
T24	1	2,500	$5,800	$6,100	$8,000	$10,450	$25,000	$15,000	$2,624
T36	1	5,700	$10,000	$11,200	$18,000	$15,050	$25,000	$15,000	$3,666
T48	1	10,000	$17,000	$18,800	$31,700	$22,362	$30,000	$15,000	$5,067
T60	1	15,800	$23,000	$26,200	$44,500	$28,112	$35,000	$15,000	$6,964
T72	1	22,700	$34,000	$39,500	$69,700	$35,708	$35,000	$20,000	$9,227
T84	1	31,000	$45,000	$51,900	$93,400	$43,588	$35,000	$20,000	$11,961
T96	1	40,750	$61,000	$70,200	$124,000	$49,338	$35,000	$25,000	$15,189
T96	2	81,500	$122,000	$140,400	$248,000	$49,338	$49,000	$25,000	$28,865
T96	3	122,250	$183,000	$210,600	$372,000	$49,338	$73,500	$30,000	$42,840
T96	4	163,000	$244,000	$280,800	$496,000	$49,338	$98,000	$30,000	$57,113

The same costs are used for both fine mesh and very fine mesh with major difference being the design flow for each screen size.

Connecting Wall Cost Development

The cost for the connecting wall that blocks off the existing intake and provides the connection to the screen pipes is based on the cost of an interlocking sheet pile wall constructed directly in front of the existing intake. In general, the costs are mostly a function of the total area of the wall and will vary with depth. Cost estimates were developed for a range of wall dimensions. The first step was to estimate the nominal length of the existing intake for each of the design flow values shown in Exhibits 3-1 and 3-2. The nominal length was estimated using an assumed water depth and intake velocity. The use of actual depths and intake velocities imparted too many variables for the selected costing methodology. A depth of 20 feet was selected because it was close to both the mean and median intake water depth values reported by Phase III facilities in their Detailed Technical Questionnaires.

The length of the wall was also based on an assumed existing intake, through-screen velocity of 1 foot per second, and an existing screen open area of 50%. Most existing coarse screens have an open area of 68%. However, a 50% area was chosen to produce a larger (i.e., more costly) wall size. Selecting a screen velocity of 1 foot per second also will overestimate wall length (and therefore, costs) for existing screen velocities greater than 1 foot per second. This is the case for most of the facilities (approximately 50% of Phase III facilities reported screen velocities of 1 foot per second or greater for at least one cooling water intake structure and just under 70% of the Phase II Facilities reported screen velocities of 1 foot per second or greater). An additional length of 30 to 60 feet (scaled between 30 feet for 2,500 gpm to 60 feet for 163,000 gpm with a minimum of 30 ft for lower flows) was added to cover the end portions of the wall and to cover fixed costs for smaller intakes. The costs are based on the following:

- Sheet pile unit cost of $24.50/square (sq) ft (RS Means 2001)
- An additional 50% of sheet pile cost to cover costs not included in sheet pile unit cost[1]
- Total pile length of 45 feet for 20-foot depth including 15-foot penetration and 10-foot extension above water level
- Mobilization of $18,300 for 20-foot depth (RS Means 2001), added twice (assuming sheet pile would be installed in two stages to minimize generating unit downtime (see Downtime discussion)). The same mobilization costs are used for both saltwater and freshwater environments.
- An additional cost of 33% for corrosion-resistant coating for saltwater environments.

Exhibits 3-6 and 3-7 present the estimated wall lengths, mobilization costs, and total costs for 20-foot depth for both freshwater and saltwater environments for fine mesh and very fine mesh screens, respectively.

Exhibit 3-6. Sheet Pile Wall Capital Costs for Fine Mesh Screens

Sheet Pile Wall Capital Costs for Fine Mesh Screens

Design Flow	Total Estimated Wall Length	Mobilization	Sheet Pile Wall Total Costs 20 Ft Water Depth*	
gpm	Ft		Freshwater	Saltwater
2,500	31	$36,600	$87,157	$103,840
5,700	32	$36,600	$89,351	$106,758
10,000	34	$36,600	$92,359	$110,759
15,800	36	$36,600	$96,416	$116,155
22,700	39	$36,600	$101,243	$122,575
31,000	43	$36,600	$107,049	$130,297
40,750	47	$36,600	$113,870	$139,369
81,500	64	$36,600	$142,376	$177,283
122,250	81	$36,600	$170,883	$215,196
163,000	96	$36,600	$195,960	$248,549

* Total costs include mobilization

[1] Note that this 50% value was derived by comparing the estimated costs of a sheet pile wall presented in a feasibility study for the Salem Nuclear Plant to the cost estimated for a similarly sized sheet pile wall using the EPA method described here. This factor was intended to cover the cost of items such as walers, bracing and installation costs not included in the RS Means unit cost. The Salem facility costs included bypass gates, which are assumed to be similar in cost to the pipe connections.

Exhibit 3-7. Sheet Pile Wall Capital Costs for Very Fine Mesh Screens

Sheet Pile Wall Capital Costs for Very Fine Mesh Screens

Design Flow	Total Estimated Wall Length	Mobilization	Sheet Pile Wall Costs 20 Ft Water Depth*	
gpm	Ft		Freshwater	Saltwater
1,680	30	$36,600	$86,854	$103,438
3,850	31	$36,600	$88,056	$105,037
6,750	32	$36,600	$90,085	$107,735
10,700	34	$36,600	$92,848	$111,410
15,300	36	$36,600	$96,066	$115,690
20,900	38	$36,600	$99,984	$120,900
27,500	41	$36,600	$104,601	$127,041
55,000	53	$36,600	$123,838	$152,627
82,500	64	$36,600	$143,076	$178,213
110,000	76	$36,600	$162,314	$203,799
165,000	99	$36,600	$200,789	$254,971

* Total costs include mobilization

Pipe Manifold Cost Development

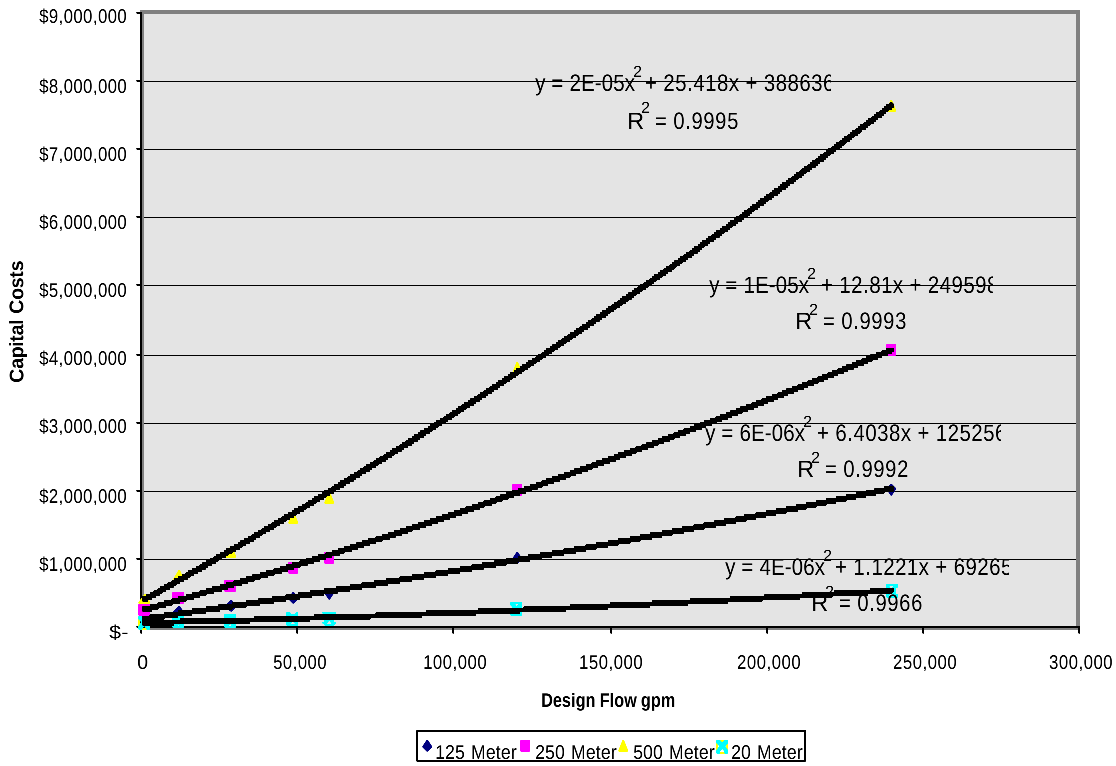
For facilities with design intake flows that are 10% or more greater than the 163,000 gpm to 165,000 gpm (i.e., maximum costed, above 180,000 gpm), multiple intakes are costed and the costs are summed. This approach leads to probable costing over-estimates for both the added length of end section wall costs.

Pipe costs are developed using the same general methodology as described in Appendix A of the Economic and Engineering Analyses of the Proposed Section 316(b) New Facility Rule, but modified based on a design pipe velocity of 5 feet per second. The pipe laying cost methodology was revised to include costs for several different pipe lengths. These pipe lengths include: 66 feet (approximately 20 meters), 410 feet (approximately 125 meters), 820 feet (approximately 250 meters), and 1640 feet (approximately 500 meters). The cost for pipe installation includes an equipment rental component for the pipe laying vessel, support barge, crew, and pipe laying equipment. The Phase I proposed rule Economic and Engineering Analyses document estimates that 500 feet of pipe can be laid in a day under favorable conditions. Equipment rental costs for the longer piping distances were adjusted upward, in single-day increments, to limit daily production rates not to exceed 550 feet/day. For the shorter distance of 66 feet (approximately 20 meters), the single-day pipe laying vessel/equipment costs were reduced by a factor of 40%. This reduction is based on the assumption that, in most cases, a pipe laying vessel is not needed because installation can be performed via crane located on the shoreline.

Figure 3-1 presents the capital cost curves for the pipe-laying portion only for each of the offshore distance scenarios. The pipe cost development methodology adopted from the Phase I effort used a different set of flow values than are shown in Exhibit 3-1. Therefore, second-order, best-fit equations were derived from pipe cost data. These equations were applied to the flow values in Exhibit 3-1 to obtain the relevant installed pipe cost component.

An additional equipment component representing the cost of pipe fittings such as tees or elbows are included in the screen equipment costs. The costs are based on the cost estimates developed for the Phase I proposed rule, adjusted to a pipe velocity of 5 feet per second and 2002 dollars.

Figure 3-1. Capital Costs for Conventional Steel Pipe Laying Method at Various Offshore Distances



Airburst System Costs

Capital costs for airburst equipment sized to backwash each of the T-screens were obtained from vendor estimates. These costs included air supply equipment (compressor, accumulator, distributor) minus the piping to the screens, air supply housing, and utility connections and wiring. Capital costs of the airburst air supply system are shown in Exhibit 3-8. Costs for a housing structure, electrical, and controls were added based on the following:

- Electrical costs = 10% of air supply equipment (BPJ)
- Controls = 5% of air supply equipment (BPJ)
- Housing = $142/sq ft for area shown in Exhibit 3-8. This cost was based on the $130/sq ft cost used in the Phase I cost for pump housing, adjusted to 2002 dollars.

Exhibit 3-8. Capital Costs of Airburst Air Supply Equipment

Screen Size	Vendor Supplied Equipment Costs	Estimated Housing Area	Housing Area	Housing Costs	Electrical	Controls	Total Airburst Minus Air Piping to Screens
			sq ft		10%	5%	
T24	$6,000	5x5	25	$3,550	$600	$300	$10,450
T36	$10,000	5x5	25	$3,550	$1,000	$500	$15,050
T48	$15,000	6x6	36	$5,112	$1,500	$750	$22,362
T60	$20,000	6x6	36	$5,112	$2,000	$1,000	$28,112
T72	$25,000	7x7	49	$6,958	$2,500	$1,250	$35,708
T84	$30,000	8x8	64	$9,088	$3,000	$1,500	$43,588
T96	$35,000	8x8	64	$9,088	$3,500	$1,750	$49,338

The costs of the air supply pipes, or "blow pipes," are calculated for each installation depending on the length of the intake pipe, plus an assumed average distance of 70 feet from the airburst system housing to the intake pipe at the front of the sheet pile wall. Pipe costs are based on this total distance multiplied by a derived unit cost of installed pipe. Vendors indicated that the pipes are typically made of schedule 10 stainless steel or high density polyethylene and that material costs are only a portion of the total installed costs. Consistent with the selection of screen materials, EPA chose to assume that the blow pipes are constructed of 304 stainless steel for freshwater and 316 stainless steel for saltwater applications.

The unit costs for the installed blow pipes are based on the installed cost of similar pipe in a structure on land multiplied by an underwater installation factor. This underwater installation factor was derived by reviewing the material-versus-total costs for underwater steel pipe installation, which ranged from about 3.2 to 4.5, with values decreasing with increasing pipe size. A review of the material-versus-installed-on-land costs for the smaller diameter stainless steel pipe (RS Means 2001) found that if the installed-on-land unit costs are multiplied by 2.0, the resulting material-to-total- estimated (underwater)-installed-cost ratios fell within a similar range. These costs are considered as over-estimating costs somewhat because they include 304 and 316 stainless steel where less costly materials may be used. Also, they do not consider potential savings associated with concurrent installation alongside the much larger water intake pipe.

Blow pipe sizes were provided by vendors for T60 and smaller screens. For larger screens, the blow pipe diameter was derived by calculating pipe diameters (and rounding up to even pipe sizes) using the same ratio of screen area to blow pipe area calculated for T60 screens. This is based on the assumption that blow pipe air velocities are proportional to the needed air/water backwash velocities at the screen surface. A separate blow pipe was included for each T-screen where multiple screens are included, but only one set of the air supply equipment (compressor, accumulator, distributor, controls etc.) is included in each installation. The calculated costs for the air supply pipes are shown in Exhibit 3-9.

Exhibit 3-9. Capital Costs of Installed Air Supply Pipes for Fine Mesh Screens

Design Flow Fine Mesh	Design Flow Very Fine Mesh	Air Pipe Unit Cost - Schedule 1 304 SS	Air Pipe Unit Cost - Schedule 1 316 SS	Freshwater Airburst Distribution Installed Pipe Costs				Saltwater Airburst Distribution Installed Pip Costs			
gpm	gpm	$/Ft	$/Ft	20 Meters	125 Meters	250 Meters	500 Meters	20 Meters	125 Meters	250 Meters	500 Meters
2,500	1,680	$57.3	$119.5	$7,764	$27,485	$50,961	$97,915	$16,210	$57,379	$106,391	$204,413
5,700	3,850	$85.4	$102.0	$11,575	$40,973	$75,970	$145,966	$13,834	$48,970	$90,798	$174,454
10,000	6,750	$102.0	$118.7	$13,834	$48,970	$90,798	$174,454	$16,093	$56,966	$105,625	$202,943
15,800	10,700	$160.3	$188.4	$21,739	$76,954	$142,685	$274,147	$25,550	$90,442	$167,694	$322,198
22,700	15,300	$222.8	$279.0	$30,209	$106,934	$198,274	$380,954	$37,830	$133,910	$248,292	$477,056
31,000	20,900	$304.0	$368.5	$41,220	$145,910	$270,542	$519,806	$49,971	$176,890	$327,983	$630,169
40,750	27,500	$376.8	$456.0	$51,100	$180,883	$335,388	$644,396	$61,828	$218,861	$405,804	$779,692
81,500	55,000	$376.8	$456.0	$102,199	$361,766	$670,775	$1,288,793	$123,656	$437,722	$811,609	$1,559,383
122,250	82,500	$376.8	$456.0	$153,299	$542,650	$1,006,163	$1,933,189	$185,485	$656,582	$1,217,413	$2,339,075
163,000	110,000	$376.8	$456.0	$204,398	$723,533	$1,341,550	$2,577,586	$247,313	$875,443	$1,623,218	$3,118,766
-	165,000	$376.8	$456.0	$306,597	$1,085,299	$2,012,326	$3,866,378	$370,969	$1,313,165	$2,434,826	$4,678,150

<u>Indirect Costs</u>

The total calculated capital costs were adjusted to include the following added costs:

- Engineering at 10% of direct capital costs
- Contractor overhead and profit at 15% of direct capital costs (based on overhead and profit component of installing lift station in RS Means 2001); some direct cost components, e.g., the intake pipe cost and blow pipe cost, already include costs for contractor overhead and profit

- Contingency at 10% of direct capital costs
- Sitework at 10% of direct capital costs; based on the sitework component of Fairfax Water Intake costs data, including costs for erosion & sediment control, trash removal, security, dust control, access road improvements, and restoration (trees, shrubs, seeding, and sodding).

Total Capital Costs

Fine Mesh

Exhibit 3-10 presents the total capital costs of the complete system for fine mesh screens including indirect costs. Figures 3-2, 3-3, and 3-4 present the plotted capital costs in Exhibit 3-10 for freshwater, saltwater, and freshwater with Zebra mussels, respectively. Figures 3-2, 3-3, and 3-4 also present the best-fit, second order equations used in estimating compliance costs.

Very Fine Mesh

Exhibit 3-11 presents the total capital costs of the complete system for very fine mesh screens including indirect costs. Figures 3-5, 3-6, and 3-7 present the plotted capital costs in Exhibit 3-11 for freshwater, saltwater, and freshwater with Zebra mussels, respectively.

Exhibit 3-10. Total Capital Costs of Installed Fine Mesh T-screen System at Existing Shoreline Based Intakes

Design Flow	Total Costs 20 Meters Offshore			Total Costs 125 Meters Offshore			Total Costs 250 Meters Offshore			Total Costs 500 Meters Offshore		
gpm	304 SS	316 SS	CuNi	304 SS	316 SS	CuNi	304 SS	316 SS	CuNi	304 SS	316 SS	CuNi
	Freshwater	Saltwater	Zebra Mussels	Freshwater	Saltwater	Zebra Mussels	Freshwater	Saltwater	Zebra Mussels	Freshwater	Saltwater	Zebra Mussels
2,500	$330,608	$356,632	$333,958	$458,425	$487,945	$461,775	$694,677	$728,359	$698,027	$1,007,472	$1,049,477	$1,010,822
5,700	$359,106	$389,320	$371,286	$524,990	$563,194	$537,170	$807,170	$854,887	$819,350	$1,210,950	$1,277,690	$1,223,130
10,000	$405,008	$437,575	$427,389	$612,009	$652,566	$634,390	$944,036	$994,105	$966,417	$1,446,429	$1,515,522	$1,468,810
15,800	$460,179	$498,982	$492,913	$739,998	$792,284	$772,732	$1,160,061	$1,228,398	$1,192,795	$1,837,241	$1,937,682	$1,869,975
22,700	$530,563	$580,486	$584,916	$893,959	$970,848	$948,312	$1,415,327	$1,524,319	$1,469,680	$2,293,842	$2,467,040	$2,348,195
31,000	$602,745	$659,150	$676,434	$1,069,950	$1,157,317	$1,143,639	$1,717,372	$1,841,598	$1,791,061	$2,846,829	$3,044,774	$2,920,518
40,750	$691,543	$757,467	$787,461	$1,270,404	$1,374,281	$1,366,322	$2,054,067	$2,203,125	$2,149,984	$3,455,143	$3,694,566	$3,551,061
81,500	$1,034,259	$1,142,774	$1,226,094	$2,120,425	$2,304,845	$2,312,260	$3,526,716	$3,801,500	$3,718,551	$6,175,421	$6,630,933	$6,367,256
122,250	$1,420,292	$1,571,396	$1,708,044	$3,023,393	$3,288,357	$3,311,146	$5,071,576	$5,472,086	$5,359,329	$9,016,065	$9,687,666	$9,303,817
163,000	$1,813,456	$2,005,510	$2,197,126	$3,943,125	$4,286,990	$4,326,795	$6,652,462	$7,177,056	$7,036,132	$11,940,891	$12,826,940	$12,324,561

Figure 3-2. Capital Costs for Fine Mesh Passive Screen Relocation Offshore in Freshwater at Selected Offshore Distances

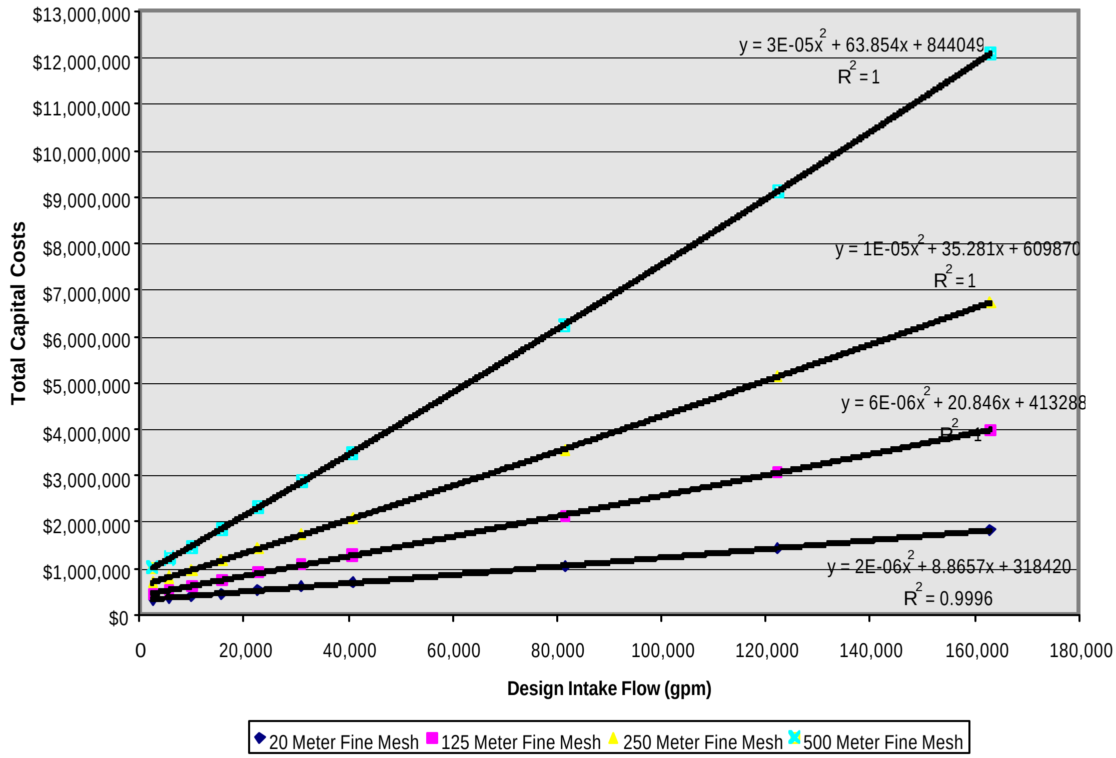


Figure 3-3. Capital Costs for Mesh Passive Screen Relocation Offshore in Saltwater at Selected Offshore Distances

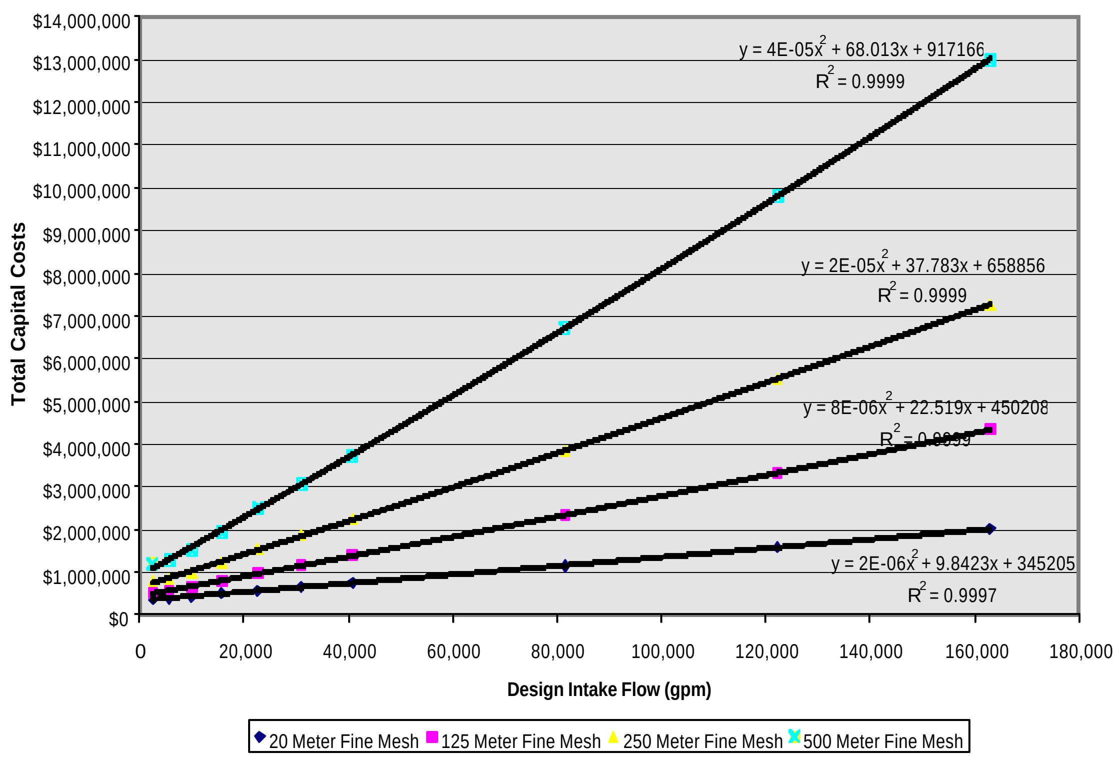


Figure 3-4. Capital Costs for Fine Mesh Passive Screen Relocation Offshore in Freshwater with Zebra Mussels at Selected Offshore Distances

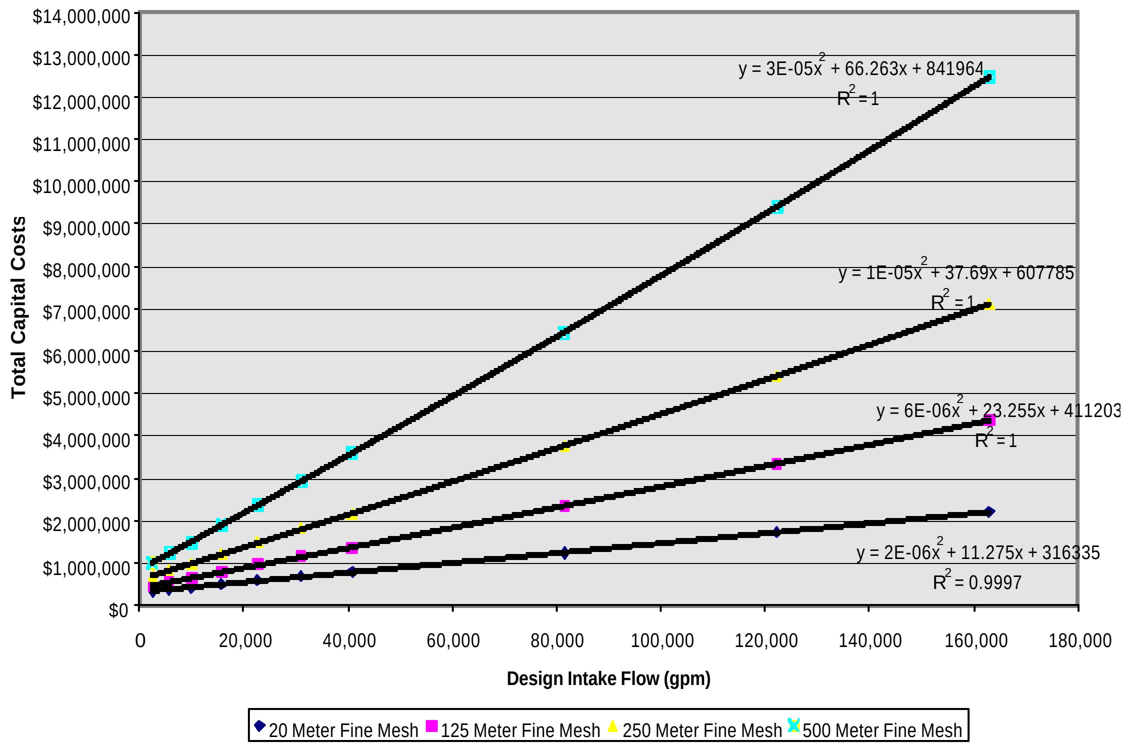


Exhibit 3-11. Total Capital Costs of Installed Very Fine Mesh T-screen System at Existing Shoreline Based Intakes

Design Flow	Total Costs 20 Meters Offshore			Total Costs 125 Meters Offshore			Total Costs 250 Meters Offshore			Total Costs 500 Meters Offshore		
gpm	304 SS Freshwater	316 SS Saltwater	CuNi Zebra Mussels	304 SS Freshwater	316 SS Saltwater	CuNi Zebra Mussels	304 SS Freshwater	316 SS Saltwater	CuNi Zebra Mussels	304 SS Freshwater	316 SS Saltwater	CuNi Zebra Mussels
1,680	$329,296	$355,254	$332,813	$451,952	$481,545	$455,469	$681,911	$715,832	$685,428	$982,352	$1,024,929	$985,869
3,850	$354,622	$384,438	$367,411	$507,964	$546,100	$520,753	$774,855	$822,895	$787,644	$1,148,553	$1,216,401	$1,161,342
6,750	$396,579	$428,325	$420,079	$580,540	$620,605	$604,039	$884,451	$934,421	$907,951	$1,331,420	$1,401,198	$1,354,919
10,700	$446,379	$483,934	$480,749	$689,904	$741,492	$724,274	$1,065,566	$1,133,860	$1,099,937	$1,655,065	$1,756,769	$1,689,435
15,300	$510,005	$558,302	$567,076	$820,297	$896,659	$877,368	$1,276,515	$1,386,288	$1,333,586	$2,026,108	$2,202,703	$2,083,179
20,900	$573,744	$627,794	$651,118	$968,061	$1,054,341	$1,045,435	$1,525,747	$1,650,395	$1,603,120	$2,477,203	$2,678,590	$2,554,577
27,500	$652,189	$714,992	$752,903	$1,134,364	$1,236,677	$1,235,077	$1,798,524	$1,947,874	$1,899,238	$2,961,902	$3,205,326	$3,062,615
55,000	$944,813	$1,047,085	$1,146,240	$1,832,361	$2,013,654	$2,033,788	$2,989,159	$3,264,526	$3,190,586	$5,136,240	$5,599,755	$5,337,667
82,500	$1,270,016	$1,411,756	$1,572,156	$2,567,323	$2,827,597	$2,869,463	$4,225,531	$4,626,915	$4,527,671	$7,378,247	$8,061,852	$7,680,387
110,000	$1,596,585	$1,777,795	$1,999,439	$3,308,039	$3,647,292	$3,710,892	$5,476,429	$6,003,830	$5,879,283	$9,656,711	$10,560,407	$10,059,565
165,000	$2,276,664	$2,536,812	$2,880,944	$4,829,568	$5,326,782	$5,433,848	$8,044,641	$8,824,075	$8,648,921	$14,345,849	$15,689,726	$14,950,129

Figure 3-5. Capital Costs for Very Fine Mesh Passive Screen Relocation Offshore in Freshwater at Selected Offshore Distances

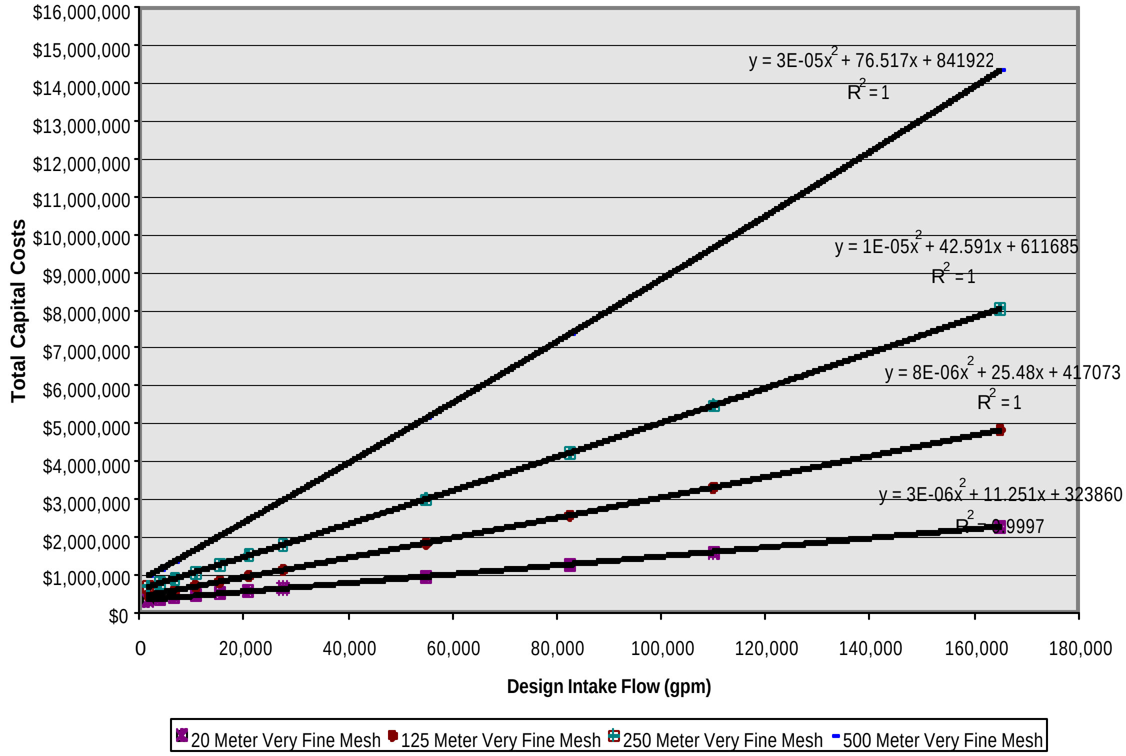


Figure 3-6. Capital Costs for Very Fine Mesh Passive Screen Relocation Offshore in Selected Offshore Distances

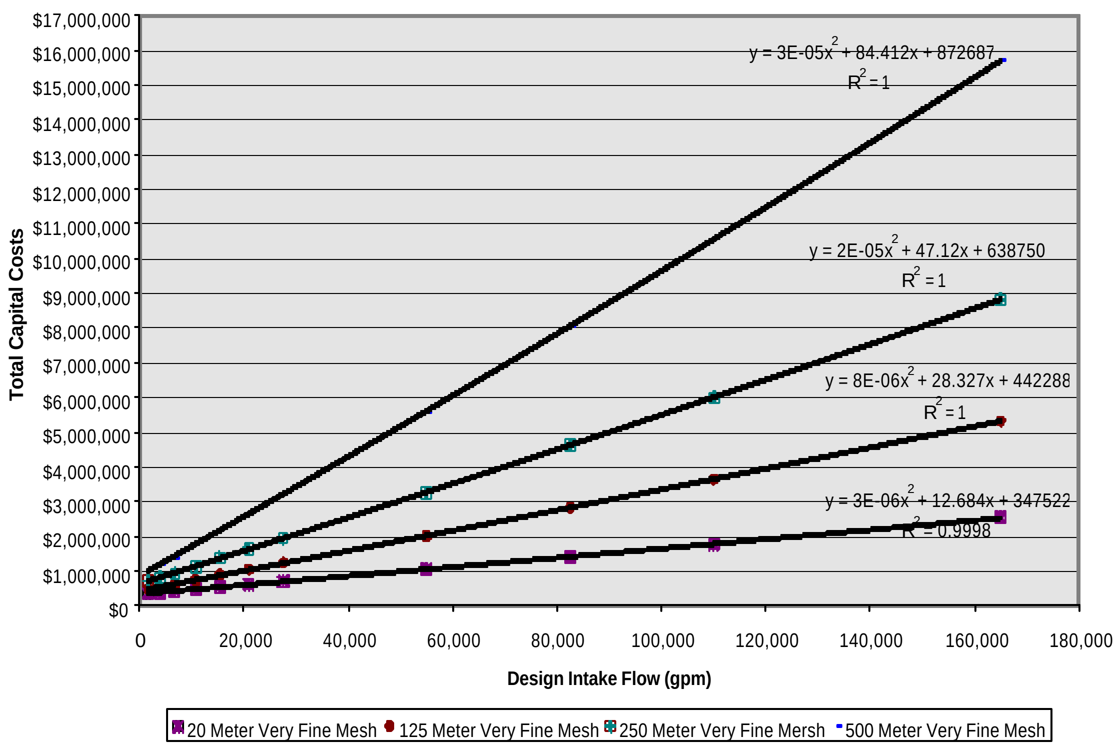
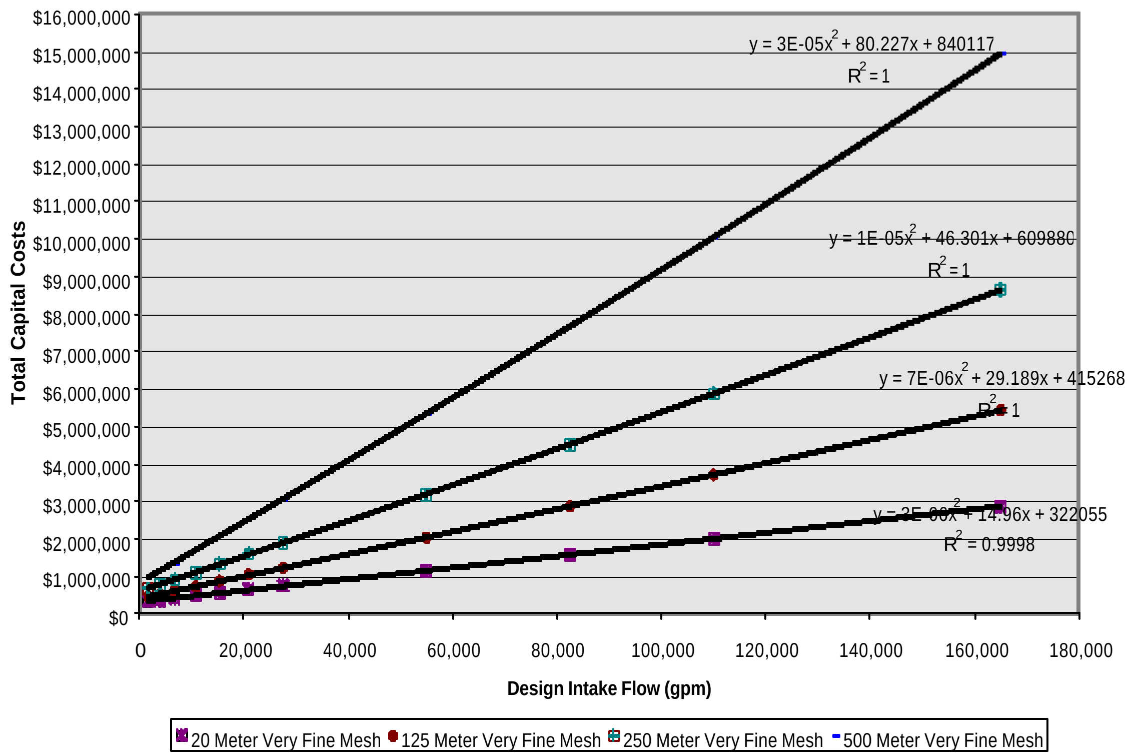


Figure 3-7. Capital Costs for Very Fine Mesh Passive Screen Relocation Offshore in Freshwater with Zebra Mussels at Selected Offshore Distances



Nuclear Facilities

Few facilities considered for the Phase III rulemaking were nuclear facilities. Therefore, this section is primarily provided for informational purposes. No electric facilities below 50 MGD are regulated by the final Phase III regulations.

Construction and material costs tend to be substantially greater for nuclear facilities due to the burden of increased security and the requirements for more robust system design. Rather than performing a detailed evaluation of the differences in capital costs for nuclear facilities, EPA has chosen to apply a simple cost factor based on total costs.

In the Phase I costing effort, EPA used data from an Argonne National Lab study on retrofitting costs of fossil fuel power plants and nuclear power plants. This study reported average, comparative costs of $171 for nuclear facilities and $108 for fossil fuel facilities, resulting in a 1.58 costing factor. In comparison, during a recent consultation with a traveling screen vendor, the vendor indicated that, based on their experience, costing factors in the range of 1.5-2.0 were reasonable for estimating the increase in costs associated with nuclear power plants. Because today there are likely to be additional security burdens above those experienced when the Argonne Report was generated, EPA has selected 1.8 as a capital costing factor for nuclear facilities. Capital costs for nuclear facilities are not presented here but can be estimated by multiplying the applicable non-nuclear facility costs by the 1.8 costing factor.

O&M Costs

O&M cost are based on the sum of costs for annual inspection and cleaning of the intake screens by a dive team and for estimated operating costs for the airburst air supply system. Dive team costs were estimated for a total job duration of one to four days and are shown in Exhibit 3-12. Dive team cleaning and inspections were estimated at once per year for low debris locations and twice per year for high debris locations. The O&M costs for the airburst system are based on power requirements of the air compressor and labor requirements for routine O&M. Vendors cited a backwash frequency per screen from as low as once per week to as high as once per hour for fine mesh screens. The time needed to recharge the accumulator is about 0.5 hours, but can be as high as 1 hour for those with smaller compressors or accumulators that backwash more than one screen simultaneously.

Exhibit 3-12. Estimated Costs for Dive Team to Inspect and Clean T-screens

Installation and Maintenance Diver Team Costs

Item	Daily Cost*	One Time Cost*	Total	Adjusted Total			
Duration			**One Day**	**One Day**	**Two Day**	**Three Day**	**Four Day**
Cost Year			**1999**	**2002**	**2002**	**2002**	**2002**
Supervisor	**$575**		$575	$627	$1,254	$1,880	$2,507
Tender	**$200**		$200	$218	$436	$654	$872
Diver	**$375**		$750	$818	$1,635	$2,453	$3,270
Air Packs	**$100**		$100	$109	$218	$327	$436
Boat	**$200**		$200	$218	$436	$654	$872
Mob/Demob		**$3,000**	$3,000	$3,270	$3,270	$3,270	$3,270
Total			$4,825	**$5,260**	**$7,250**	**$9,240**	**$11,230**

***Source: Paroby 1999 (cost adjusted to 2002 dollars).**

The Hp rating of the typical size airburst compressor for each screen size was obtained from a vendor and is presented in Exhibit 3A-1. A vendor stated that several hours per week would be more than enough labor for routine maintenance. Hence, labor is assumed to be two to four hours per week based on roughly half-hour daily inspection of the airburst system. However, during seasonal periods of high debris such as leaves in the fall, it may be necessary for someone to man the backwash system 24 hours/day for several weeks (Frey 2002). Thus, an additional one to 4.5 weeks of 24-hour labor are included for these periods (one week low debris fine mesh; 1.5 weeks low debris very fine mesh; three weeks high debris fine mesh; and 4.5 weeks high debris very fine mesh). Since very fine mesh screens will tend to collect debris at a more rapid rate, backwash frequencies and labor requirements were increased by 50% for very fine mesh screens.

The O&M cost of the airburst system are based on the following:

- Average backwash frequency in low debris areas is 2 times per day (3 times per day for very fine mesh)
- Average backwash frequency in high debris areas is 12 times per day (18 times per day for very fine mesh)
- Time to recharge accumulator is 0.5 hours (hrs)
- Compressor motor efficiency is 90%
- Cost of electric power consumed is $0.04/Kilowatt hour (kWh)
- Routine inspection and maintenance labor is 3 hours per week (4.5 hours per week for very fine mesh) for systems up to 182,400 gpm
- O&M labor rate per hour is $41.10/hr. The rate is based on Bureau of Labor Statistics Data using the median labor rates for electrical equipment maintenance technical labor (SOC 49-2095) and managerial labor (SOC 11-1021); benefits and other compensation are added using factors based on SIC 29 data for blue collar and white collar labor. The two values were combined into a single rate assuming 90% technical labor and 10% managerial. See Doley 2002 for details.

Exhibit 3-13 presents the total O&M cost for relocating intakes offshore with fine mesh and very fine mesh passive screens. These data are plotted in Figures 3-8 and 3-9, which also shows the second-order equations that were fitted to these data and used to estimate the O&M costs for individual Phase III facilities. Exhibit 3A-2 presents the worksheet data used to develop the annual O&M costs. As with the capital costs, at facilities where the design flow exceeds the maximum cost model design flow of 165,000 gpm plus 10% (180,000 gpm), the design flow are divided and the corresponding costs are summed.

Exhibit 3-13. Total O&M Costs for Passive Screens Relocated Offshore

Relocate Ofshore With New Fine Mesh Screens			Relocate Ofshore With New Very Fine Mesh Screens		
Design Flow	Total O&M Costs - Low Debris	Total O&M Costs - High Debris	Design Flow	Total O&M Costs - Low Debris	Total O&M Costs - High Debris
gpm			gpm		
2,500	$16,463	$35,654	1,680	$22,065	$48,221
5,700	$16,500	$35,872	3,850	$22,120	$48,548
10,000	$16,560	$36,235	6,750	$22,210	$49,092
15,800	$20,712	$42,497	10,700	$27,442	$56,496
22,700	$20,748	$42,715	15,300	$27,497	$56,823
31,000	$20,808	$43,078	20,900	$27,588	$57,367
40,750	$20,869	$43,441	27,500	$27,678	$57,912
81,500	$25,299	$51,374	55,000	$33,328	$67,821
122,250	$25,601	$53,189	82,500	$33,782	$70,544
163,000	$27,894	$58,984	110,000	$36,226	$77,246
-	-	-	165000	$37,133	$82,692

Figure 3-8. Total O&M Cost for Fine Mesh Passive Screen Relocated Offshore with Airburst Backwash

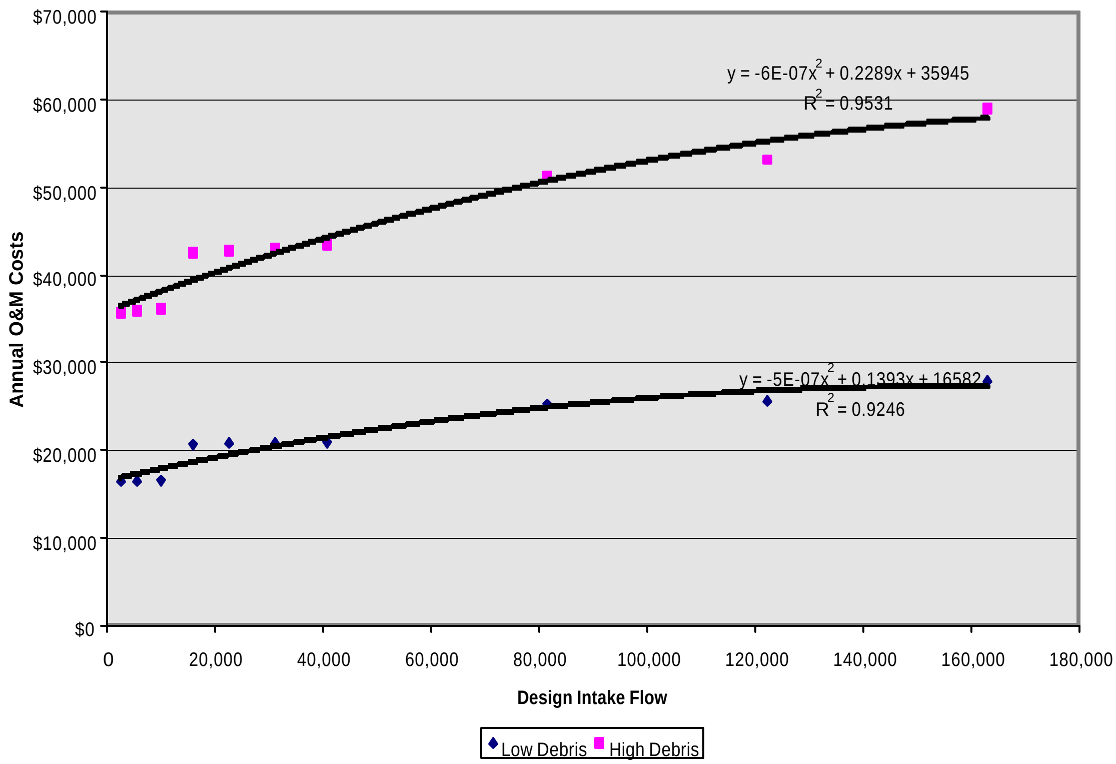
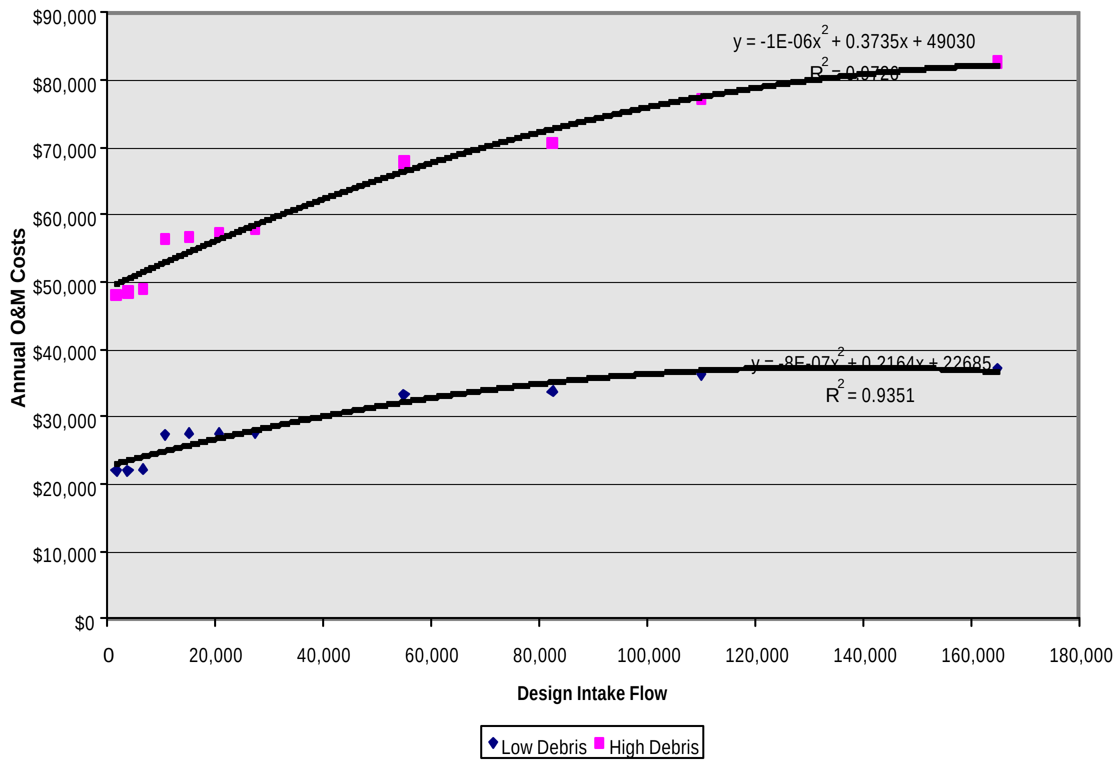


Figure 3-9. Total O&M Cost for Very Fine Mesh Passive Screen Relocated Offshore with Airburst Backwash



ATTACHMENT 3A
O&M DEVELOPMENT DATA

Exhibit 3A-1. O&M Development Data - Relocate Offshore with Fine Mesh Screens

Design Flow	Compressor Power	Low Debris Backwash Frequency	High Debris Backwash Frequency	Annual Power Required Low Debris	Annual Power Required High Debris	Annual Power Costs - Low Debris*	Annual Power Costs - High Debris*	Annual Labor Required - Low Debris	Annual Labor Cost - Low Debris	Annual Labor Required High Debris	Annual Labor Cost - High Debris	Dive Team Days Low Debris	Dive Team Costs Low Debris	Dive Team Costs High Debris
		Events/day	Events/day	Kwh	Kwh	$0.04	$0.04	Hours		Hours				
2,500	2	2	12	605	3,631	$24	$145	272	$11,179	608	$24,989	1	$5,260	$10,520
5,700	5	2	12	1,513	9,076	$61	$363	272	$11,179	608	$24,989	1	$5,260	$10,520
10,000	10	2	12	3,025	18,153	$121	$726	272	$11,179	608	$24,989	1	$5,260	$10,520
15,800	12	2	12	3,631	21,783	$145	$871	324	$13,316	660	$27,126	2	$7,250	$14,500
22,700	15	2	12	4,538	27,229	$182	$1,089	324	$13,316	660	$27,126	2	$7,250	$14,500
31,000	20	2	12	6,051	36,305	$242	$1,452	324	$13,316	660	$27,126	2	$7,250	$14,500
40,750	25	2	12	7,564	45,382	$303	$1,815	324	$13,316	660	$27,126	2	$7,250	$14,500
81,500	25	4	24	15,127	90,763	$605	$3,631	376	$15,454	712	$29,263	3	$9,240	$18,480
122,250	25	6	36	22,691	136,145	$908	$5,446	376	$15,454	712	$29,263	3	$9,240	$18,480
163,000	25	8	48	30,254	181,527	$1,210	$7,261	376	$15,454	712	$29,263	4	$11,230	$22,460

Exhibit 3A-2. O&M Development Data - Relocate Offshore with Very Fine Mesh Screens

Design Flow	Compressor Power	Low Debris Backwash Frequency	High Debris Backwash Frequency	Annual Power Required - Low Debris	Annual Power Required - High Debris	Annual Power Costs - Low Debris*	Annual Power Costs - High Debris*	Annual Labor Required - Low Debris	Annual Labor Cost - Low Debris	Annual Labor Required High Debris	Annual Labor Cost - High Debris	Dive Team Days Low Debris	Dive Team Costs Low Debris	Dive Team Costs High Debris
gpm	Hp					at $/kw =	at $/kw =							
		Events/day	Events/day	Kwh	Kwh	$0.04	$0.04	Hours		Hours				
1,680	2	3	18	908	5,446	$36	$218	408	$16,769	912	$37,483	1	$5,260	$10,520
3,850	5	3	18	2,269	13,615	$91	$545	408	$16,769	912	$37,483	1	$5,260	$10,520
6,750	10	3	18	4,538	27,229	$182	$1,089	408	$16,769	912	$37,483	1	$5,260	$10,520
10,700	12	3	18	5,446	32,675	$218	$1,307	486	$19,975	990	$40,689	2	$7,250	$14,500
15,300	15	3	18	6,807	40,844	$272	$1,634	486	$19,975	990	$40,689	2	$7,250	$14,500
20,900	20	3	18	9,076	54,458	$363	$2,178	486	$19,975	990	$40,689	2	$7,250	$14,500
27,500	25	3	18	11,345	68,073	$454	$2,723	486	$19,975	990	$40,689	2	$7,250	$14,500
55,000	25	6	36	22,691	136,145	$908	$5,446	564	$23,180	1068	$43,895	3	$9,240	$18,480
82,500	25	9	54	34,036	204,218	$1,361	$8,169	564	$23,180	1068	$43,895	3	$9,240	$18,480
110,000	25	12	72	45,382	272,290	$1,815	$10,892	564	$23,180	1068	$43,895	4	$11,230	$22,460
165000	25	18	108	68,073	408,435	$2,723	$16,337	564	$23,180	1068	$43,895	4	$11,230	$22,460

Construction Related Downtime

Downtime may be a substantial cost item for retrofits using the existing pump wells and pumps. The EPA retrofit scenario includes a sheet pile wall in front of the existing intake. This is modeled after a proposed scenario presented in a feasibility study for the Salem Nuclear Plant. In this scenario, a sheet pile plenum with bypass gates is constructed 40 feet in front of the existing intake with approximately twelve 10-foot diameter header pipes connecting the plenum to approximately 240 T-screens. Construction is estimated to take 2 years, with installation of the sheet pile plenum in the first year. The facility projects the installation of the 10-foot header pipes and screens to take nine months and the air backwash piping to take two months. The feasibility study states that Units 1 & 2 would each have to be shut down for about six months to install the plenum and for an additional two months to install the 10-foot header pipe connection to the plenum and to install the air piping. Thus, an estimated total of eight months of downtime is estimated for this very large (near worst case) intake scenario. This scenario was discarded by the facility due to uncertainty about biofouling and debris removal at slack tides. No cost estimates were developed; thus, there was no incentive to focus on a system design and a construction sequence that would minimize downtime.

In the same feasibility study, a scenario is proposed where a new intake with dual flow traveling screens is installed at a distance of 65 feet offshore inside a cofferdam. In this scenario, a sheet pile plenum wall connects the new intake to the existing shore intake. The intake is constructed first; Units 1 & 2 are estimated to be shut down for about one month each to construct and connect the plenum walls to the existing intake.

It would seem that the T-screen plenum construction scenario could follow the same approach, i.e., performed while the units are operating. This approach would result in a much shorter downtime, similar to that for the offshore intake, but including consideration for added time for near-shore air pipe installation. There are two relevant differences between these scenarios. One is the distance offshore to the T-screen piping connection versus the new intake structure (40 feet versus 65 feet). The second is that T-screens, pipes, and plenum would be installed underwater while the new intake would be constructed behind a coffer dam. Conceivably, the offshore portion of the T-screen plenum (excluding the ends) and all pipe and screen installation on the offshore side could be performed without shutting down the intake.

The WH Zimmer plant is a facility that EPA has identified as actually having converted an existing shoreline intake with traveling screens to submerged offshore T-screens. This facility was originally constructed as a nuclear facility but was never completed. In the late 1980s it was converted to a coal fired plant. The original intake was meant to supply service water and make-up water for recirculating wet towers and had been completed. However, the area in front of the intake was plagued with sediment deposition. A decision was made to abandon the traveling screens and install T-screens approximately 50 feet offshore. However, because the facility was not operating at the time of this conversion, there was no monetary incentive to minimize construction time. Actual construction took six to eight months for this intake, with a design flow of about 61,000 gpm (Frey 2002). The construction method in this case used a steel wall installed in front of the existing intake pump wells.

The Agency consulted the WH Zimmer plant engineer and asked him to estimate how long it would take to perform this retrofit with a goal of minimizing generating unit downtime. The estimated downtime was a minimum of seven to nine weeks, assuming mobilization goes smoothly and a tight construction schedule is maintained. A more generous estimate of a total of 12 to 15 weeks was estimated for their facility, assuming some predictable disruption to construction schedules. This estimate includes five to six weeks for installing piping (some support piles can be laid ahead of time), an additional five to six weeks to tie in piping and install the wall, and an additional two to three weeks to clean and dredge the intake area. This last two- to three-week period was a construction step somewhat unique to the Zimmer plant, because the presence of sediment was the driving factor in the decision to convert the system.

Based on the above information, EPA has concluded that a reasonable unit total downtime should be in the range of 13 to 15 weeks. It is reasonable to assume that this downtime can be scheduled to coincide with routine generating unit downtime of approximately four weeks, resulting in a total potential lost generation period of nine to 11 weeks. Rather than select a single downtime for all facilities installing passive screens, EPA chose to apply a 13 to 15 week total downtime duration based on variations in project size using design flow as a measure of size. As such, EPA assumed a downtime of

13 weeks for facilities with intake flow volumes of less than 400,000 gpm, 14 weeks for facilities with intake flow volumes greater than 400,000 gpm but less than 800,000 gpm, and 15 weeks for facilities with intake flow volumes greater than 800,000 gpm.

Unlike electric generators, manufacturing facilities typically involve numerous sequential processes with varying water requirements for the processes and in many cases, additional water requirements for plant electric power and steam generation. Many large manufacturing facilities not only have multiple types of processes, but also have multiple parallel process trains. Maintenance operations for the more complex operations may involve the shutdown of individual process trains or series of trains, but this leaves the remainder of the plant in operation. The sequential processes often have storage capacity for the intermediate products. The ability to store intermediate product facilitates this practice. As such, the need for electricity and process steam tends to be continuous. Because of the wide variety of process arrangements at different manufacturing facilities, there is the potential for wide variations in the frequency and duration of whole facility shutdowns between the various manufacturing sectors. It appears that the larger, more complex manufacturing operations, unlike electric generators, are less likely to schedule simultaneous annual shutdown of *all* processing units.

For manufacturing facilities, EPA chose to apply 11 to 13 week total downtime duration using design intake flow as a measure of size. Downtime durations applied for Phase III manufacturing facilities are presented in Exhibit 5-22.

Application

General Applicability

The following site-related conditions may preclude the use of passive T-screens or create operational problems:

- Water depths of <2 feet at screen location; for existing facilities this should not be an issue
- Stagnant waterbodies with high debris load
- Waterbodies with frazil ice during winter.

Frazil ice consists of fine, small, needle-like structures or thin, flat, circular plates of ice suspended in water. In rivers and lakes it is formed in supercooled, turbulent water. Remedies for this problem include finding another location such as deeper water that is outside of the turbulent water or creating a provision for periodically applying heated water to the screens. The application of heated water may not be feasible or economically justifiable in many instances.

Some facilities have reported limited success in alleviating frazil ice problems by blowing a small constant stream of air through the screen backwash system (Whitaker 2002b).

Application of Different Pipe Lengths

As noted previously, the shortest pipe length cost scenario (20 meters) are assumed to be applicable only to facilities with flows less than 163,000 gpm. Conversely, facilities located on large waterbodies that are subject to wave action and shifting sediment are assumed to install the longest pipe length scenario of 500 meters. Large waterbodies in this instance will include Great Lakes, oceans, and some estuarine/tidal rivers. The matrix in Exhibit 3-14 will provide some initial guidance. Generally, if the waterbody width is known, the pipe length should not exceed half the width of the waterbody.

Exhibit 3-14. Selection of Applicable Relocation Offshore Pipe Lengths By Waterbody

Pipe Lengths	Freshwater Rivers/Streams	Lakes/Reservoirs	Estuaries/Tidal Rivers	Great Lakes	Oceans
20 Meters	Flow <163,000	Flow <163,000	N/A	N/A	N/A
125 Meters	To be determined (TBD)	TBD	TBD	N/A	N/A
250 Meters	TBD	TBD	TBD	TBD	N/A
500 Meters	N/A	N/A	TBD	TBD	ALL

TBD: Criteria or selection to be determined; criteria may include design flow, waterbody size (if readily available).

1.2 Add Submerged Fine Mesh Passive Screens to Existing Offshore Intakes

Please note that much of the supporting documentation has been previously described in section 1.1.

Capital Costs

Adding passive screens to an existing submerged offshore intake requires many of the same construction steps and components described in section 1.1 above, excluding those related to the main trunk of the manifold pipe and connecting wall. Similar construction components include: modifying the submerged inlet to connect the new screens, installing T-screens, and installing the airburst backwash air supply equipment and the blowpipes. Nearly all of these components will require similar equipment, construction steps, and costs as described in section 1.1 for the specific components. One possible difference is that the existing submerged piping distance may not match one of the four lengths for which costs were estimated. This difference only affects this component of cost. The distance chosen is the one that closely matches or exceeds the existing offshore distance. Exhibits 3-15 and 3-16 present the combined costs of the installed T-screens, airburst air supply system, and air supply pipes for fine mesh and very fine mesh screens, respectively. The costs in Exhibit 3-15 and 3-16 include direct and indirect costs, as described in section 1.1. Figures 3-10, 3-11, 3-12, 3-13, 3-14, and 3-15 present plots of the data in Exhibits 3-15 and 3-16. The figures include the second-order, best-fit equations used to estimate technology costs for specific facilities.

Exhibit 3-15. Capital Cost of Installing Fine Mesh Passive T-screens at an Existing Submerged Offshore Intake

Design Flow	Total Costs 20 Meters Offshore			Total Costs 125 Meters Offshore			Total Costs 250 Meters Offshore			Total Costs 500 Meters Offshore		
gpm	304 SS	316 SS	CuNi	304 SS	316 SS	CuNi	304 SS	316 SS	CuNi	304 SS	316 SS	CuNi
	Freshwater	Saltwater	Zebra Mussels	Freshwater	Saltwater	Zebra Mussels	Freshwater	Saltwater	Zebra Mussels	Freshwater	Saltwater	Zebra Mussels
2,500	$100,137	$112,839	$103,487	$128,732	$172,535	$132,081	$162,773	$243,602	$166,122	$230,855	$385,735	$234,204
5,700	$120,312	$125,414	$132,492	$162,939	$176,361	$175,119	$213,685	$237,012	$225,865	$315,178	$358,314	$327,358
10,000	$154,594	$160,610	$176,975	$205,541	$219,877	$227,922	$266,192	$290,432	$288,573	$387,494	$431,543	$409,874
15,800	$194,029	$204,426	$226,763	$274,090	$298,519	$306,823	$369,400	$410,535	$402,134	$560,020	$634,566	$592,754
22,700	$245,131	$264,554	$299,484	$356,382	$403,871	$410,736	$488,825	$569,725	$543,178	$753,711	$901,432	$808,064
31,000	$293,433	$316,628	$367,122	$445,234	$500,659	$518,923	$625,950	$719,744	$699,639	$987,382	$1,157,915	$1,061,071
40,750	$352,983	$382,546	$448,900	$541,169	$610,243	$637,086	$765,200	$881,312	$861,118	$1,213,263	$1,423,448	$1,309,181
81,500	$562,086	$621,213	$753,921	$938,458	$1,076,608	$1,130,293	$1,386,521	$1,618,744	$1,578,356	$2,282,647	$2,703,017	$2,474,482
122,250	$795,243	$883,934	$1,082,995	$1,359,802	$1,567,025	$1,647,554	$2,031,896	$2,380,230	$2,319,649	$3,376,084	$4,006,639	$3,663,837
163,000	$1,021,242	$1,139,497	$1,404,912	$1,773,988	$2,050,286	$2,157,658	$2,670,113	$3,134,559	$3,053,783	$4,462,364	$5,303,105	$4,846,034

Exhibit 3-16. Capital Cost of Installing Very Fine Mesh Passive T-screens at an Existing Submerged Offshore Intake

Design Flow	Total Costs 20 Meters Offshore			Total Costs 125 Meters Offshore			Total Costs 250 Meters Offshore			Total Costs 500 Meters Offshore		
gpm	304 SS	316 SS	CuNi	304 SS	316 SS	CuNi	304 SS	316 SS	CuNi	304 SS	316 SS	CuNi
	Freshwater	Saltwater	Zebra Mussels	Freshwater	Saltwater	Zebra Mussels	Freshwater	Saltwater	Zebra Mussels	Freshwater	Saltwater	Zebra Mussels
1,680	$100,173	$102,084	$103,690	$128,768	$134,314	$132,284	$162,809	$172,683	$166,326	$230,891	$249,421	$234,408
3,850	$120,156	$125,350	$132,945	$162,783	$176,297	$175,572	$213,530	$236,948	$226,319	$315,023	$358,250	$327,812
6,750	$154,275	$160,428	$177,774	$205,221	$219,694	$228,721	$265,872	$290,250	$289,372	$387,174	$431,360	$410,674
10,700	$193,241	$203,882	$227,611	$273,302	$297,975	$307,672	$368,612	$409,990	$402,982	$559,232	$634,022	$593,603
15,300	$244,023	$263,866	$301,094	$355,275	$403,183	$412,346	$487,718	$569,036	$544,789	$752,603	$900,743	$809,674
20,900	$291,795	$315,515	$369,168	$443,596	$499,547	$520,970	$624,313	$718,632	$701,686	$985,745	$1,156,802	$1,063,118
27,500	$350,954	$381,218	$451,667	$539,140	$608,915	$639,854	$763,172	$879,984	$863,885	$1,211,235	$1,422,120	$1,311,948
55,000	$557,781	$618,309	$759,208	$934,154	$1,073,703	$1,135,580	$1,382,216	$1,615,840	$1,583,643	$2,278,342	$2,700,113	$2,479,769
82,500	$788,414	$879,206	$1,090,554	$1,352,973	$1,562,298	$1,655,113	$2,025,067	$2,375,502	$2,327,207	$3,369,255	$4,001,912	$3,671,395
110,000	$1,011,641	$1,132,697	$1,414,495	$1,764,387	$2,043,486	$2,167,240	$2,660,512	$3,127,759	$3,063,366	$4,452,763	$5,296,305	$4,855,617
165,000	$1,458,718	$1,640,302	$2,062,999	$2,587,837	$3,006,486	$3,192,117	$3,932,025	$4,632,895	$4,536,305	$6,620,401	$7,885,714	$7,224,682

Figure 3-10. Capital Costs for Fine Mesh Passive Screen Existing Offshore in Freshwater at Selected Offshore Distances

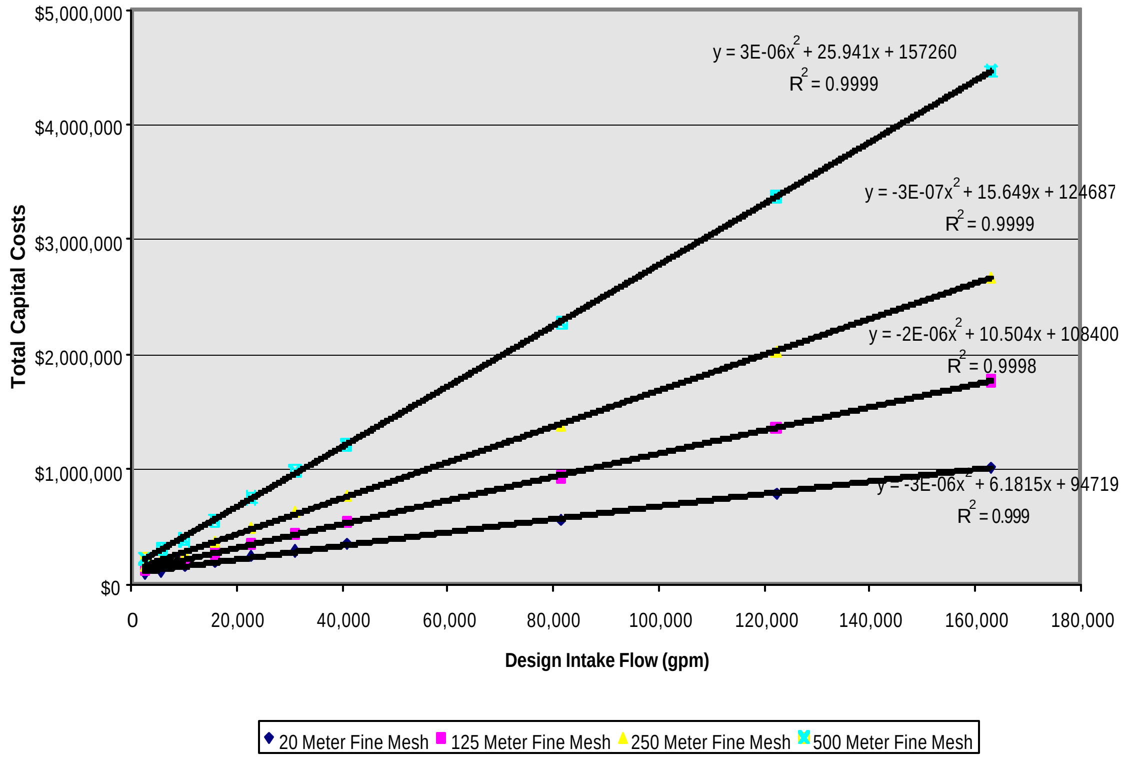


Figure 3-11. Capital Costs for Fine Mesh Passive Screen Existing Offshore in Saltwater at Selected Offshore Distances

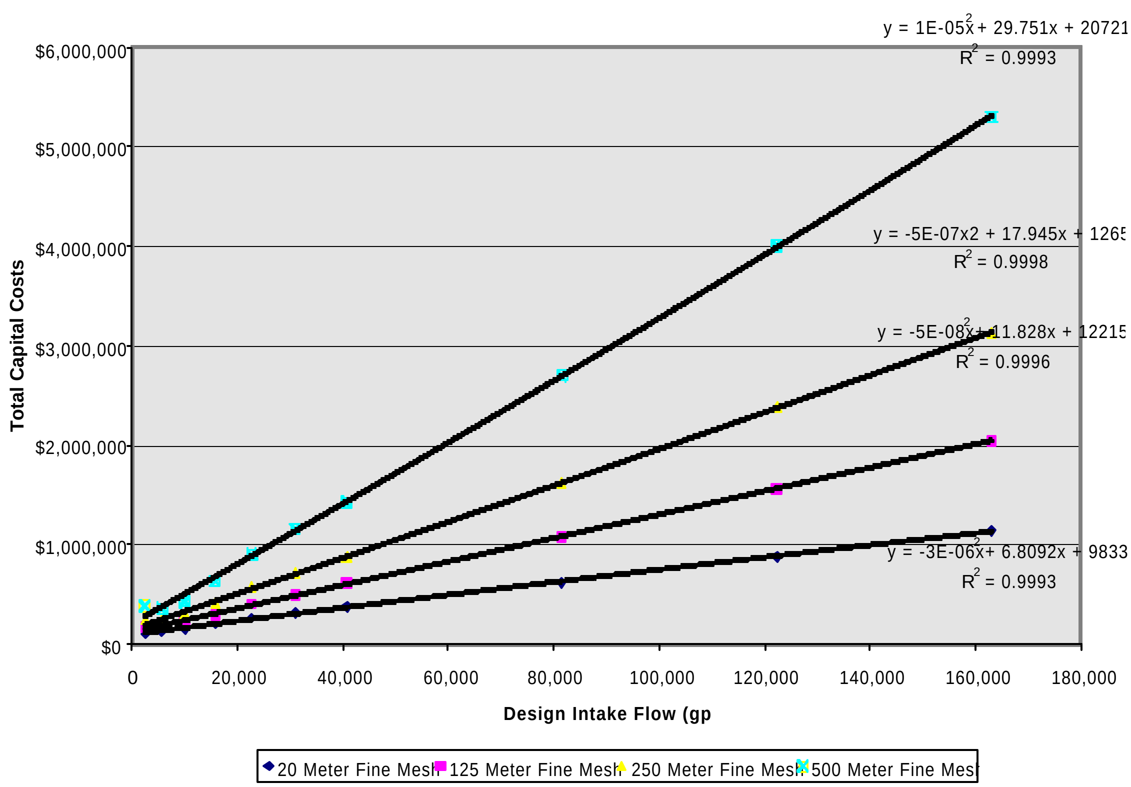


Figure 3-12. Capital Costs for Fine Mesh Passive Screen Existing Offshore in Freshwater with Zebra Mussels at Selected Offshore Distances

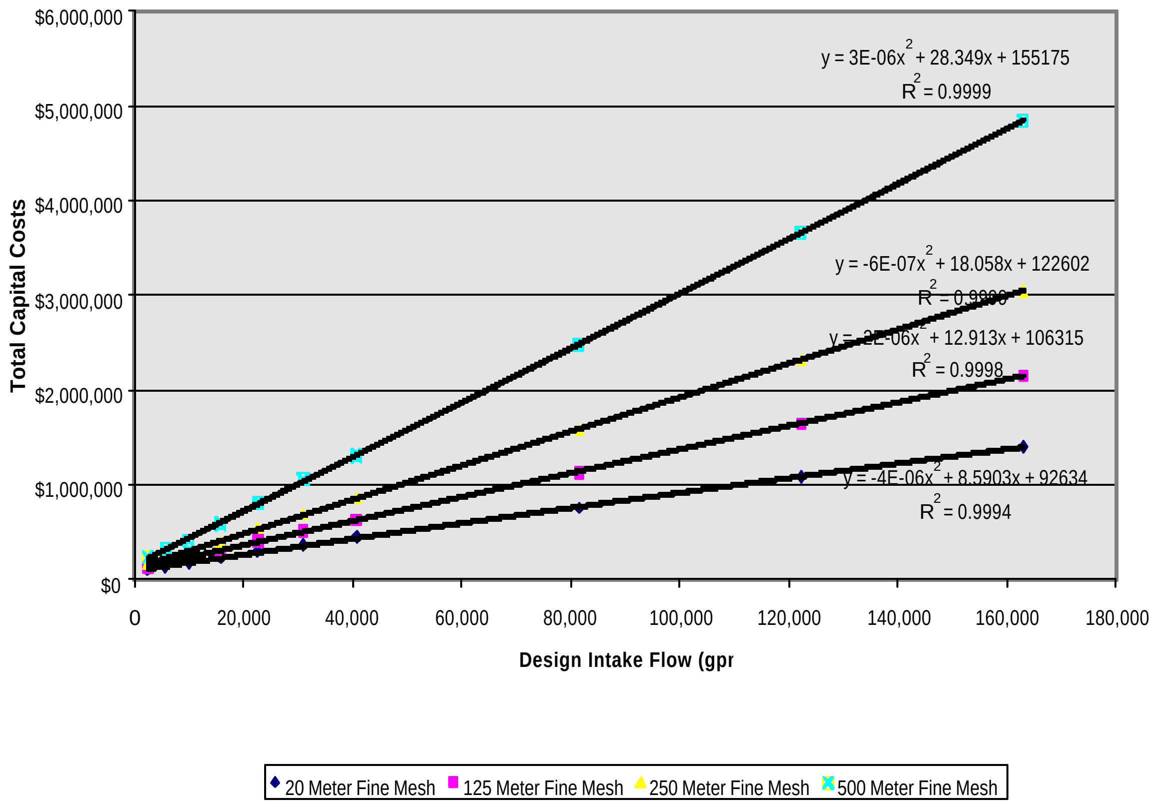


Figure 3-13. Capital Costs for Very Fine Mesh Passive Screen Existing Offshore in Freshwater at Selected Offshore Distances

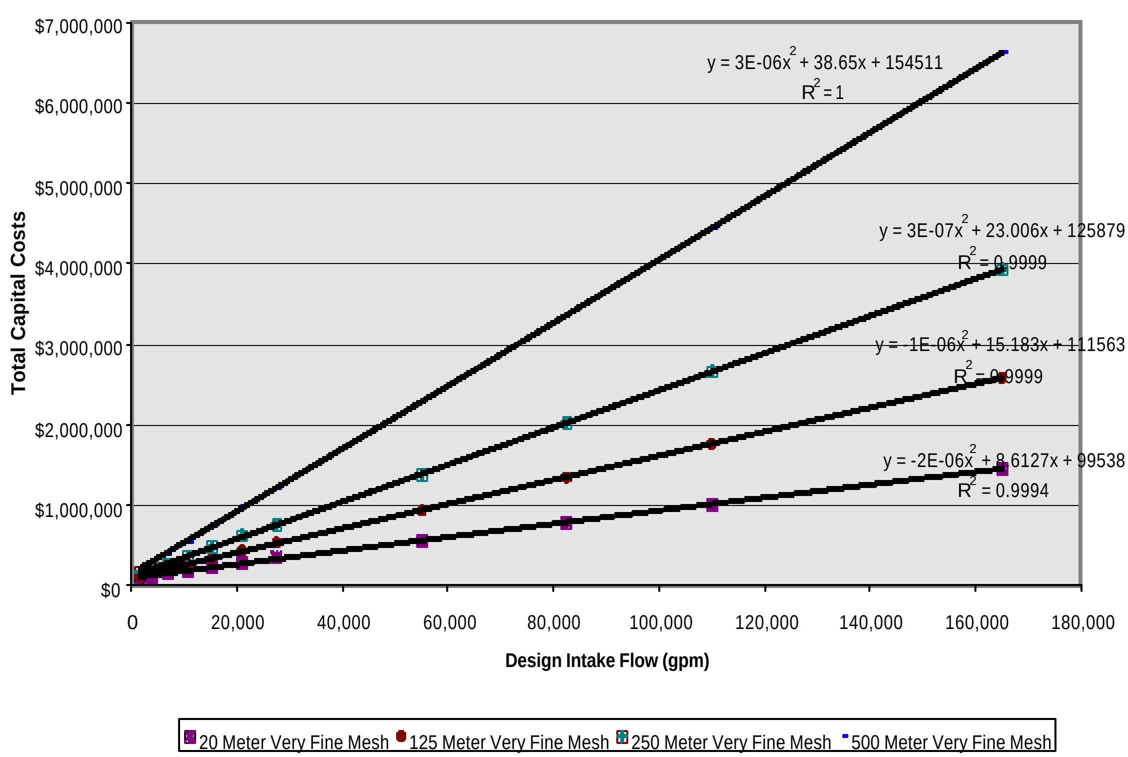


Figure 3-14. Capital Costs for Very Fine Mesh Passive Screen Existing Offshore in Saltwater in Selected Offshore Distances

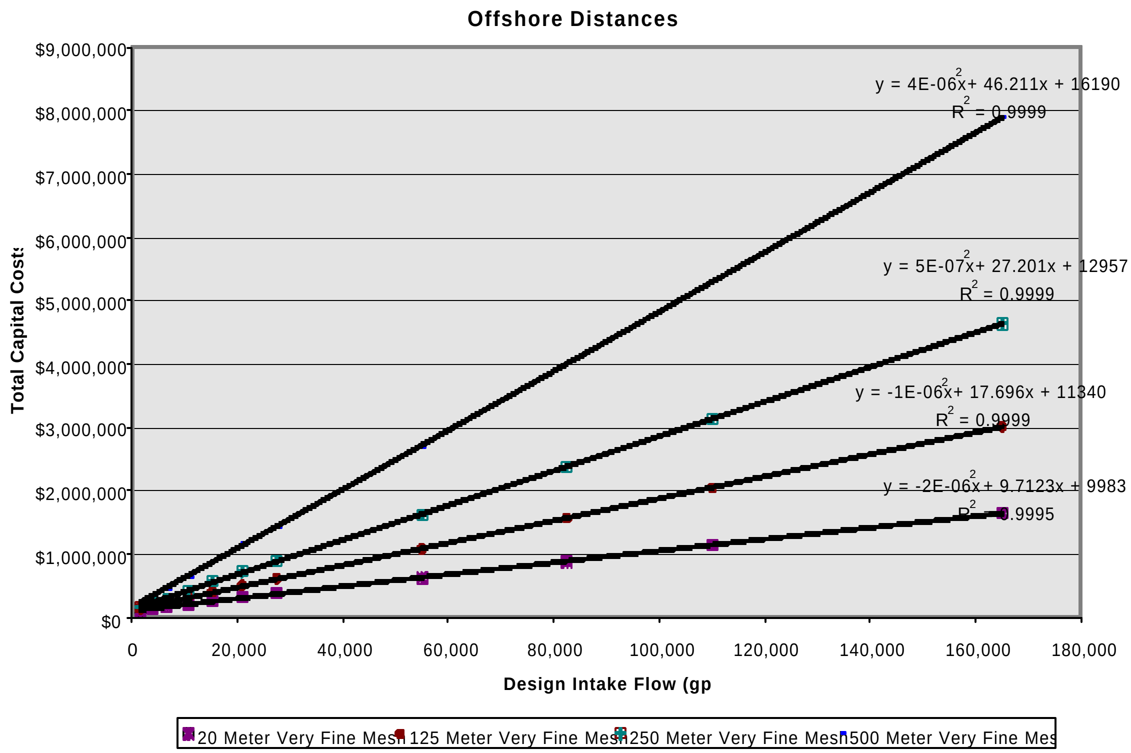
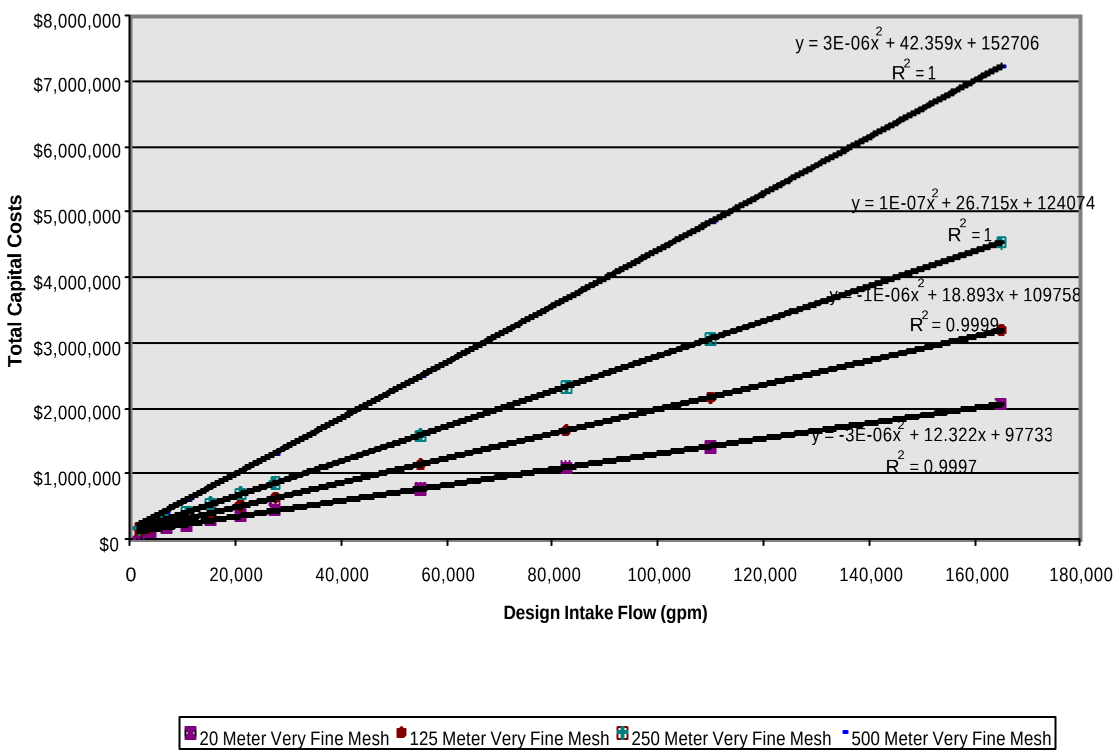


Figure 3-15. Capital Costs for Very Fine Mesh Passive Screen Existing Offshore in Freshwater with Zebra Mussels at Selected Offshore Distances



O&M Costs

O&M costs are assumed to be nearly the same as for relocating the intake offshore with passive screens. EPA assumes there are some offsetting costs associated with the fact that the existing intake should already have periodic inspection/cleaning by divers. The portion of the costs representing a single annual inspection has therefore been deducted. Exhibits 3-17 presents the annual O&M costs for fine mesh and very fine mesh screens. Separate costs are provided for low debris and high debris locations. Figures 3-16 and 3-17 present the plotted O&M data along with the second-order, best-fit equations.

Construction Downtime

Unlike the cost for relocating the intake from shore-based to submerged offshore, the only construction activities that would require shutting down the intake are the modification of the inlet and the installation of the T-screens. Installing the air supply system and the major portion of the air blowpipes can be performed while the intake is operating. Downtimes are assumed to be similar to those for adding velocity caps, which were reported to range from two to seven days. An additional one to two days may be needed to connect the blowpipes to the T-screens. The total estimated intake downtime of three to nine days can be easily scheduled to coincide with the routine maintenance period for power plants (which the Agency assumed to be four weeks for typical plants).

Exhibit 3-17. Net Intake O&M Costs for Fine Mesh Passive T-screens Installed at Existing Submerged Offshore Intakes

Existing Offshore With New Fine Mesh Screens			Existing Offshore With New Very Fine Mesh Screens		
Design Flow	Total O&M Costs - Low Debris	Total O&M Costs - High Debris	Design Flow	Total O&M Costs - Low Debris	Total O&M Costs - High Debris
gpm			gpm		
2,500	$11,203	$30,394	1,680	$16,805	$42,961
5,700	$11,240	$30,612	3,850	$16,860	$43,288
10,000	$11,300	$30,975	6,750	$16,950	$43,832
15,800	$13,462	$35,247	10,700	$20,192	$49,246
22,700	$13,498	$35,465	15,300	$20,247	$49,573
31,000	$13,558	$35,828	20,900	$20,338	$50,117
40,750	$13,619	$36,191	27,500	$20,428	$50,662
81,500	$16,059	$42,134	55,000	$24,088	$58,581
122,250	$16,361	$43,949	82,500	$24,542	$61,304
163,000	$16,664	$47,754	110,000	$24,996	$66,016
-	-	-	165000	$25,903	$71,462

Figure 3-16. Total O&M Costs for Fine Mesh Passive Screen Existing Offshore with Airburst Backwash

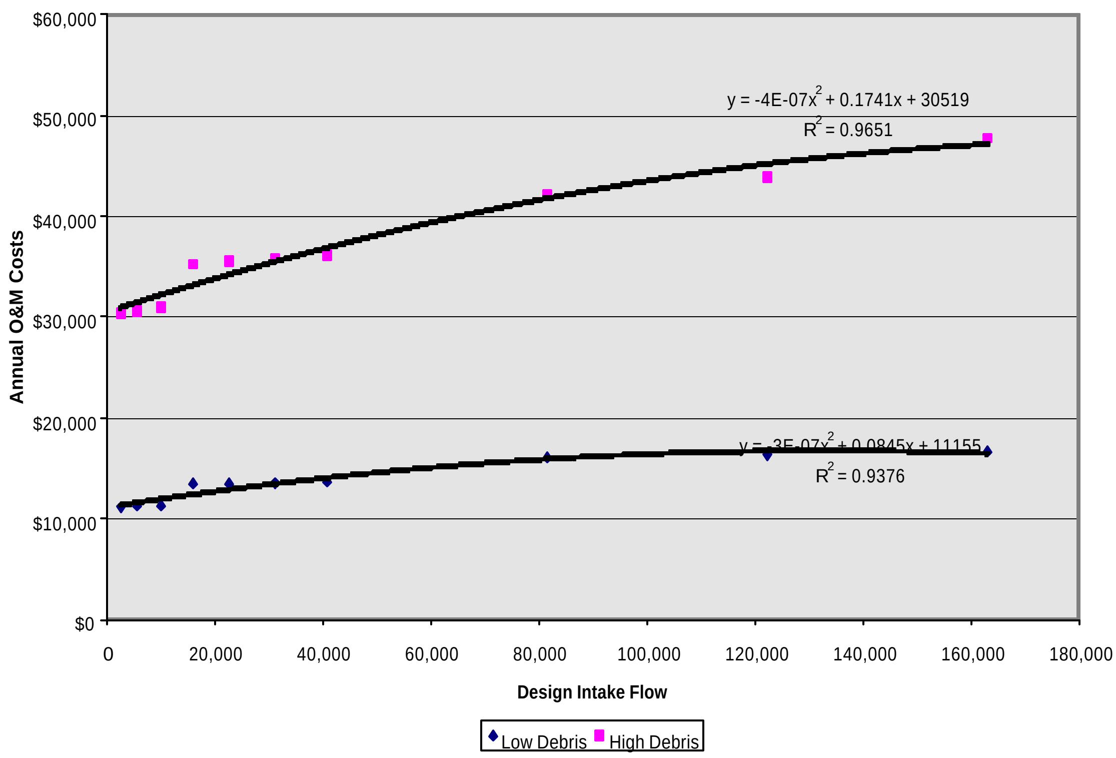
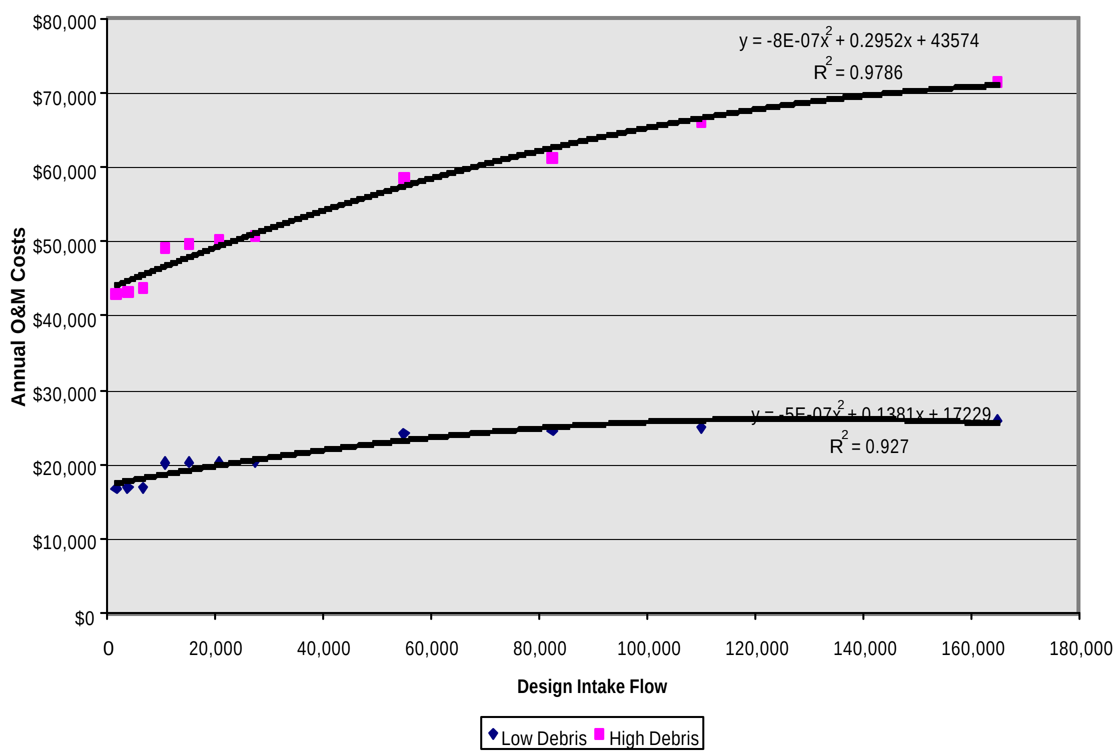


Figure 3-17. Total O&M Costs for Very Fine Mesh Passive Screen Existing Offshore with Airburst Backwash



Application

Separate capital costs have been developed for freshwater, freshwater with Zebra mussels, and saltwater environments. In selecting the materials of construction, the same methodology described in section 1.1 is used. Because the retrofit is an addition to an existing intake, selecting the distance offshore involves matching the existing distance to the nearest or next highest distance costed.

Similarly, the O&M costs are applied using the same method as described in section 1.1.

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2.0 IMPROVEMENTS TO EXISTING SHORELINE INTAKES WITH TRAVELING SCREENS

2.1 Replace Existing Traveling Screens with New Traveling Screen Equipment

The methodology described below is based on data, where available, from the Detailed Technical Questionnaires (DTQs). Where certain facility data are unavailable (e.g., Short Technical Questionnaire (STQ) facilities), the methodology generally uses statistical values (e.g., median values). The costs for traveling screen improvements described below are for installation in an existing or newly built intake structure. Where the existing intake is of insufficient design or size, construction costs for increasing the intake size are developed in a separate cost module and the cost for screen modification/installation at both the existing and/or new intake structure(s) are applied according to the estimated size of each.

Estimating Existing Intake Size

The capital cost of traveling screen equipment is highly dependent on the size and surface area of the screens employed. In developing compliance costs for existing facilities in Phase I, a single target, through-screen velocity was used. This decision ensured the overall screen area of the units being costed was a direct function of design flow. Thus, EPA could rely on a cost estimating methodology for traveling screens that focused primarily on design flow. In the Phase I approach, a single screen width was chosen for a given flow range. Variations in cost were generally based on differences in screen well depth. Where the flow exceeded the maximum flow for the largest screen costed, multiples of the largest (14 feet wide) screens were costed. Because, in this instance, EPA was applying its cost methodology to hypothetical facilities, screen well depth could be left as a dependent variable. However, this approach is not tenable for existing facilities because existing screen velocities vary considerably between facilities. Because the size of the screens is very much dependent on design flow and screen velocity, a different approach -- one that first estimates the size of the existing screens -- is warranted.

Estimating Total Screen Width

Available data from the DTQs concerning the physical size of existing intake structures and screens are limited to vertical dimensions (e.g., water depth, distance of water surface to intake deck, and intake bottom to water surface). Screen width dimensions (parallel to shore) are not provided. For each model facility EPA has developed data concerning actual and estimated design flow. Through-screen velocity is available for most facilities--even those that completed only the STQ. Given the water depth, intake flow, and through-screen velocity, the aggregate width of the intake screens can be estimated using the following equation:

Screen Width (Ft) = Design Flow (cubic feet/second (cfs)) / (Screen Velocity (feet per second (fps)) x Water Depth (Ft) x Open Area (decimal %))

The variables “design flow,” “screen velocity,” and “water depth” can be obtained from the questionnaire for most facilities that completed the DTQ. These database values may not always correspond to the same waterbody conditions. For example, the screen velocity may correspond to low flow conditions while the water depth may represent average conditions. Thus, calculated screen widths may differ from actual values, but likely represents a reasonable estimate, especially given the limited available data. EPA considers the above equation to be a reasonable method for estimating the general size of the existing intake for cost estimation purposes. The method for determining the value for water depth at an intake where no data is available is described below.

The last variable in the screen width equation is the percent open area, which is not available in the database. However, the majority of the existing traveling screens are coarse mesh screens (particularly those requiring equipment upgrades). In most cases (at least for power plants), the typical mesh size is 3/8-inch (Petrovs 2002, Gathright 2002). This mesh size corresponds to an industry standard that states the mesh size should be half the diameter of the downstream heat exchanger tubes. These tubes are typically around 7/8 inch in diameter for power plant steam condensers. For a mesh size of 3/8 inch, the corresponding percent open area for a square mesh screen using 14-gauge wire is 68%. This combination was reported as “typical” for coarse mesh screens (Gathright 2002). Thus, EPA will use an assumed percent open area value of 68% in the above equation.

At facilities where the existing through-screen velocity has been determined to be too high for fine mesh traveling screens to perform properly, a target velocity of 1.0 foot per second was used in the above equation to estimate the screen width that would correspond to the larger size intake that would be needed.

Screen Well Depth

The costs for traveling screens are also a function of screen well depth, which is not the same as the water depth. The EPA cost estimates for selected screen widths have been derived for a range of screen well depths ranging from 10 feet to 100 feet. The screen well depth is the distance from the intake deck to the bottom of the screen well, and includes both water depth and distance from the water surface to the deck. For those facilities that reported “distance from intake bottom to water surface” and “distance from water surface to intake top,” the sum of these two values can be used to determine actual screen well depth. For those Phase III facilities that did not report this data, statistical values (such as the median) were used. The median value for the ratio of the water depth to the screen well depth for all facilities that reported such data was 0.66. Thus, based on median reported values, the screen well depth can be estimated by assuming it is 1.5 times the water depth where only water depth is reported. For those Phase III facilities that reported water depth data, the median water depth at the intake was 18.0 feet.

Based on this discussion, screen well depth and intake water depth are estimated using the following hierarchy:

- If “distance from intake bottom to water surface” plus “distance from water surface to intake top” are reported, then the sum of these values are used for screen well depth
- If only the “distance from intake bottom to water surface” and/or the “depth of water at intake” are reported, one of these values (if both are known, the former selected is over the latter) is multiplied by a factor of 1.5
- If no depth data are reported, this factor (1.5) is applied to the median water depth value of 18 feet (i.e., 27 feet) and the resulting value is used.

This approach leaves open the question of which costing scenario well depth should be used where the calculated or estimated well depth does not correspond to the depths selected for cost estimates. EPA has selected a factor of 1.2 as the cutoff for using a shallower costing well depth. Exhibit 3-18 shows the range of estimated well depths that correspond to the specific well depths used for costing.

Exhibit 3-18. Guidance for Selecting Screen Well Depth for Cost Estimation

Calculated or Estimated Screen Well Depth (Ft)	Well Depth to be Costed
0-12 ft	10 ft
>12-30 ft	25 ft
>30-60 ft	50 ft
>60-90 ft	75 ft

Traveling Screen Replacement Options

Compliance action requirements developed for each facility may result in one of the following traveling screen improvement options:

- No Action.
- Add Fine Mesh Only (improves entrainment performance).
- Add Fish Handling Only (improves impingement performance).
- Add Fine Mesh and Fish Handling (improves entrainment and impingement performance).

Exhibit 3-19 shows potential combinations of existing screen technology and replacement technologies that are applied to these traveling screen improvement options. In each case, there are separate costs for freshwater and saltwater environments.

Areas highlighted in gray in Exhibit 3-19 indicate that the compliance scenario is not compatible with the existing technology combination. The table shows three possible technology combination scenarios for a retrofit involving modifying the existing intake structure only. Each scenario is described briefly below:

Scenario A - Add fine mesh only

This scenario involves simply purchasing a separate set of fine mesh screen overlay panels and installing them in front of the existing coarse mesh screens. This placement may be performed on a seasonal basis. This option is not considered applicable to existing screens without fish handling and return systems, since the addition of fine mesh will retain additional aquatic organisms that would require some means for returning them to the waterbody. Corresponding compliance O&M costs include seasonal placement and removal of fine mesh screen overlay panels.

Exhibit 3-19. Compliance Action Scenarios and Corresponding Cost Components

Compliance Action	Cost Component Included in EPA Cost Estimates	Existing Technology	
		Traveling Screens Without Fish Return	Traveling Screens With Fish Return
Add Fine Mesh Only (Scenario A)	New Screen Unit	N/A	No
	Add Fine Mesh Screen Overlay	N/A	Yes
	Fish Buckets	N/A	No
	Add Spray Water Pumps	N/A	No
	Add Fish Flume	N/A	No
Add Fish Handling Only (Scenario B)	New Screen Unit[1]	Yes	N/A
	Add Fine Mesh Screen Overlay[2]	No	N/A
	Fish Buckets	Yes	N/A
	Add Spray Water Pumps	Yes	N/A
	Add Fish Flume	Yes	N/A
Add Fine Mesh With Fish Handling (Scenario C and Dual-Flow Traveling Screens)	New Screen Unit	Yes	N/A
	Add Fine Mesh Screen Overlay	Yes[3]	N/A
	Fish Buckets	Yes	N/A
	Add Spray Water Pumps	Yes	N/A
	Add Fish Flume	Yes	N/A

[1] Replace entire screen unit, includes one set of smooth top or fine mesh screens.
[2] Add fine mesh includes costs for a separate set of overlay fine mesh screen panels that can be placed in front of coarser mesh screens on a seasonal basis.
[3] Does not include initial installation labor for fine mesh overlays. Seasonal deployment and removal of fine mesh overlays is included in O&M costs.

Scenario B - Add fish handling and return

This scenario requires the replacement of all of the traveling screen units with new screens that include fish handling features, but does not specify mesh requirements. Mesh size is assumed to be 1/8-inch by ½-inch smooth top. A less costly option would be to retain and retrofit portions of the existing screen units. However, vendors noted that approximately 75% of the existing screen components would require replacement and that it would be more prudent to replace the entire screen unit (Gathright 2002, Petrovs 2002). Costs for additional spray water pumps and a fish return flume are included. Capital and O&M costs do not include any component for seasonal placement of fine mesh overlays.

Scenario C - Add fine mesh with fish handling and return

This scenario requires replacement of all screen units with units that include fish handling and return features plus additional spray water pumps and a fish return flume. Costs for a separate set of fine mesh screen overlay panels with seasonal placement are included.

Double Entry-Single Exit (Dual-Flow) Traveling Screens

The conditions for scenario C also apply to dual-flow traveling screens described separately below.

Fine Mesh Screen Overlay

Several facilities that have installed fine mesh screens found that, during certain periods of the year, the debris loading created operating problems. These problems prompted operators to remove fine mesh screens and replace them with coarser screens for the duration of the period of high and/or troublesome debris. As a high-side approach, when fine mesh screens replace coarse mesh screens (scenarios A and C), EPA has decided to include costs for using two sets of screens (one coarser mesh screen such as 1/8-inch by 1/4-inch smooth top and one fine mesh overlay) with annual placement and removal of the fine mesh overlay. This placement of fine mesh overlay can occur for short periods when sensitive aquatic organisms are present or for longer periods, being removed only during periods when debris is present. Fine mesh screen overlays are also included in the costs for dual-flow traveling screens described separately below.

Mesh Type

Three different types of mesh are considered here. One is the coarse mesh that is typical in older installations. Coarse mesh is considered to be the baseline mesh type and the typical mesh size is 3/8-inch square mesh. When screens are replaced, two additional types of mesh are considered. One is fine mesh, which is assumed to have openings in the 1 to 2 mm range. The other mesh type is the smooth top mesh. Smooth top mesh has smaller openings (at least in one dimension) than coarse mesh (e.g., 1/8-inch by ½-inch is a common size) and is manufactured in a way that reduces the roughness that is associated with coarse mesh. Smooth top mesh is used in conjunction with screens that have fish handling and return systems. The roughness of standard coarse mesh has been blamed for injuring (descaling) fish as they are washed over the screen surface when they pass from the fish bucket to the return trough during the fish wash step. Due to the tighter weave of fine mesh screens, roughness is not an issue when using fine mesh.

2.1.1 Traveling Screen Capital Costs

The capital cost of traveling screen equipment is generally based on the size of the screen well (width and depth), construction materials, type of screen baskets, and ancillary equipment requirements. While EPA has chosen to use the same mix of standard screen widths and screen well depths as were developed for new facilities in the Phase I effort, as described above, the corresponding water depth, design flow, and through-screen velocities in most cases differ. As presented in Exhibit 3-19, cost estimates do not need to include a compliance scenario where replacement screen units without fish handling and return equipment are installed. Unlike the cost methodology developed for Phase I, separate costs are developed in Phase III costing for equipment suitable for freshwater and saltwater environments. Costs for added spray water pumps and fish return flumes are described below, but unlike the screening equipment, they are generally a function of screen width only.

Screen Equipment Costs

EPA contacted traveling screen vendors to obtain updated costs for traveling screens with fine mesh screens and fish handling equipment for comparison to the 1999 costs developed for Phase I. Specifically, costs for single entry-single exit (through-flow) screens with the following attributes were requested:

-Spray systems

-Fish trough
-Housings and transitions
-Continuous operating features
-Drive unit
-Frame seals
-Engineering
-Freshwater versus saltwater environments.

Only one vendor provided comparable costs (Gathright 2002). The costs for freshwater environments were based on equipment constructed primarily of epoxy-coated carbon steel with stainless steel mesh and fasteners. Costs for saltwater and brackish water environments were based on equipment constructed primarily of 316 stainless steel with stainless steel mesh and fasteners.

EPA compared these newly obtained equipment costs to the costs for similar freshwater equipment developed for Phase I, adjusted for inflation to July 2002 dollars. EPA found that the newly obtained equipment costs were lower by 10% to 30%. In addition, a comparison of the newly obtained costs for brackish water and freshwater screens showed that the costs for saltwater equipment were roughly twice the costs for freshwater equipment. This factor of approximately 2 was also suggested by a separate vendor (Petrovs 2002). Rather than adjust the Phase I equipment costs downward, EPA chose to conclude that the Phase I freshwater equipment costs adjusted to 2002 dollars were valid (if not somewhat overestimated), and that a factor of 2 would be reasonable for estimating the cost of comparable saltwater/brackish water equipment. Exhibits 3-20 and 3-21 present the Phase I equipment costs, adjusted for inflation to July 2002 dollars, for freshwater and saltwater environments respectively.

Costs for fine mesh screen overlay panels were cited as approximately 8% to 10% of the total screen unit costs (Gathright 2002). The EPA cost estimates for fine mesh overlay screen panels are based on a 10% factor applied to the screen equipment costs shown in Exhibit 3-20 and 3-21. Note that if the entire screen basket required replacement, then the costs would increase to about 25% to 30% of the screen unit costs (Gathright 2002, Petrovs 2002). However, in the scenarios considered here, basket replacement would occur only when fish handling is being added. In those scenarios, EPA has chosen to assume that the entire screen unit will require replacement. The cost of new traveling screen units with smooth top mesh is only about 2% above that for fine mesh (Gathright 2002). EPA has concluded that the cost for traveling screen units with smooth top mesh is nearly indistinguishable from that for fine mesh. Therefore, EPA has not developed separate costs for each.

Exhibit 3-20. Equipment Costs for Traveling Screens with Fish Handling for Freshwater Environments, 2002 Dollars

Well Depth	Basket Screening Panel Width (Ft)			
(Ft)	2	5	10	14
10	$69,200	$80,100	$102,500	$147,700
25	$88,600	$106,300	$145,000	$233,800
50	$133,500	$166,200	$237,600	$348,300
75	$178,500	$228,900	$308,500	$451,800
100	$245,300	$291,600	$379,300	$549,900

Exhibit 3-21. Equipment Costs for Traveling Screens with Fish Handling for Saltwater Environments, 2002 Dollars

Well Depth	Basket Screening Panel Width (Ft)			
(Ft)	2	5	10	14
10	$138,400	$160,200	$205,000	$295,400
25	$177,200	$212,600	$290,000	$467,600
50	$267,000	$332,400	$475,200	$696,600
75	$357,000	$457,800	$617,000	$903,600
100	$490,600	$583,200	$758,600	$1,099,800

Screen Unit Installation Costs

Vendors indicated that the majority of intakes have stop gates or stop log channels that enable the isolation and dewatering of the screen wells. Thus, EPA assumes, in most cases, that screens can be replaced and installed in dewatered screen wells without the use of divers. When asked whether most screens were accessible by crane, a vendor noted that about 70% to 75% might have problems accessing the intake screens by crane from overhead. In such cases, the screens are dismantled (i.e., screen panels are removed, chains are removed and screen structure is removed in sections that key into each other). Such overhead access problems may be due to structural cover or buildings, and access is often through the side wall. According to one vendor, this screen-dismantling requirement may add 30% to the installation costs. For those installations that do not need to dismantle screens, these costs typically are $15,000 to $30,000 per unit (Petrovs 2002). Another vendor cited screen installation costs as approximately $45,000 per screen, giving an example of $20,000 for a 15-foot screen plus the costs of a crane and forklift ($15,000 - $20,000 divided between screens) (Gathright 2002). Note that these installation costs are for the typical range of screen sizes; vendors noted that screens in the range of the 100-foot well depth are rarely encountered.

Exhibit 3-22 presents the installation costs developed from vendor-supplied data. These costs include crane and forklift costs and are presented on a per screen basis. Phase I installation costs included an intake construction component not included in Phase III costs. The costs shown here assume the intake structure and screen wells are already in place. Therefore, installation involves removing existing screens and installing new screens in their place. Any costs for increasing the intake size are developed as a separate module. Vendors indicated costs for disposing of the existing screens were minimal. The cost of removal and disposal of old screens, therefore, are assumed to be included in the Exhibit 3-22 estimates.

Exhibit 3-22. Traveling Screen Installation Costs

Well Depth	Basket Screening Panel Width (Ft)			
(Ft)	2	5	10	14
10	$15,000	$18,000	$21,000	$25,000
25	$22,500	$27,000	$31,500	$37,000
50	$30,000	$36,000	$42,000	$50,000
75	$37,500	$45,000	$52,500	$62,500
100	$45,000	$54,000	$63,000	$75,000

Installation of Fine Mesh Screen Panel Overlays

Screen panel overlay installation and removal costs are based on an estimate of the amount of labor required to replace each screen panel. Vendors provided the following estimates for labor to replace screen baskets and panels (Petrovs 2002, Gathright 2002):

- 1.0 hour per screen panel overlay (1.5 hours to replace baskets and panel)
- Requires two-man team for small screen widths (assumed to be 2- and 5-foot wide screens)
- Requires three-man team for large screen widths (assumed to be 10- and 14-foot wide screens)
- Number of screen panels is based on 2-foot tall screen panels on front and back extending 6 feet above the deck. Thus, a screen for a 25-foot screen well is estimated to have 28 panels.

Labor costs are based on a composite labor rate of $41.10/hr (See O&M cost section).

These assumptions apply to installation costs for scenario A. These same assumptions also apply to O&M costs for fine mesh screen overlay in scenarios A and C, where it is applied twice for seasonal placement and removal.

Indirect Costs Associated with Replacement of Traveling Screens

EPA noted that equipment costs (Exhibits 3-20 and 3-21) included the engineering component and that installation costs (Exhibit 3-22) included costs for contractor overhead and profit. Because the new screens are designed to fit the existing screen well channels and the existing structure is of a known design, contingency and allowance costs should be minimal. Also, no costs for sitework were included because existing intakes, in most cases, should already have provisions for equipment access. Because inflation-adjusted equipment costs exceeded the recently obtained equipment vendor quotation by 10% to 30%, EPA has concluded that indirect costs are already included in the equipment cost component.

Combining Per Screen Costs with Total Screen Width

As noted above, total screen costs are estimated using a calculated screen width as the independent variable. In many cases, this calculated width would involve using more than one screen, particularly if the width is greater than 10 to 14 feet. Vendors have indicated that there is a general preference for using 10-foot wide screens over 14-foot screens, but that 14-foot screens are more economical (reducing civil structure costs) for larger installations. The screen widths and corresponding number and screens used to plot screen cost data and develop cost equations are as follows:

2 ft	=	a single	2-ft screen
5 ft	=	a single	5-ft screen
10 ft	=	a single	10-ft screen
20 ft	=	two	10-ft screens
30 ft	=	three	10-ft screens
40 ft	=	four	10-ft screens
50 ft	=	five	10-ft screens
60 ft	=	six	10-ft screens
70 ft	=	five	14-ft screens
84 ft	=	six	14-ft screens
98 ft	=	seven	14-ft screens
112 ft	=	eight	14-ft screens
126 ft	=	nine	14-ft screens
140 ft	=	ten	14-ft screens.

Any widths greater than 140 feet are divided and the costs for the divisions are summed.

Ancillary Equipment Costs for Fish Handling and Return System

When adding a screen with a fish handling and return system where no fish handling system existed before, there are additional requirements for spray water and a fish return flume. The equipment and installation costs for the fish troughs directly adjacent to the screen and spray system are included in the screen unit and installation costs. However, the costs for pumping additional water for the new fish spray nozzles and the costs for the fish return flume from the end of the intake structure to the discharge point are not included. Fish spray and flume volume requirements are based solely on screen width and are independent of depth.

Pumps for Spray Water

Wash water requirements for the debris wash and fish spray were obtained from several sources. Where possible, the water volume was divided by the total effective screen width to obtain the unit flow requirements (gpm/ft). Total unit flow requirements for both debris wash and fish spray combined ranged from 26.7 gpm/ft to 74.5 gpm/ft. The only data with a breakdown between the two uses reported a flow of 17.4 gpm/ft for debris removal and 20.2 gpm/ft for fish spray, with a total of 37.5 gpm/ft (Petrovs 2002). Based on these data, EPA assumed a total of 60 gpm/ft, with each component being equal at 30 gpm/ft. These values are near the high end of the ranges reported and were selected to account for additional water needed at the upstream end of the fish trough to maintain a minimum depth.

Because the existing screens already have pumps to provide the necessary debris spray flow, only the costs for pumps sized to deliver the added fish spray are included in the capital cost totals. Costs for the added fish spray pumps are based on the installed equipment cost estimates developed for Phase I, adjusted to July 2002 dollars. These costs already include an engineering component. An additional 10% was added for contingency and allowance. Also, 20% was added to these costs to account for any necessary modifications to the existing intake (based on BPJ). Exhibit 3-23 presents the costs for adding pumps for the added fish spray volume.

The costs in Exhibit 3-23 were plotted and a best-fit, second-order equation was derived from the data. Pump costs were then projected from this equation for the total screen widths described earlier.

Exhibit 3-23. Fish Spray Pump Equipment and Installation Costs

Centrifugal Pump Flow (gpm)	Costs for Centrifugal Pumps - Installed (1999 Dollars)	Pump Costs Adjusted to July 2002	Retrofit Cost & Indirect Costs	Total Installed Cost
10	$800	$872	$262	$1,134
50	$2,250	$2,453	$736	$3,189
75	$2,500	$2,725	$818	$3,543
100	$2,800	$3,052	$916	$3,968
500	$3,700	$4,033	$1,210	$5,243
1,000	$4,400	$4,796	$1,439	$6,235
2,000	$9,000	$9,810	$2,943	$12,753
4,000	$18,000	$19,620	$5,886	$25,506

Fish Return Flume

In the case of the fish return flume, the total volume of water to be carried was assumed to include both the fish spray water and the debris wash water. A total unit flow of 60 gpm/ft screen width was assumed as a conservative value for estimating the volume to be conveyed. Return flumes may take the form of open troughs or closed pipe and are often constructed of reinforced fiberglass (Gathright 2002, Petrovs 2002). The pipe diameter is based on an assumed velocity of 1.5 feet per second, which is at the low end of the range of pipe flow velocities. Higher velocities will result in smaller pipes. Actual velocities may be much higher to ensure that fish are transported out of the pipe. With lower velocities, fish can continually swim upstream. Vendors have noted that the pipes do not tend to flow at full capacity, so basing the cost on a larger pipe sized on the basis of a low velocity is a reasonable approach.

Observed flume return lengths varied considerably. In some cases, where the intake is on a tidal waterbody, two return flumes may be used alternately to maintain the discharge in the downstream direction of the receiving water flow. A traveling screen vendor suggested lengths of 75 to 150 feet (Gathright 2002). EPA reviewed facility description data and found example flume lengths ranging from 30 ft to 300 ft for intakes without canals, and up to several thousand feet for those with canals. For the compliance scenario typical flume length, EPA chose the upper end of the range of examples for facilities without intake canals (300 ft). For those intakes located at the end of a canal, the cost for the added flume length to get to the waterway (assumed equal to canal length) is estimated by multiplying an additional unit cost-per-ft times the canal length. This added length cost is added to the non-canal facility total cost.

To simplify the cost estimation approach, a unit pipe/support structure cost ($/inch-diameter/ft-length) was developed based on the unit cost of a 12-inch reinforced fiberglass pipe at $70/ft installed (RS Means 2001) and the use of wood piles at 10-foot intervals as the support structure. Piling costs assume that the average pile length is 15 feet and unit cost for installed piles is $15.80/ft (RS Means 2001). The unit costs already include the indirect costs for contractor overhead and profit. Additional costs include 10% for engineering, 10% for contingency and allowance, and 10% for sitework. Sitework costs are intended to cover preparation and restoration of the work area adjacent to the flume. Based on these cost applied to an assumed 300-foot flume, a unit cost of $10.15/in diameter/ft was derived. Flume costs for the specific total screen widths were then derived based on a calculated flume diameter (using the assumed flow volume of 60 gpm/ft, the 1.5-feet per second velocity when full) times the unit cost and the length.

EPA was initially concerned whether there would be enough vertical head available to provide the needed gradient, particularly for the longer applications. In a typical application, the upstream end of the flume is located above the intake deck and the water flows down the flume to the water surface below. A vendor cited a minimum gradient requirement in the range of 0.001 to 0.005 ft drop/ft length. For a 300-foot pipe, the needed vertical head based on these gradients is only 0.3 feet to 1.5 feet. The longest example fish return length identified by EPA was 4,600 feet at the Brunswick plant in South Carolina. The head needed for that return, based on the above minimum gradient range, is 4.6 feet to 23 feet. Based on median values from the industry questionnaire database, in which it was found that intake decks are often about half the intake water depth above the water surface, EPA has concluded that, in most cases, there was more than enough gradient available. Indeed, the data suggest if the return length is too short, there may be a potential problem from too great a gradient producing vebcities that could injure fish.

Exhibit 3-24 presents the added spray water pumps costs, 300-foot flume costs and the unit cost for additional flume length above 300 feet. Note that a feasibility study for the Drayton Point power plant cited an estimated flume unit cost of $100/ft, which does not include indirect costs, but is still well below comparable costs shown in Exhibit 3-24.

Exhibit 3-24. Spray Pump and Flume Costs

Total Screen Width (ft)	2	5	10	20	30	40	50	60	70	84	98	112	126	140
Fish Spray Flow at 30 gpm/ft (gpm)	60	150	300	600	900	1200	1500	1800	2100	2520	2940	3360	3780	4200
Pump Costs	$3,400	$3,900	$4,400	$5,500	$6,700	$8,100	$9,500	$11,100	$12,800	$15,300	$18,000	$21,000	$24,100	$27,500
Total Wash Flow at 60 gpm/ft (gpm)	120	300	600	1200	1800	2400	3000	3600	4200	5040	5880	6720	7560	8400
Pipe Dia at 1.5 fps (In)	6.0	8.0	12.0	16.0	20.0	23.0	25.0	28.0	30.0	33.0	35.0	38.0	40.0	42.0
Flume Costs at $10.15	$18,272	$24,362	$36,543	$48,724	$60,905	$70,041	$76,131	$85,267	$91,358	$100,493	$106,584	$115,720	$121,810	$127,901
Flume Cost per Ft Added	$61	$81	$122	$162	$203	$233	$254	$284	$305	$335	$355	$386	$406	$426

Total Capital Costs

Indirect costs such as engineering, contractor overhead and profit, and contingency and allowance have been included in the individual component costs as they apply. Exhibit 3-25 through 3-30 present the total capital costs for compliance scenarios A, B, and C for both freshwater and saltwater environments. These costs are then plotted in Figures 3-18 through 3-23, which also include the best-fit, second-order equations of the data. These equations are used in the estimation of capital costs for the various technology applications.

Exhibit 3-25. Total Capital Costs for Scenario A - Adding Fine Mesh without Fish Handling - Freshwater Environments

Total Width	2	5	10	20	30	40	50	60	70	84	98	112	126	140
Well Depth	One 2 ft	One 5 ft	One 10 ft	Two 10 ft	Three 10 ft	Four 10 ft	Five 10 ft	Six 10 ft	Five 14 ft	Six 14 ft	Seven 14 ft	Eight 14 ft	Nine 14 ft	Ten 14 ft
10'-0	$7,989	$9,079	$11,853	$23,706	$35,559	$47,412	$59,265	$71,117	$81,865	$98,237	$114,610	$143,806	$147,356	$163,729
25'-0	$11,162	$12,932	$17,952	$35,905	$53,857	$71,810	$89,762	$107,714	$134,162	$160,994	$187,827	$242,278	$241,492	$268,324
50'-0	$17,707	$20,977	$30,295	$60,590	$90,885	$121,180	$151,475	$181,769	$206,825	$248,189	$289,554	$383,198	$372,284	$413,649
75'-0	$24,262	$29,302	$40,467	$80,935	$121,402	$161,870	$202,337	$242,804	$273,987	$328,784	$383,582	$515,318	$493,177	$547,974
100'-0	$32,997	$37,627	$50,630	$101,260	$151,890	$202,520	$253,150	$303,779	$338,450	$406,139	$473,829	$643,118	$609,209	$676,899

Exhibit 3-26. Total Capital Costs for Scenario A - Adding Fine Mesh without Fish Handling - Saltwater Environments

Total Width	2	5	10	20	30	40	50	60	70	84	98	112	126	140
Well Depth	One 2 ft	One 5 ft	One 10 ft	Two 10 ft	Three 10 ft	Four 10 ft	Five 10 ft	Six 10 ft	Five 14 ft	Six 14 ft	Seven 14 ft	Eight 14 ft	Nine 14 ft	Ten 14 ft
10'-0	$14,909	$17,089	$22,103	$44,206	$66,309	$88,412	$110,515	$132,617	$155,715	$186,857	$218,000	$249,143	$280,286	$311,429
25'-0	$20,022	$23,562	$32,452	$64,905	$97,357	$129,810	$162,262	$194,714	$251,062	$301,274	$351,487	$401,699	$451,912	$502,124
50'-0	$31,057	$37,597	$54,055	$108,110	$162,165	$216,220	$270,275	$324,329	$380,975	$457,169	$533,364	$609,559	$685,754	$761,949
75'-0	$42,112	$52,192	$71,317	$142,635	$213,952	$285,270	$356,587	$427,904	$499,887	$599,864	$699,842	$799,819	$899,797	$999,774
100'-0	$57,527	$66,787	$88,560	$177,120	$265,680	$354,240	$442,800	$531,359	$613,400	$736,079	$858,759	$981,439	$1,104,119	$1,226,799

Exhibit 3-27. Total Capital Costs for Scenario B - Adding Fish Handling and Return - Freshwater Environments

Total Width	2	5	10	20	30	40	50	60	70	84	98	112	126	140
Well Depth (	One 2 ft	One 5 ft	One 10 ft	Two 10 ft	Three 10 ft	Four 10 ft	Five 10 ft	Six 10 ft	Five 14 ft	Six 14 ft	Seven 14 ft	Eight 14 ft	Nine 14 ft	Ten 14 ft
10'-0	$105,872	$126,362	$164,443	$301,224	$438,105	$572,141	$703,131	$837,367	$967,658	$1,151,993	$1,333,484	$1,518,320	$1,700,210	$1,882,401
25'-0	$132,772	$161,562	$217,443	$407,224	$597,105	$784,141	$968,131	$1,155,367	$1,460,658	$1,743,593	$2,023,684	$2,307,120	$2,587,610	$2,868,401
50'-0	$185,172	$230,462	$320,543	$613,424	$906,405	$1,196,541	$1,483,631	$1,773,967	$2,095,658	$2,505,593	$2,912,684	$3,323,120	$3,730,610	$4,138,401
75'-0	$237,672	$302,162	$401,943	$776,224	$1,150,605	$1,522,141	$1,890,631	$2,262,367	$2,675,658	$3,201,593	$3,724,684	$4,251,120	$4,774,610	$5,298,401
100'-0	$311,972	$373,862	$483,243	$938,824	$1,394,505	$1,847,341	$2,297,131	$2,750,167	$3,228,658	$3,865,193	$4,498,884	$5,135,920	$5,770,010	$6,404,401

Exhibit 3-28. Total Capital Costs for Scenario B - Adding Fish Handling and Return - Saltwater Environments

Total Width	2	5	10	20	30	40	50	60	70	84	98	112	126	140
Well Depth (	One 2 ft	One 5 ft	One 10 ft	Two 10 ft	Three 10 ft	Four 10 ft	Five 10 ft	Six 10 ft	Five 14 ft	Six 14 ft	Seven 14 ft	Eight 14 ft	Nine 14 ft	Ten 14 ft
10'-0	$175,072	$206,462	$266,943	$506,224	$745,605	$982,141	$1,215,631	$1,452,367	$1,706,158	$2,038,193	$2,367,384	$2,699,920	$3,029,510	$3,359,401
25'-0	$221,372	$267,862	$362,443	$697,224	$1,032,105	$1,364,141	$1,693,131	$2,025,367	$2,629,658	$3,146,393	$3,660,284	$4,177,520	$4,691,810	$5,206,401
50'-0	$318,672	$396,662	$558,143	$1,088,624	$1,619,205	$2,146,941	$2,671,631	$3,199,567	$3,837,158	$4,595,393	$5,350,784	$6,109,520	$6,865,310	$7,621,401
75'-0	$416,172	$531,062	$710,443	$1,393,224	$2,076,105	$2,756,141	$3,433,131	$4,113,367	$4,934,658	$5,912,393	$6,887,284	$7,865,520	$8,840,810	$9,816,401
100'-0	$557,272	$665,462	$862,543	$1,697,424	$2,532,405	$3,364,541	$4,193,631	$5,025,967	$5,978,158	$7,164,593	$8,348,184	$9,535,120	$10,719,110	$11,903,401

Exhibit 3-29. Total Capital Costs for Scenario C - Adding Fine Mesh with Fish Handling and Return - Freshwater Environments

Total Width	2	5	10	20	30	40	50	60	70	84	98	112	126	140
Well Depth (	One 2 ft	One 5 ft	One 10 ft	Two 10 ft	Three 10 ft	Four 10 ft	Five 10 ft	Six 10 ft	Five 14 ft	Six 14 ft	Seven 14 ft	Eight 14 ft	Nine 14 ft	Ten 14 ft
10'-0	$112,772	$134,362	$174,743	$321,824	$469,005	$613,341	$754,631	$899,167	$1,041,658	$1,240,793	$1,437,084	$1,636,720	$1,833,410	$2,030,401
25'-0	$141,672	$172,162	$231,943	$436,224	$640,605	$842,141	$1,040,631	$1,242,367	$1,577,658	$1,883,993	$2,187,484	$2,494,320	$2,798,210	$3,102,401
50'-0	$198,572	$247,062	$344,343	$661,024	$977,805	$1,291,741	$1,602,631	$1,916,767	$2,269,658	$2,714,393	$3,156,284	$3,601,520	$4,043,810	$4,486,401
75'-0	$255,572	$325,062	$432,843	$838,024	$1,243,305	$1,645,741	$2,045,131	$2,447,767	$2,901,658	$3,472,793	$4,041,084	$4,612,720	$5,181,410	$5,750,401
100'-0	$336,472	$403,062	$521,143	$1,014,624	$1,508,205	$1,998,941	$2,486,631	$2,977,567	$3,503,658	$4,195,193	$4,883,884	$5,575,920	$6,265,010	$6,954,401

Exhibit 3-30. Total Capital Costs for Scenario C - Adding Fine Mesh with Fish Handling and Return - Saltwater Environments

Total Width	2	5	10	20	30	40	50	60	70	84	98	112	126	140
Well Depth (	One 2 ft	One 5 ft	One 10 ft	Two 10 ft	Three 10 ft	Four 10 ft	Five 10 ft	Six 10 ft	Five 14 ft	Six 14 ft	Seven 14 ft	Eight 14 ft	Nine 14 ft	Ten 14 ft
10'-0	$188,872	$222,462	$287,543	$547,424	$807,405	$1,064,541	$1,318,631	$1,575,967	$1,854,158	$2,215,793	$2,574,584	$2,936,720	$3,295,910	$3,655,401
25'-0	$239,172	$289,062	$391,443	$755,224	$1,119,105	$1,480,141	$1,838,131	$2,199,367	$2,863,658	$3,427,193	$3,987,884	$4,551,920	$5,113,010	$5,674,401
50'-0	$345,472	$429,862	$605,743	$1,183,824	$1,762,005	$2,337,341	$2,909,631	$3,485,167	$4,185,158	$5,012,993	$5,837,984	$6,666,320	$7,491,710	$8,317,401
75'-0	$451,972	$576,862	$772,243	$1,516,824	$2,261,505	$3,003,341	$3,742,131	$4,484,167	$5,386,658	$6,454,793	$7,520,084	$8,588,720	$9,654,410	$10,720,401
100'-0	$606,272	$723,862	$938,343	$1,849,024	$2,759,805	$3,667,741	$4,572,631	$5,480,767	$6,528,158	$7,824,593	$9,118,184	$10,415,120	$11,709,110	$13,003,401

Figure 3-18. Scenario A – Capital Cost – Add Fine Mesh Replacement Screen Panels - Freshwater

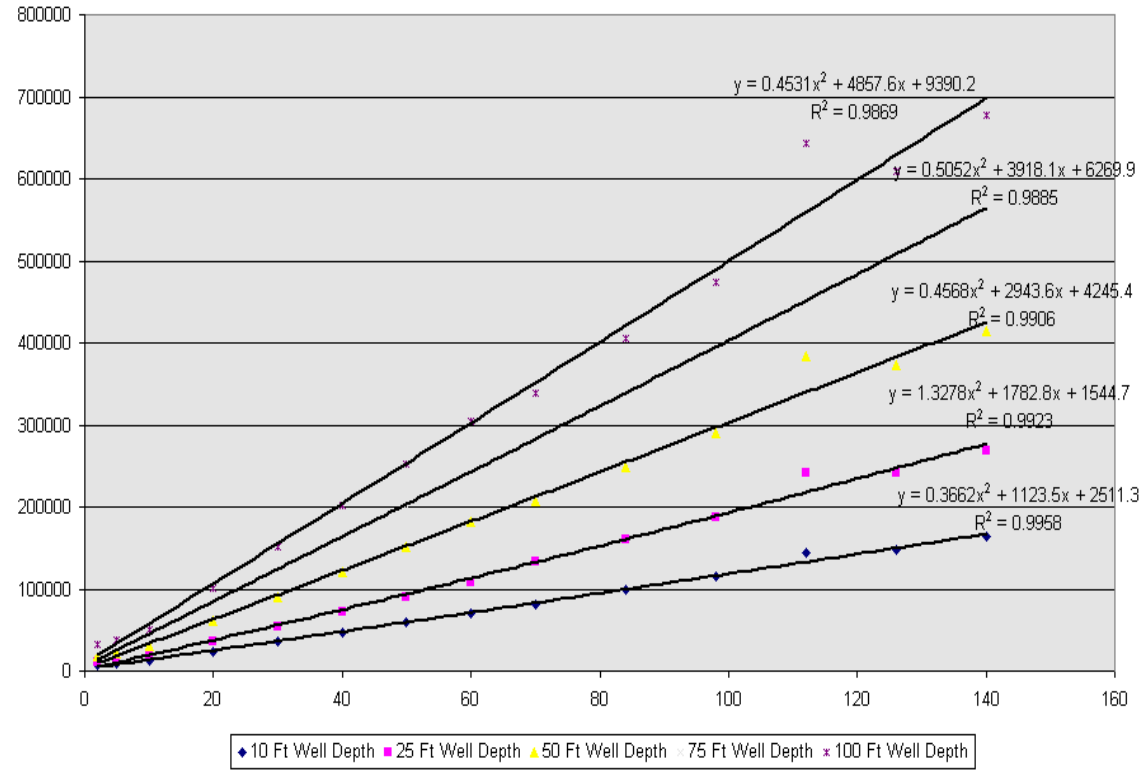


Figure 3-19. Scenario A – Capital Cost – Add Fine Mesh Replacement Screen Panels - Saltwater

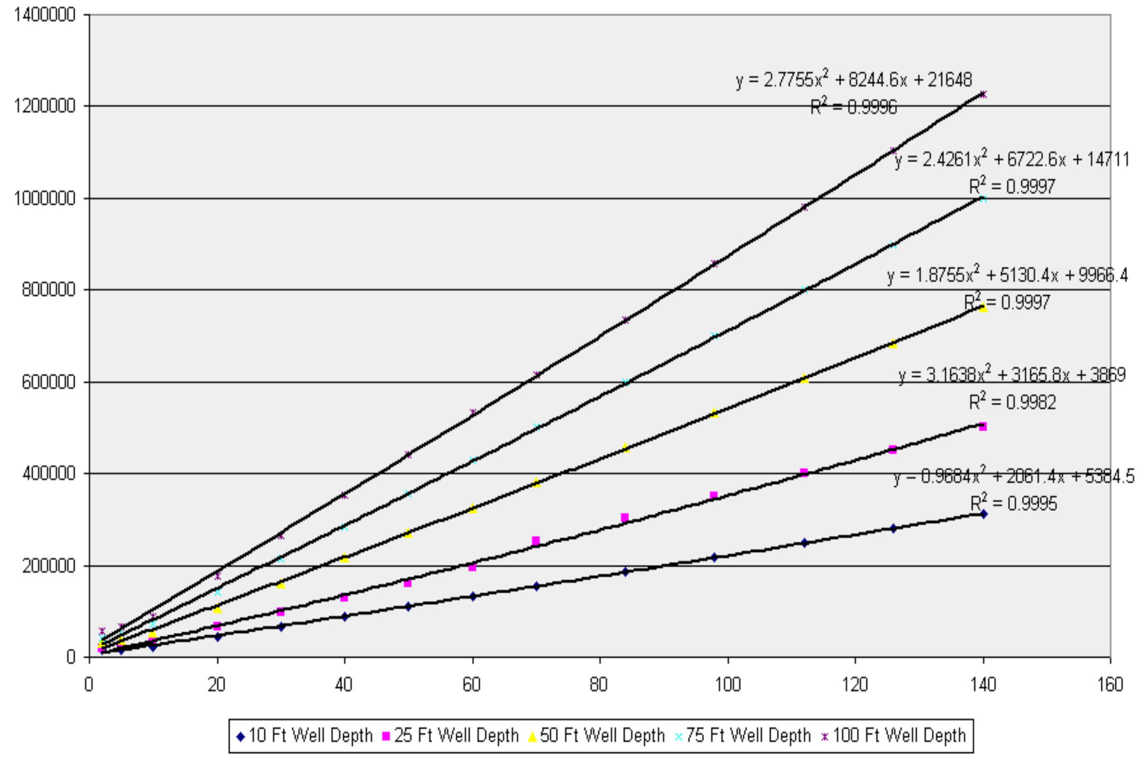


Figure 3-20. Scenario B – Capital Cost – Add Traveling Screen with Fish Handling and Return - Freshwater

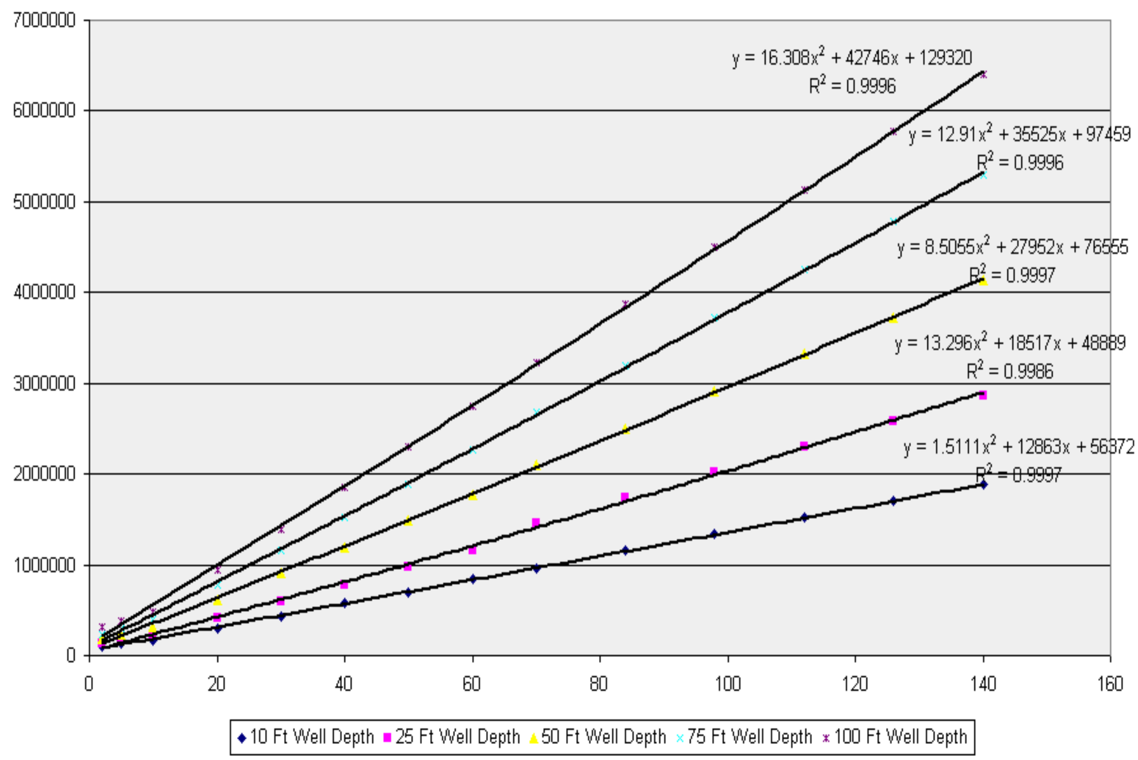


Figure 3-21. Scenario B – Capital Cost – Add Traveling Screen with Fish Handling and Return - Saltwater

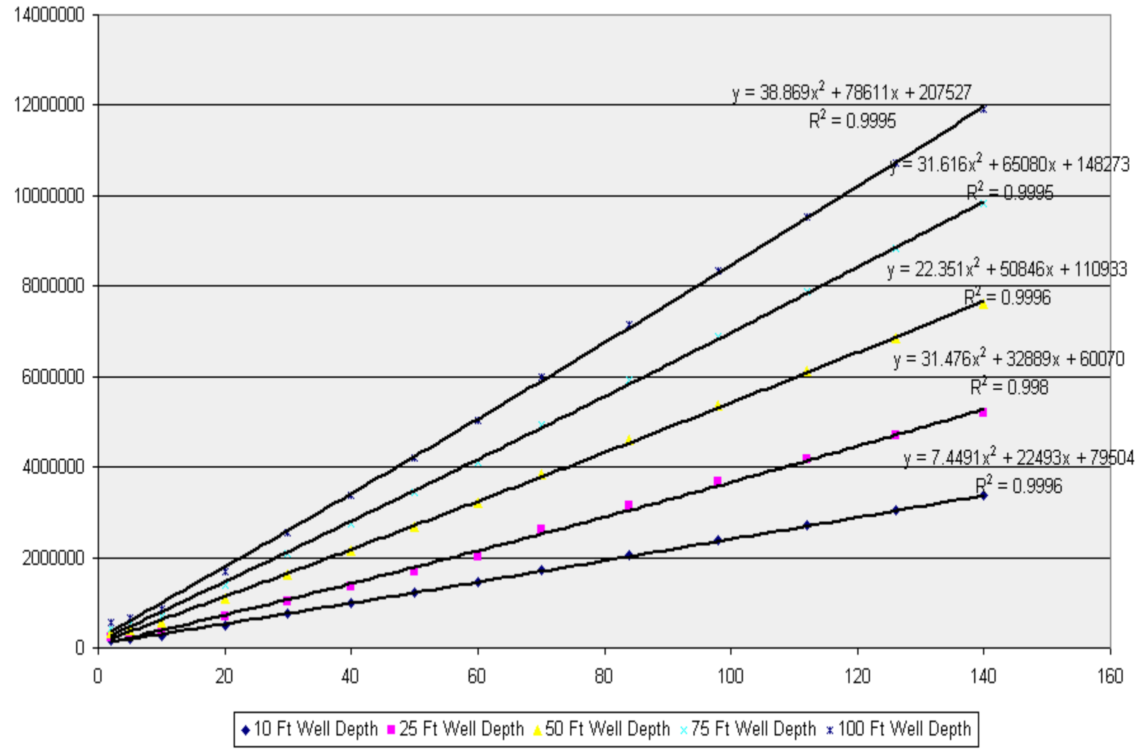


Figure 3-22. Scenario C – Capital Cost – Add Fine Mesh Traveling Screen with Fish Handling and Return - Saltwater

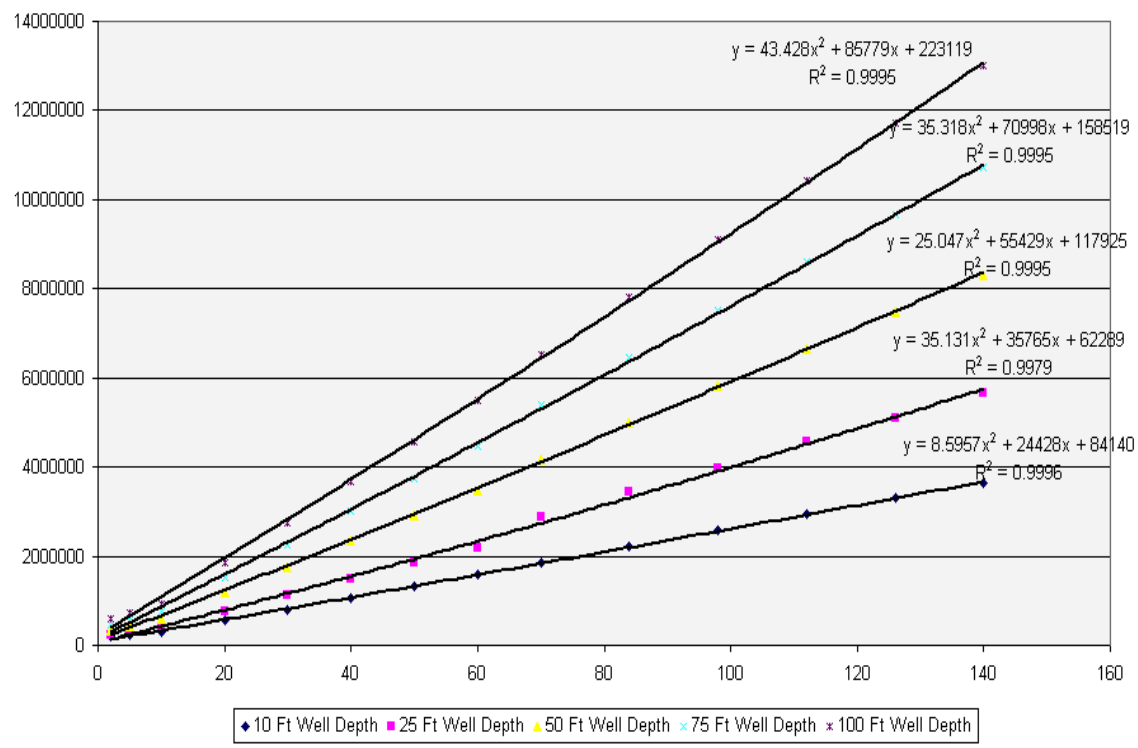
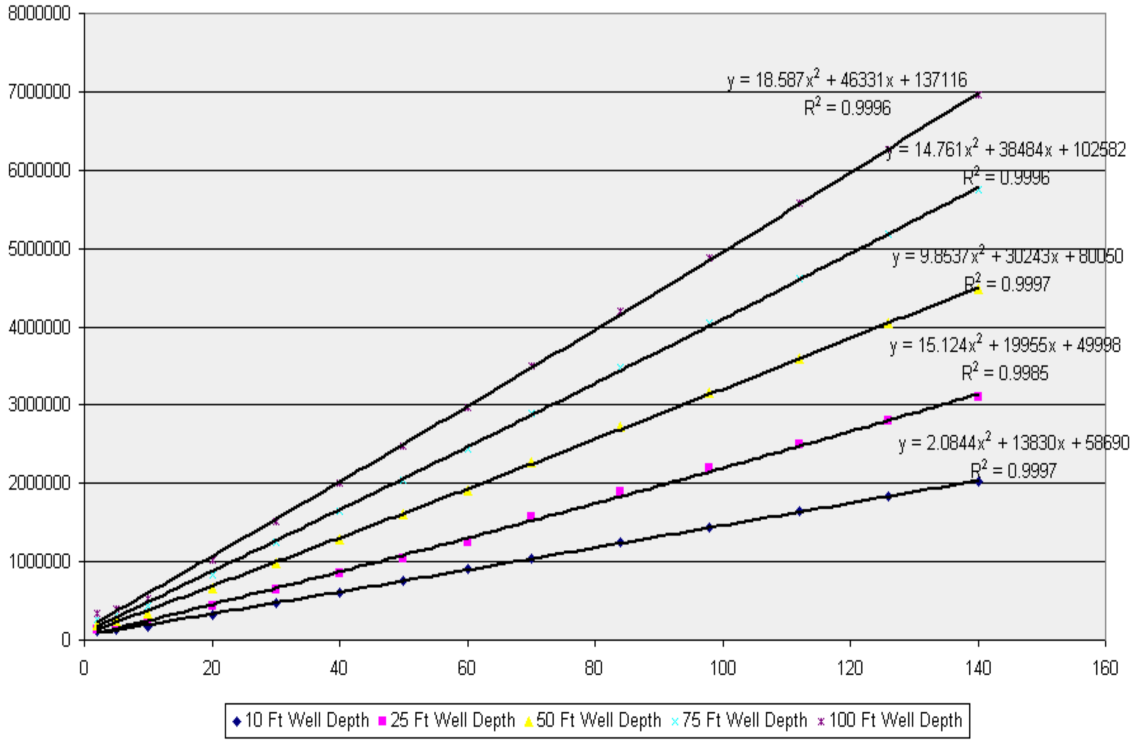


Figure 3-23. Scenario C – Capital Cost – Add Fine Mesh Traveling Screen with Fish Handling and Return - Freshwater



2.1.2 Downtime Requirements

Placement of the fine screen overlay panels (scenarios A and C) can be done while the screen is operating. The operations are stopped during the placement and the screens are rotated once between the placement of each panel. Installation of the ancillary equipment for the fish return system can be performed prior to screen replacement. Only the step of replacing the screen units would require shutdown of that portion of the intake. Vendors have reported that it would take from one to three days to replace traveling screen units where fish troughs and new spray piping are needed. The total time should take no more than two weeks for multiple screens (Gathright 2002). If necessary, facilities with multiple screens and pumps could operate at the reduced capacity associated with taking a single pump out of service. However, it would be more prudent to schedule the screen replacement during a scheduled maintenance shutdown, which typically occurs on an annual basis. Even at the largest installations with numerous screens, there should be sufficient time during the scheduled maintenance period to replace the screens and install controls and piping. Therefore, EPA is not including any monetary consideration for unit downtime associated with screen replacement or installation. Downtime for modification or addition to the intake structure to increase its size is discussed in a separate cost module.

2.1.3 O&M Cost Development

In general, O&M costs for intake system retrofit involve calculating the net difference between the existing system O&M costs and the new system O&M costs. The Phase I O&M cost estimates for traveling screens were generally derived as a percentage of the capital costs. This approach, however, does not lend itself well to estimating differences in operating costs for retrofits that involve similar equipment but have different operating and maintenance requirements such as changes in the duration of the screen operation. Therefore, a more detailed approach was developed.

The O&M costs developed here include only those components associated with traveling screens. Because cooling water flow rates are assumed not to change as a result of the retrofit, the O&M costs associated with the intake pumps are not considered. For traveling screens, the O&M costs are broken down into three components: labor, power requirements, and parts replacement. The basis and assumptions for each are described below.

Labor Requirements

The basis for estimating the total annual labor cost is based on labor hours as described below. In each baseline and compliance scenario the estimated number of hours is multiplied times a single hourly rate of $41.10/hour. This rate was derived by first estimating the hourly rate for a manager and a technician. The estimated management and technician rates were based on Bureau of Labor Statistics hourly rates for management and electrical equipment technicians. These rates were multiplied by factors that estimate the additional costs of other compensation (e.g., benefits) to yield estimates of the total labor costs to the employer. These rates were adjusted for inflation to represent June 2002 dollars (see Doley 2002 for details). The two labor category rates were combined into one compound rate using the assumption that 90% of the hours applied to the technicians and 10% to management. A 10% management component was considered as reasonable because the majority of the work involves physical labor, with managers providing oversight and coordination with the operation of the generating units.

A vendor provided general guidelines for estimating basic labor requirements for traveling screens as averaging 200 hours and ranging from 100 to 300 hours per year per screen for coarse mesh screens without fish handling and double that for fine mesh screens with fish handling (Gathright 2002). The lower end of the range corresponds to shallow narrow screens and the high end of the range corresponds to the widest deepest screens. Exhibits 3-31 and 3-32 present the estimated annual number of labor hours required to operate and maintain a "typical" traveling screen.

Exhibit 3-31. Basic Annual O&M Labor Hours for Coarse Mesh Traveling Screens Without Fish Handling

Well Depth	Basket Screening Panel Width			
feet	2	5	10	14
10	100	150	175	200
25	120	175	200	225
50	130	200	225	250
75	140	225	250	275
100	150	250	275	300

Exhibit 3-32. Basic Annual O&M Labor Hours for Traveling Screens With Fish Handling

Well Depth	Basket Screening Panel Width (Ft)			
feet	2	5	10	14
10	78	78	117	117
25	168	168	252	252
50	318	318	477	477
75	468	468	702	702
100	618	618	927	927

When fine mesh screens are added as part of a compliance option, they are included as a screen overlay. EPA has assumed when sensitive aquatic organisms are present these fine mesh screens will be in place. EPA also assumes during times when levels of troublesome debris are present, the facility will remove the fine mesh screen panels, leaving the coarse mesh screen panels in place. The labor assumptions for replacing the screen panels are described earlier, but in this application the placement and removal steps occur once each per year. Exhibit 3-33 presents the estimated annual labor hours for placement and removal of the fine mesh overlay screens.

Exhibit 3-33. Total Annual O&M Hours for Fine Mesh Overlay Screen Placement and Removal

Well Depth	Basket Screening Panel Width			
feet	2	5	10	14
10	78	78	117	117
25	168	168	252	252
50	318	318	477	477
75	468	468	702	702
100	618	618	927	927

Operating Power Requirement

Power is needed to operate the mechanical equipment, specifically the motor drives for the traveling screens and the pumps that deliver the spray water for both the debris wash and the fish spray.

Screen Drive Motor Power Requirement

Coarse mesh traveling screens without fish handling are typically operated on an intermittent basis. When debris loading is low, the screens may be operated several times per day for relatively short durations. Traveling screens with fish handling and return systems, however, must operate continuously if the fish return system is to function properly.

A vendor provided typical values for the horsepower rating for the drive motors for traveling screens, which are shown in Exhibit 3-34. These values were assumed to be similar for all the traveling screen combinations considered here. Different operating hours are assumed for screens with and without fish handling. This is due to the fact that screens with fish handling must be operated continuously. A vendor estimated that coarse mesh screens without fish handling are typically operated for a total of 4 to 6 hrs/day (Gathright 2002). The following assumptions apply:

- The system will be shut down for four weeks out of the year for routine maintenance
- For fine mesh, operating hours will be continuous (24 hrs/day)
- For coarse mesh, operating hours will be an average of 5 hours/day (range of 4 to 6)
- Electric motor efficiency of 90%
- Power cost of $0.04/kWh for power plants.

Exhibit 3-34. Screen Drive Motor Power Costs

				Power Costs - Fine Mesh			Power Costs - Coarse Mes[h]		
Screen Width	Well Depth	Motor Power	Electric Power	Operating Hours	Annual Power	Annual Power Costs at $/Kwh of	Operating Hours	Annual Power	Annual Power Costs at $/Kwh of
Ft	Ft	Hp	Kw		Kwh	$0.04		Kwh	$0.04
2	10	0.5	0.414	8,064	3,342	$134	1,680	696	$28
2	25	1	0.829	8,064	6,684	$267	1,680	1,393	$56
2	50	2.7	2.210	8,064	17,824	$713	1,680	3,713	$149
2	75	5	4.144	8,064	33,421	$1,337	1,680	6,963	$279
2	100	6.7	5.512	8,064	44,450	$1,778	1,680	9,260	$370
5	10	0.75	0.622	8,064	5,013	$201	1,680	1,044	$42
5	25	1.5	1.243	8,064	10,026	$401	1,680	2,089	$84
5	50	4	3.316	8,064	26,737	$1,069	1,680	5,570	$223
5	75	7.5	6.217	8,064	50,131	$2,005	1,680	10,444	$418
5	100	10.0	8.268	8,064	66,674	$2,667	1,680	13,891	$556
10	10	1	0.829	8,064	6,684	$267	1,680	1,393	$56
10	25	3.5	2.901	8,064	23,395	$936	1,680	4,874	$195
10	50	10	8.289	8,064	66,842	$2,674	1,680	13,925	$557
10	75	15	12.433	8,064	100,262	$4,010	1,680	20,888	$836
10	100	20.0	16.536	8,064	133,349	$5,334	1,680	27,781	$1,111
14	10	2	1.658	8,064	13,368	$535	1,680	2,785	$111
14	25	6.25	5.181	8,064	41,776	$1,671	1,680	8,703	$348
14	50	15	12.433	8,064	100,262	$4,010	1,680	20,888	$836
14	75	20	16.578	8,064	133,683	$5,347	1,680	27,851	$1,114
14	75	26.6	22.048	8,064	177,799	$7,112	1,680	37,041	$1,482

Wash Water and Fish Spray Pump Power Requirement

As noted previously, spray water is needed for both washing debris off of the screens (which occurs at all traveling screens) and for a fish spray (which is needed for screens with fish handling and return systems). The nozzle pressure for the debris spray can range from 80 to 120 pounds per square inch (psi). A value of 120 psi was chosen as a high value, which would include any static pressure component. The following assumptions apply:

- Spray water pumps operate for the same duration as the traveling screen drive motors
- Debris wash requires 30 gpm/ft screen length
- Fish spray requires 30 gpm/ft screen length
- Pumping pressure is 120 psi (277 ft of water) for both
- Combined pump and motor efficiency is 70%
- Electricity cost is $0.04/kWh for power plants.

The pressure needed for fish spray is considerably less than that required for debris, but it is assumed that all wash water is pumped to the higher pressure and regulators are used to step down the pressure for the fish wash. Exhibits 3-35 and 3-36 present the power costs for the spray water for traveling screens without and with fish handling, respectively. Spray water requirements depend on the presence of a fish return system but are assumed to otherwise be the same regardless of the screen mesh size.

Exhibit 3-35. Wash Water Power Costs Traveling Screens Without Fish Handling

						Fine Mesh			Coarse Mesh		
Screen Width	Flow Rate	Total Head	Hydraulic-Hp	Brake-Hp	Power Requirement	Annual Hours	Annual Power	Total Costs at $/Kwh of	Annual Hours	Annual Power	Total Costs at $/Kwh of
ft	gpm	ft	Hp	Hp	Kw	hr	Kwh	$0.04	hr	Kwh	$0.04
2	60	277	4.20	6.0	4.5	8064	36,072	$1,443	1680	7,515	$301
5	150	277	10.49	15.0	11.2	8064	90,179	$3,607	1680	18787	$751
10	300	277.1	20.98	30.0	22.4	8064	180,359	$7,214	1680	37575	$1,503
14	420	277	29.37	42.0	31.3	8064	252,502	$10,100	1680	52605	$2,104

Exhibit 3-36. Wash Water and Fish Spray Power Costs Traveling Screens With Fish Handling

						Fine Mesh			Coarse Mesh		
Screen Width	Flow Rate	Total Head	Hydraulic-Hp	Brake-Hp	Power Requirement	Annual Hours	Annual Power	Total Costs at $/Kwh of	Annual Hours	Annual Power	Total Costs at $/Kwh of
ft	gpm	ft	Hp	Hp	Kw	hr	Kwh	$0.04	hr	Kwh	$0.04
2	120	277	8.39	12.0	8.9	8064	72,143	$2,886	1680	15,030	$601
5	300	277	20.98	30.0	22.4	8064	180,359	$7,214	1680	37575	$1,503
10	600	277	41.97	60.0	44.7	8064	360,717	$14,429	1680	75149	$3,006
14	840	277	58.76	83.9	62.6	8064	505,004	$20,200	1680	105209	$4,208

Parts Replacement

A vendor estimated that the cost of parts replacement for coarse mesh traveling screens without fish handling would be approximately 15% of the equipment costs every 5 years (Gathright 2002). For traveling screens with fish handling, the same 15% would be replaced every 2.5 years. EPA has assumed for all screens that the annual parts replacement costs would be 6% of the equipment costs for those operating continuously and 3% for those operating intermittently. These factors are applied to the equipment costs in Exhibits 3-20 and 3-21. Traveling screens without fish handling (coarse mesh) operate fewer hours (estimated at 5 hrs/day) and should therefore experience less wear on the equipment. While the time of operation is nearly five times longer for continuous operation, the screen speed used is generally lower for continuous operation. Therefore, the wear and tear, hence O&M costs, are not directly proportional.

Baseline and Compliance O&M Scenarios

Exhibit 3-37 presents the six baseline and compliance O&M scenario cost combinations developed by EPA.

For the few baseline operations with fine mesh, nearly all had fish returns and/or low screen velocities, indicating that such facilities will likely not require compliance action. Thus, there is no baseline cost scenario for traveling screens with fine mesh without fish handling and return. Exhibits 3-38 through 3-43 present the O&M costs for the cost scenarios shown in Exhibit 3-37. Figures 3-24 through 3-29 present the graphic plots of the O&M costs shown in these tables with best-fit, second-order equations of the plots. These equations are used in the estimation of O&M costs for the various technology applications.

Exhibit 3-37. Mix of O&M Cost Components for Various Scenarios

	Baseline Without Fish Handling	**Baseline Without Fish Handling**	**Baseline with Fish Handling & Scenario B Compliance**	**Baseline with Fish Handling & Scenario B Compliance**	**Scenario A & C Compliance**	**Scenario A & C Compliance**
Mesh Type	Coarse	Coarse	Coarse or Smooth Top	Coarse or Smooth Top	Smooth Top & Fine	Smooth Top & Fine
Fish Handling	None	None	Yes	Yes	Yes	Yes
Water Type	Freshwater	Saltwater	Freshwater	Saltwater	Freshwater	Saltwater
Screen Operation	5 hrs/day	5 hrs/day	Continuous	Continuous	Continuous	Continuous

Basic Labor	100-300 hrs	100-300 hrs	200-600 hrs	200-600 hrs	200-600 hrs	200-600 hrs
Screen Overlay Labor	None	None	None	None	Yes	Yes
Screen Motor Power	5 hrs/day	5 hrs/day	Continuous	Continuous	Continuous	Continuous
Debris Spray Pump Power	5 hrs/day	5 hrs/day	Continuous	Continuous	Continuous	Continuous
Fish Spray Pump Power	None	None	Continuous	Continuous	Continuous	Continuous
Parts Replacement - % Equipment Costs	3%	3%	6%	6%	6%	6%

Exhibit 3-38. Baseline O&M Costs for Traveling Screens without Fish Handling - Freshwater Environments

Total Width	2	5	10	20	30	40	50	60	70	84	98	112	126	140
Well Depth (Ft)	One 2 ft	One 5 ft	One 10 ft	Two 10 ft	Three 10 ft	Four 10 ft	Five 10 ft	Six 10 ft	Five 14 ft	Six 14 ft	Seven 14 ft	Eight 14 ft	Nine 14 ft	Ten 14 ft
10	$5,419	$8,103	$10,223	$20,445	$30,668	$40,891	$51,113	$61,336	$62,805	$75,367	$87,928	$100,489	$113,050	$125,611
25	$6,433	$9,499	$11,880	$23,760	$35,640	$47,520	$59,400	$71,280	$75,667	$90,800	$105,933	$121,067	$136,200	$151,333
50	$7,591	$11,483	$14,741	$29,482	$44,223	$58,964	$73,705	$88,446	$89,781	$107,737	$125,693	$143,650	$161,606	$179,562
75	$8,786	$13,687	$16,865	$33,729	$50,594	$67,458	$84,323	$101,187	$101,216	$121,459	$141,702	$161,946	$182,189	$202,432
100	$10,597	$15,833	$18,985	$37,970	$56,956	$75,941	$94,926	$113,911	$112,279	$134,735	$157,191	$179,647	$202,103	$224,558

Exhibit 3-39. Baseline O&M Costs for Traveling Screens without Fish Handling - Saltwater Environments

Total Width	2	5	10	20	30	40	50	60	70	84	98	112	126	140
Well Depth (Ft)	One 2 ft	One 5 ft	One 10 ft	Two 10 ft	Three 10 ft	Four 10 ft	Five 10 ft	Six 10 ft	Five 14 ft	Six 14 ft	Seven 14	Eight 14 ft	Nine 14 ft	Ten 14 ft
10	$6,400	$9,247	$11,694	$23,388	$35,083	$46,777	$58,471	$70,165	$73,433	$88,120	$102,806	$117,493	$132,179	$146,866
25	$7,577	$10,971	$13,842	$27,684	$41,526	$55,368	$69,210	$83,052	$92,834	$111,401	$129,968	$148,535	$167,101	$185,668
50	$9,389	$13,772	$18,175	$36,349	$54,524	$72,698	$90,873	$109,047	$113,498	$136,186	$158,884	$181,582	$204,279	$226,977
75	$11,238	$16,957	$21,116	$42,231	$63,347	$84,462	$105,578	$126,693	$129,829	$155,794	$181,760	$207,726	$233,691	$259,657
100	$14,357	$20,084	$24,054	$48,107	$72,161	$96,215	$120,269	$144,322	$144,979	$173,975	$202,971	$231,967	$260,963	$289,958

Exhibit 3-40. Baseline & Scenario B Compliance O&M Totals for Traveling Screens with Fish Handling - Freshwater Environments

Total Width	2	5	10	20	30	40	50	60	70	84	98	112	126	140
Well Depth (Ft)	One 2 ft	One 5 ft	One 10 ft	Two 10 ft	Three 10 ft	Four 10 ft	Five 10 ft	Six 10 ft	Five 14 ft	Six 14 ft	Seven 14 ft	Eight 14 ft	Nine 14 ft	Ten 14 ft
10	$15,391	$24,551	$35,231	$70,462	$105,693	$140,924	$176,155	$211,386	$230,185	$276,221	$322,258	$368,295	$414,332	$460,369
25	$18,333	$28,378	$40,504	$81,009	$121,513	$162,018	$202,522	$243,027	$271,971	$326,365	$380,759	$435,154	$489,548	$543,942
50	$22,295	$34,696	$49,853	$99,707	$149,560	$199,413	$249,267	$299,120	$328,293	$393,952	$459,611	$525,269	$590,928	$656,587
75	$26,441	$41,449	$57,499	$114,998	$172,498	$229,997	$287,496	$344,995	$376,302	$451,563	$526,823	$602,084	$677,344	$752,605
100	$31,712	$47,927	$65,126	$130,251	$195,377	$260,503	$325,628	$390,754	$424,831	$509,797	$594,763	$679,729	$764,695	$849,661

Exhibit 3-41. Baseline & Scenario B Compliance O&M Totals for Traveling Screens with Fish Handling - Saltwater Environments

Total Width	2	5	10	20	30	40	50	60	70	84	98	112	126	140
Well Depth (Ft)	One 2 ft	One 5 ft	One 10 ft	Two 10 ft	Three 10 ft	Four 10 ft	Five 10 ft	Six 10 ft	Five 14 ft	Six 14 ft	Seven 14 ft	Eight 14 ft	Nine 14 ft	Ten 14 ft
10	$19,543	$29,357	$41,381	$82,762	$124,143	$165,524	$206,905	$248,286	$274,495	$329,393	$384,292	$439,191	$494,090	$548,989
25	$23,649	$34,756	$49,204	$98,409	$147,613	$196,818	$246,022	$295,227	$342,111	$410,533	$478,955	$547,378	$615,800	$684,222
50	$30,305	$44,668	$64,109	$128,219	$192,328	$256,437	$320,547	$384,656	$432,783	$519,340	$605,897	$692,453	$779,010	$865,567
75	$37,151	$55,183	$76,009	$152,018	$228,028	$304,037	$380,046	$456,055	$511,842	$614,211	$716,579	$818,948	$921,316	$1,023,685
100	$46,430	$65,423	$87,884	$175,767	$263,651	$351,535	$439,418	$527,302	$589,801	$707,761	$825,721	$943,681	$1,061,641	$1,179,601

Exhibit 3-42. Scenario A & C Compliance O&M Totals for Traveling Screens with Fish Handling - Freshwater Environments

Total Width	2	5	10	20	30	40	50	60	70	84	98	112	126	140
Well Depth (Ft)	One 2 ft	One 5 ft	One 10 ft	Two 10 ft	Three 10 ft	Four 10 ft	Five 10 ft	Six 10 ft	Five 14 ft	Six 14 ft	Seven 14 ft	Eight 14 ft	Nine 14 ft	Ten 14 ft
10	$17,529	$26,688	$38,437	$76,874	$115,311	$153,747	$192,184	$230,621	$246,214	$295,456	$344,699	$393,942	$443,184	$492,427
25	$22,936	$32,982	$47,409	$94,819	$142,228	$189,637	$237,046	$284,456	$306,495	$367,794	$429,093	$490,392	$551,691	$612,990
50	$31,008	$43,409	$62,923	$125,846	$188,769	$251,693	$314,616	$377,539	$393,642	$472,371	$551,099	$629,828	$708,556	$787,285
75	$39,264	$54,272	$76,734	$153,468	$230,202	$306,936	$383,670	$460,404	$472,476	$566,972	$661,467	$755,962	$850,458	$944,953
100	$48,645	$64,861	$90,525	$181,051	$271,576	$362,102	$452,627	$543,153	$551,830	$662,195	$772,561	$882,927	$993,293	$1,103,659

Exhibit 3-43. Scenario A & C Compliance O&M Totals for Traveling Screens with Fish Handling - Saltwater Environments

Total Width	2	5	10	20	30	40	50	60	70	84	98	112	126	140
Well Depth (Ft)	One 2 ft	One 5 ft	One 10 ft	Two 10 ft	Three 10 ft	Four 10 ft	Five 10 ft	Six 10 ft	Five 14 ft	Six 14 ft	Seven 14 ft	Eight 14 ft	Nine 14 ft	Ten 14 ft
10	$21,681	$31,494	$44,587	$89,174	$133,761	$178,347	$222,934	$267,521	$290,524	$348,628	$406,733	$464,838	$522,942	$581,047
25	$28,252	$39,360	$56,109	$112,219	$168,328	$224,437	$280,546	$336,656	$376,635	$451,962	$527,289	$602,616	$677,943	$753,270
50	$39,018	$53,381	$77,179	$154,358	$231,537	$308,717	$385,896	$463,075	$498,132	$597,759	$697,385	$797,012	$896,638	$996,265
75	$49,974	$68,006	$95,244	$190,488	$285,732	$380,976	$476,220	$571,464	$608,016	$729,620	$851,223	$972,826	$1,094,430	$1,216,033
100	$63,363	$82,357	$113,283	$226,567	$339,850	$453,134	$566,417	$679,701	$716,800	$860,159	$1,003,519	$1,146,879	$1,290,239	$1,433,599

Figure 3-24. Baseline O&M Costs for Traveling Screens without Fish Handling – Freshwater Environments

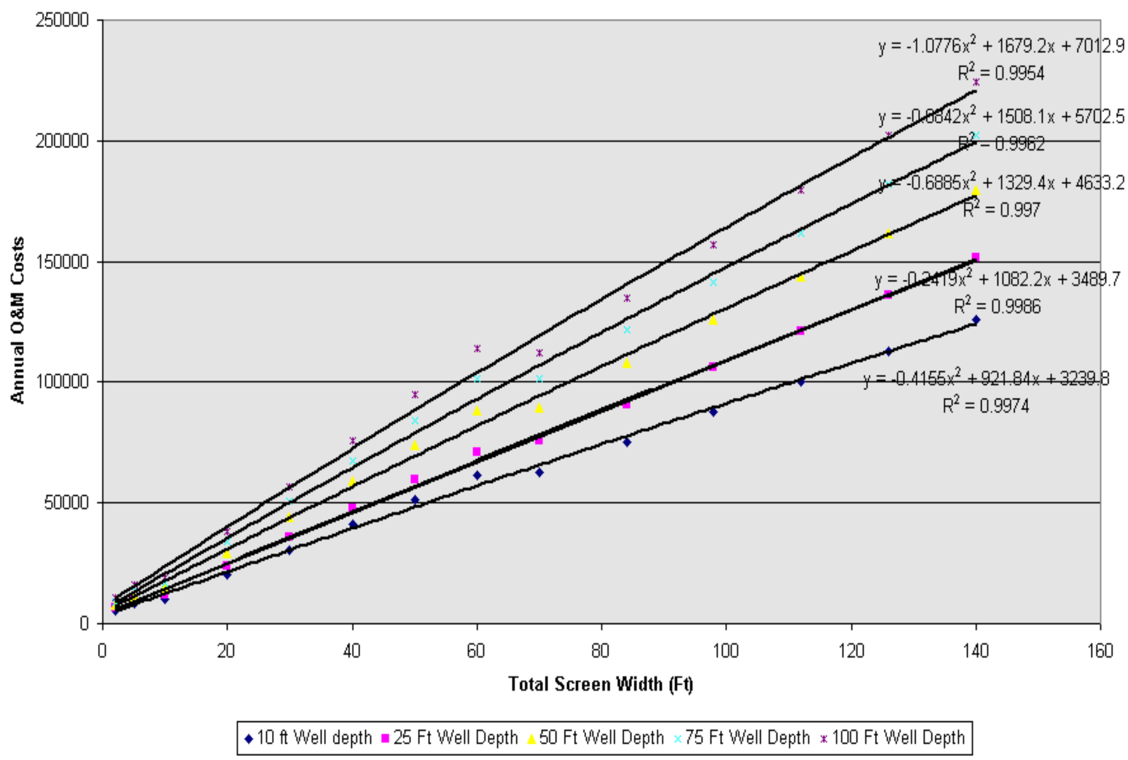


Figure 3-25. Baseline O&M Costs for Traveling Screens without Fish Handling – Saltwater Environments

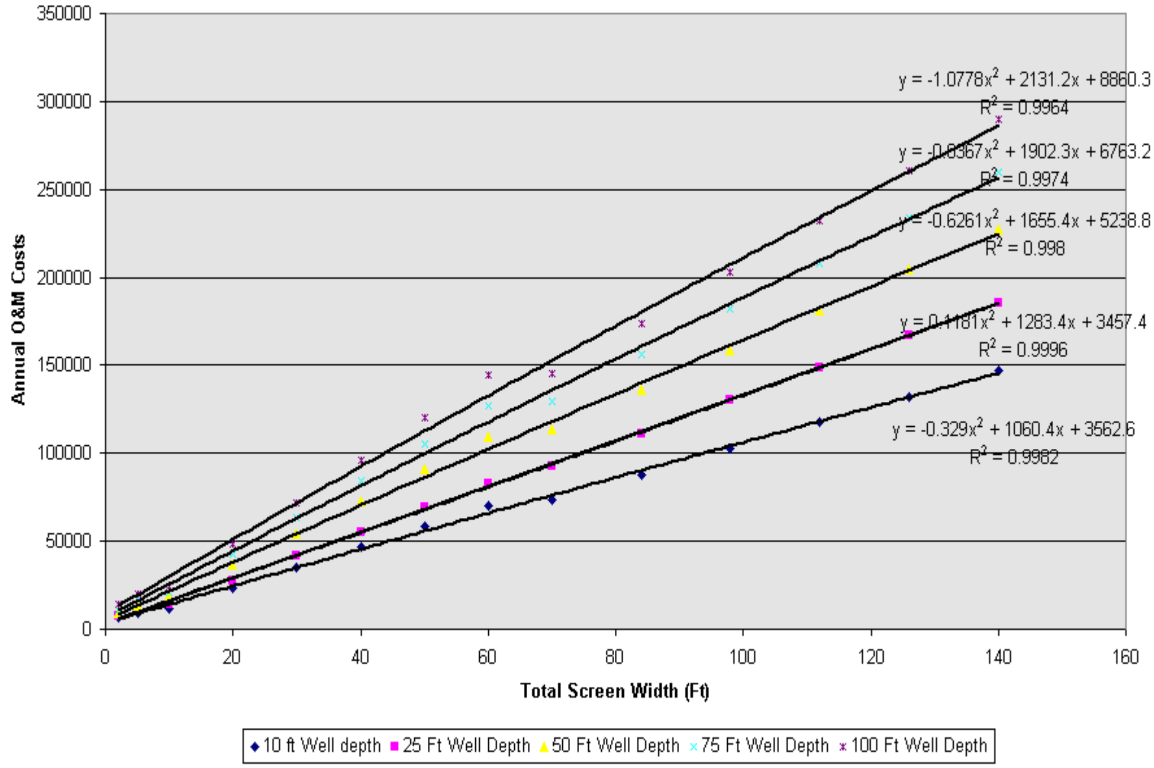


Figure 3-26. Scenarios A&C Compliance O&M Total Costs for Traveling Screens with Fish Handling - Freshwater Environments

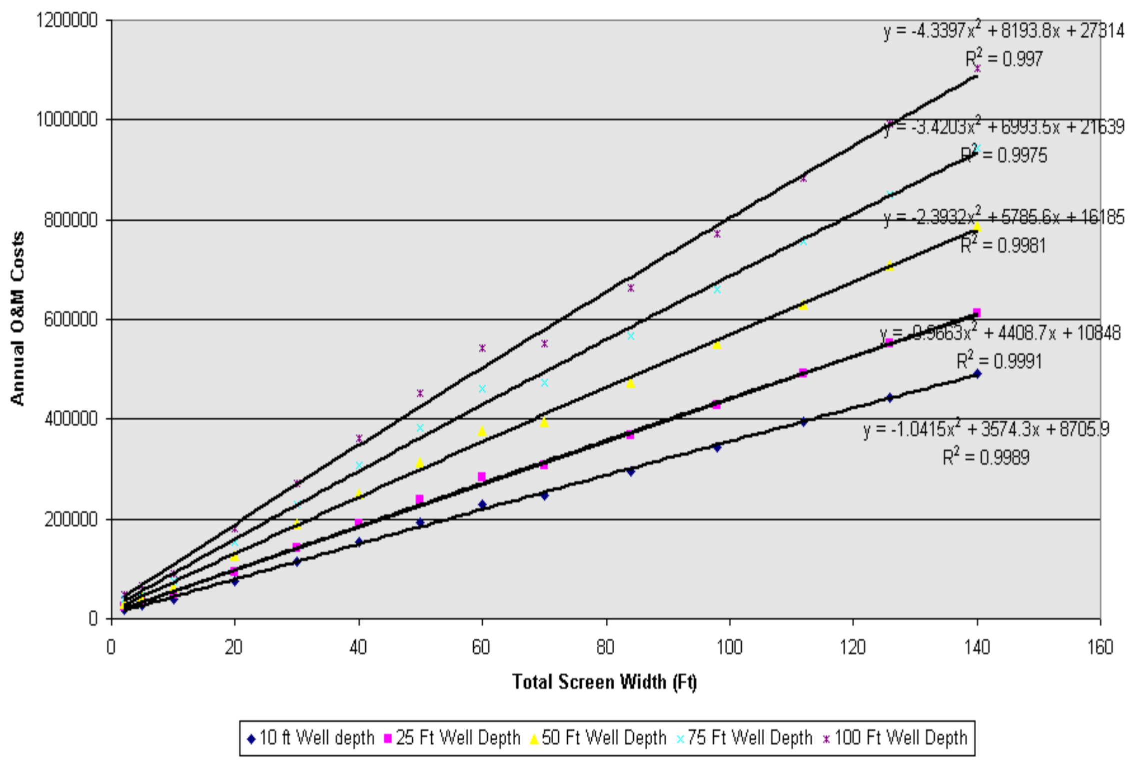


Figure 3-27. Scenarios A&C Compliance O&M Total Costs for Traveling Screens with Fish Handling – Saltwater Environments

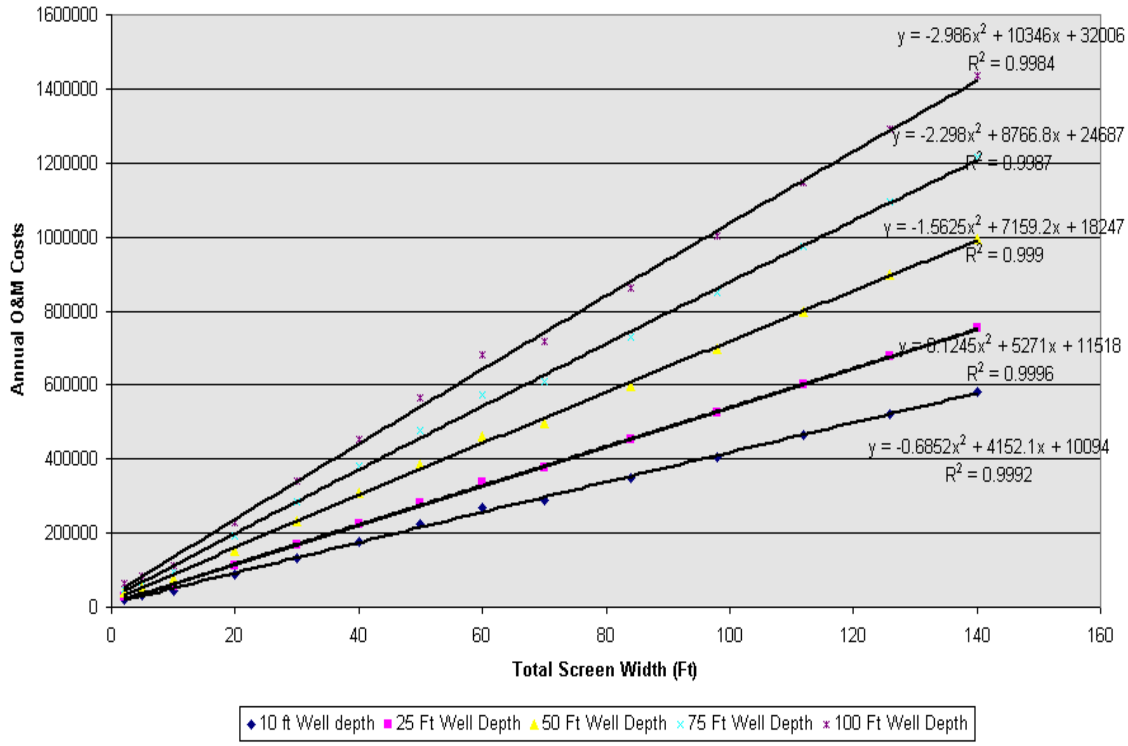


Figure 3-28. Baseline & Scenarios B Compliance O&M Total Costs for Traveling Screens with Fish Handling - Freshwater Environments

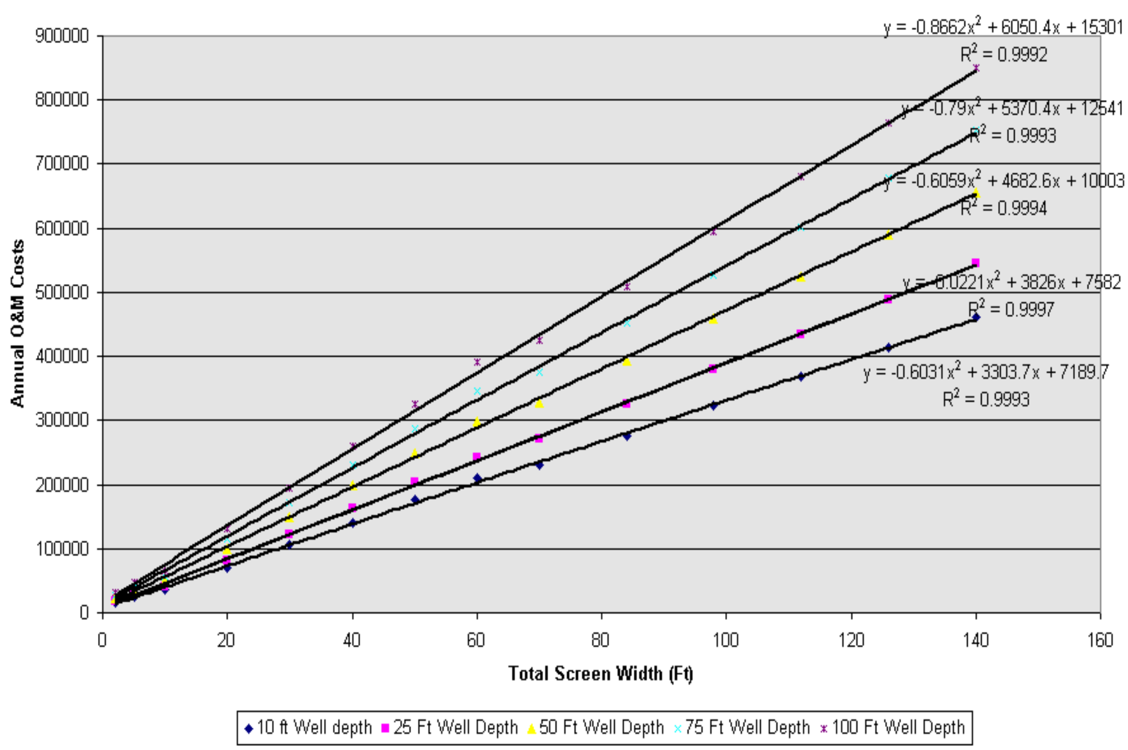
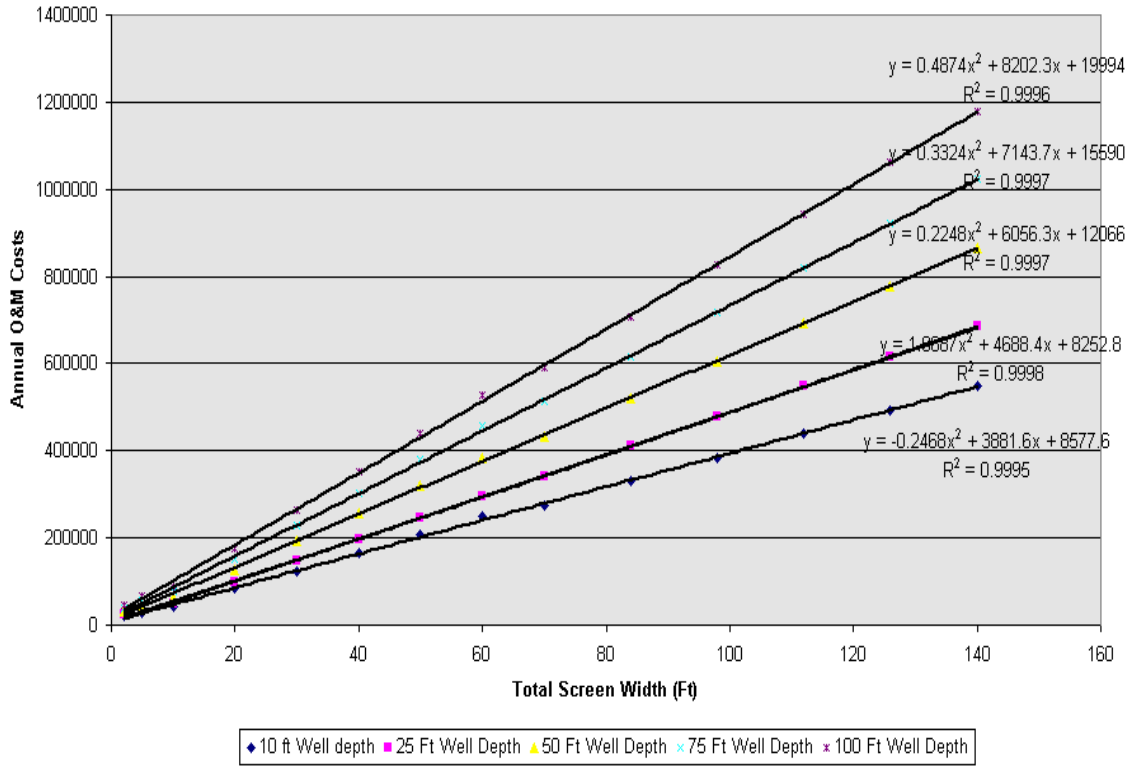


Figure 3-29. Baseline & Scenarios B Compliance O&M Total Costs for Traveling Screens with Fish Handling - Saltwater Environments



Baseline and Compliance O&M for Nuclear Facilities

Unlike the assumption for capital costs, the O&M costs for nuclear facilities consider the differences in the component costs. The power cost component is assumed to be the same. The equipment replacement cost component uses the same annual percentage of equipment cost factors, but is increased by the same factor as the capital costs. A Bureau of Labor Statistics document (BLS 2002) reported that the median annual earnings of a nuclear plant operator were $57,220 in 2002, compared to $46,090 for power plant operators in general. Thus, nuclear operators earnings were 24% higher than the industry average. No comparable data were available for maintenance personnel. This factor of 24% is used for estimating the increase in labor costs for nuclear facilities. This factor may be an overestimation; nuclear plant operators require a proportionally greater amount of training and the consequences of their actions engender greater overall risks than the power plant personnel. EPA recalculated the O&M costs using the revised equipment replacement and labor costs. EPA found that the ratio of non-nuclear to nuclear O&M costs did not vary much for each scenario and water depth. Therefore, EPA chose to use the factor derived from the average ratio (across total width values) of estimated nuclear facility O&M to non-nuclear facility O&M for each scenario and well depth to estimate the nuclear facility O&M costs. Exhibit 3-44 presents the cost factors to be used to estimate nuclear facility O&M costs for each cost scenario and well depth using the non-nuclear O&M values as the basis.

Exhibit 3-44. Nuclear Facility O&M Cost Factors

Well Dept	Baseline O&M Traveling Screens Without Fish Handli	Baseline O&M Traveling Screens Without Fish Handli	Baseline & Scenari B Compliance O&M Traveling Screens With Fish Handling	Baseline & Scenari B Compliance O&M Traveling Screens With Fish Handling	Scenario A & C Compliance O&M Traveling Screens With Fish Handling	Scenario A & C Compliance O&M Traveling Screens With Fish Handling
Ft	Freshwater	Saltwater	Freshwater	Saltwater	Freshwater	Saltwater
10	1.32	1.41	1.29	1.40	1.28	1.39
25	1.35	1.46	1.33	1.46	1.32	1.44
50	1.39	1.51	1.39	1.53	1.36	1.49
75	1.41	1.53	1.43	1.57	1.38	1.51
100	1.42	1.55	1.45	1.60	1.40	1.53

2.1.4 Double Entry-Single Exit (Dual-flow) Traveling Screens

Another option for replacing coarse mesh single entry-single exit (through-flow) traveling screens is to install double entry-single exit (dual-flow) traveling screens. Such screens are designed and installed to filter water continuously, using both upward and downward moving parts of the screen. The interior space between the upward and downward moving screen panels is closed off on one side (oriented in the upstream direction), while screened water exits towards the pump well through the open end on the other side.

One major advantage of dual-flow screens is that the direction of flow through the screen does not reverse as it does on the backside of a through-flow screen. As such, there is no opportunity for debris stuck on the screen to dislodge on the downstream side. In through-flow screens, debris that fails to dislodge as it passes the spray wash can become dislodged on the downstream side (essentially bypassing the screen). Such debris continues downstream where it can plug condenser tubes or require more frequent cleaning of fixed screens set downstream of the intake screen to prevent condenser tube plugging. Such maintenance typically requires the shut down of the generating units. Since dual-flow screens eliminate the opportunity for debris carryover, the spray water pressure requirements are reduced with dual-flow screens requiring a wash water spray pressure of 30 psi, compared to 80 to 120 psi, for through-flow screens (Gathright 2002). Dual-flow screens are oriented such that the screen face is parallel to the direction of flow. By extending the screen width forward (perpendicular to the flow) to a size greater than one half the screen well width, the total screen surface area of a dual-flow screen can exceed that of a through-flow screen in the same application. Therefore, if high through-screen velocities are affecting the survival of impinged organisms in existing through-flow screens, the retrofit of dual-flow screens may help alleviate this problem. The degree of through-screen velocity reduction will be dependent on the space constraints of the existing intake configuration. In new intake construction, dual-flow screens can be installed with no walls separating the screens.

Retrofitting existing intakes containing through-flow screens with dual-flow screens can be performed with little or minor modifications to the existing intake structure. In this application, the dual-flow screens are constructed such that the open outlet side will align with the previous location of the downstream side of the through-flow screen. The screen is constructed with supports that slide into the existing screen slots and with “gull wing” baffles that close off the area between the screen’s downstream end and the screen well walls. The baffles are curved to better direct the flow. For many existing screen structures, the opening where the screen passes through the intake deck (including the open space in front of the screen) is limited to a five-foot opening front to back, which limits the equivalent total overall per screen width to just under 10 ft for dual-flow retrofit screens. Because dual-flow screens filter on both sides, the effective width is twice that of one screen panel. However, as indicated by a vendor, in many instances the screen well opening can be extended forward by demolishing a portion of the concrete deck at the front end. The feasibility and extent of such a modification (such as maximum width of the retrofit screen) is dependent on specific design of the existing intake, particularly concerning the proximity of obstructions upstream of the existing screen units. Certainly, most through-flow screens of less than 10 ft widths could be retrofitted with dual-flow screens that result in greater effective screen widths. Those 10 ft wide or greater that have large deck openings and/or available space could also install dual-flow screens with greater effective screen widths.

Capital Cost for Dual-Flow Screens

A screen vendor provided general guidance for both capital and O&M costs for dual-flow screens (Gathright 2002). The cost of dual-flow screens with fish handling sized to fit in existing intake screen wells could be estimated using the following factors applied to the costs of a traveling screen with fish handling that fit the existing screen well:

- For a screen well depth of 0 to <20 ft add 15% to the cost of a similarly sized through-flow screen.
- For a screen well depth of 20 ft to <40 ft add 10% to the cost of a similarly sized through-flow screen.
- For a screen well depth of greater than 40 ft add 5% to the cost of a similarly sized through-flow screen.

Installation costs are assumed to be similar to that for through-flow screens. The above factors were applied to the total installed cost of similarly sized through-flow screens; however, an additional 5% was added to the above cost factors to account for modifications that may be necessary to accommodate the new dual-flow screens, such as demolition of a portion of the deck area. It is assumed that dual-flow screens can be installed in place of most through-flow screens but the benefit of lower through-screen velocities may be limited for larger width (e.g., 14-ft) existing screens. The dual-flow screens are assumed to include fine mesh overlays and fish return systems, so the cost factors are applied to the scenario C through-flow screens only. The costs for dual-flow screens are not presented here but can be derived by applying the factor shown in Exhibit 3-45 below.

Exhibit 3-45. Capital Cost Factors for Dual-Flow Screens

Screen Depth	Capital Cost Factor[1]
10 Ft	1.2
25 Ft	1.15
50 Ft	1.1
75 Ft	1.1

[1] Applied to capital costs for similarly sized through-flow screens derived from equations shown in Figures 3-22 and 3-23 (Scenario C freshwater and saltwater).

The capital costs for adding fine mesh overlays to existing dual-flow screens (scenario A) is assumed to be the same as for through-flow screens. This assumption is based on the fact that installation labor is based on the number of screen panels and should be the nearly the same and that the cost of the screen overlays themselves should be nearly the same. The higher equipment costs for dual-flow screens is mostly due to the equipment and equipment modifications located above the deck.

O&M Costs for Dual-Flow Screens

A vendor indicated that a significant benefit of dual-flow screens is reduced O&M costs compared to similarly sized through-flow screens. O&M labor was reported to be as low as one tenth that for similarly sized through-flow traveling screens (Bracket Green 2002). Also, wash water flow is nearly cut in half and the spray water pressure requirement drops from 80 to 120 psi to about 30 psi for through-flow screens. Examples were cited where dual-flow retrofits paid for themselves in a two to five year period. Using an assumption of 90% reduction in routine O&M labor combined with an estimated reduction of 70% in wash water energy requirements (based on combined reduction in flow and pressure), EPA calculated that the O&M costs for dual-flow screens would be equal approximately 30% of the O&M costs for similarly sized through-flow screens with fine mesh overlays and fish handling and return systems. O&M costs for dual-flow screens were calculated as 30% of the O&M costs for similarly sized through-flow screens derived from the equations shown in Figures 3-26 and 3-27 (scenario C, freshwater and saltwater).

The O&M costs for adding fine mesh overlays to existing dual-flow screens (scenario A) is assumed to be the same as the net difference between through-flow screens with fish handling with and without fine mesh overlays (net O&M costs for scenario A versus scenario B). The majority of the net O&M costs are for deployment and removal of the fine mesh overlays.

Downtime for Dual-Flow Screens

As with through-flow screens, dual-flow screens can be retrofitted with minimal generating unit downtime and can be scheduled to occur during routine maintenance downtime. While there may be some additional deck demolition work, this effort should add no more than one week to the two-week estimate for multiple through-flow screens described above.

Technology Application

Capital Costs

The cost scenarios included here assume that the existing intake structure is designed for and includes through-flow (single entry, single exit) traveling screens, either with or without fish handling and return. For those systems with different types of traveling screens or fixed screens, the cost estimates derived here may also be applied. However, they should be viewed as a rough estimate for a retrofit that would result in similar performance enhancement. The cost scenario applied to each facility is based on the compliance action required and whether or not a fish handling and return system is in place. For those facilities with acceptable through-screen velocities, no modification, other than described above, is considered necessary. For those with high through-screen velocities that would result in unacceptable performance, costs for modifications/additions to the existing intake are developed through another cost module. The costs for new screens to be installed in these new intake structures will be based on the design criteria of the new structure.

Capital costs are applied based on waterbody type, with costs for freshwater environments being applied to facilities in freshwater rivers/streams, lakes/reservoirs and the Great Lakes, and costs for saltwater environments being applied to facilities in estuaries/tidal rivers and oceans.

No distinction is being made here for freshwater environments with Zebra mussels. A vendor indicated that the mechanical movement and spray action of the traveling screens tend to prevent mussel attachment on the screens.

For facilities with intake canals, an added capital cost component for the additional length of the fish return flume (where applicable) is added. Where the canal length is not reported, the median canal length for other facilities with the same waterbody type is used.

O&M Costs

The compliance O&M costs are calculated as the net difference between the compliance scenario O&M costs and the baseline scenario O&M costs. For compliance scenarios that start with traveling screens where the traveling screens are then rendered unnecessary (e.g., relocating a shoreline intake to submerged offshore), the baseline scenario O&M costs presented here can be used to determine the net O&M cost difference for those technologies.

2.2 New Larger Intake Structure for Decreasing Intake Velocities

The efficacy of traveling screens can be affected by both through-screen and approach velocities. Through-screen velocity affects the rate of debris accumulation, the potential for entrainment and impingement of swimming organisms, and the amount of injury that may occur when organisms become impinged and a fish return system is in use. Performance, with respect to impingement and entrainment, generally tends to deteriorate as intake velocities increase. For older intake structures, the primary function of the screen was to ensure downstream cooling system components continued to function without becoming plugged with debris. The design often did not take into consideration the effect of through-screen velocity on entrainment and impingement of aquatic organisms. For these older structures, the standard design value for through-screen velocity was in the range of 2.0 to 2.5 feet per second (Gathright 2002). These design velocities were based on the performance of coarse mesh traveling screens with respect to their ability to remove debris as quickly as it collected on the screen surface. As demonstrated in the industry questionnaire database, actual velocities may be even higher than standard design values. These higher velocities may result from cost-saving, site-specific designs or from an increased withdrawal rate compared to the original design.

As described previously, solutions considered for reducing entrainment on traveling screens are to replace the coarse mesh screens with finer mesh screens or to install fine mesh screen overlays. However, a potential problem with replacing the existing intake screens with finer mesh screens is that a finer mesh will accumulate larger quantities of debris. Thus, retrofitting existing coarse mesh screens with fine mesh may affect the ability of screens to remove debris quickly enough to function properly. Exacerbating this potential problem is finer mesh may result in slightly higher through-screen velocities (Gathright 2002). If the debris problems associated with using fine mesh occur on a seasonal basis, then one possible solution (see section 2.1, above) is to use fine mesh overlays during the period when sensitive aquatic organisms are present. This solution is predicated on the assumption that the period of high debris loading does not substantially coincide with the period when sensitive aquatic organisms are most prevalent. When such an approach is not feasible, some means of decreasing the intake velocities may be necessary.

The primary intake attributes that determine intake through-screen velocities are the flow volume, effective screen area, and percent open area of the screen. The primary intake attributes that determine approach velocity are flow volume and cross-sectional area of the intake. In instances where flow volume cannot be reduced, a reduction in intake velocities can only be obtained in two ways: for through-screen velocities, an increased screen area and/or percent open area, or for approach velocity, an increased intake cross-sectional area. In general, there are practical limits regarding screen materials and percent open area. These limits prevent significant modification of this attribute to reduce through-screen velocities. Thus, an increase in the screen area and/or intake cross-sectional area generally must be accomplished to reduce intake velocities. Passive screen technology (such as T-screens) relies on lower screen velocities to improve performance with respect to impingement and entrainment and to reduce the rate of debris accumulation. For technology options that rely on the continued use of traveling screens, a means of increasing the effective area of the screens is warranted. EPA has researched this problem and has identified the following three approaches to increasing the screen size:

- Replace existing through flow (single entry-single exit) traveling screens with dual-flow (double entry-double exit) traveling screens. Dual-flow screens can be placed in the same screen well as existing through flow screens. However, they are oriented perpendicular to the orientation of the original through-flow screens and extend outward towards the front of the intake. Installation may require some demolition of the existing intake deck. This solution may work where screen velocities do not need to be reduced appreciably. This technology has a much-improved performance with respect to debris carry over and is often selected based on this attribute alone (Gathright 2002; see also section 2.1.4 above).
- Replace the function of the existing intake screen wells with larger wells constructed in front of the existing intake and hydraulically connected to the intake front opening. This approach retains the use and function of the existing intake pumps and pump wells with little or no modification to the original structure. A concern with this approach (besides construction costs) is whether the construction can be performed without significant downtime for the generating units.
- Add a new intake structure adjacent to, or in close proximity to, the existing intake. The old intake remains functional, but with the drive system for the existing pumps modified to reduce the flow rate. The new structure will include new pumps sized to pump an additional flow. The new structure can be built without a significant shutdown of the existing intake. Shutdown would only be required at the final construction step, where the pipes from new pumps are connected to the existing piping and the pumps and/or pump drives for the existing pumps are modified or replaced. In this case, generating downtime is minimized. However, the need for new pumps and modification to existing pumps that reduce their original flow, entail significant additional costs.

Option 3 is a seemingly simple solution where the addition of new intake bays adjacent or in close proximity to the existing intake would add to the total intake and screen cross-sectional area. A problem with this approach is that the current pumping capacity needs to be distributed between the old and new intake bays. Utilizing the existing pump wells and pumps is desirable to help minimize costs. However, where the existing pumps utilize single speed drives, the distribution of flow to the new intake bays would require either an upstream hydraulic connection or a pump system modification. Where the existing intake has only one or two pump wells a hydraulic connection with a new adjacent intake bay could be created through demolition of a sidewall downstream of the traveling screen. While this approach is certainly feasible in certain instances, the limitations regarding intake configurations prevents EPA from considering this a viable regulatory compliance alternative for all but a few existing systems. A more widely applicable solution would be to reduce pump flow rate of the existing pumps; either by modifying the pump drive to a multi-speed or variable speed drive system, or by replacing the existing pumps with smaller ones. The new intake bays would be constructed with new smaller pumps that produce lower flow rates. The combined flows of the new and older, modified pumps satisfy the existing intake flow requirement. The costs of modifying existing pumps, plus the new pumps and pump wells, represent a substantial cost component.

Option 2 does not require modifications or additions to the existing pumping equipment. In this approach a new intake structure to house more and/or larger screen wells would be constructed in front of the existing intake. The old and new intake structures could then be hydraulically connected by closing off the ends with sheet pile walls or similar structures. EPA is not aware of any installations that have performed this retrofit but it was proposed as an option in the Demonstration Study for the Salem Nuclear Plant (PSE&G 2001). In that proposal, the new screens were to be dual-flow screens, but the driving factor for the new structure was a need to increase the intake size.

EPA initially developed rough estimates of the comparative costs of applying option 2 versus option 3 (in the hypothetical case the intake area was doubled in size). The results indicated that adding a new screen well structure in front of the existing intake was less costly and therefore, this option was selected for consideration as a compliance technology option. This cost efficiency is primarily due to the reuse of the existing intake in a more cost efficient manner in option 2. However, option 2 has one important drawback; it may not be feasible where sufficient space is not available in front of the existing intake. To minimize construction downtime, EPA assumes the new intake structure is placed far enough in front of the existing intake to allow the existing intake to continue functioning until construction of the structure is completed. As a result of the need for sufficient space in front of the intake, the Agency has applied the technology in appropriate circumstances in developing model facility costs.

Scenario Description

In this scenario, modeled on option 2 described above, a new, reinforced concrete structure is designed for new through-flow or dual-flow intake screens. This structure will be built directly in front of the existing intake. The structure will be built inside a temporary sheet pile coffer dam. Upon completion of the concrete structure, the coffer dam will be removed. A permanent sheet pile wall will be installed at both ends, connecting the rear of the new structure to the front of the old intake structure hydraulically. Such a configuration has the advantage of providing for flow equalization between multiple new intake screens and multiple existing pumps. The construction includes costs for site development for equipment access. Capital costs were developed for the same set of screen widths (2 feet through 140 feet) and depths (10 feet through 100 feet) used in the traveling screen cost methodology. Best-fit, second-order equations were used to estimate costs for each different screen well depth, using total screen width as the independent variable. Construction duration is estimated to be nine months.

Capital Costs

Capital costs were derived for different well depths and total screen widths based on the following assumptions.

<u>Design Assumptions - On-shore Activities</u>

- Clearing and grabbing: this is based on clearing with a dozer, and clearing light to medium brush to 4" diameter; clearing assumes a 40 feet width for equipment maneuverability near the shore line and 500 feet accessibility lengthwise at $3,075/acre (RS Means 2001); surveying costs are estimated at $1,673/acre (RS Means 2001), covering twice the access area.
- Earth work costs: these include mobilization, excavation, and hauling, etc., along a water front width, with a 500-foot inland length; backfill with structural sand and grave; (backfill structural based on using a 200 horse power (HP) bulldozer, 300-foot haul, sand and gravel; unit earthwork cost is $395/ cubic yard (cu yd) (RS Means 2001).

- Paving and surfacing, using concrete 10" thick; assuming a need for a 20-foot wide and 2-foot long equipment staging area at a unit cost of $33.5/ sq yd (RS Means 2001).
- Structural cost is calculated at $1,250/cu yd (RS Means 2001), assuming two wing walls 1.5 feet thick and 26 feet high, with 10 feet above ground level, and 36 feet long with 16 feet onshore (these walls are for tying in the connecting sheet pile walls).
- Sheet piling, steel, no wales, 38 psf, left in place; these are assumed to have a width twice the width of the screens + 20 feet, with onshore construction distance, and be 30 feet deep, at $24.5/ sq ft (RS Means 2001).

Design Assumptions - Offshore Components

- Structure width is 20% greater than total screen width and 20 ft front to back
- Structural support consists of the equivalent of four 3-foot by 3-foot reinforced concrete columns at $935/ cu yd (RS Means 2001) plus two additional columns for each additional screen well (a 2-foot wide screen assumes an equivalent of 2-foot by 2-foot columns)
- Overall structure height is equal to the well depth plus 10%
- The elevated concrete deck is 1.5 ft thick at $48/ cu yd (RS Means 2001)
- Dredging mobilization is $9,925 if total screen width is less than 10 feet; is $25,890 if total screen width is 10 feet to 25 feet; and is $52,500 if total screen width is greater than 25 ft (RS Means 2001)
- The cost of dredging in the offshore work area is $23/cu yd to a depth of 10 feet
- The cost of the temporary coffer dam for the structure is $22.5/ sq ft (RS Means 2001), with total length equal to the structure perimeter times a factor of 1.5 and the height equal to 1.3 times well depth.

Field Project Personnel Not Included in Unit Costs:

- Project Field Manager at $2,525 per week (RS Means 2001)
- Project Field Superintendent at $2,375 per week (RS Means 2001)
- Project Field Clerk at $440 per week (RS Means 2001).

The above cost components were estimated and summed and the costs were expanded using the following cost factors.

Add-on and Indirect Costs:

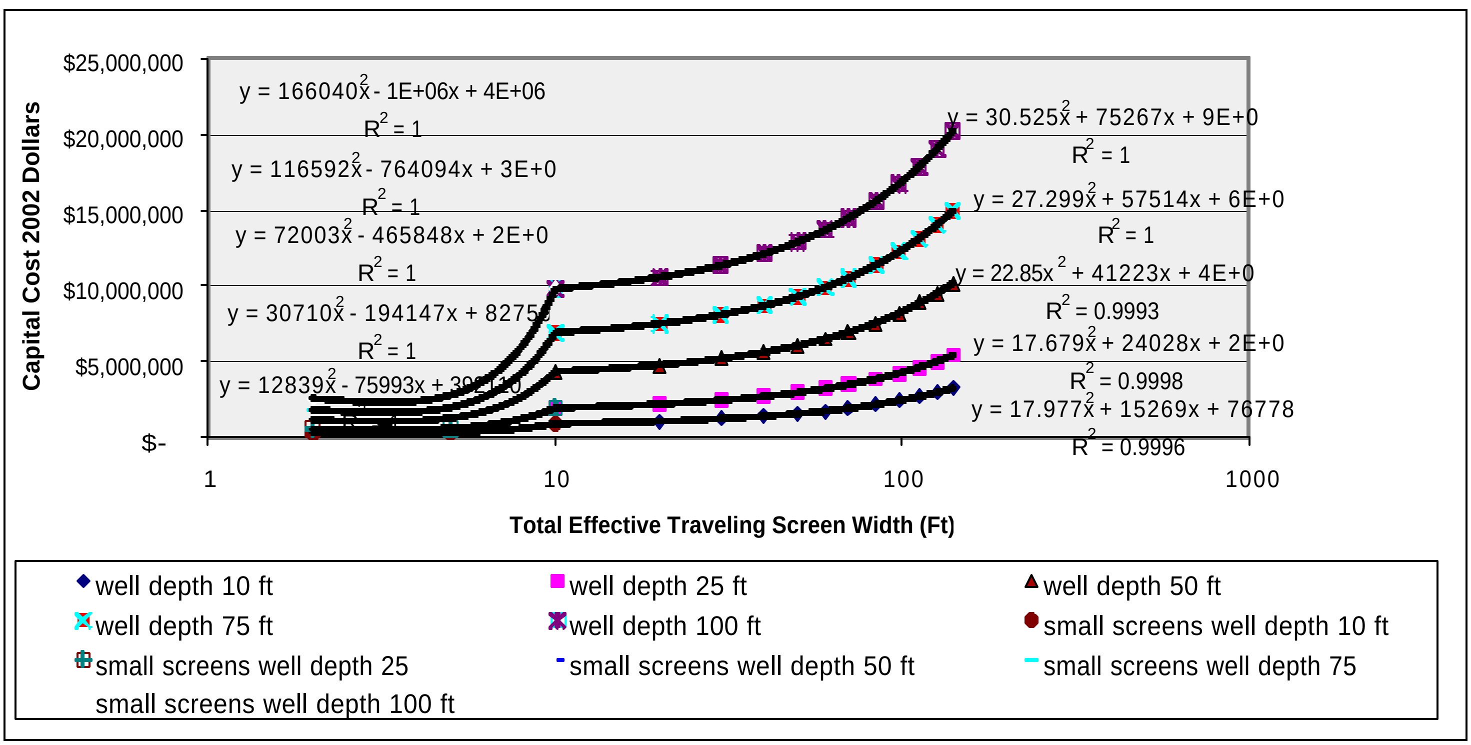
- Construction Management is 4.5% of direct costs
- Engineering and Architectural fees for new construction is 17% of direct costs
- Contingency is 10% of direct costs
- Overhead and profit is 15% of direct costs
- Permits are 2% of direct costs
- Metalwork is 5% of direct costs
- Performance bond is 2.5% of direct costs
- Insurance is 1.5% of direct costs.

The total capital costs were then adjusted for inflation from 2001 dollars to July 2002 dollars using the Engineering News Record (ENR) Construction Cost Index. Exhibit 3-46 presents the total capital costs for various screen well depths and total screen widths. No distinction was made between freshwater and brackish or saltwater environments. Figure 3-30 plots the data in Exhibit 3-46 and presents the best-fit cost equations. The shape of these curves indicates a need for separate equations for structures with widths less than and greater than 10 feet. In general, however, the Phase III compliance applications of this technology option included only new structures greater than 10 feet wide.

Exhibit 3-46. Total Capital Costs for Adding New Larger Intake Screen Well Structure in Front of Existing Shoreline Intake

Well Depth	10 Ft	25 Ft	50 Ft	75 ft	100 Ft
Width (Ft)					
2	$ 291,480	$ 562,140	$ 1,176,330	$ 1,842,570	$ 2,581,680
5	$ 333,120	$ 624,600	$ 1,290,840	$ 1,998,720	$ 2,800,290
10	$ 916,080	$1,957,080	$ 4,361,790	$ 6,922,650	$ 9,806,220
20	$ 1,051,410	$2,175,690	$ 4,757,370	$ 7,484,790	$10,545,330
30	$ 1,270,020	$2,487,990	$ 5,236,230	$ 8,130,210	$11,378,130
40	$ 1,426,170	$2,727,420	$ 5,642,220	$ 8,713,170	$12,138,060
50	$ 1,582,320	$2,977,260	$ 6,058,620	$ 9,306,540	$12,908,400
60	$ 1,748,880	$3,227,100	$ 6,485,430	$ 9,899,910	$13,689,150
70	$ 1,925,850	$3,487,350	$ 6,922,650	$ 10,503,690	$14,469,900
84	$ 2,165,280	$3,851,700	$ 7,536,840	$ 11,367,720	$15,583,770
98	$ 2,425,530	$4,236,870	$ 8,161,440	$ 12,242,160	$16,718,460
112	$ 2,696,190	$4,622,040	$ 8,994,240	$ 13,127,010	$17,863,560
126	$ 2,977,260	$5,028,030	$ 9,462,690	$ 14,032,680	$19,029,480
140	$ 3,268,740	$5,444,430	$ 10,139,340	$ 14,948,760	$20,205,810

Figure 3-30. Total Capital Costs of New Larger Intake Structure



O&M Costs

No separate O&M costs were derived for the structure itself because the majority of the O&M activities are covered in the O&M costs for the traveling screens to be installed in the new structure.

Construction Downtime

As described above, this scenario is modeled after an option described in a 316(b) Demonstration Study for the Salem Nuclear Plant (PSE&G 2001). In that scenario, which applies to a very large nuclear facility, the existing intake continues to operate during the construction of the offshore intake structure inside the sheet pile cofferdam. Upon completion of the offshore structure and removal of the cofferdam, the final phase on the construction requires the shut down of the generating units for the placement of the sheet pile end walls. The feasibility study states that units 1 and 2 would be required to shut down for one month each. Based on this estimate and the size of the Salem facility (average daily flow of over 2 million gpm), EPA has concluded that a total construction downtime estimate in the range of 6 to 8 weeks is reasonable. EPA did not select a single downtime for all facilities installing an offshore structure. Instead, EPA applied a six- to eight-week downtime duration based on variations in project size, using design flow as a measure of size. EPA assumed a total downtime of six weeks for facilities with intake flow volumes of less than 400,000 gpm; seven weeks for facilities with intake flow volumes greater than 400,000 gpm but less than 800,000 gpm; and eight weeks for facilities with intake flow volumes greater than 800,000 gpm.

Downtime durations applied for Phase III manufacturing facilities are shown in Exhibit 5-22.

Application

The input value for the cost equation is the screen well depth and the total screen width (see section 1.1 for a discussion of the methodology for determining the screen well depth). The width of the new larger screen well intake structure was based on the design flow, and an assumed through-screen velocity of 1.0 foot per second and a percent open area of 50%. The 50% open area value used is consistent with the percent open area of a fine mesh screen. The same well depth and width values are used for estimating the costs of new screen equipment for the new structure. New screen equipment consisted of fine mesh dual flow (double entry single exit) traveling screens with fish handling and return system.

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3.0 EXISTING SUBMERGED OFFSHORE INTAKES - ADD VELOCITY CAPS

Velocity caps are applicable to submerged offshore intakes. Adding velocity caps to facilities with existing or new submerged offshore intakes can provide appreciable impingement reduction. Therefore, this module may be most applicable when the compliance option only requires impingement controls and the intake requires upgrading. However depending on site-specific conditions, velocity caps could conceivably be used in conjunction with onshore screening systems tailored for entrainment reduction.

Research on velocity cap vendors identified only one vendor, which is located in Canada. (A possible reason for this scarcity in vendors is that many velocity caps are designed and fabricated on a site-specific basis, often called “intake cribs”.) This vendor manufactures a velocity cap called the “Invisihead,” and was contacted for cost information (Elarbash 2002a and 2002b). The Invisihead is designed with a final entrance velocity of 0.3 feet per second and has a curved cross-section that gradually increases the velocity as water is drawn farther into the head. The manufacturer states the gradual increase in velocity though the velocity cap minimizes entrainment of sediment and suspended matter and minimizes inlet pressure losses (Elmosa 2002). All costs presented below are in July 2002 dollars.

3.1 Capital Costs

The vendor provided information for estimating retrofit costs for velocity caps manufactured with carbon steel and with stainless steel. Stainless steel construction is recommended for saltwater conditions to minimize corrosion. Carbon steel is recommended for freshwater systems. Due to the rather large opening, Invisihead performance is not affected by the attachment of Zebra mussels, so no special materials of construction are required where Zebra mussels are present.

Installation costs include the cost for a support vessel and divers to cut, weld and/or bolt the fitting flange for the velocity cap; make any needed minor reinforcements of the existing intake; and install the cap itself. Installation was said to take between two and seven days, depending on the size and number of heads in addition to the retrofit steps listed above. Costs also include mobilization and demobilization of the installation personnel, barge, and crane. The vendor indicated these costs included engineering and contractor overhead and profit, but did not provide break-out or percentages for these cost components. EPA has concluded that the installation costs for adding a velocity cap on a new intake (relocated offshore) and on an existing offshore intake should be similar because most of the costs involve similar personnel and equipment. (See the “Application” section below for a discussion of new/existing submerged offshore intake cost components.)

Exhibit 3-47 presents the component (material, installation, and mobilization/demobilization) and total capital costs for stainless steel and carbon steel velocity caps provided by the vendor (Elarbash 2002a and 2002b). Data are presented for flows ranging from 5,000 gpm to 350,000 gpm. Figure 3-31 presents a plot of these data. The upper end of this flow range covers existing submerged pipes up to 15 feet in diameter at pipe velocities of approximately 5 feet per second. Second-order polynomial equations provided the best fit to the data and were used to produce cost curves. These cost curves serve as the basis for estimating capital costs for installing velocity caps on existing or new intakes submerged offshore at Phase III facilities. When applying these cost curves, if the intake flow exceeds 350,000 gpm plus 10% (i.e., 385,000 gpm), the flow is divided into equal increments and these lower flows costed. The costs for these individual incremental flows are summed to estimate total capital cost. In these cases, costs are assumed to apply to multiple intake pipes. If the intake flow is less than 5,000 gpm, the capital cost for 5,000 gpm will be used rather than extrapolating beyond the lower end of the cost curve.

Exhibit 3-47. Velocity Cap Retrofit Capital and O&M Costs (2002 $)

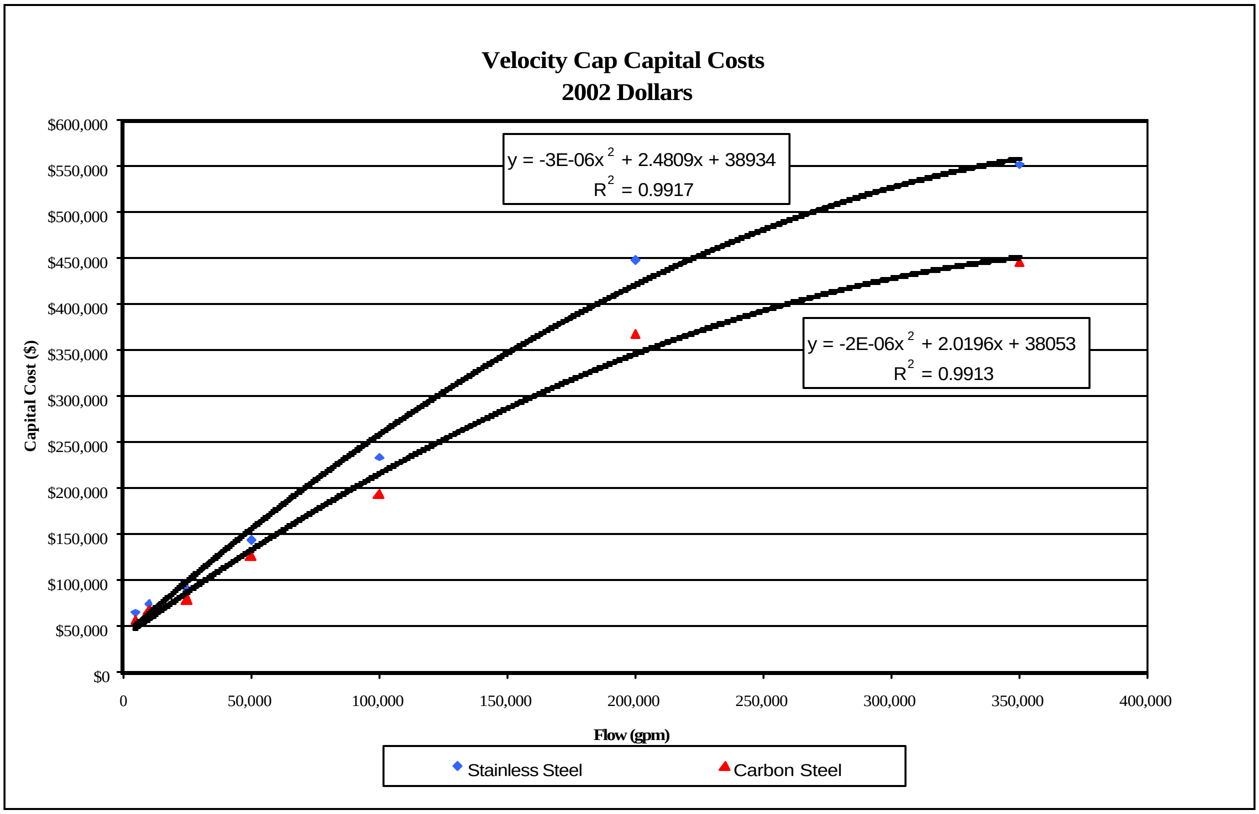
Velocity Cap Retrofit Capital and O&M Costs (2002 $)

Flow (gpm)	# Heads	Material Costs - Stainless Steel /Head	Material Costs - Stainless Steel Total	Material Costs - Carbon Steel /Head	Material Costs - Carbon Steel Total	Installation	Mobilization/ Demobilization	Total Capital Costs - Stainless Steel	Total Capital Costs - Carbon Steel	Total O&M
Water Type	All	Saltwater	Saltwater	Freshwater	Freshwater	All	All	Saltwater	Freshwater	All
5,000	1	$30,000	$30,000	$22,500	$22,500	$25,000	$10,000	$65,000	$57,500	$5,260
10,000	1	$30,000	$30,000	$22,500	$22,500	$30,000	$15,000	$75,000	$67,500	$5,260
25,000	1	$40,000	$40,000	$30,000	$30,000	$35,000	$15,000	$90,000	$80,000	$5,260
50,000	2	$35,000	$70,000	$26,250	$52,500	$49,000	$25,000	$144,000	$126,500	$7,250
100,000	2	$80,000	$160,000	$60,000	$120,000	$49,000	$25,000	$234,000	$194,000	$7,250
200,000	4	$80,000	$320,000	$60,000	$240,000	$98,000	$30,000	$448,000	$368,000	$11,230
350,000	4	$106,000	$424,000	$79,500	$318,000	$98,000	$30,000	$552,000	$446,000	$11,230

Note: Vendor indicated installation took 2 to 7 days

Note: Installation includes retrofit activities such as cutting pipe and & attaching connection flange on intake inlet pipe.

Figure 3-31. Velocity Cap Capital Costs (2002 Dollars)



3.2 O&M Costs

For velocity caps, O&M costs generally include routine inspection and cleaning of the intake head. As noted above, biofouling does not affect the performance of velocity caps, and hence, rigorous cleaning is not necessary. The vendor stated that their equipment is relatively maintenance free. However, O&M costs based on an annual inspection and cleaning of offshore intakes by divers were cited by facilities with existing offshore intakes, including some with velocity caps and especially those with bar racks at the intake. Therefore, estimated O&M costs are presented for an annual inspection and cleaning by divers because EPA believes this is common practice for submerged offshore intakes of all types.

Exhibit 3-48 presents the component and total O&M costs for the diver inspection and cleaning, for one to four days (Paroby 1999). In general, O&M costs are based on less than one day per head for inspection and cleaning of smaller intake heads and one day per head for the largest intake head. There is a minimum of one day for each inspection event. Inspection and cleaning events are assumed to occur once per year. Figure 3-32 presents the plot of the O&M costs by flow. A second-order polynomial equation provided the best fit to this data and serves as the basis for estimating the O&M costs.

Figure 3-32 also shows data for two facilities that reported actual O&M costs based on diver inspection and cleaning of submerged offshore intakes. While these two facilities use different intake technologies (passive screens for the smaller flow and bar rack type intakes for the larger flow), the inspection and cleaning effort should be similar for all three types of intakes. For both facilities, the actual reported O&M costs were less than the costs estimated using the cost curves, indicating that the estimated O&M costs should be considered as high-side estimates.

3.3 Application

As Retrofit of Existing Offshore Intake

Adding velocity caps to facilities with existing offshore intakes will provide impingement reduction only. For facilities withdrawing from saltwater/brackish waters (ocean and estuarine/tidal rivers), the capital cost curve for stainless steel caps will be applied. For the remaining facilities withdrawing freshwater (freshwater rivers/streams, reservoirs/lakes, Great Lakes), the capital cost curve for carbon steel caps will be applied. The same O&M cost curve will be used for both freshwater and saltwater systems. It is assumed that the existing intake is in a location that will provide sufficient clearance and is away from damaging wave action.

As Component of Relocating Existing Shoreline Intake to Submerged Offshore

These same velocity cap retrofit costs can be incorporated into retrofits where an existing shoreline intake is relocated to a submerged offshore intake. In this application, some of the same equipment and personnel used in velocity cap installation may also be used to install other intake components, such as the pipe. Therefore, the mobilization/demobilization component could be reduced if these tasks are determined to occur close together in time. However, a high-side costing approach would be to cost each step separately, using the same velocity cap costs for both new and existing offshore intake pipes. In this case, the installation costs for velocity caps at existing offshore intakes (which include costs for cutting, and welding and/or bolting the velocity cap in place) are assumed to cover costs of installing connection flanges at new offshore intakes. Costs for other components of relocating existing shoreline intakes to submerged offshore are developed as a separate cost module associated with passive screens. The compliance cost estimates did not include this scenario.

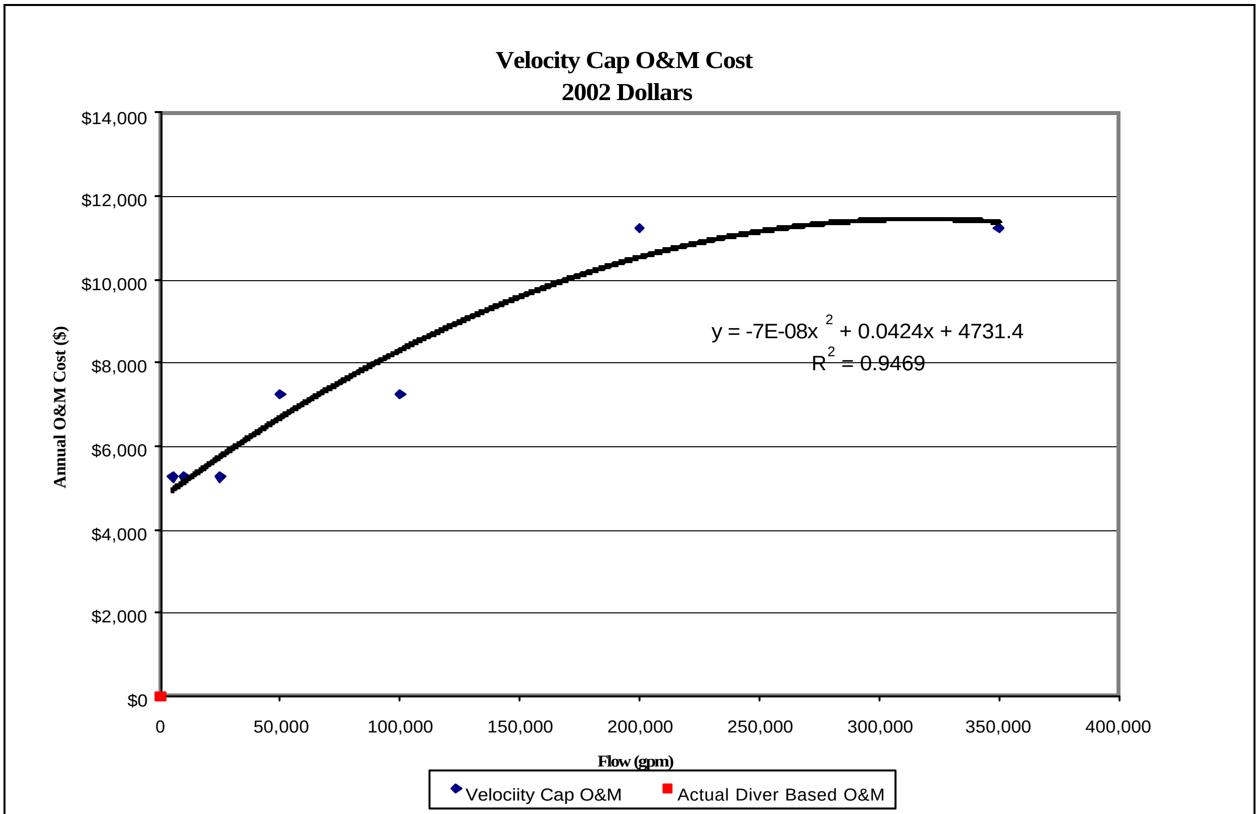
Exhibit 3-48. Installation and Maintenance Diver Team Costs

Installation and Maintenance Diver Team Costs

Item	Daily Cost*	One Time Cost*	Total	Adjusted Total			
Duration			One Day	One Day	Two Day	Three Day	Four Day
Cost Year			1999	2002	2002	2002	2002
Supervisor	$575		$575	$627	$1,254	$1,880	$2,507
Tender	$200		$200	$218	$436	$654	$872
Diver	$375		$750	$818	$1,635	$2,453	$3,270
Air Packs	$100		$100	$109	$218	$327	$436
Boat	$200		$200	$218	$436	$654	$872
Mob/Demob		$3,000	$3,000	$3,270	$3,270	$3,270	$3,270
Total			$4,825	$5,260	$7,250	$9,240	$11,230

*Source: Paroby 1999 (cost adjusted to 2002 dollars).

Figure 3-32. Velocity Cap O&M Cost (2002 Dollars)



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4.0 FISH BARRIER NETS

Fish barrier nets can be used where improvements to impingement performance are needed. Because barrier nets can be installed independently of intake structures, there is no need to include any costs for modifications to the existing intake or technology employed. Costs are assumed to be the same for both new and existing facilities. Barrier nets can be installed while the facility is operating. Thus, there is no need to coordinate barrier net installation with generating unit downtime.

Fish Barrier Net Questionnaire

EPA identified seven facilities from its database that employed fish barrier nets and sent them a brief questionnaire requesting barrier net design and cost data (EPA 2002). The following four facilities received questionnaires, but did not submit a response:

Bethlehem Steel - Sparrows Point
Consumers Energy Co. - J.R. Whiting Plant
Exelon Corp. (formerly Commonwealth Edison) - LaSalle County Station
Southern Energy - Bowline Generating Station

The following three facilities submitted completed questionnaires:

Entergy Arkansas, Inc. - Arkansas Nuclear One
Potomac Electric Power Co. - Chalk Point
Minnesota Power - Laskin Energy Center

Net Velocity

An important design criterion for determining the size of fish barrier nets is the velocity of the water as it passes through the net. Net velocity (which is similar to the approach velocity for a traveling screen) determines how quickly debris will collect on the nets. Net velocity also determines the force exerted on the net, especially if it becomes clogged with debris. For facilities that supplied technical data, Exhibit 3-49 presents the design intake flow (estimated by EPA) and facility data reported in the Barrier Net Questionnaire. These data include net size, average daily intake flow, and calculated net velocities based on average and design flows. Note that the Chalk Point net specifications used for purchasing the net indicated a net width of 27 ft (Langley 2002), while the Net Questionnaire reported a net width of 30 ft. A net width of 27 ft was used for estimating net velocities and unit net costs. The two larger facilities have similar design net velocity values that, based on design flow, is equal to 0.06 feet per second. These values are roughly an order of magnitude lower than compliance velocities used for rigid screens in the Phase I Rule, as well as design velocities recommended for passive screens. There are two reasons for this difference. One difference is rigid screens can withstand greater pressure differentials because they are firmly held in place. The second is rigid screens can afford to collect debris at a more rapid rate because they have an active means for removing debris collected on the surface.

Exhibit 3-49. Net Velocity Data Derived from Barrier Net Questionnaire Data

Facility Owner	Facility Name	Depth*	Length*	Area	EPA Design Flow	Net Velocity at Design Flow	Average Daily Flow*	Net Velocity at Daily Flow
		Ft	Ft	sq ft	gpm	fps	gpm	fps
PEPCO	Chalk Point	27	1000	27,000	762,500	0.06	500,000	0.04
Entergy	Arkansas Nuclear One	20	1500	30,000	805,600	0.06	593,750	0.04
Minn. Power	Laskin Energy Center	16	600	9,600	101,900	0.02	94,250	0.02

* Source: 2002 EPA Fish Barrier Net Questionnaire and Langley 2002

Based on the data presented in Exhibit 3-49, EPA has selected a net velocity of 0.06 feet per second (using the design flow) as the basis for developing compliance costs for fish barrier nets. Nets tested at a high velocity (> 1.3 feet per second) at a power plant in Monroe, Michigan clogged and collapsed. Velocities higher than 0.06 feet per second may be acceptable at locations where the debris loading is low or where additional measures are taken to remove debris. While tidal locations can have significant water velocities, the periodic reversal of flow direction can help dislodge some of the debris that collects on the nets. The technology scenario described below, for tidal waterbodies, is designed to accommodate significant debris loading through the use of dual nets and frequent replacement with cleaned nets.

Mesh Size

Mesh size determines the fish species and juvenile stages that will be excluded by the net. While smaller mesh size has the ability to exclude more organisms, it will plug more quickly with debris. The Chalk Point facility tried to use 0.5-inch stretch mesh netting and found that too much debris collected on the netting; it instead uses 0.75-inch stretch (0.375-inch mesh) netting (Langley 2002). Unlike rigid screens, fish nets are much more susceptible to lateral forces which can collapse the net.

Mesh size is specified in one of two ways; either as a "bar" or "stretch" dimension. A "stretch" measurement refers to the distance between two opposing knots in the net openings when they are stretched apart. Thus, assuming a diamond-shaped netting, when the netting is relaxed, the distance between two opposing sides of an opening will be roughly ½ the stretch diameter. A "bar" measurement is the length of one of the four sides of the net opening and would be roughly equal to ½ the stretch measurement. The term "mesh size" as used in this document refers to either ½ the "stretch" measurement or is equal to the "bar" measurement.

Exhibit 3-50 presents reported mesh sizes from several power plant facilities that either now or in the past employed fish barrier nets. An evaluation report of the use of barrier fish nets at the Bowline Plant in New York cited that 0.374-inch mesh was more effective than 0.5-inch mesh at reducing the number of fish entering the plant intake (Hutcheson 1988). Both fish barrier net cost scenarios described below are based on nets with a mesh size of 0.375 in. (9.5 mm) and corresponds to the median mesh size of those identified by EPA.

Exhibit 3-50. Available Barrier Net Mesh Size Data

Facility	Description	Reported Mesh Size		Type of Measurement and Source	Effective Mesh Size	
		Inch	mm		Inch	mm
Chalk Point	Inner Net	0.75	19	Stretch (1)	0.375	9.5
	Outer Net	1.25	32	Stretch (1)	0.625	15.9
Entergy Arkansas Nuclear One	Low	0.375	10	Mesh (Bar) (1)	0.375	9.5
	High (preferred)	0.5	13	Mesh (Bar) (1)	0.5	12.7
Laskin Energy		0.25	6.4	Mesh (Bar) (1)	0.25	6.4
Bowline Point	More Effective Size	0.374	9.5	Bar (3)	0.374	9.5
J.P. Pulliam		0.25	6.4	Stretch (2)	0.126	3.2
				Median	0.374	9.5

(1): 2002 EPA Fish Barrier Survey
(2):ASCE 1982
(3): Hutcheson 1988

Twine

Twine size mostly determines the strength and weight of the fish netting. Only the Chalk Point facility reported twine size data as #252 knotless nylon netting. Netting #252 is a 75-pound (lb) test braided nylon twine in which the twine joints are braided together rather than knotted (Murelle 2002). The netting used at the Bowline Power Plant was cited as multi-filament knotted nylon, chosen because of its low cost and high strength (Hutcheson 1988).

Support/Anchoring System

EPA has identified two different types of support and anchoring systems. In the simplest system the nets are held in-place and the bottom is sealed with weights running the length of the bottom usually consisting of a chain or a lead line. The weights may be supplemented with anchors placed at intervals. Vendors indicated the requirement for anchors varies depending on the application and waterbody conditions. The nets are anchored along the shore and generally placed in a semi-circle or arc in front of the intake. The Bowline Facility net used a v-shape configuration with an anchor and buoy at the apex and additional anchors placed midway along the 91-meter length sides. In some applications anchors may not be needed at all. If the nets are moved by currents or waves, they can be set back into the proper position using a boat. The nets are supported along the surface with buoys and floats. The buoys may support signs warning boaters of the presence of the net. The required spacing and size of the anchors and buoys is somewhat dependent on the size of the net and lateral water velocities. The majority of facilities investigated used this float/anchor method of installation. This net support configuration, using weights, anchors, floats, and buoys, is the basis for compliance scenario A.

A second method is to support nets between evenly spaced piles. This method is more appropriate for water bodies with currents. The Chalk Point Power Plant uses this method in a tidal river. The Chalk Point facility uses two concentric nets. Each has a separate set of support piles with a spacing between piles of about 18 feet to 20 feet (Langley 2002). Nets are hung on the outside of the piles with spikes and are weighted on the bottom with galvanized chain. During winter, the net is suspended below the water surface to avoid ice damage, but thick ice does not generally persist during the winter months at the facility location.

Debris

Debris problems generally come in two forms. In one case, large floating debris can get caught in the netting near the surface and result in tearing of the netting. In the other cases, floating and submerged debris can plug the openings in the net. This increases the hydraulic gradient across the net, resulting in the net being pulled in the downstream direction. The force can become so great that it can collapse the net, and water flows over the top and/or beneath the bottom. If the net is held in place by only anchors and weights it may be moved out of place. At the Chalk Point facility, debris that catches on the nets mostly comes in the form of jellyfish and colonial hydroids (Langley 2002).

Several solutions are described for mitigating problems created by debris. At the Chalk Point Power Plant two concentric nets are deployed. The outer net has a larger mesh opening designed to capture and deflect larger debris so it does not encounter the inner net, which catches smaller debris. This configuration reduces the debris buildup on any one net extending the time period before net cleaning is required. Growth of algae and colonization with other organisms (biofouling) can also increase the drag force on the nets. Periodic removal and storage out of the water can solve this problem. At Chalk Point both nets are changed out with cleaned nets on a periodic basis. This approach is considered to be appropriate for high debris locations.

Another solution is to periodically lift the netting and manually remove debris. A solution for floating debris is to place a debris boom in front of the net (Hutcheson 1988).

Ice

During the wintertime, ice can create problems. The net can become embedded in surface ice, with the net subject to tear forces when the ice breaks up or begins to move. Flowing ice can create similar problems as floating debris. Ice will also affect the ability to perform net maintenance such as debris removal. Solutions include:

- Removing the nets during winter
- Dropping the upper end of the net to a submerged location; can only be used with fixed support, such as piles and in locations where thick ice is uncommon
- Installing an air bubbler below the surface. Does not solve problems with flowing ice.

Net Deployment

EPA assumes that barrier nets will be used to augment performance of the existing shore-based intake technology such as traveling screens. The float/anchor-supported nets are assumed to be deployed on a seasonal basis to reduce impingement of fish present during seasonal migration. The Arkansas Entergy Nuclear One Plant deploys their net for about 120 days during winter months. The Minnesota Power Laskin Energy Center, which is located on a lake, deploys the net when ice has broken up in spring and removes the net in the fall before ice forms. Thus, the actual deployment period will vary depending on presence of ice and seasonal migration of fish. For the compliance scenario that relies upon float/anchor-supported nets, a total deployment period of eight months (240 days) is assumed. This is equal to or greater than most of the deployment periods observed by EPA.

EPA notes that the Chalk Point facility currently uses year round deployment and avoids problems with ice in the winter time by lowering the net top to a location below the surface. Prior to devising this approach, nets were removed during the winter months. This option is available because the nets are supported on piles. Thus, the surface support rope (with floats removed) can be stretched between the piles several feet below the surface. Therefore, a scenario where nets are supported by piles may include year round deployment as was the case for the Chalk Point Power Plant. However, in northern climates the sustained presence of thick ice during the winter may prevent net removal and cleaning and therefore, it may still be necessary to remove the nets during this period.

4.1 Capital Cost Development

Compliance costs are developed for the two different net scenarios.

Scenario A Installation at Freshwater Lake Using Anchors and Buoys/Floats

This scenario is intended for application in freshwater waterbodies where low water velocities and low debris levels occur, such as lakes and reservoirs. This scenario is modeled on the barrier net data from the Entergy Arkansas Nuclear One facility but has been modified to double the annual deployment period from 120 days to 240 days. Along with doubling the deployment period, the labor costs were increased to include an additional net removal and replacement step midpoint through this period. To facilitate the mid season net replacement, the initial net capital costs will include purchase of a replacement net.

Scenario B Installation Using Piles

This scenario is modeled after the system used at Chalk Point. In this case two nets are deployed in concentric semi-circles with the inner net having a smaller mesh (0.375 in) and the outer net having a larger mesh. Deployment is assumed to be year round. A marine contractor performs all O&M, which mostly involves periodically removing and the replacing both nets with nets they have cleaned. The initial capital net costs will include purchase of a set of replacement nets. This scenario is intended for application in waterbodies with low or varying currents such as tidal rivers and estuaries. Two different O&M cost estimates are developed for this scenario. In one the deployment is assumed to be year round, as is the case at Chalk Point. In the second, the net is deployed for only 240 days being taken out during the winter months. This would apply to facilities in northern regions where ice formation would make net maintenance difficult.

Net Costs

The capital costs for each scenario includes two components, the net and the support. The net portion includes a rope and floats spaced along the top and weights along the bottom consisting of either a “leadline” or chain. If similar netting specifications are used, the cost of the netting is generally proportional to the size of the netting and can be expressed in a unitized manner such as “dollars/sq ft.” Exhibit 3-51 presents the reported net costs and calculated unit costs. While different water depths will change the general ratio of net area to length of rope/floats and bottom weights, the differences in depth also result in different float and weight requirements. For example, a shallower net will require more length of surface rope and floats and weights per unit net area, but a shallower depth net will also exert less force and require smaller floats and weights.

Exhibit 3-51 Net Size and Cost Data

Facility	Depth	Length	Area	Component	Cost/net	Cost/sq ft
	ft	ft	sq ft			
Chalk Point	27	300	8,100	Replacement Net 0.675 in.*	$4,640	$0.57
	27	300	8,100	Replacement Net 0.375 in.*	$4,410	$0.54
Chalk Point (equivalen	10	300	3,000	Replacement Net*	$1,510	$0.50
Entergy Arkansas	20	250	5,000	Replacement Net*	$3,920	$0.78
Entergy Arkansas	20	1500	30,000	Net & Support Costs**	$36,620	$1.22
Laskin Energy Center	16	600	9,600	Net Costs***	$1,600	$0.17

*Costs include floats and lead line or chain and are based on replacement costs plus 12% shipping.
** Costs include replacement net components plus anchors, buoys & cable plus 12% shipping
***Cost based on reported 1980 costs adjusted to 2002 dollars plus 12% for shipping.

EPA is using the cost of nets in the average depth range of 20 to 30 feet as the basis for costing. This approach is consistent with the median Phase III facility shoreline intake depth of 18 feet and median "average bay depth" of 20 feet. While nets are deployed offshore in water deeper than a shoreline intake, costs are for average depths, which include the shallow sections at the ends, and net placement can be configured to minimize depth. To see how shallower depths may affect unit costs, the costs for a shallower 10-foot net with specifications similar to the Chalk Point net (depth of 27 feet) were obtained from the facility's net supplier. As shown in Exhibit 3-51, the unit cost per square foot for the shallower net was less than the deeper net. Therefore, EPA has concluded that the use of shallower nets does not increase unit costs and has chosen to apply the unit costs, based on the 20-foot and 30-foot depth nets, to shallower depths.

Exhibit 3-51 presents costs obtained for the net portion only from the facilities that completed the Barrier Net Questionnaire. These costs have been increased by 12% over what was reported to include shipping costs. This 12% value was obtained from the Chalk Point net supplier, who confirmed that the costs reported by Chalk Point did not include shipping. (Murelle 2002) The unit net costs range from $0.17/sq ft to $0.78/sq ft. Consultation with net vendors indicates that the barrier net specifications vary considerably and that there is no standard approach. Although no net specification data (besides mesh size) was submitted with the Laskin Energy Center data, EPA has concluded that the data for this net probably represents lower strength netting, which would be suitable for applications where the netting is not exposed to significant forces. Because the compliance cost scenarios will be applied to facilities with a variety net strength requirements, EPA has chosen to use the higher net costs that correspond to higher net strength requirements. As such, EPA has chosen to use the cost data for the Chalk Point and Arkansas Nuclear One facilities as the basis for each scenario.

Scenario A Net Costs

In this scenario the net and net support components are included in the unit costs. At the Arkansas Nuclear One facility unitized costs for the net and anchors/buoys are $1.22/sq ft plus $0.78/sq ft for the replacement net, resulting in a total initial unit net costs of $2.00/sq ft for both nets. Because the data in Exhibit 3-50 indicate that, if anything, unit costs for nets may decrease with shallower depths, EPA concluded that this unit cost was representative of most of the deeper nets and may slightly overestimate the costs for shallower nets.

Scenario A Net Installation costs

Installation costs for Arkansas Nuclear One (scenario A) were reported as $30,000 (in 1999 dollars; $32,700 when adjusted for inflation to 2002 dollars) for the 30,000 sq ft net. This included placement of anchors and cable including labor. To extrapolate the installation costs for different net sizes, EPA has assumed that approximately 20% ($6,540) of this installation cost represents fixed costs (e.g., mobilization/demobilization). The remainder ($26,160) divided by the net area results in an installation unit cost of $0.87/sq ft to be added to the fixed cost.

Scenario A Total Capital Costs

Exhibit 3-52 presents the component and total capital costs for scenario A. Indirect costs are added for engineering (10%) and contingency/allowance (10%). Contractor labor and overhead are already included in the component costs. Because most of the operation occurs offshore no cost for sitework are included.

Exhibit 3-52. Capital Costs for Scenario A Fish Barrier Net With Anchors/Buoys as Support Structure

Flow (gpm)	2,000	10,000	50,000	100,000	250,000	500,000	750,000	1,000,000	1,250,000
Net Area (sq ft)	74	371	1,857	3,714	9,284	18,568	27,852	37,136	46,420
Net Costs	$149	$744	$3,722	$7,445	$18,611	$37,223	$55,834	$74,445	$93,057
Installation Costs Fixed	$6,540	$6,540	$6,540	$6,540	$6,540	$6,540	$6,540	$6,540	$6,540
Installation Costs Variab	$65	$324	$1,619	$3,238	$8,096	$16,191	$24,287	$32,383	$40,478
Total Direct Capital Cost	$6,754	$7,608	$11,881	$17,223	$33,247	$59,954	$86,661	$113,368	$140,075
Indirect Costs	$1,351	$1,522	$2,376	$3,445	$6,649	$11,991	$17,332	$22,674	$28,015
Total Capital Costs	$8,104	$9,130	$14,258	$20,667	$39,896	$71,945	$103,993	$136,042	$168,090

Scenario B Net Costs

In this scenario the net costs are computed separately from the net support (piles) costs. In this scenario there are two separate nets and an extra set of replacement nets for each. The unit costs for the nets will be two times the sum of the unit net costs for each of the large and small mesh nets. As shown in Exhibit 3-51, the unit costs for each net was $0.57/sq ft and $0.54/sq ft, resulting in a total cost for all four nets of $2.24/sq ft for the area of a single net.

Scenario B Installation Costs

Installation costs were not provided for the Chalk Point facility. Initial net installation is assumed to be performed by the O&M contractor and is assumed to be a fixed cost regardless of net size. EPA assumed the initial installation costs to be two-thirds of the contractor, single net replacement job cost of $1,400 or $933 (See O&M Costs - scenario B).

Scenario B Piling Costs

The costs for the piles at the Chalk Point facility were not provided. The piling costs for scenario B is based primarily on the estimated cost for installing two concentric set of treated wooden piles with a spacing of 20 ft between piles. To see how water depth affects piling costs, separate costs were developed at water depths of 10 feet, 20 feet, and 30 feet. Piling costs are based on the following assumptions:

- Costs for piles are based on a unit cost of $28.50/ ft of piling (RS Means, 2001).
- Piling installation mobilization costs are equal to $2,325 based on a mobilization rate of $46.50/mile for barge-mounted pile driving equipment (RS Means 2001) and an assumed distance of 50 miles.
- Each pile length includes the water depth plus a 6-foot extension above the water surface plus a penetration depth (at two-thirds the water depth); the calculated length was rounded up to the next even whole number.
- The two concentric nets are nearly equal in length, with one pile for every 20 feet in length and one extra pile to anchor the end of each net.

Exhibit 3-53 presents the individual pile costs and intake flow for each net section between two piles (at 0.06 feet per second).

Exhibit 3-53. Pile Costs and Net Section Flow

Water Depth	Total Pile Length	Cost Per Pile	Flow Per 20 ft Net Section	Fixed Cost Mobilization
Ft	Ft		gpm	
10	24	684	5385.6	2325
20	40	1140	10771.2	2325
30	56	1596	16156.8	2325

Exhibits 3-54, 3-55, and 3-56 present the total capital costs and cost components for the installed nets and piles. Indirect costs are added for engineering (10%) and contingency/allowance (10%). Contractor labor and overhead are already included in the component costs. Because most of the operation occurs offshore, no costs for sitework are included. The costs were derived for nets with multiple 20-ft sections. Because the net costs are derived such that the cost equations are linear with respect to flow, the maximum number of sections shown is selected so they cover a similar flow range. Values that exceed this range can use the same cost equation.

Exhibit 3-54. Capital Costs for Fish Barrier Net With Piling Support Structure for 10 Ft Deep Nets

Number of 20 ft Sections	2	4	8	12	25	50	75	100	200
Total Number of Pilings	6	10	18	26	52	102	152	202	402
Single Net Length (ft)	40	80	160	240	500	1000	1500	2000	4000
Net Area (sq ft)	400	800	1,600	2,400	5,000	10,000	15,000	20,000	40,000
Flow (gpm)	10,771	21,542	43,085	64,627	134,640	269,280	403,920	538,560	1,077,120
Total Piling Cost	$6,429	$9,165	$14,637	$20,109	$37,893	$72,093	$106,293	$140,493	$277,293
Net Costs	$1,380	$1,827	$2,721	$3,614	$6,519	$12,106	$17,692	$23,279	$45,624
Total Direct Costs	$7,809	$10,992	$17,358	$23,723	$44,412	$84,199	$123,985	$163,772	$322,917
Indirect Costs	$1,562	$2,198	$3,472	$4,745	$8,882	$16,840	$24,797	$32,754	$64,583
Total Capital Costs	$9,371	$13,190	$20,829	$28,468	$53,295	$101,039	$148,782	$196,526	$387,501

Exhibit 3-55 Capital Costs for Fish Barrier Net With Piling Support Structure for 20 Ft Deep Nets

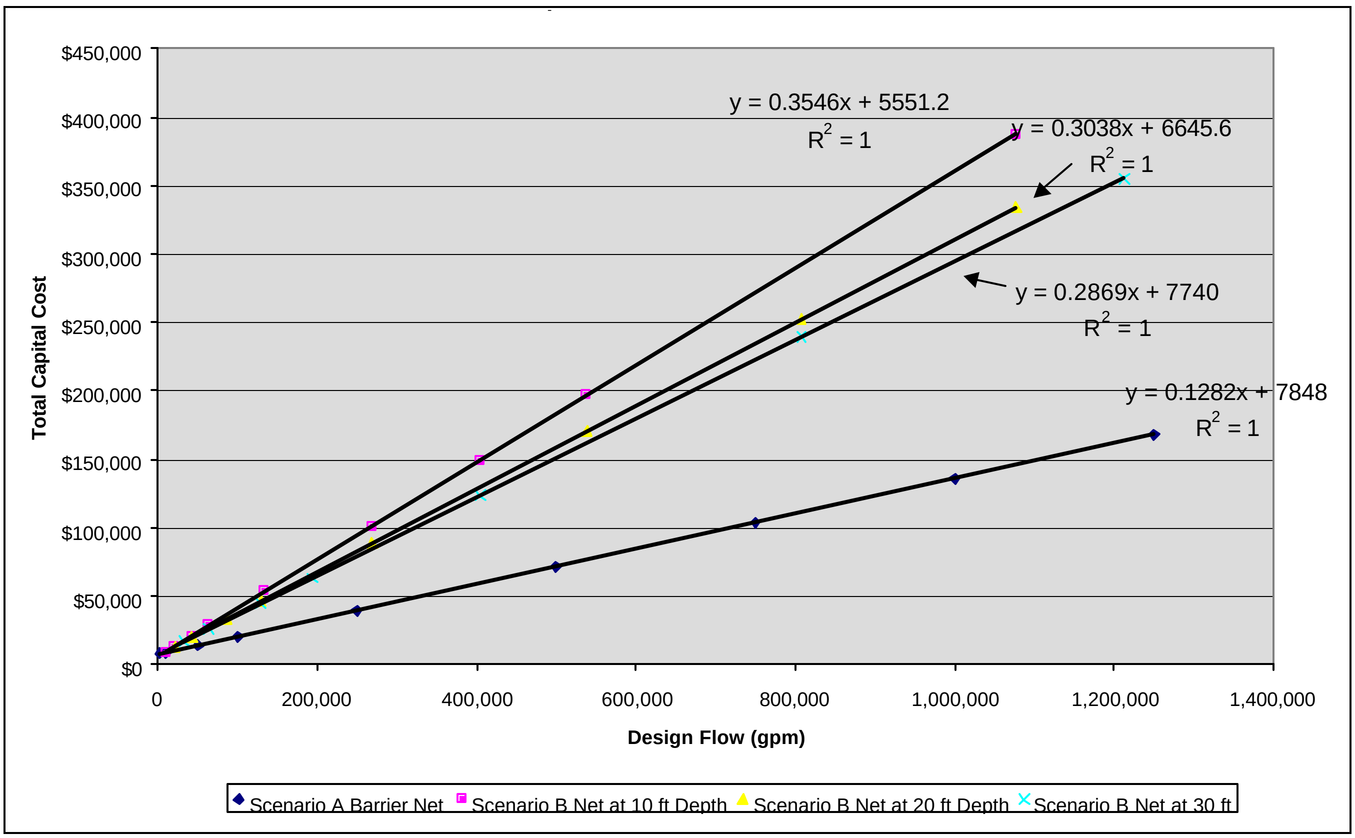
Number of 20 ft Sections	2	4	8	12	25	50	75	100
Total Number of Pilings	6	10	18	26	52	102	152	202
Single Net Length (ft)	40	80	160	240	500	1000	1500	2000
Net Area (sq ft)	800	1600	3200	4800	10000	20000	30000	40000
Flow (gpm)	21,542	43,085	86,170	129,254	269,280	538,560	807,840	1,077,120
Total Piling Cost	$9,165	$13,725	$22,845	$31,965	$61,605	$118,605	$175,605	$232,605
Net Costs	$1,827	$2,721	$4,508	$6,296	$12,106	$23,279	$34,452	$45,624
Total Direct Costs	$10,992	$16,446	$27,353	$38,261	$73,711	$141,884	$210,057	$278,229
Indirect Costs	$2,198	$3,289	$5,471	$7,652	$14,742	$28,377	$42,011	$55,646
Total Capital Costs	$13,190	$19,735	$32,824	$45,913	$88,453	$170,260	$252,068	$333,875

Exhibit 3-56. Capital Costs for Fish Barrier Net With Piling Support Structure for 30 Ft Deep Nets

Number of 20 ft Sections	2	4	8	12	25	50	75
Total Number of Pilings	6	10	18	26	52	102	152
Single Net Length (ft)	40	80	160	240	500	1000	1500
Net Area (sq ft)	1,200	2,400	4,800	7,200	15,000	30,000	45,000
Flow (gpm)	32,314	64,627	129,254	193,882	403,920	807,840	1,211,760
Total Piling Cost	$9,576	$15,960	$28,728	$41,496	$82,992	$162,792	$242,592
Net Costs	$2,274	$3,614	$6,296	$8,977	$17,692	$34,452	$51,211
Total Direct Costs	$11,850	$19,574	$35,024	$50,473	$100,684	$197,244	$293,803
Indirect Costs	$2,370	$3,915	$7,005	$10,095	$20,137	$39,449	$58,761
Total Capital Costs	$14,220	$23,489	$42,029	$60,568	$120,821	$236,692	$352,563

Figure 3-33 presents the total capital costs for scenarios A and B from Exhibits 3-52 through 3-56, plotted against design flow. Figure 3-33 also presents the best-fit linear equations used to estimate compliance costs. EPA notes that piles for shallower depths costed out more, due to the need for many more piles. Scenario B costs for 10-foot deep nets will be applied wherever the intake depth is less than 12 ft. For scenario B applications in water much deeper than 12 feet, EPA will use the cost equation for 20-foot deep nets.

Figure 3-33. Total Capital Costs for Fish Barrier Nets



4.2 O&M Costs Development

Scenario A O&M Costs - Float/Anchor-Supported Nets

Barrier net O&M costs generally include costs for replacement netting, labor for net inspection, repair, and cleaning, and labor for net placement and removal. The Arkansas Nuclear One facility supplied data that estimate all three components for its 1,500 ft long by 20 ft deep net located on a reservoir. Net deployment, however, was for only a 120-day period. This net is installed in November and removed in March (in-place for 120 days total). Each year two 250-foot sections of the net (one-third of the total) are replaced due to normal wear and tear.

EPA assumes the labor rate is similar to the estimate for traveling screen maintenance labor ($41.10/hr). The reported Arkansas Nuclear One O&M labor requirements includes 3 hrs per day during the time the net is deployed for inspection & cleaning by personnel on a boat (calculated at $14,800). This involves lifting and partially cleaning the nets on a periodic basis. Labor to deploy and remove the net was reported at 240 hrs (calculated at $9,860). Two sections of the six total net sections were replaced annually at a cost of $7,830 total (including shipping). Total annual O&M costs are calculated to be $32,500.

Because other facilities on lakes reported longer deployment periods (generally when ice is not present), EPA chose to adjust O&M costs to account for longer deployment. EPA chose to base O&M costs for scenario A on a deployment period of 240 days (approximately double the Arkansas Nuclear One facility deployment period). EPA also added costs for an additional net removal and deployment step using the second replacement net midway through the annual deployment period. The result is a calculated annual O&M cost of $57,200.

Scenario B O&M Costs – Piling-Supported Nets

Nearly all of the O&M labor for Chalk Point facility is performed by a marine contractor who charges $1,400 per job to simultaneously remove the existing net and replace it with a cleaned net. This is done with two boats where one boat removes the existing net followed quickly by the second that places the cleaned net keeping the open area between nets minimized. The contractor's fee includes cleaning the removed nets between jobs. This net replacement is performed about 52 to 54 times per year. It is performed about twice per week during the summer and once every two weeks during the winter. The facility relies upon the contractor to monitor the net. Approximately one third of the nets are replaced each year, resulting in a net replacement cost of $9,050.

Using an average of 53 contractor jobs per year and a net replacement cost of $9,050 the resulting annual O&M cost was $83,250. EPA notes that some facilities that employ scenario B technology may choose to remove the nets during the winter. As such, EPA has also estimated the scenario B O&M costs based on a deployment period of approximately 240 days by reducing the estimated number of contractor jobs from 53 to 43 (deducting 10 jobs using the winter frequency of roughly 1 job every 2 weeks). The resulting O&M costs are shown in Exhibits 3-57 and 3-58.

EPA notes that other O&M costs reported in literature are often less than what is shown in Exhibit 3-57. For example, 1985 O&M cost estimates for the JP Pulliam plant ($7,500/year, adjusted to 2002 dollars) calculate to $11,800 for a design flow roughly half that of Arkansas Entergy. This suggests the scenario A and B estimates represent the high end of the range of barrier net O&M costs. Other O&M estimates, however, do not indicate the cost components that are included and may not represent all cost components.

To extrapolate costs for other flow rates, EPA has assumed that roughly 20% of the scenario A and B O&M costs represent fixed costs. Exhibit 3-57 presents the fixed and unit costs based on this assumption for both scenarios.

Exhibit 3-57. Cost Basis for O&M Costs

	Deployment	Net Replacement	O&M Labor	Model Facility O&M	Fixed Cost	Variable Costs	Unit Variable O&M Costs
	Days						$/sq ft
Scenario A	240	$7,830	$49,320	$57,150	$11,430	$45,720	$1.52
Scenario B	365	$9,050	$74,200	$83,250	$16,650	$66,600	$2.47
Scenario B	240	$9,050	$60,200	$69,250	$13,850	$55,400	$2.05

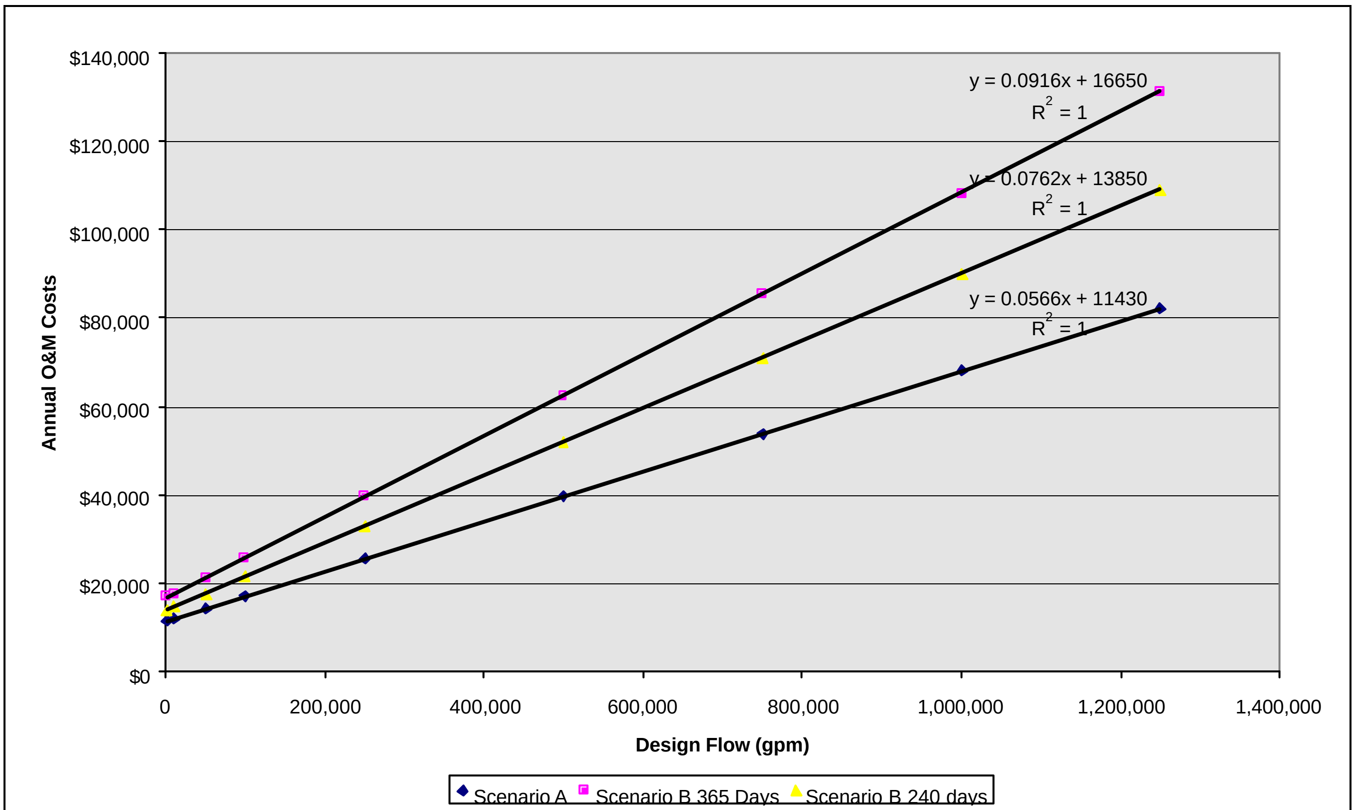
Note that Unit Variable O&M Costs are based on a total net area of 30,000 sq ft (Entergy Arkansas) for scenario A and 27,000 sq ft for scenario B (Chalk Point).

Exhibit 3-58 presents the calculated O&M costs based on the cost factors in Exhibit 3-57 and Figure 3-34 presents the plotted O&M costs and the linear equations fitted to the cost estimates.

Exhibit 3-58. Annual O&M Cost Estimates

Flow (gpm)		2,000	10,000	50,000	100,000	250,000	500,000	750,000	1,000,000	1,250,000
Net Area (sq ft)		74	371	1,857	3,714	9,284	18,568	27,852	37,136	46,420
Scenario A	240 days	$11,543	$11,996	$14,260	$17,090	$25,579	$39,728	$53,877	$68,025	$82,174
Scenario B	365 days	$16,833	$17,566	$21,230	$25,810	$39,551	$62,451	$85,352	$108,252	$131,153
Scenario B	240 days	$14,002	$14,612	$17,660	$21,470	$32,899	$51,949	$70,998	$90,048	$109,097

Figure 3-34. Barrier Net Annual O&M Costs



4.3 Nuclear Facilities

Even though the scenario A costs are modeled after the barriers nets were installed at a nuclear facility, the higher unit net costs cited by the Arkansas Nuclear One facility include components that are not included with the non-nuclear Chalk Point nets, and thus the differences may be attributed to equipment differences and not differences between nuclear and non-nuclear facilities. In addition, the labor rates used for scenario A and B O&M were for non-nuclear facilities Because the function of barrier nets is purely for environmental benefit, and not critical to the continued function of the cooling system (as would be technologies such as traveling screens), EPA does not believe that a much more rigorous design is warranted at nuclear facilities. However, higher labor rates plus greater paperwork and security requirements at nuclear facilities should result in higher costs. As such, EPA has concluded that the capital costs for nuclear facilities should be increased by a factor of 1.58 (lower end of range cited in passive screen section). Because O&M costs rely heavily on labor costs, EPA has concluded that the O&M costs should be increased by a factor of 1.24 (based on nuclear versus non-nuclear operator labor costs).

4.4 Application

Fish barrier net technology will augment, but not replace, the function of any existing technology. Therefore, the calculated net O&M costs will include the O&M costs described here without any deductions for reduction in existing technology O&M costs. Fish barrier nets may not be applicable in locations where they would interfere with navigation channels or boat traffic.

Fish barrier nets require low waterbody currents to avoid becoming plugged with debris that could collapse the net. Such conditions can be found in most lakes and reservoirs, as well as some tidal waterbodies such as tidal rivers and estuaries. Placing barrier nets in a location with sustained lateral currents in one direction may cause problems because the section of net facing the current will continually collect debris at higher rate than the remainder of the net. In this case, net maintenance cleaning efforts must be able to keep up with debris accumulation. As such, barrier nets are suitable for intake locations that are sheltered from currents, e.g., locations within an embayment, bay, or cove. On freshwater rivers and streams only those facilities within an embayment, bay, or cove will be considered as candidates for barrier nets. The sheltered area needs to be large enough for the net sizes described above. The fish barrier net designs considered here would not be suitable for waterbodies with the strong wave action typically found in ocean environments.

Scenario A is most suitable for lakes and reservoirs where water currents are low or almost nonexistent. Scenario B is more suitable for tidal waterbodies and any other location where higher quantities of debris and light or fluctuating currents may be encountered. In northern regions where formation of thick ice in winter would prevent access to the nets, scenario B may be applied and the scenario B O&M costs for a 240-day deployment should be used. However, because this scenario results in reduced costs, EPA has chosen to apply scenario B for a 365-day deployment for all facilities in suitable waterbodies.

EPA notes that nets with net velocities higher than 0.07 feet per second have been successfully employed (EPRI 1985). While such nets will be smaller than those described here, they will accumulate debris at a faster rate. Because the majority of the O&M costs are related to cleaning nets, EPA expects the increase in frequency of cleaning smaller nets will be offset by the smaller net size such that the smaller nets should require similar costs to maintain.

Facilities with Canals

Most facilities with canals have in-canal velocities of between 0.5 and 1 foot per second based on average flow. These velocities are an order of magnitude greater than the design net velocity used here. If nets with mesh sizes in the range considered here were placed within the canals, they will likely experience problems with debris. Therefore, if barrier nets are used at facilities with canals, the net would need to be placed in the waterbody just outside the canal entrance.

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5.0 AQUATIC FILTER BARRIERS

Filter Barrier

Aquatic filter barrier (AFB) systems are barriers that employ a filter fabric designed to allow passage of water into a cooling water intake structure, while excluding aquatic organisms. One company, Gunderboom, Inc., has a patented system, the Marine/Aquatic Life Exclusion System (MLES™) that can be deployed as a full-water-depth filter curtain suspended from floating booms extending out in the waterway or supported on a fixed structure as described below. The filter fabric material is constructed of matted unwoven synthetic fibers.

Pore Size and Surface Loading Rate

Filter fabric materials with different pore sizes can be employed depending on performance requirements. In the MLES™ system two layers of fabric are used. Because the material is a fabric and thus the openings are irregular, the measure of the mesh or pore size is determined by an American Society for Testing and Materials (ASTM) method that relies on a sieve analysis of the passage of tiny glass beads. The results of this analysis are referred to as apparent opening size. The standard MLES™ filter fabric material has an apparent opening size (AOS) of 0.15 millimeter (mm). (McCusker 2003b). Gunderboom can also provide filter fabric material that has been perforated to increase the apparent opening size. Available perforation sizes range from 0.4 mm to 2.0 mm AOS. The "apparent opening size" is referred to as the "pore size" in the discussion below. While smaller pore sizes can protect a greater variety of aquatic organisms, the smaller pore sizes also increase the proportion of suspended solids collected and thus the rate at which it collects. In addition, smaller pore sizes tend to impede the flow of water through the filter fabric, which becomes even more pronounced as solids collect on the surface. This impedance of flow results in an increase in the lateral forces acting on the AFB. The filter surface loading rate (gpm/ sq ft) or equivalent approach velocity (feet per second) determines both the rate at which suspended particles collect on the filter fabric and the intensity of the lateral forces pushing against the AFB. While the airburst system (see description below) is designed to help dislodge and removed such suspended particles, there are practical limits regarding pore size and surface loading rate. For filter fabric of any given pore size, decreasing the surface loading rate will reduce the rate of solids accumulation and the lateral forces acting upon the AFB. Thus, pore size is an important design parameter in that it determines the types of organisms excluded as well as contributes to the selection of an acceptable surface loading rate. The surface loading rate combined with the cooling water intake design flow determines the required AFB surface area. This total filter fabric area requirement, when combined with the local bathymetry, determines the area that resides within the AFB.

Since the AFB isolates and essentially restricts the function of a portion of the local ecosystem, anything that increases the AFB total surface area will also increase the size of the isolated portion of the ecosystem. As such, there is an environmental trade off between minimizing the pore size to protect small size organisms/lifestages versus minimizing the size of the area being isolated. In addition, requirements for large AFB surface areas may preclude its use where it conflicts with other waterbody uses (e.g., navigation) or where the waterbody size or configuration restricts the area that can be impacted. Vendors can employ portable test equipment or pilot scale installations to test pore size selection and performance, which can aid in the selection of the optimal pore size. Acceptable design filter loading rates will vary with the pore size and the amount of sediment and debris present. An initial target loading rate of 3 to 5 gpm/sq ft has been suggested (EPA 2001). This is equivalent to approach or net face velocities of 0.007 to 0.01 feet per second, which is nearly an order of magnitude lower than the 0.06 feet per second design velocity used by EPA for barrier nets. This difference is consistent with the fact that barrier net use much greater mesh sizes. Use of larger AFB pore sizes can result in greater net velocities. Since the cost estimates as presented here are based on design flow, differences in design filter loading rates will affect the size of the AFB which directly affects the costs. The range between the high and low estimates in capital and O&M costs presented below account at least in part for the differences associated with variations in pore size as well as other design variations that result from differences in site conditions.

Floating Boom

For large volume intakes such as once-through systems, an AFB supported at the top by a floating boom that extends out into the waterbody and anchored onshore at each end is the most likely design configuration to be employed because of the large surface area required. In this design, a filter fabric curtain is supported by the floating boom at the top and is held against the bottom of the waterbody by weights such as a heavy chain. The whole thing is held in place by cables attached to fixed anchor points placed at regular intervals along the bottom. The Gunderboom MLES™ design employs a two-layer filter fabric curtain that is divided vertically into sections to allow for replacement of an individual section when necessary. The estimated capital and O&M costs described below are for an AFB using this floating boom-type construction.

Fixed Support

The AFB vendor, Gunderboom Inc., also provides an AFB supported by rigid panels that can be placed across the opening of existing intake structures. This technology is generally applicable to existing intakes where the intake design flow has been substantially reduced, such as where once-through systems are being converted to recirculating cooling towers. For other installations, Gunderboom has developed what they refer to as a cartridge-type system, which consists of rigid structures surrounded by filter fabric with filtered water removed from the center (McCusker 2003). Costs for either of these rigid types of installation have not been provided.

Air Backwash

The Gunderboom MLES™ employs an automated airburst technology that periodically discharges air bubbles between the two layers of fabric at the bottom of each MLES™ curtain panel. The air bubbles create turbulence and vibrations that help dislodge particulates that become entrained in the filter fabric. The airburst system can be set to purge individual curtain panels on a sequential basis automatically or can be operated manually. The airburst technology is included in the both the capital and O&M costs provided by the vendor.

5.1 Capital Cost Development

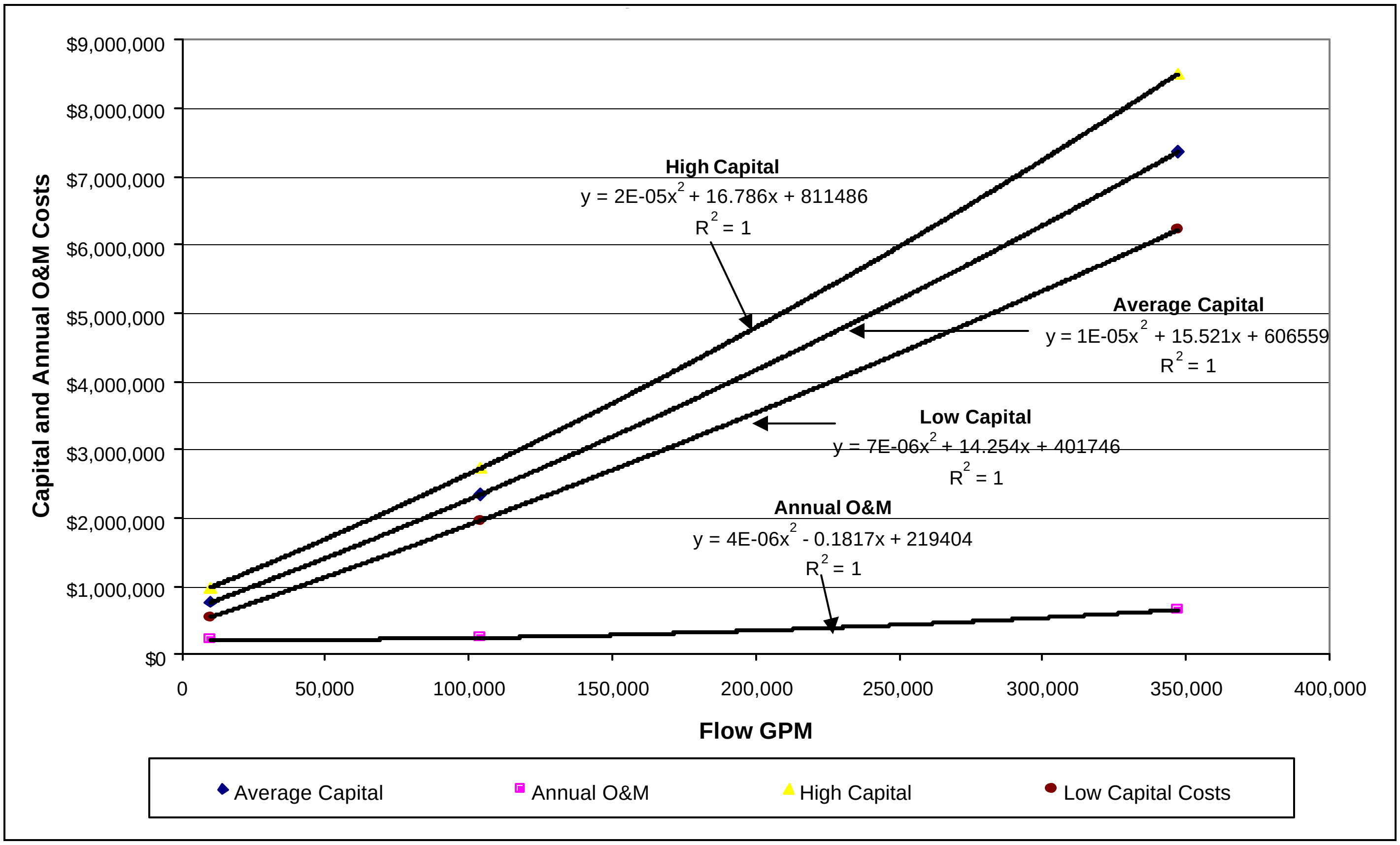
Estimated capital costs were provided by the only known aquatic filter barrier manufacturer, Gunderboom, Inc. Cost estimates were provided for AFBs supported by floating booms representing a range of costs; low, high, and average that may result from differences in construction requirements that result from different site specific requirements and conditions. Such requirements can include whether sheetwall piles or other structures are needed and whether dredging is required, which can result in substantial disposal costs. Costs were provided for three design intake flow values: 10,000 gpm, 104,000 gpm, and 347,000 gpm. Theses costs were provided in 1999 dollars and have been adjusted for inflation to July 2002 dollars using the ENR construction cost index. The capital costs are total project costs including installation. Figure 3-35 presents a plot of the data in Exhibit 3-59 along with the second order equation fitted to this data.

The vendor recently provided a total capital cost estimate of 8 to 10 million dollars for a full scale MLES™ system at the Arthur Kill Power Station in Staten Island, NY (McCusker 2003a). The vendor is in the process of conducting a pilot study with an estimated cost of $750,000. The New York Department of Environmental Conservation (NYDEC) reported the permitted cooling water flow rate for the Arthur Kill facility as 713 MGD or 495,000 gpm. Applying the cost equations in Figure 3-35 results in a total capital cost of $8.7, $10.1 and $12.4 million dollars for low, average and high costs, respectively. These data indicate that the inflation adjusted cost estimates are consistent with this more recent estimate provided by the vendor. Note that since the Arthur Kill intake flow exceeded the range of the cost equation input values, the cost estimates presented above for this facility were derived by first dividing the flow by two and then adding the answers.

Exhibit 3-59. Capital Costs for Aquatic Filter Barrier Provided by Vendor

	Floating Boom		
Flow	Capital Cost (2002 Dollars)		
gpm	Low	High	Average
10,000	$545,000	$980,900	$762,900
104,000	$1,961,800	$2,724,800	$2,343,300
347,000	$6,212,500	$8,501,300	$7,356,900

Figure 3-35. Gunderboom Capital and O&M Costs for Floating Structure (2002 Dollars)



5.2 O&M Costs

Estimated O&M costs were also provided by Gunderboom Inc. As with the capital costs, the O&M costs provided apply to floating boom type AFBs and include costs to operate an airburst system. Exhibit 3-60 presents a range of O&M costs; from low to high and the average, which served as the basis for cost estimates. As with the capital costs, the costs presented in Exhibit 3-60 have been adjusted for inflation to July 2002 dollars. Figure 3-35 presents a plot of the data in Exhibit 3-60 along with the second order equation fitted to this data.

Exhibit 3-60. Estimated AFB Annual O&M Costs

Flow	O&M	O&M	O&M
gpm	Low	High	Average
10,000	$109,000	$327,000	$218,000
104,000	$163,500	$327,000	$245,200
347,000	$545,000	$762,900	$653,900

5.3 Application

AFBs can be used where improvements to impingement and entrainment performance is needed. Because they can be installed independently of intake structures, there is no need to include any costs for modifications to the existing intake structure or technology employed. Costs are assumed to be the same for both new and existing facilities. AFBs can be installed while the facility is operating. Thus, there is no need to coordinate AFB installation with generating unit downtime. Capital cost estimates used in the economic impact analysis used average costs.

EPA assumed that the existing screen technology would be retained as a backup following the installation of floating boom AFBs. Therefore, as with barrier nets, the O&M costs of the existing technology was not deducted from the estimated net O&M cost used in the Phase III economic impact analysis. Upon further consideration, EPA has concluded that at a minimum there should be a reduction in O&M cost of the existing intake screen technology equivalent to the variable O&M cost component estimated for that technology.

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II. TECHNOLOGY COST MODULES FOR SEAFOOD PROCESSING VESSELS

APPLICATION OF THE FINAL RULE

Under the final Phase III rule, no seafood processing vessels are subject to national performance standards.

INTRODUCTION

EPA has identified a typical 280-foot catcher-processor as an indicative vessel to assemble cost estimates for retrofitting cooling water intake structures with suitable technology options. Information gathered during interviews with industry representatives were used to characterize the intake structure of a typical 280-foot vessel. It is reasonable to assume that the majority of these vessels use a sea chest arrangement for cooling water intake.

Four primary technology option configurations have been costed:

1. Replace the existing grill with a fine mesh screen, without any other modifications;
2. Enlarge the intake structure internally to achieve 0.5 feet per second through-screen velocity. Under this option, the screen will be in flush with the hull;
3. Install a fine mesh screen intake structure externally to achieve 0.5 feet per second through-screen velocity. The screen protrudes outside of the hull under this option; and
4. Install a horizontal flow modifier externally to the intake structure to achieve 0.5 feet per second through-screen velocity. The flow modifier protrudes outside of the hull. Cost estimates for two configurations, one for vessels with bottom sea chests and one for side sea chests are presented.

Material costs for both 316 stainless steel and CuNi alloy fine mesh screens obtained from vendors are presented. In addition, material costs for steel fabrication and associated labor rates, including diver team costs obtained using various vendor sources, are presented. The capital costs estimated in this report are incremental costs for a facility. A 10% engineering and 10% contingency sum has been included in the cost estimates. One of the key assumptions for the development of capital costs is that the vessel is in dry dock for routine maintenance and that this work does not prolong the dry dock time for the vessel. No allowances have been made for docking fees.

Inspection frequency for fine mesh screens and horizontal flow modifiers is assumed to be one per year. This is based on typical inspection frequencies for onshore and coastal facilities. The estimates for inspection and cleaning frequencies are based on vendor data and data from operators of similar equipment in high marine growth areas. It is assumed that the existing sea chests are inspected annually with the use of divers. The inspection and maintenance of the proposed enlarged intake structures will take significantly longer than current practices. An allowance of an additional day per intake has been included for these intake modification options for divers to inspect and clean the new intake structures. However, for the option where no enlargement of the intake is proposed, a lump sum cost of $100 is estimated for annual inspection and maintenance. An allowance of 6% of the capital cost has been allowed as annual replacement costs for parts. Mobilization or demobilization costs are not included in this estimate. The O&M costs estimated in this report are incremental costs for the facility.

1.0 REPLACE EXISTING GRILL WITH FINE MESH SCREEN

1.1 Capital Cost Development

In this option, the existing grill is replaced with a larger (typically 32" diameter) fine mesh screen. Costs are estimated for replacing the existing coarse grill with 316 stainless steel and CuNi alloy fine mesh screens. In addition to the material cost of the screen, installation costs are included in this cost estimate.

1.2 O&M Cost Development

A lump sum cost of $100 is estimated as the annual O&M cost to inspect and clean the fine mesh screen. Exhibit 3-61 below presents the summary of incremental capital and O&M costs to replace the existing grill with fine mesh screen. These costs are presented for three design intake flow values.

Exhibit 3-61. Capital and O&M costs for Replacing Existing Coarse Screen with Fine Mesh Screen

Design Flow (MGD)	Stainless Steel Fine Mesh Screen		CuNi Fine Mesh Screen	
	Capital Cost ($)	O&M Cost ($)	Capital Cost ($)	O&M Cost ($)
0.6	404	100	423	100
6.3	764	100	965	100
12.7	1,190	100	1,604	100

Figures 3-36 and 3-37 show the cost curves for replacing an existing grill.

Figure 3-36. Capital Cost for Replacing Existing Grill with Fine Mesh Stainless Steel Screen

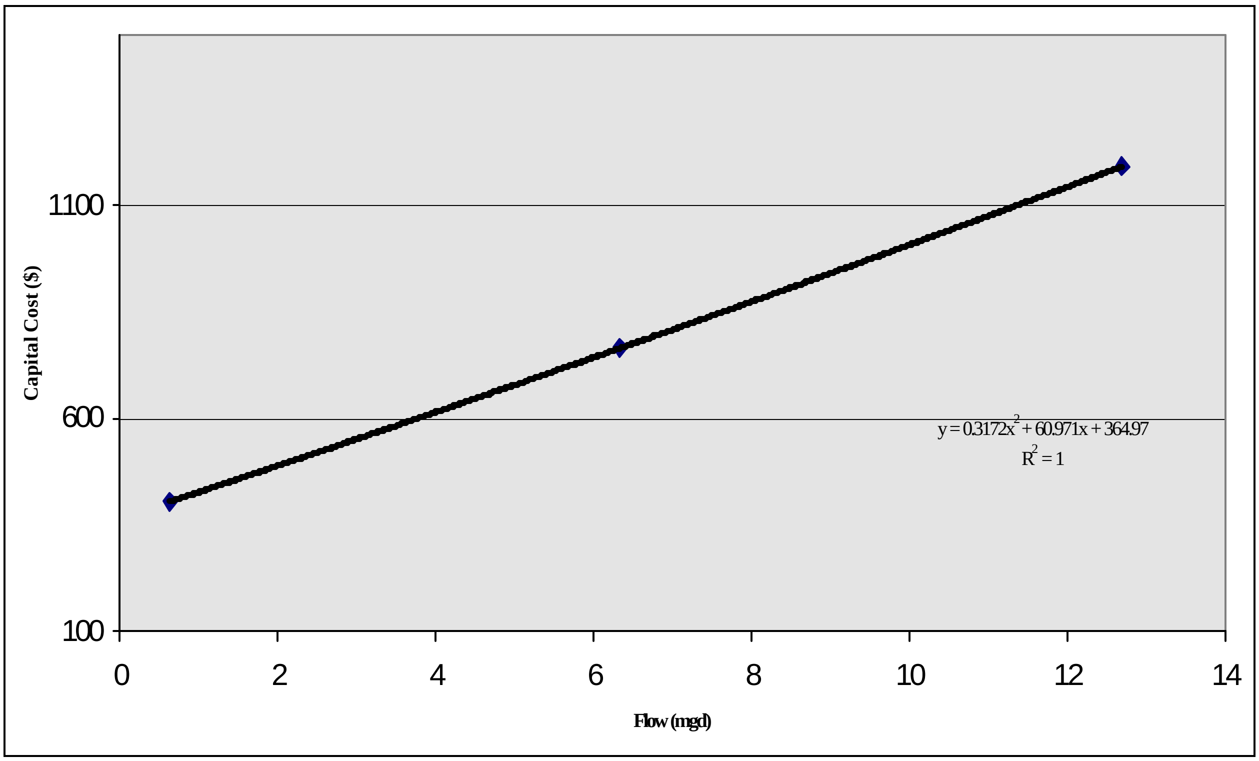
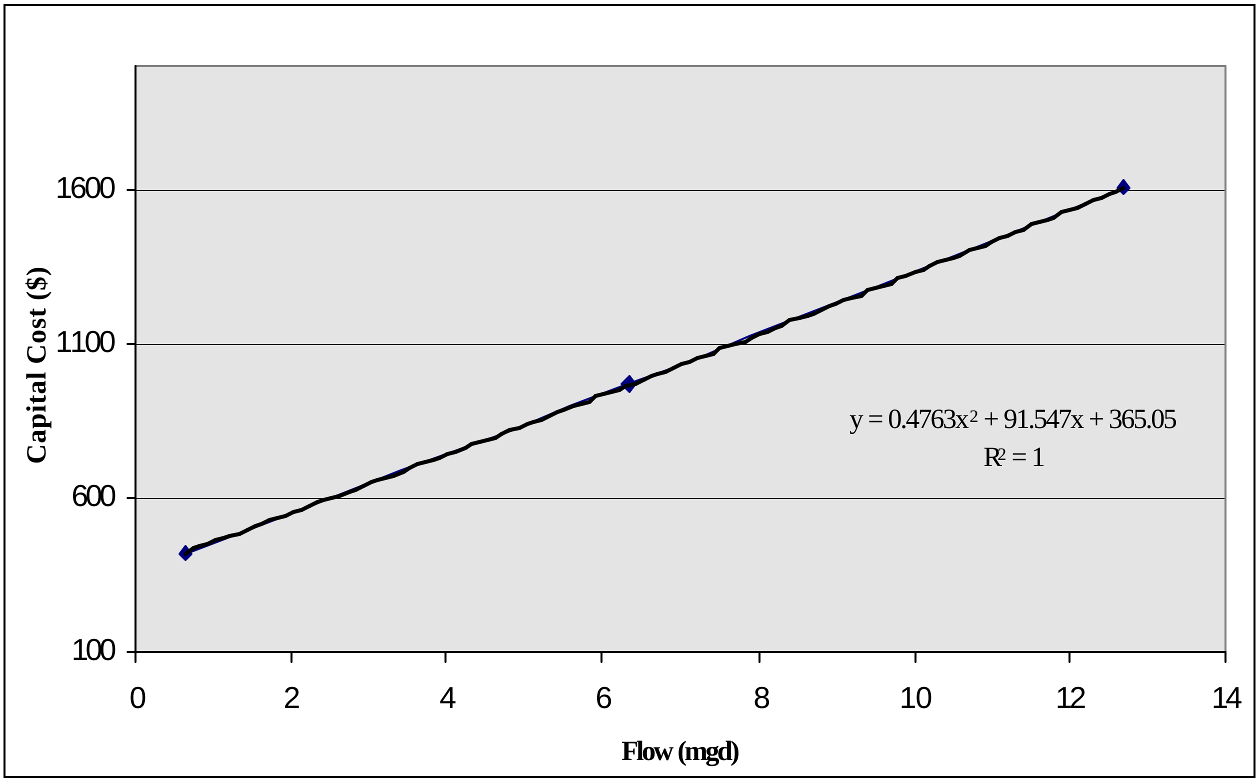


Figure 3-37. Capital Cost for Replacing Existing Grill with Fine Mesh CuNi Screen



2.0 ENLARGE THE INTAKE STRUCTURE INTERNALLY

2.1 Capital Cost Development

It is proposed to modify the existing 32@ intake with a new intake structure that has a large enough surface area to reduce the through-screen velocity to 0.5 feet per second. The primary problem with this type of intake modification is that there is typically very little room at the intake. As such, a low profile design has been developed to minimize the impacts on surrounding equipment and services of the vessel. The intake pipe suction is dispersed across the face of a large mesh using a diffuser arrangement. This type of flow modifier is often used to limit vortex problems on suction lines. It will only marginally increase the head loss through the system, as the available flow area is still large (but at right angles to the pipe flow). The similarity with a velocity cap is easily noted. The insertion of a large intake will typically require the cutting of several hull stiffeners. The design presented is intended to transfer the loads directly through the main frame. Figures 3-38 through 3-42 present the proposed modification for the existing intake.

Figure 3-38. Enlarged (Internal) Fine Mesh Sea Water Intake Configuration

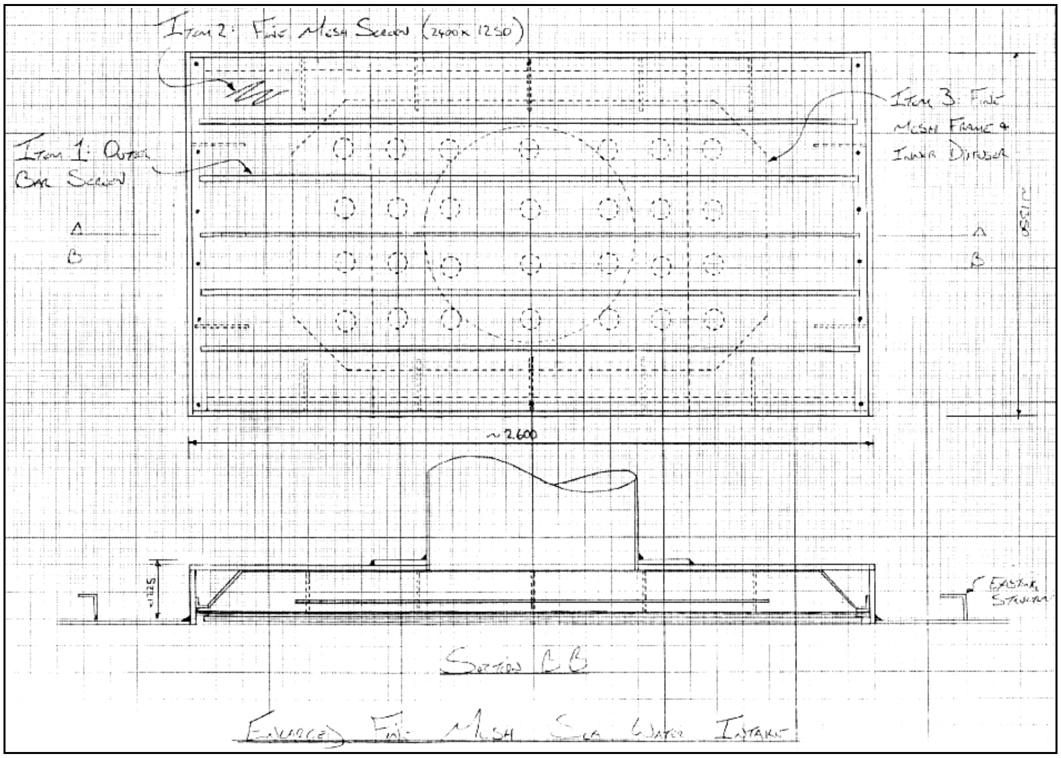


Figure 3-39. Outer Bar Screen (for Internal and Eternal Intake Modification)

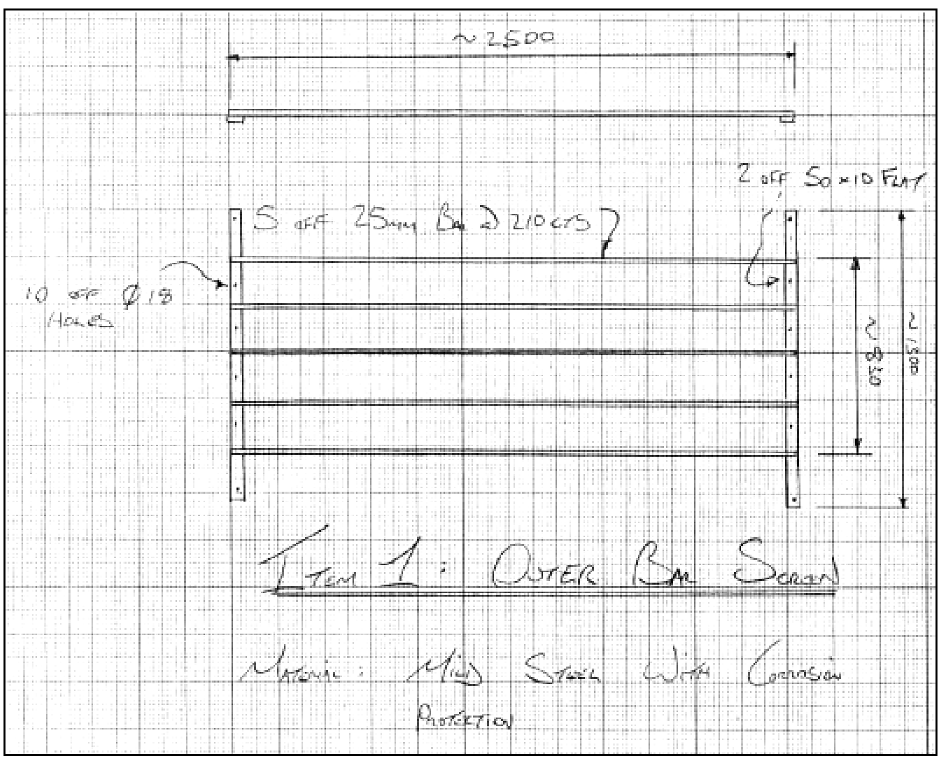


Figure 3-40. Fine Mesh Inner Screen (for Internal and External Intake Modification)

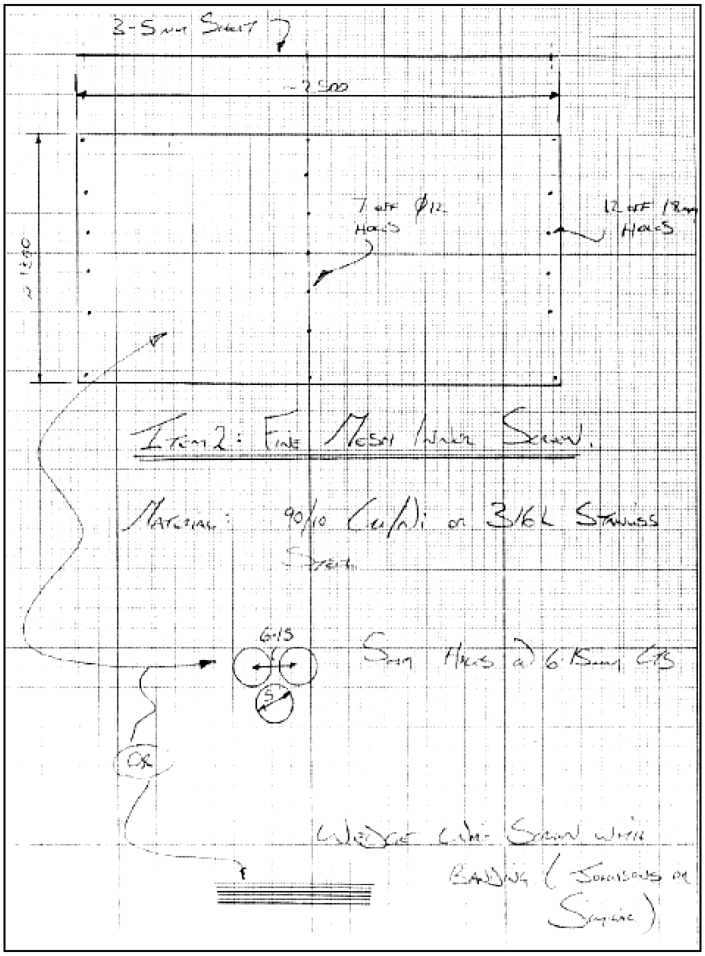


Figure 3-41. Fine Mesh Frame and Inner Diffuser (for Internal and External Intake Modification)

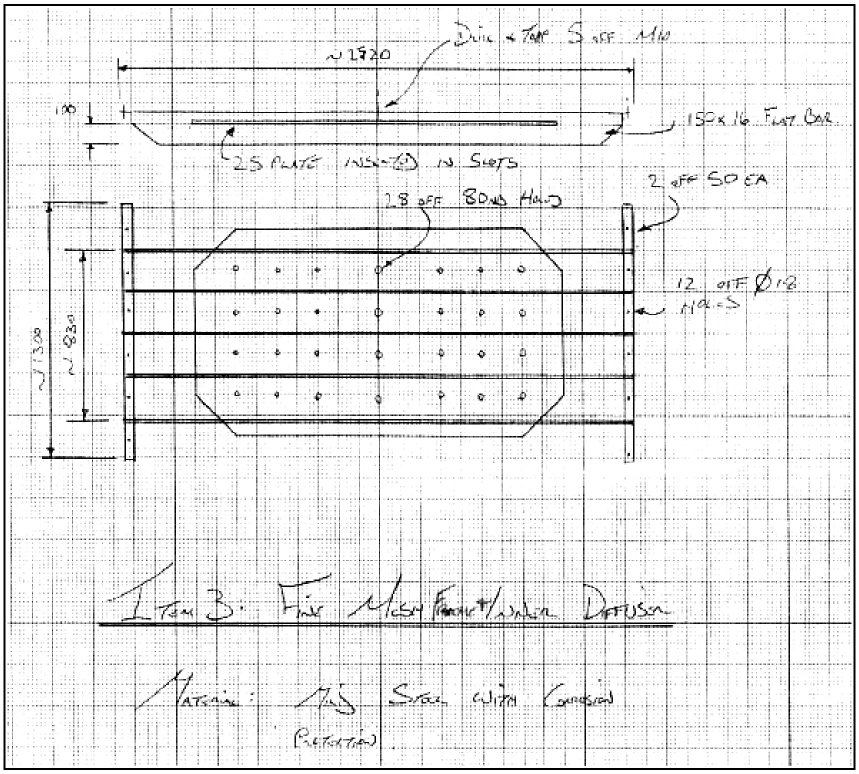
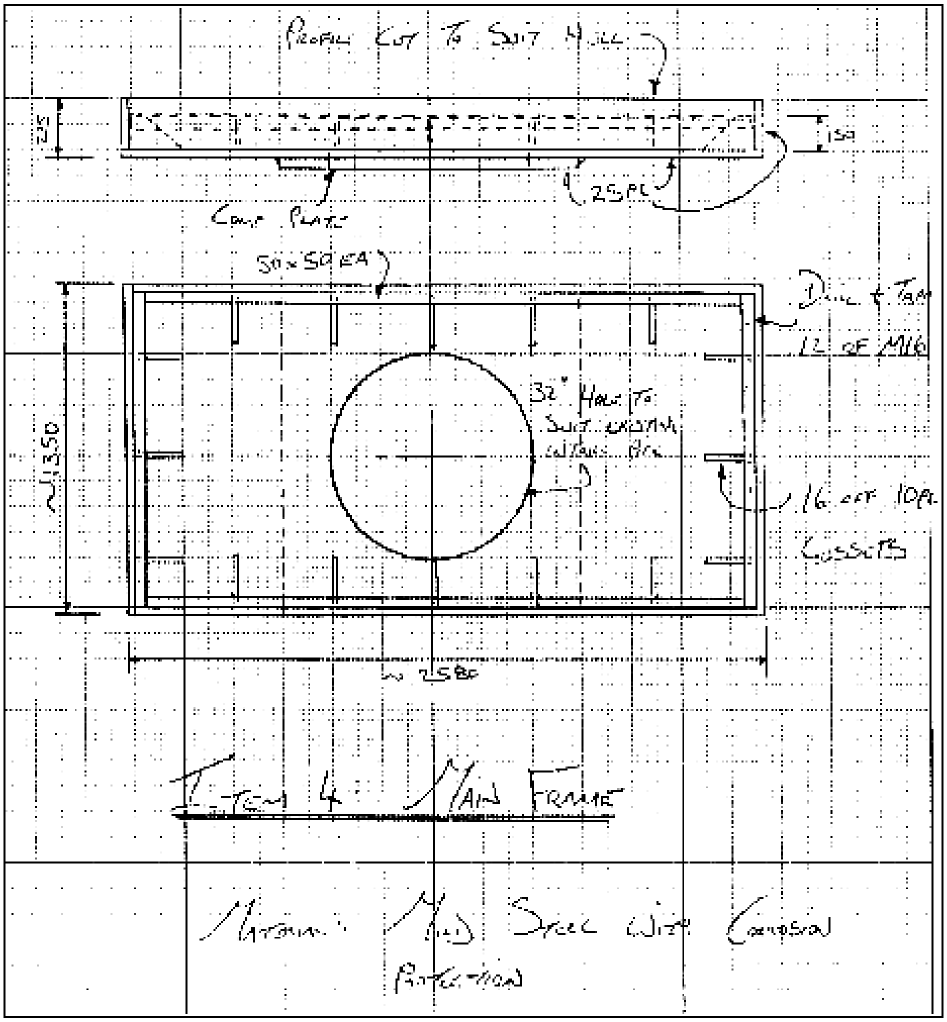


Figure 3-42. Main Frame for Internal Intake Modification



2.2 O&M Cost Development

The O&M costs are based on the labor cost for a team of divers, including the cost of equipment and boat to inspect and clean the intake once per year, and an allowance of 6% of the capital cost for parts replacement. The estimates for inspection and cleaning frequencies are based on vendor data and data from operators of similar equipment in high marine growth areas.

Exhibit 3-62 below presents the summary of incremental capital and O&M costs to enlarge the intake structure internally with fine mesh screen. These costs are presented for three design intake flow values.

Exhibit 3-62. Capital and O&M Costs for Enlarging Intake Internally

Design Flow (MGD)	Stainless Steel Fine Mesh Screen		CuNi Fine Mesh Screen	
	Capital Cost ($)	O&M Cost ($)	Capital Cost ($)	O&M Cost ($)
0.6	26,882	2,365	27,010	2,371
6.3	50,923	3,431	52,218	3,496
12.7	70,652	4,332	73,235	4,461

Figures 3-43 through 3-46 show the cost curves for enlarging an intake.

Figure 3-43. Capital Costs for Enlarging Intake Internally with Stainless Steel Fine Mesh Screen

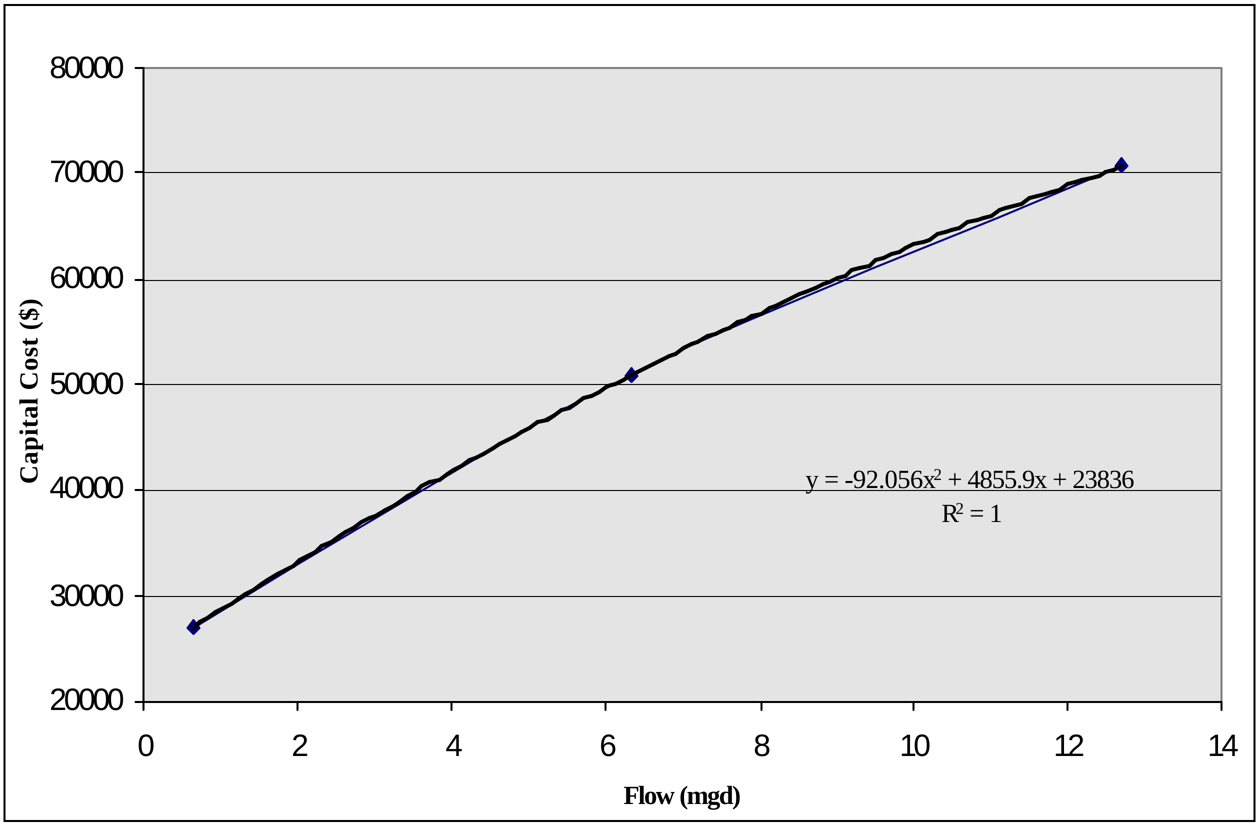


Figure 3-44. O&M Costs for Enlarging Intake Internally with Stainless Steel Fine Mesh Screen

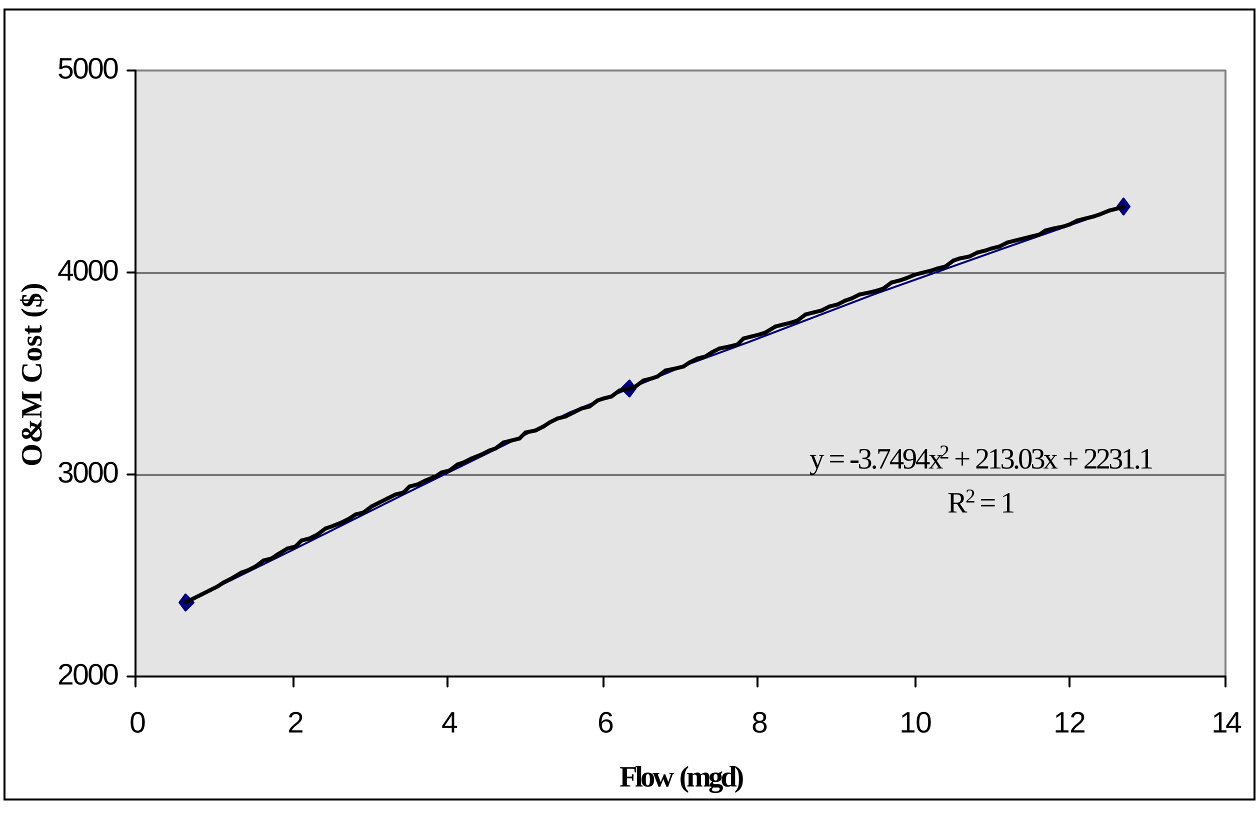


Figure 3-45. Capital Costs for Enlarging Intake Internally with CuNi Fine Mesh Screen

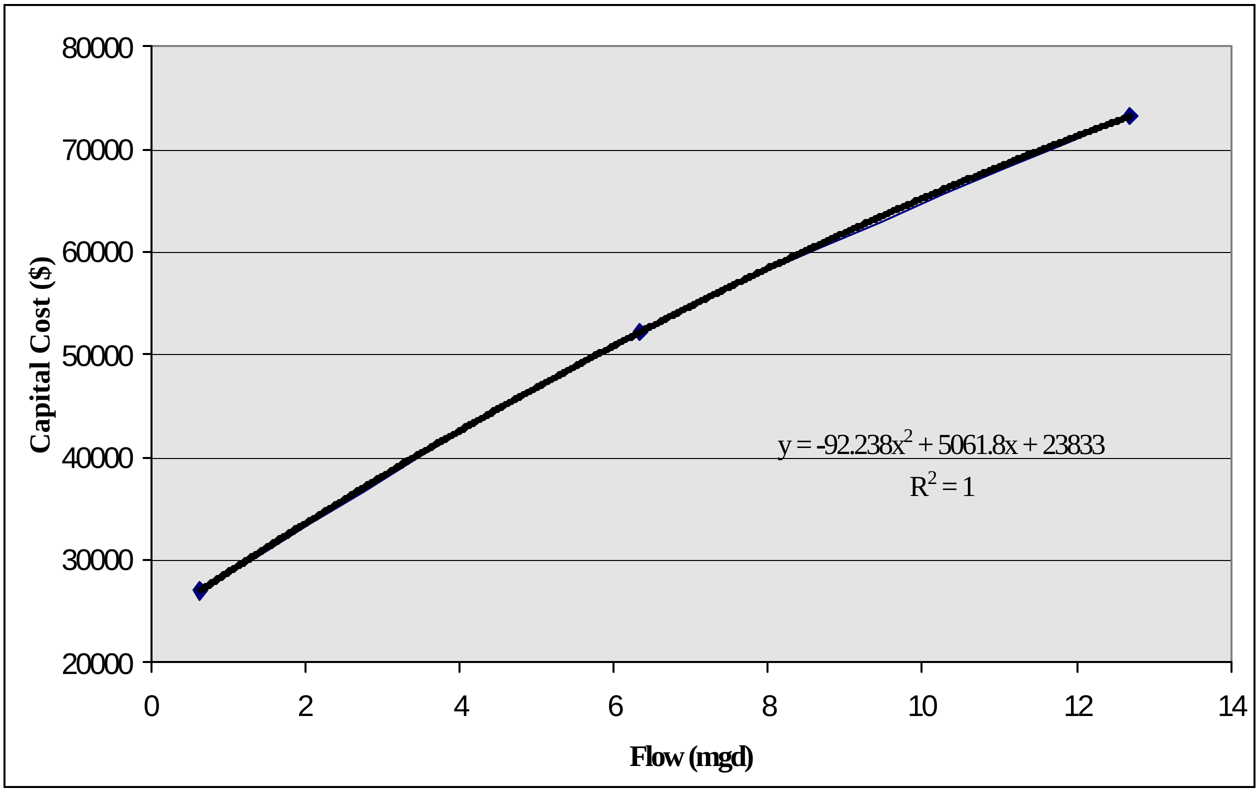
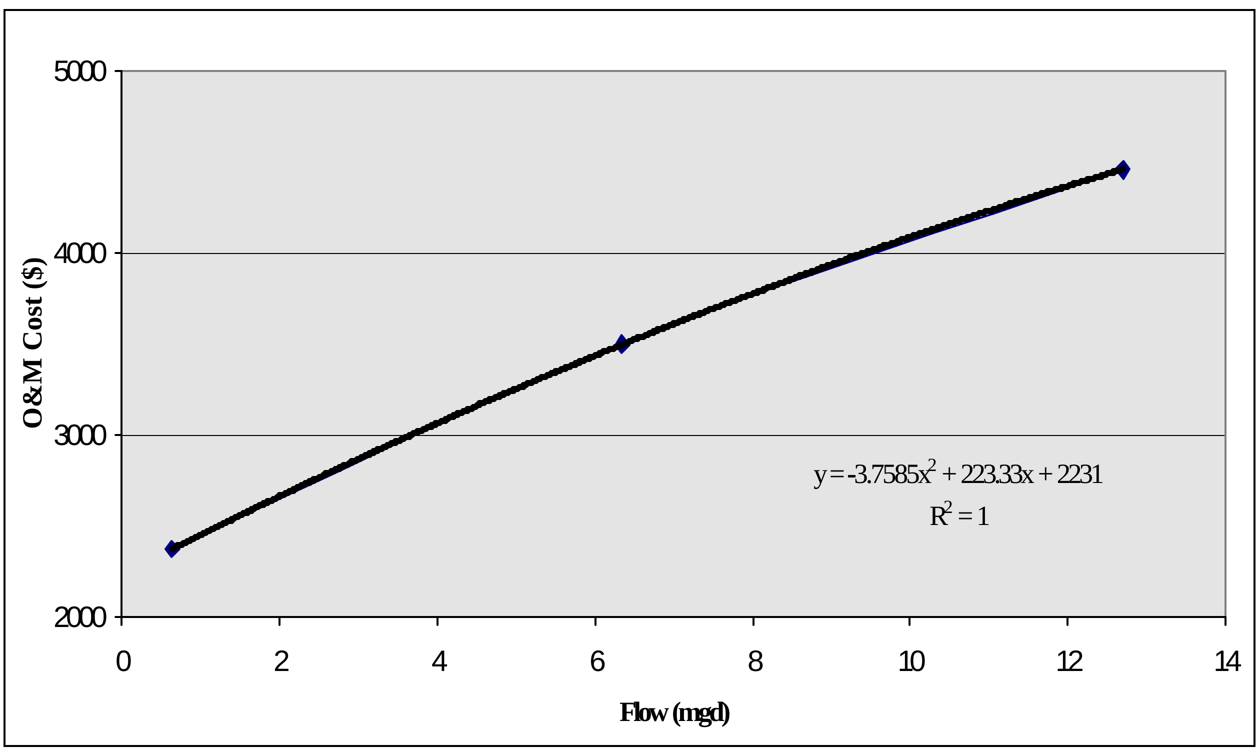


Figure 3-46. O&M Costs for Enlarging Intake Internally with CuNi Fine Mesh Screen

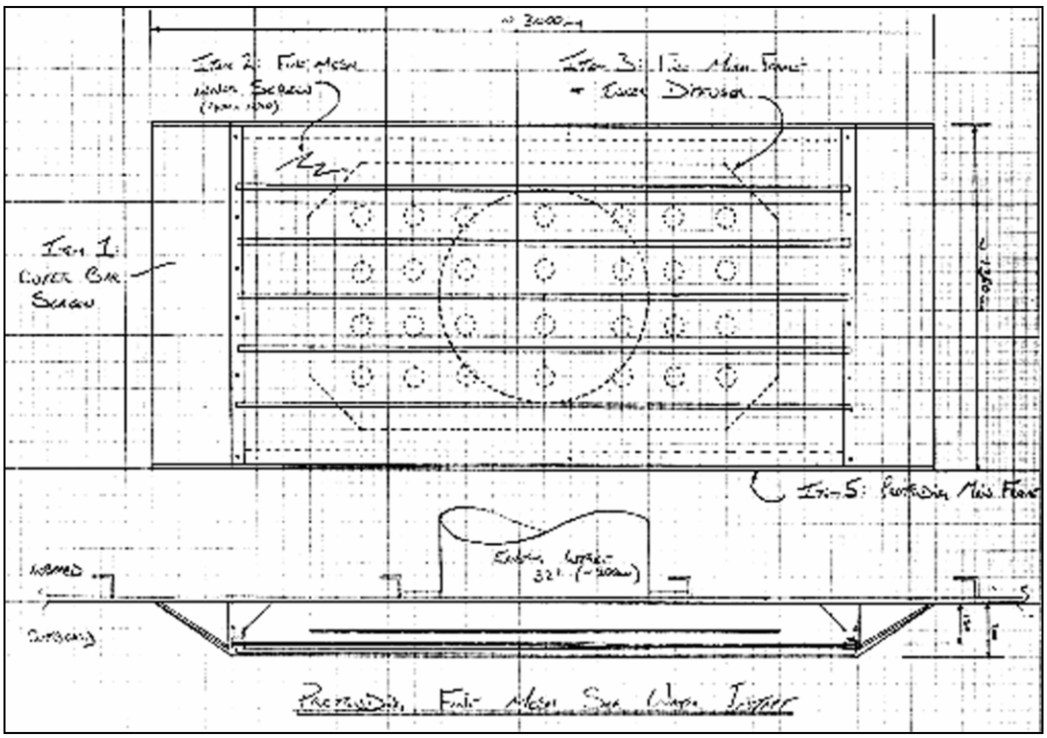


3.0 ENLARGE THE INTAKE STRUCTURE EXTERNALLY

3.1 Capital Cost Development

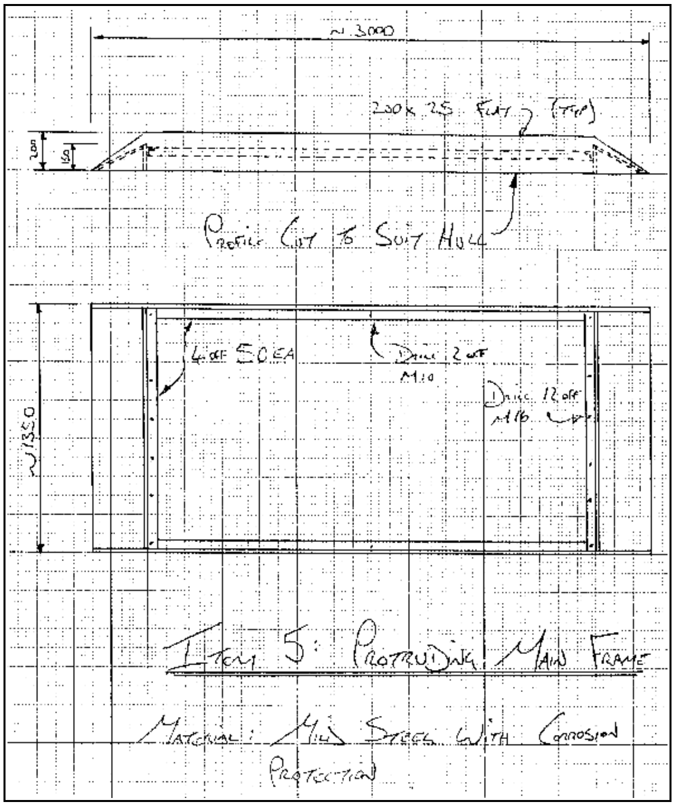
In this proposed modification, the existing 32@ intake is replaced with a new external intake structure that has a large enough surface area to reduce the through-screen velocity to 0.5 feet per second. An external intake does not affect the structure of the vessel and it is fairly simple and economical to retrofit the proposed intake to an existing vessel. However, with this type of intake modification, additional drag would be induced by its inclusion on the hull. Consequently, the low profile approach similar to the proposed internal enlargement is applicable for this configuration as well. Consultation with a naval architect confirmed that the additional drag induced by this modification would be negligible and that the cost benefit and ease of installation would likely outweigh any detrimental effects. The naval architect also confirmed that this design was reasonable for the stated purpose. Figures 3-39 through 3-41 and Figures 3-47 and 3-48 present the proposed modification to enlarge the existing intake externally.

Figure 3-47. External (Protruding) Fine Mesh Sea Water Intake Configuration



Refer to Figures 3-39 through 3-41 for details of Outer Bar Screen, Fine Mesh Inner Screen and Fine Mesh Frame and Inner Diffuser, respectively.

Figure 3-48. Main Frame for External (Protruding) Intake Modification



3.2 O&M Cost Development

The O&M costs are based on the labor cost for a team of divers, including the cost of equipment and boat to inspect and clean the intake once per year, and an allowance of 6% of the capital cost for parts replacement. The estimates for inspection and cleaning frequencies are based on vendor data and data from operators of similar equipment in high marine growth areas.

Exhibit 3-63 presents the summary of incremental capital and O&M costs to enlarge the intake structure externally with fine mesh screen. These costs are presented for three design intake flow values.

Exhibit 3-63. Capital and O&M Costs for Enlarging Intake Externally

Design Flow (MGD)	Stainless Steel Fine Mesh Screen		CuNi Fine Mesh Screen	
	Capital Cost ($)	O&M Cost ($)	Capital Cost ($)	O&M Cost ($)
0.6	12,541	2,021	12,669	2,027
6.3	28,862	2,752	30,157	2,817
12.7	43,444	3,429	46,027	3,558

Figures 3-49 through 3-52 show the cost curves for enlarging an intake externally.

Figure 3-49. Capital Costs for Enlarging Intake Externally with Stainless Steel Fine Mesh Screen

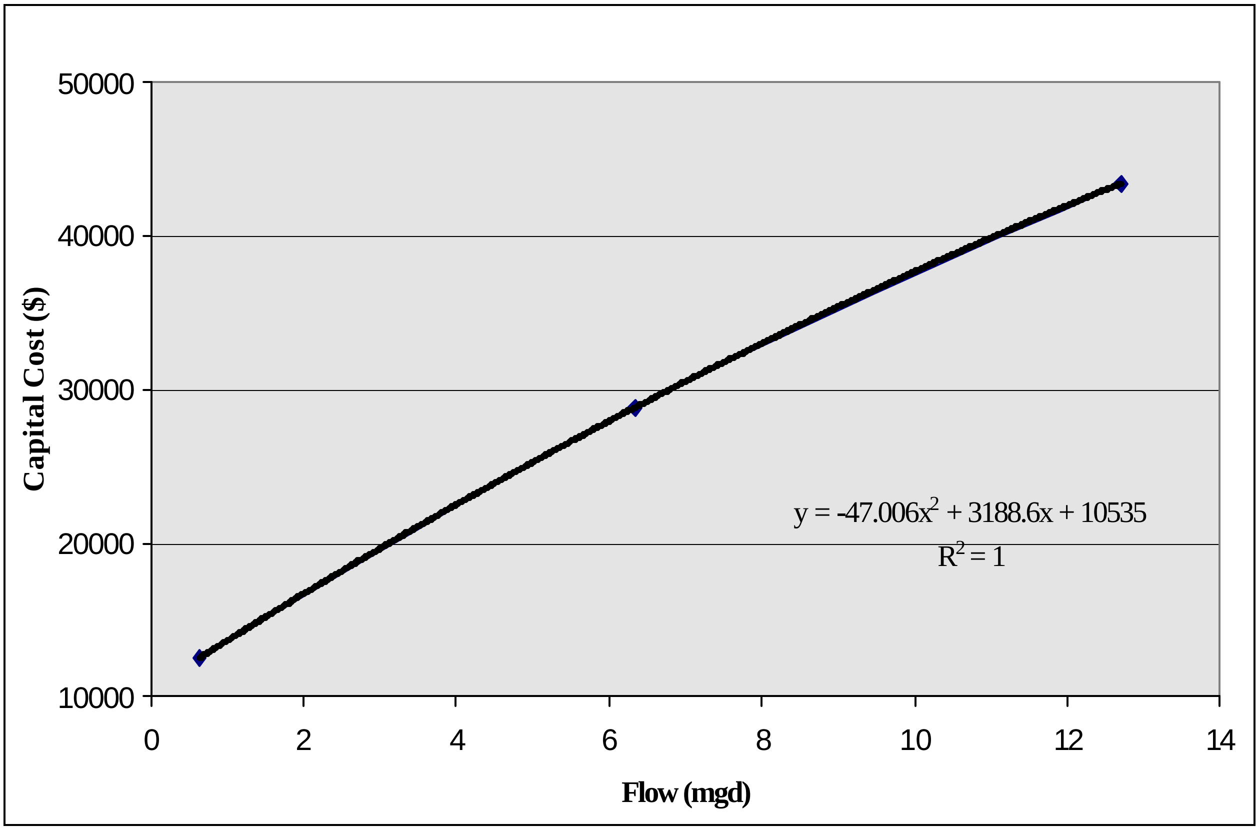


Figure 3-50. O&M Costs for Enlarging Intake Externally with Stainless Steel Fine Mesh Screen

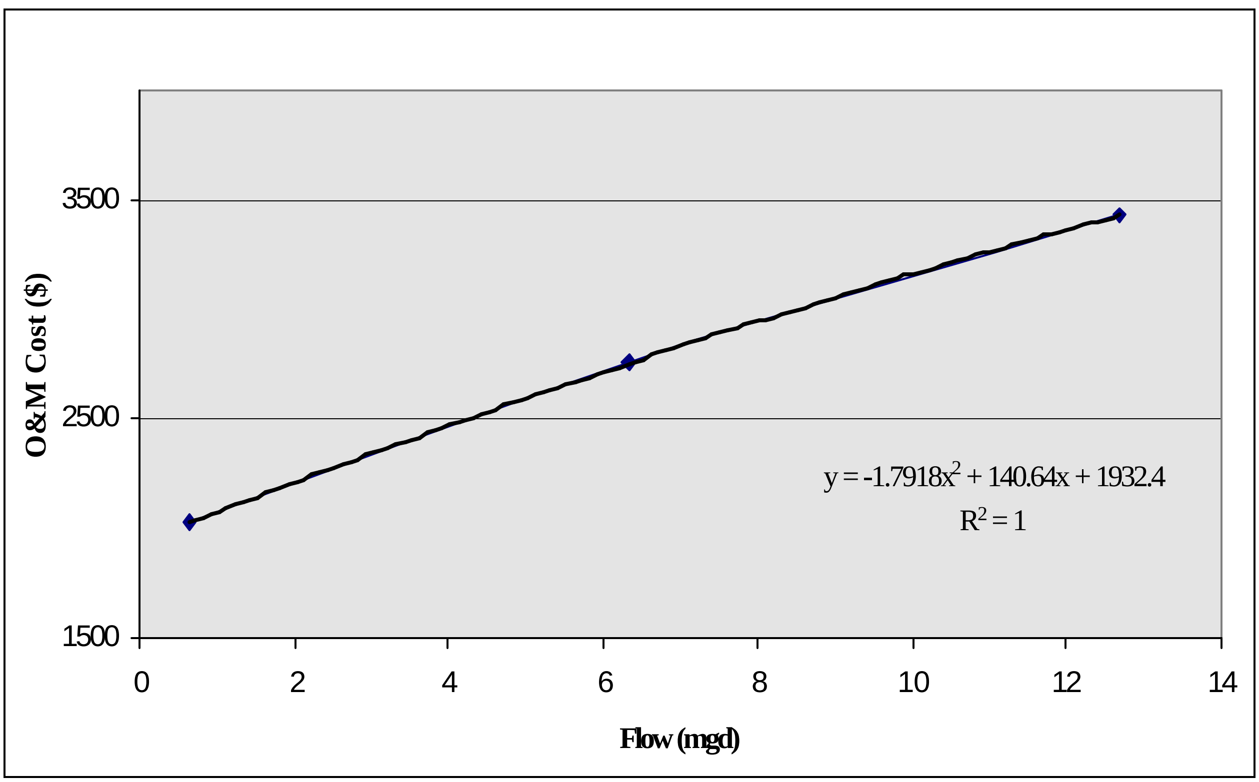


Figure 3-51. Capital Costs for Enlarging Intake Externally with CuNi Fine Mesh Screen

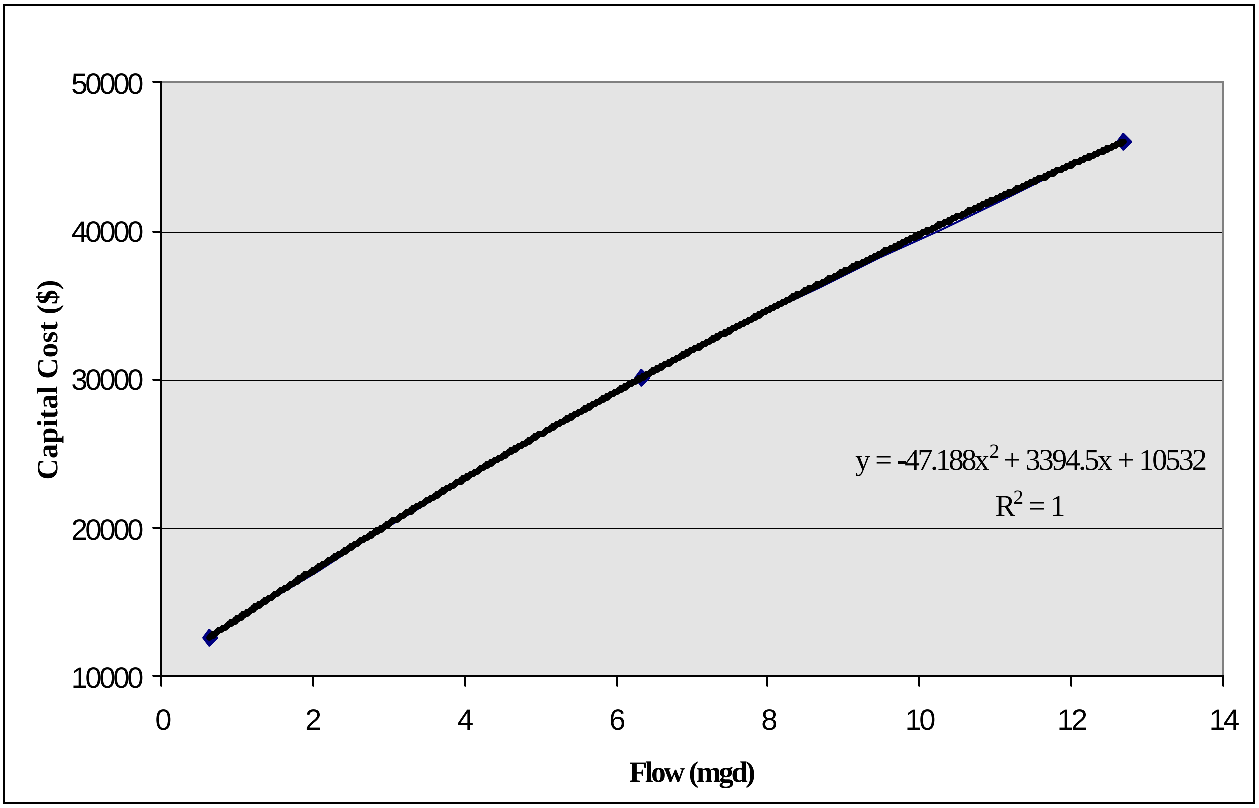
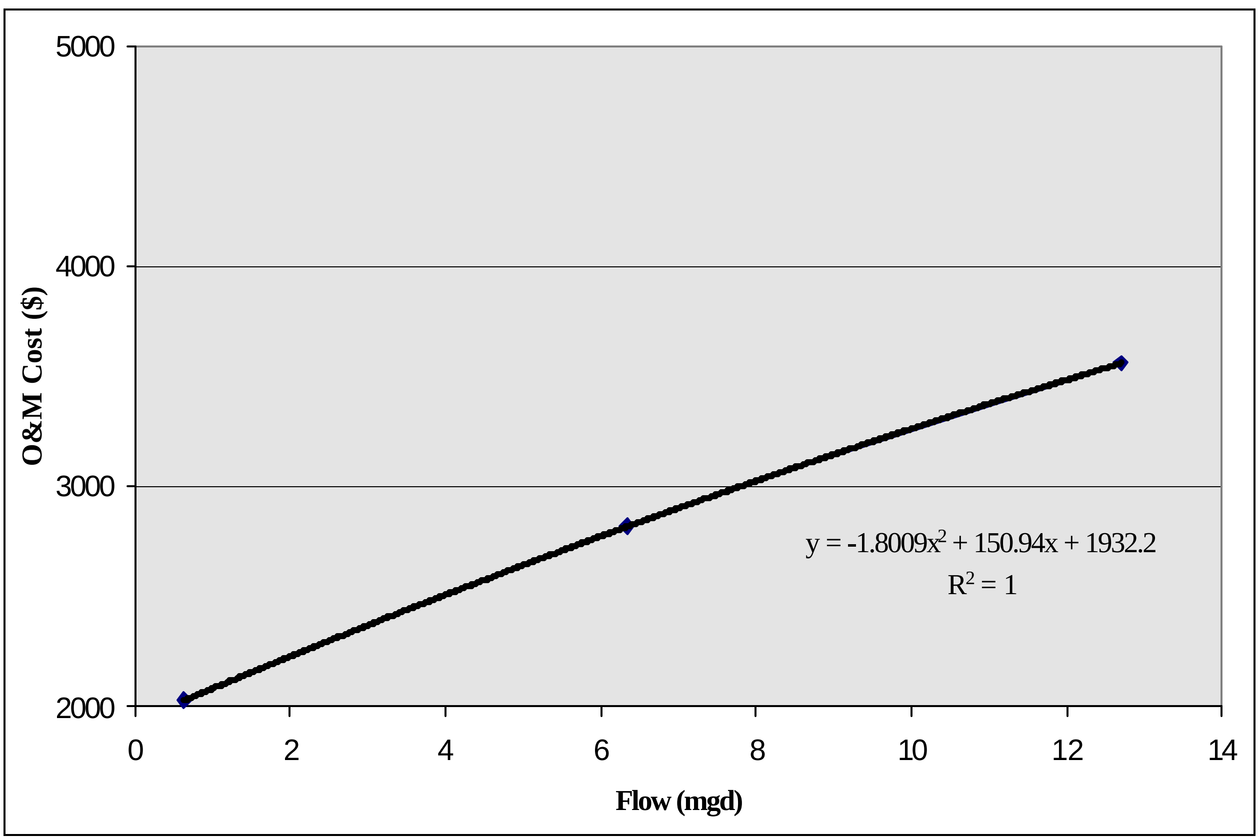


Figure 3-52. O&M Costs for Enlarging Intake Externally with CuNi Fine Mesh Screen



4.0 HORIZONTAL FLOW MODIFIER

4.1 Capital Cost Development

The horizontal flow modifier is a panel that ensures horizontal flow into the intake structure at a velocity of 0.5 feet per second or less. This is a derivative of the velocity cap technology.

The horizontal flow modifier option is divided up into two basic configurations: one for sea chests located on the bottom of the vessel and the other for sea chests located on the sidewalls of the vessel. The arrangement on the bottom sea chests closely resembles a standard velocity cap configuration. A plate is located over the intake opening to direct the flow in the horizontal direction between the plate and the hull. This arrangement will be suitable for hull angles up to 30° to the horizontal (87% of velocity will still be horizontal). For hull angles exceeding 30° and up to completely vertical, the side sea chest configuration will be required. This design includes a flow diffuser to spread the flow over a large area and louvres to direct the flow in the horizontal direction. Both of these designs are low profile to reduce any fluid dynamic effects on the hull of the vessel. The existing coarse grill over the sea chest will be retained. It is intended that the assembled horizontal flow diverter be attached using hinges to the hull to allow easy access to the existing intake structure. All materials used for the construction of this item will be mild steel coated in anti-fouling paint.

4.1.1 Vessels with Bottom Sea Chests

The proposed modification consists of a flow modifier plate that is stiffened using 4@ flat bar welded to the under side. These flat bar stiffeners also assist in funneling the flow into the existing intake structure. A coarse mesh has been included around the perimeter of the new intake structure. This is to prevent larger animals, such as turtles, from getting trapped in the gap between the hull and the flow modifier plate (looks similar to a reef ledge to some animals). Eight brackets (4@ PFC) are permanently welded to the hull as the primary attachment points. Eight legs off the flow modifier plate (1/2@ plate) attach to the brackets on the hull. Three of the bracket to leg connections use hinge pins, the other 5 legs use bolts. Releasing the bolts allows the flow modifier to swing down for maintenance or cleaning of the sea chest intake. A lifting lug should be added to the hull to allow lifting equipment that can be used to safely open and close this new structure. A lifting lug has been incorporated in the costs for this item. Figures 3-53 and 3-54 present the proposed configuration to modify the existing intake with horizontal flow modifiers for vessels with bottom sea chests.

4.1.2 Vessels with Side Sea Chests

The basic assembly consists of a diffuser plate nested in a number of flow louvres. The diffuser ensures that the flow is evenly distributed across the louvres and the louvres ensure that the flow is horizontal at a velocity of 0.5 feet per second or less. Two brackets (2@ equal angles) are permanently welded to the hull as the primary attachment points. These run the entire width and at each end of the sea chest modification. The horizontal flow modifier is attached to the brackets on the hull by way of a hinge on one side and bolts on the other. By releasing the bolts, the horizontal flow modifier may be swung out away from the hull for access to the existing sea chest. All materials used for the construction of this item will be mild steel coated in anti-fouling paint. The direction of the flow louvres should be adjusted during the design and construction of this equipment such that they are horizontal. Figures 3-55 and 3-56 present the proposed configuration to modify the existing intake with horizontal flow modifiers for vessels with side sea chests.

4.2 O&M Cost Development

The O&M costs are based on the labor cost for a team of divers, including the cost of equipment and boat to inspect and clean the intake once per year and an allowance of 6 % of the capital cost for parts replacement. The estimates for inspection and cleaning frequencies are based on vendor data and data from operators of similar equipment in high marine growth areas.

Figure 3-53. Plan View of Bottom Sea Chest Horizontal Flow Modifier

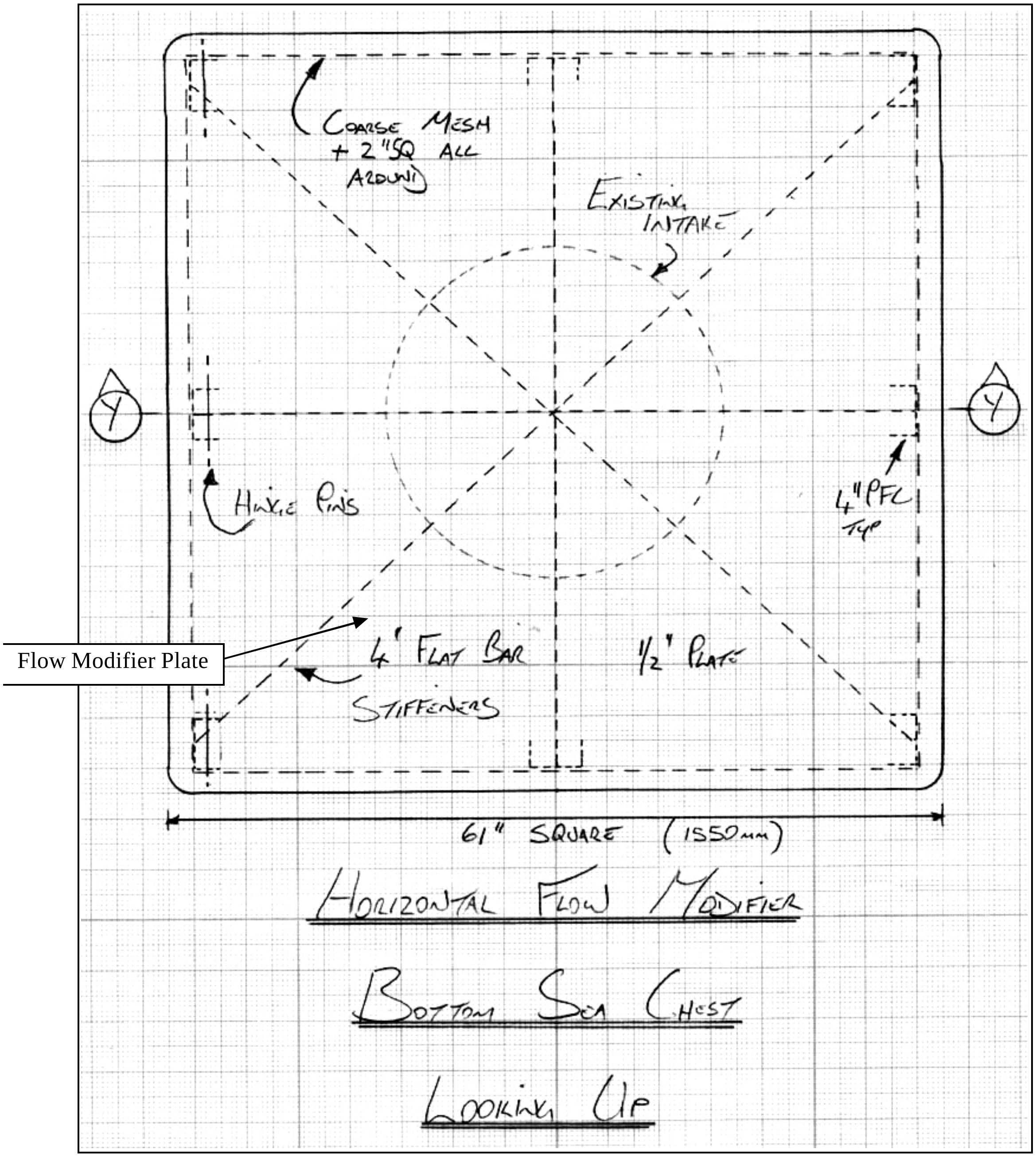


Figure 3-54. Sectional View of Bottom Sea Chest Horizontal Flow Modifier

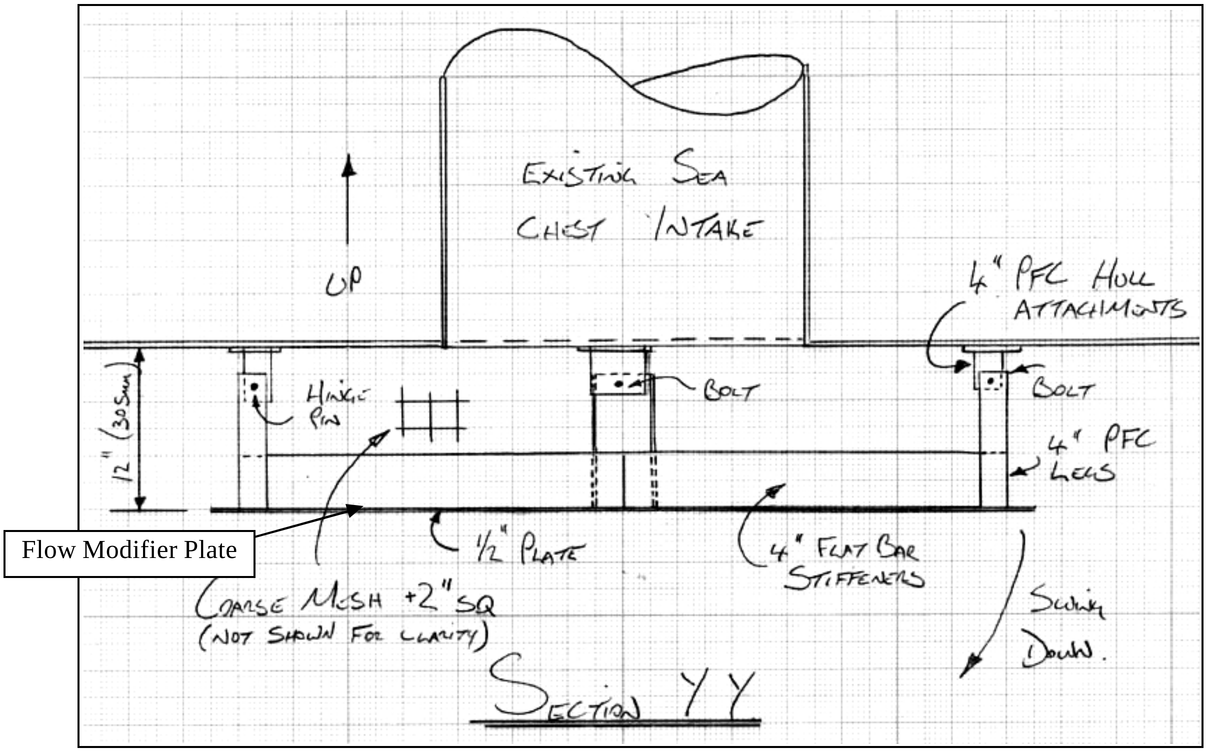


Figure 3-55. Plan View of Side Sea Chest Horizontal Flow Modifier

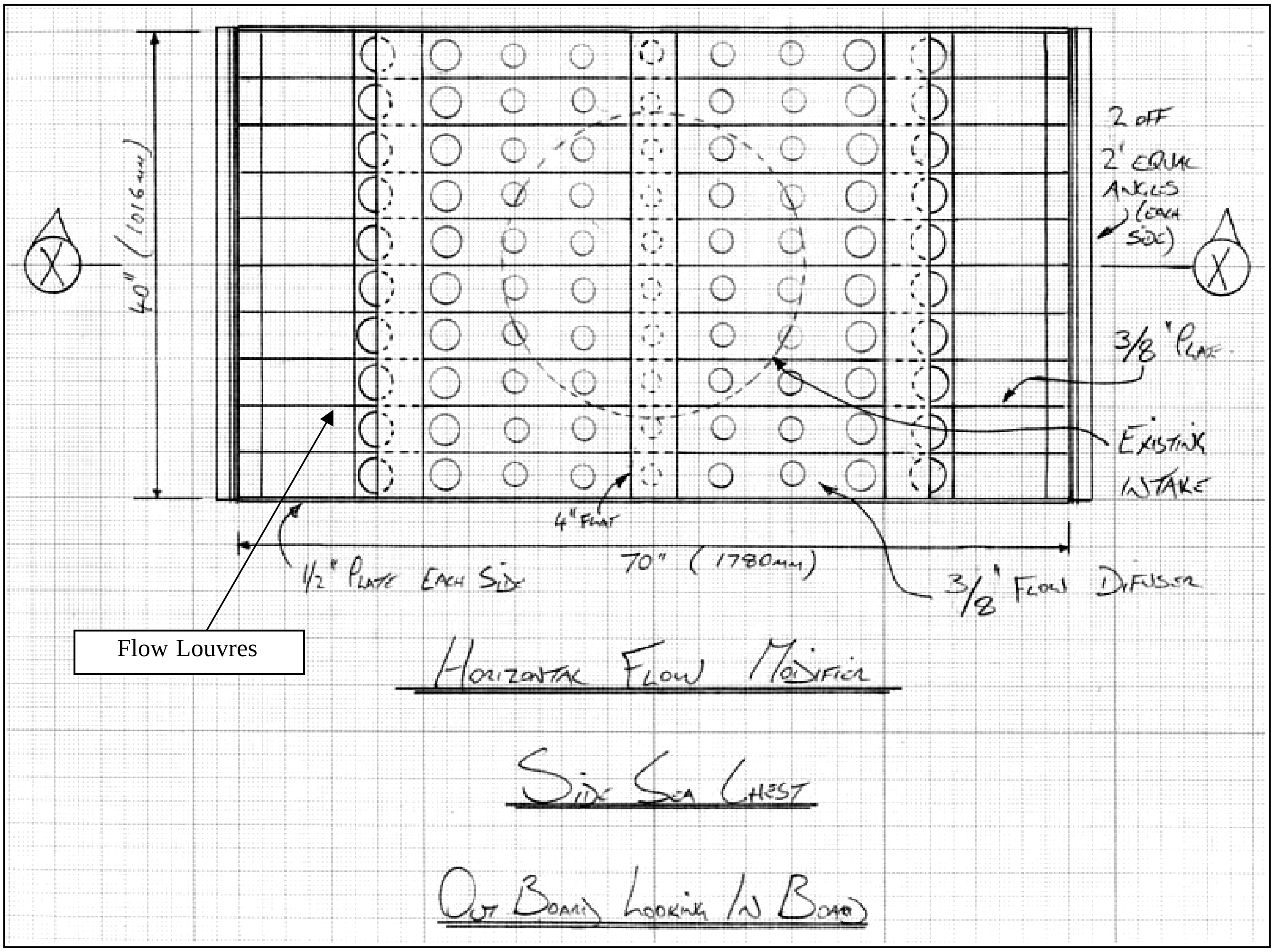
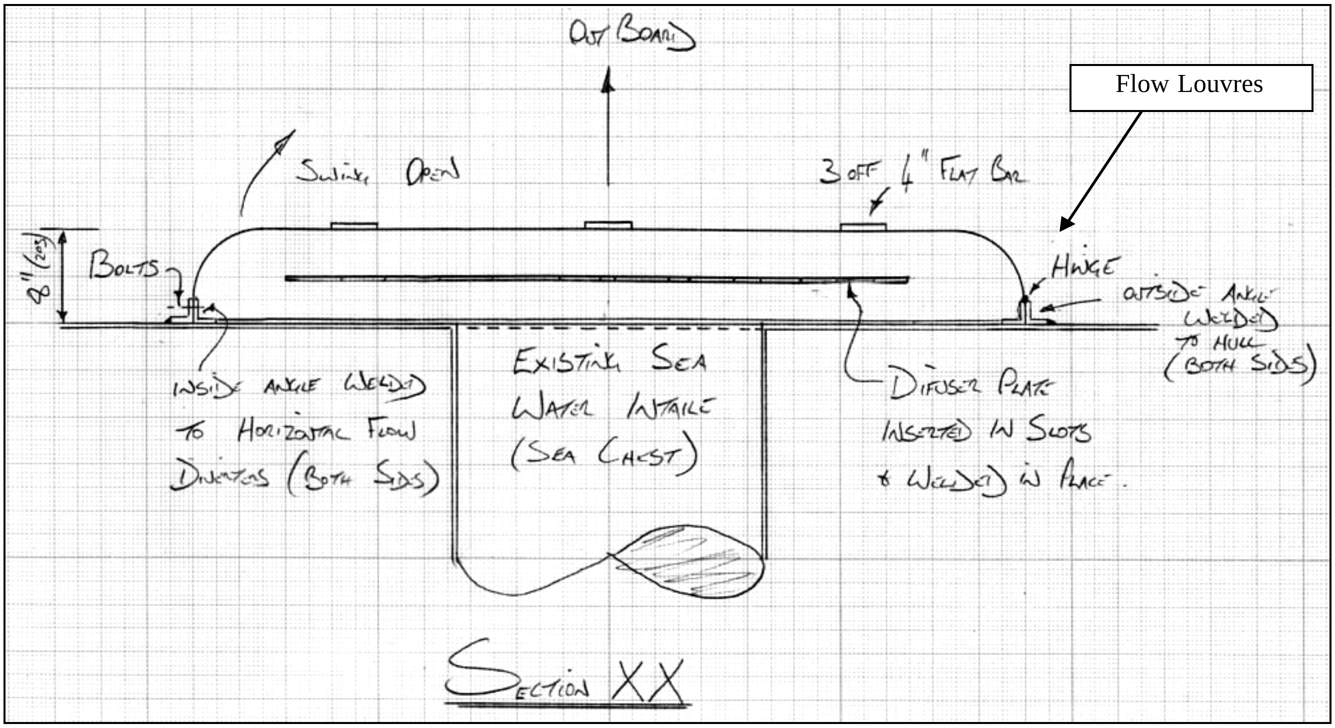


Figure 3-56. Sectional View of Side Sea Chest Horizontal Flow Modifier



Exhibits 3-64 and 3-65 below present the summary of incremental capital and O&M costs to enlarge the intake structure with flow modifier for vessels with bottom sea chests and side sea chests, respectively. These costs are presented for three design intake flow values.

Exhibit 3-64. Capital and O&M Costs for Intake Modification Using Flow Modifier for Vessels with Bottom Sea Chests

Design Flow (MGD)	Stainless Steel Fine Mesh Screen	
	Capital Cost ($)	O&M Cost ($)
0.6	6,221	1,915
6.3	11,437	2,228
12.7	17,048	2,565

Exhibit 3-65. Capital and O&M Costs for Intake Modification Using Flow Modifier for Vessels with Side Sea Chests

Design Flow (MGD)	Stainless Steel Fine Mesh Screen	
	Capital Cost ($)	O&M Cost ($)
0.6	5,343	1,863
6.3	13,266	2,338
12.7	22,240	2,876

Figures 3-57 through 3-60 show the cost curves for using a flow modifier.

Figure 3-57. Capital Costs for Intake Modification Using Flow Modifier for Vessels with Side Sea Chest

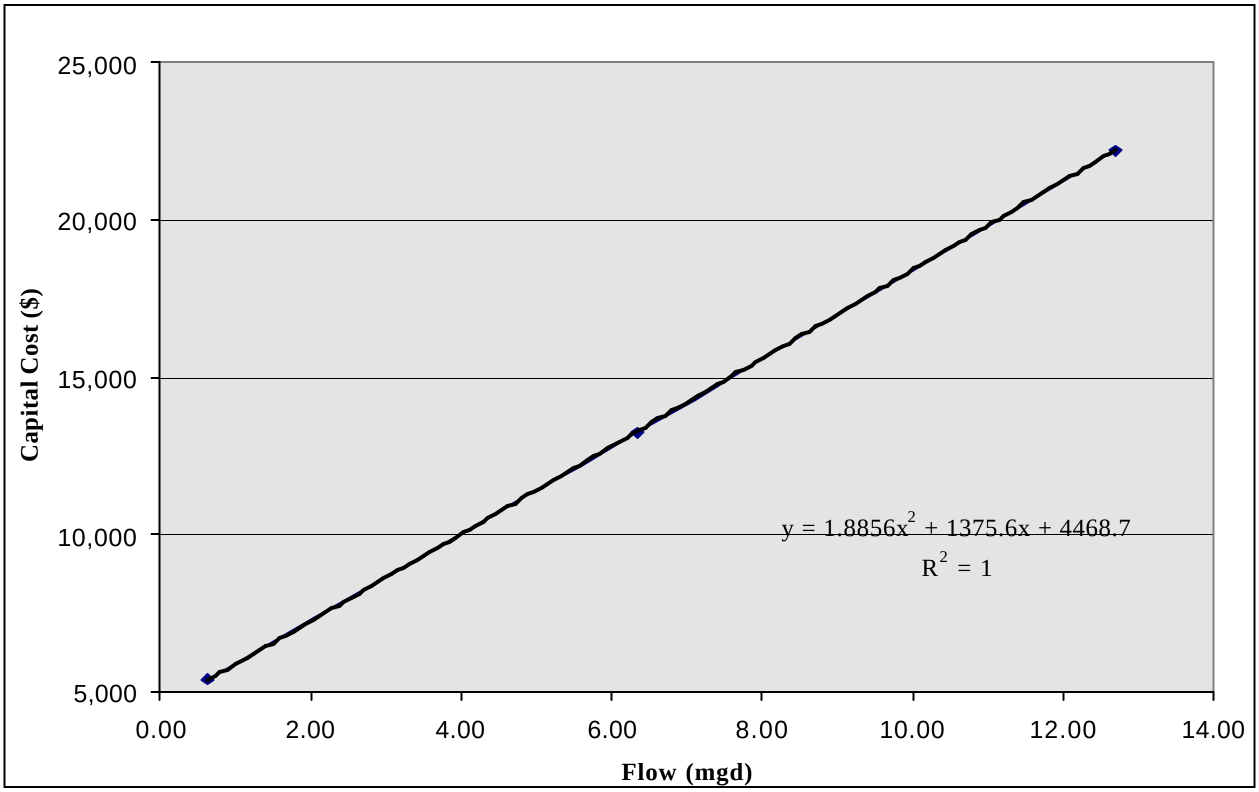


Figure 3-58. O&M Costs for Intake Modification Using Flow Modifier for Vessels with Side Sea Chest

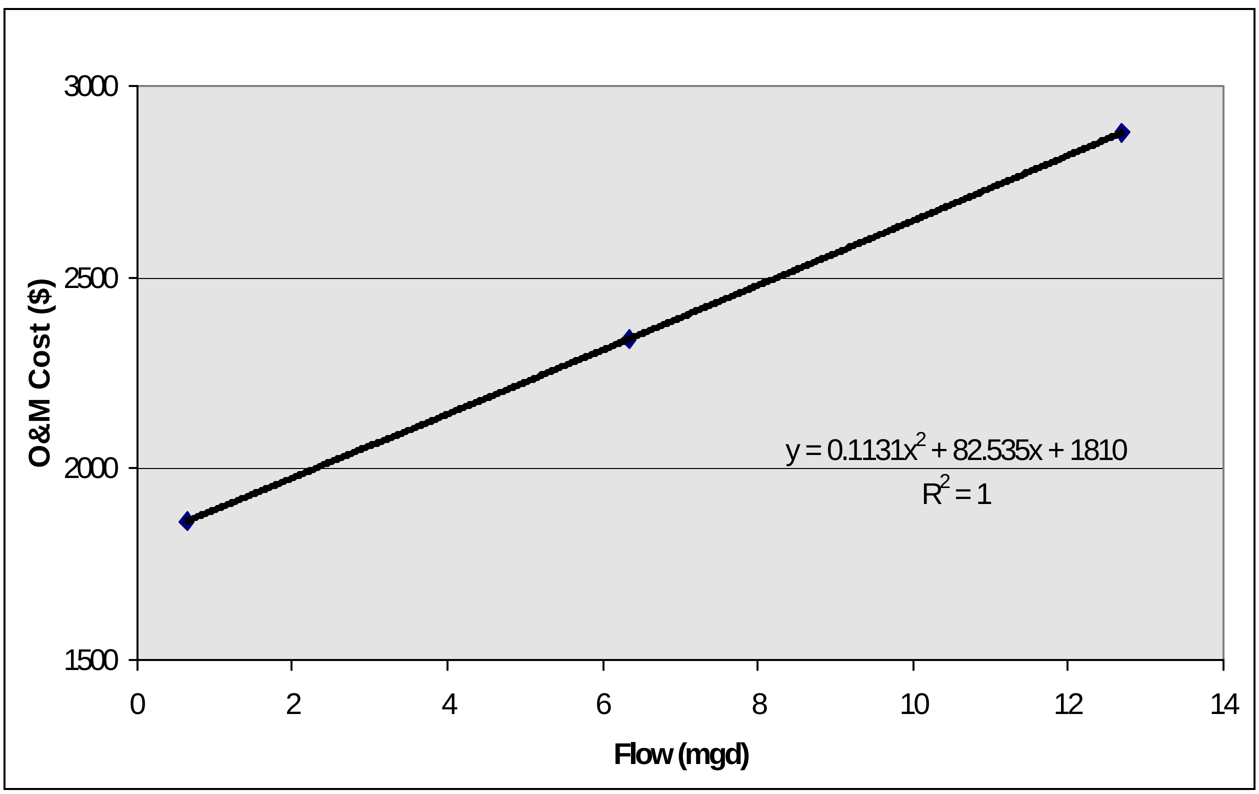


Figure 3-59. Capital Costs for Intake Modification Using Flow Modifier for Vessels with Bottom Sea Chest

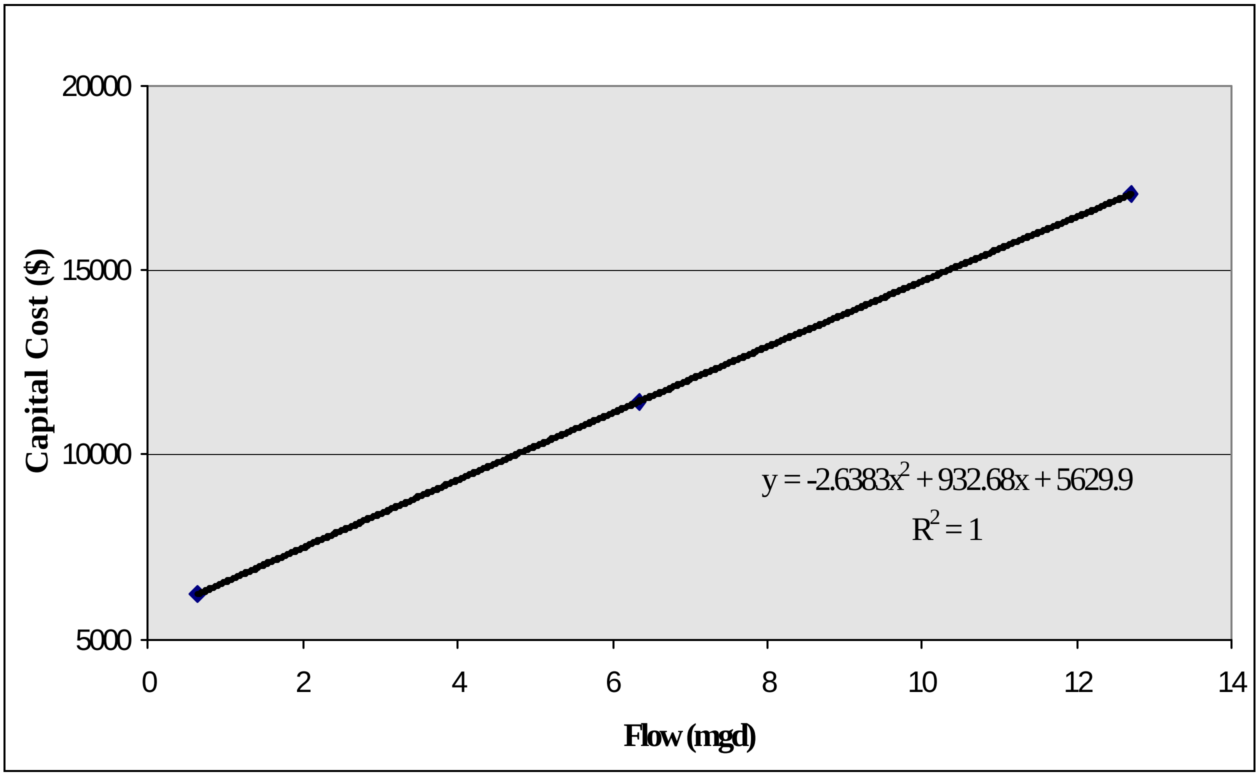
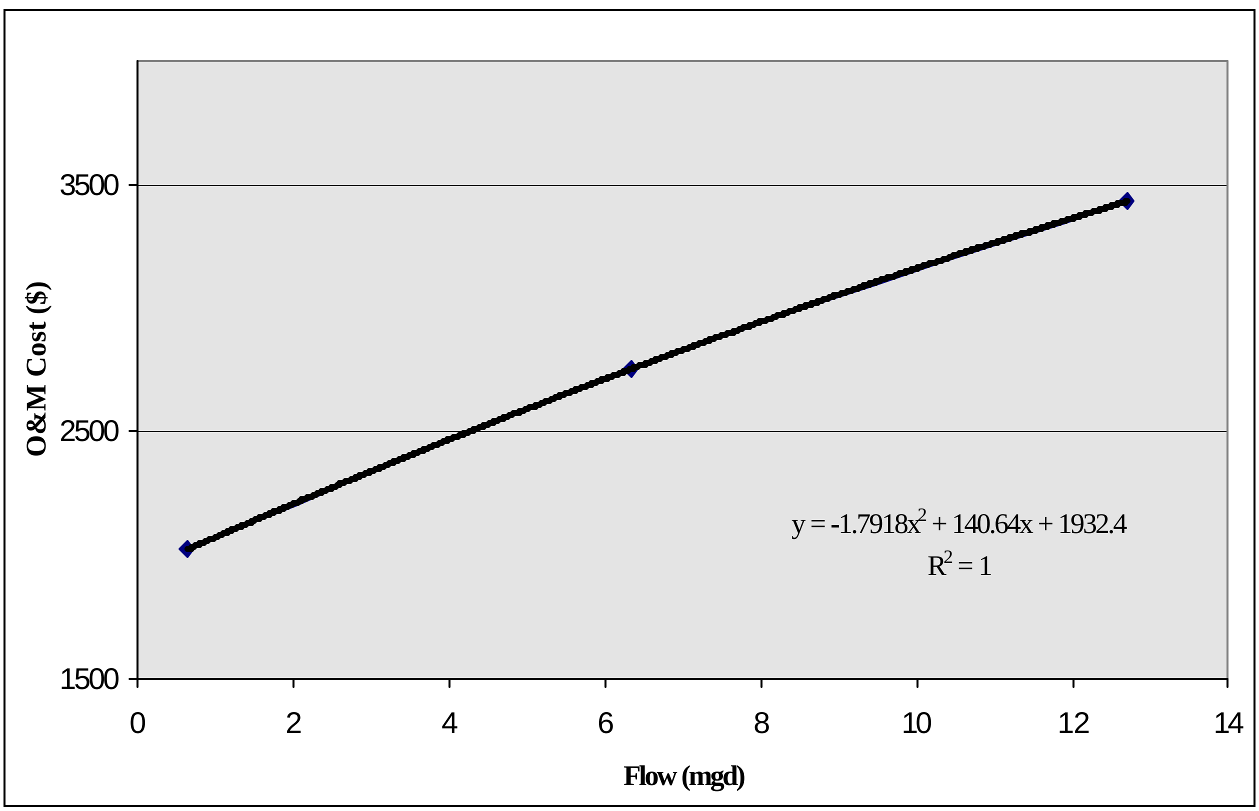


Figure 3-60. O&M Costs for Intake Modification Using Flow Modifier for Vessels with Bottom Sea Chest



III. FIXED AND VARIABLE O&M COSTS

1.0 DETERMINING FIXED VERSUS VARIABLE O&M COSTS

The annual O&M cost estimates are based on facilities' operation nearly continuously, with the only downtime being periodic routine maintenance. This routine maintenance was assumed to be approximately four weeks per year. The economic model however, considers variations in capacity utilization. Lower capacity utilization factors result in additional generating unit shutdown that may result in reduced O&M costs. However, it is not valid to assume that intake technology O&M costs drop to zero during these additional shutdown periods. Even when the generating unit is shut down, there are some O&M costs incurred. To account for this, total annual O&M costs were divided into fixed and variable components. Fixed O&M costs include items that occur even when the unit is periodically shut down, and thus are assumed to occur year round. Variable O&M costs apply to items that are allocable based on estimated intake operating time. The general assumption behind the fixed and variable determination is that shutdown periods are relatively short (on the order of several hours to several weeks).

1.1 Overall Approach

The annual O&M cost estimates used in the cost models is the net O&M cost, which is the difference between the estimated baseline and compliance O&M costs. Therefore, the fixed/variable proportions for each facility may vary depending on the mix of baseline and compliance technologies. To account for this complexity, EPA calculated the fixed O&M costs separately for both the baseline technology and each compliance technology and then calculated the total net fixed and variable components for each facility/intake.

To simplify the methodology (i.e., avoid developing a whole new set of O&M cost equations), a single fixed O&M component cost factor was estimated for each technology application represented by a single O&M cost equation. To calculate fixed O&M factors, EPA first calculated fixed O&M cost factors for the range of data input values, using the approach described below, to develop the cost equation. For baseline technologies, EPA selected the lowest value in the range of fixed component factors for each technology application. The lowest value was chosen for baseline technologies to yield a high-side net compliance costs for intermittently operating facilities. Similarly, for compliance technologies, EPA selected the highest value in the range of fixed component factors for each technology application, again, to provide a high-side estimate.

For each O&M cost equation, a single value (expressed either as a percentage or decimal value) representing the fixed component of O&M costs, is applied to each baseline and compliance technology O&M cost estimate for each facility. The variable O&M component is the difference between total O&M costs and the fixed O&M cost component. The fixed and variable cost components were then combined to derive the overall net fixed and overall net variable O&M costs for each facility/intake.

1.2 Estimating the Fixed/Variable O&M Cost Mix

Depending on the technology, the O&M cost estimates generally include components for labor, power, and materials. The cost breakdown assumes routine facility downtime will be relatively short (hours to weeks). Thus, EPA assumes any periodic maintenance tasks (e.g., changing screens, changing nets, or inspection/cleaning by divers) are performed regardless of plant operation, and therefore are considered fixed costs. Fixed costs associated with episodic cost components are allocated according to whether they would still occur even if the downtime coincided with the activity. For example, annual labor estimates for passive screens includes increased labor for several weeks during high debris episodes. This increased labor is considered a 100% variable component because it would not be performed if the system were not operating during this period. A discussion of the rationale for each general component is described below.

Power Requirements

In most cases, power costs are largely a variable cost. If there is a fixed power cost component, it will generally consist of low frequency, intermittent operations necessary to maintain equipment in working condition. For example, a 1% fixed factor for this component would equal roughly 1.0 hour of operation every four days for systems that normally operated continuously. Such a duration and frequency is considered as reasonable for most applications. For systems already operating intermittently, a factor that results in the equivalent of one hour of operation or one backwash every four days was used.

Labor Requirements

Labor costs generally have one or more of the following components:

- Routine monitoring and maintenance
- Episodes requiring higher monitoring and maintenance (high debris episodes)
- Equipment deployment and removal
- Periodic inspection/cleaning by divers.

Routine Monitoring and Maintenance

This component includes monitoring/adjustment of the equipment operation, maintaining equipment (repairs & preventive O&M), and cleaning. Of these, the monitoring/adjustment and cleaning components will drop significantly when the intakes are not operating. A range of 30% to 50% costs are considered for the fixed component.

Episodes requiring higher monitoring and maintenance

This component is generally associated with equipment that is operating and the costs are 100% variable.

Equipment deployment and removal

This activity is generally seasonal in nature and is performed regardless of operation (i.e., 100% fixed).

Periodic Inspection/Cleaning by Divers

This periodic maintenance task is performed regardless of plant operation, and therefore is considered as 100% fixed costs.

Equipment Replacement

The component includes two factors: parts replacement due to wear and tear (and varies with operation) and parts replacement due to corrosion (and occurs regardless of operation). A range of 50% to 70% of these costs will be considered the fixed component.

Technology-Specific Input Factors

Traveling Screens
To determine the range of calculated total O&M fixed factors, fixed O&M cost factors (Exhibit 3-66) were applied to individual O&M cost components for the various screen width values that were used to generate the O&M cost curves. As described earlier, the lowest value of this range was selected for the baseline O&M fixed cost factor and the highest of this range was selected as the compliance O&M fixed cost factor.

Exhibit 3-66. O&M Cost Component Fixed Factor

	Routine Labor	Parts Replacement	Equipment Power	Equipment Deployment
All Traveling Screens Without Fish Handling	0.5	0.7	0.05	1.0
All Traveling Screens With Fish Handling	0.3	0.5	0.01	1.0

Passive Screens

The fixed O&M component was based on the following:

- Seasonal high debris period monitoring labor set equal to 0 hours
- Routine labor set at 50% of full time operation
- Back washes are performed once every four days
- Dive team costs for new screens at existing offshore for high debris were set at 50% of full time operation
- Dive team costs for new screens at existing offshore were set equal to 0 assuming no net additional diver costs over what was necessary for existing submerged intake without screens.
- The same assumptions are applied to both fine mesh and very fine mesh screens.

Baseline Passive Intake

In the development of the fixed factor for the passive screens, the routine labor fixed portion was set at 50% of full time operation. The baseline O&M costs for passive intake technologies are assumed to be comprised solely of routine labor. Therefore, the fixed factor for the baseline O&M costs is estimated to be 50%.

Development of Baseline O&M Costs for Passive Intakes

After traveling screens, passive intakes make up the second most prevalent intake technology. Passive technologies reported by Phase III facilities with a DIF >50 MGD comprise mostly the following technologies:

1. Fixed Coarse Screens
2. Perforated Pipes
3. Coarse Mesh Wedgewire Screens

Depending on the design and local waterbody conditions, O&M costs for baseline passive intake technology vary significantly. The technologies described under 2 and 3 above generally are installed at submerged intakes, while fixed coarse screens can be installed at both shoreline and submerged intakes. The 316(b) surveys did not specify the location (shoreline vs. submerged offshore) of fixed screens. O&M costs are generally higher for passive T-screens with backwash systems and for intakes requiring frequent cleaning and inspection by divers. Because of the potential for wide variations in baseline costs, the costs derived below are intended to represent the low end of the range of O&M costs for passive technologies, resulting in a conservative compliance cost estimate (i.e., higher net compliance O&M estimate).

EPA received a limited number of passive technology O&M cost data in a Submerged Intake Survey sent to selected Phase II facilities with submerged intakes. Three facilities reported O&M costs associated with routine cleaning and inspection of the passive intake system including pipe and inlet. These costs are presented below in Exhibit 3-67, along with the facility design intake flow.

Exhibit 3-67. Data from the Submerged Intake Survey

Facility Name and Location	Design Intake Flow (gpm)	Annual O&M for Inspection and Cleaning Inlet
Robert E. Ritchie Plant, AR	38,200	$3,800[a]
Charles Lowman Plant (AEC), AL	53,472	$4,200[b]
Wheelabrator Westchester, NY	318,000	$10,000[a]

a. Inspect and clean underwater pipe and inlet structures.
b. Costs for cleaning inlet screens
Sources: Entergy 2002, AEC 2002, Wheelabrator 2002.

A linear equation provided a good fit to the data and, considering that only three data points are used, the selection of any other equation type would result in a curve with a shape that would be highly influenced by site-specific differences.

The equation used to estimate baseline O&M costs for passive technology based on the Submerged Intake Survey Data is:

Annual Baseline O&M = 0.0223 X "Existing Equip. DIF" + 2977

Since this equation has no upper bound it can be applied to the total design intake flow, rather than dividing the flow into cost units which are then summed together as was done for many of the cost modules and for traveling screen baseline costs. Note that the use of multiple cost units for the other technologies tends to result in a linear cost to flow relationship at higher design flows.

Velocity Caps

Because the O&M cost for velocity caps was based on annual inspection and cleaning by divers, the entire velocity cap O&M cost is assumed to be fixed (100%).

Fish Barrier Nets

Fish barrier net O&M costs are based on deployment and removal of the nets plus periodic replacement of net materials. As described above, EPA assumes seasonal deployment and removal is a 100% fixed O&M cost. The need for net maintenance and replacement is a due to its presence in the waterbody and should not vary with the intake operation. Therefore, entire fish barrier net O&M cost is assumed to be fixed (100%).

Aquatic Filter Barriers

The O&M costs for AFBs include both periodic maintenance and repair of the filter fabric and equipment plus energy used in the operation of the airburst system. As with barrier nets the need for net repairs and replacement should not vary with the intake operation. There may be a reduction in the deposition of sediment during the periods when the intake is not operating and as a result there may be a reduction in the required frequency of airburst operation. However, the presence of tidal and other waterbody currents may continue to deposit sediment on the filter fabric requiring periodic operation. Thus, the degree of reduction in the airburst frequency will be dependent on site conditions. In addition, the O&M costs provided by the vendor did not break out the O&M costs by component. Therefore, EPA concluded that AFB O&M costs being 100% fixed is reasonable and represents a conservative estimate in that it will slightly overestimate O&M costs during periods when the intake is not operating.

Recirculating Wet Cooling Towers

Because the cooling tower O&M costs were derived using cost factors that estimate total O&M costs that are based on capital costs, a detailed analysis is not possible. However, using the pumping and fan energy requirements described in the

Proposed Rule Technical Development Document, EPA was able to estimate that the O&M energy component was under 50% of the total O&M cost. This energy requirement reduction, coupled with reductions in labor and parts replacement requirements, should result in a fixed cost factor of approximately 50%.

1.3 O&M Fixed Cost Factors

Exhibits 3-68 and 3-69 present the fixed O&M cost factors for baseline technologies and compliance technologies, respectively, as derived above.

Exhibit 3-68. Baseline Technology Fixed O&M Cost Factors

Technology Description	Application	Water Type	Fixed Factor
Traveling Screen with Fish Handling	10 Ft Screen Wells	Freshwater	0.28
Traveling Screen with Fish Handling	25 Ft Screen Wells	Freshwater	0.30
Traveling Screen with Fish Handling	50 Ft Screen Wells	Freshwater	0.32
Traveling Screen with Fish Handling	75 Ft Screen Wells	Freshwater	0.33
Traveling Screen with Fish Handling	10 Ft Screen Wells	Saltwater	0.31
Traveling Screen with Fish Handling	25 Ft Screen Wells	Saltwater	0.34
Traveling Screen with Fish Handling	50 Ft Screen Wells	Saltwater	0.36
Traveling Screen with Fish Handling	75 Ft Screen Wells	Saltwater	0.38
Traveling Screen without Fish Handling	10 Ft Screen Wells	Freshwater	0.45
Traveling Screen without Fish Handling	25 Ft Screen Wells	Freshwater	0.47
Traveling Screen without Fish Handling	50 Ft Screen Wells	Freshwater	0.48
Traveling Screen without Fish Handling	75 Ft Screen Wells	Freshwater	0.49
Traveling Screen without Fish Handling	10 Ft Screen Wells	Saltwater	0.49
Traveling Screen without Fish Handling	25 Ft Screen Wells	Saltwater	0.51
Traveling Screen without Fish Handling	50 Ft Screen Wells	Saltwater	0.53
Traveling Screen without Fish Handling	75 Ft Screen Wells	Saltwater	0.53
Passive Intake	All (except bar screens only)	All	0.5

Exhibit 3-69. Compliance Technology Fixed O&M Cost Factors

Technology Description	Application	Water Type	Fixed Factor
Aquatic Filter Barrier	All	All	1.0
Add Fish Barrier Net Using Anchors and Bouys	All	Freshwater	1.0
Add Fish Barrier Net Using Pilings for Support	10 Ft Net Depth	Saltwater	1.0
Add Fish Barrier Net Using Pilings for Support	20 Ft Net Depth	Saltwater	1.0
Add Fine Mesh Passive T-screens to Existing Offshore Intake	High Debris	All	0.21
Add Fine Mesh Passive T-screens to Existing Offshore Intake	Low Debris	All	0.27
Add Very Fine Mesh Passive T-screens to Existing Offshore Intake	High Debris	All	0.19
Add Very Fine Mesh Passive T-screens to Existing Offshore Intake	Low Debris	All	0.27
Relocate Intake Offshore with Fine Mesh Passive T-screens	High Debris	All	0.46
Relocate Intake Offshore with Fine Mesh Passive T-screens	Low Debris	All	0.56
Relocate Intake Offshore with Very Fine Mesh Passive T-screens	High Debris	All	0.38
Relocate Intake Offshore with Very Fine Mesh Passive T-screens	Low Debris	All	0.49
Traveling Screen With Fish Handling and Fine Mesh	10 Ft Screen Wells	Freshwater	0.38
Traveling Screen With Fish Handling and Fine Mesh	25 Ft Screen Wells	Freshwater	0.35
Traveling Screen With Fish Handling and Fine Mesh	50 Ft Screen Wells	Freshwater	0.37
Traveling Screen With Fish Handling and Fine Mesh	75 Ft Screen Wells	Freshwater	0.39
Traveling Screen With Fish Handling and Fine Mesh	10 Ft Screen Wells	Saltwater	0.41
Traveling Screen With Fish Handling and Fine Mesh	25 Ft Screen Wells	Saltwater	0.38
Traveling Screen With Fish Handling and Fine Mesh	50 Ft Screen Wells	Saltwater	0.40
Traveling Screen With Fish Handling and Fine Mesh	75 Ft Screen Wells	Saltwater	0.41
Traveling Screen With Fish Handling	10 Ft Screen Wells	Freshwater	0.40
Traveling Screen With Fish Handling	25 Ft Screen Wells	Freshwater	0.42
Traveling Screen With Fish Handling	50 Ft Screen Wells	Freshwater	0.42
Traveling Screen With Fish Handling	75 Ft Screen Wells	Freshwater	0.42
Traveling Screen With Fish Handling	10 Ft Screen Wells	Saltwater	0.42
Traveling Screen With Fish Handling	25 Ft Screen Wells	Saltwater	0.43
Traveling Screen With Fish Handling	50 Ft Screen Wells	Saltwater	0.44
Traveling Screen With Fish Handling	75 Ft Screen Wells	Saltwater	0.44
Traveling Screen Dual-Flow	10 Ft Screen Wells	Freshwater	0.40
Traveling Screen Dual-Flow	25 Ft Screen Wells	Freshwater	0.40
Traveling Screen Dual-Flow	50 Ft Screen Wells	Freshwater	0.40
Traveling Screen Dual-Flow	75 Ft Screen Wells	Freshwater	0.40
Traveling Screen Dual-Flow	10 Ft Screen Wells	Saltwater	0.44
Traveling Screen Dual-Flow	25 Ft Screen Wells	Saltwater	0.44
Traveling Screen Dual-Flow	50 Ft Screen Wells	Saltwater	0.44
Traveling Screen Dual-Flow	75 Ft Screen Wells	Saltwater	0.44
Velocity Cap	All	All	1.0
Cooling Towers	All	All	0.5

Chapter 4: Impingement and Entrainment Controls

INTRODUCTION

This section provides a summary of the effects of impingement and entrainment, the development of the performance standards, and the regulatory options that EPA considered for the final Phase III rule.

1.0 IMPINGEMENT AND ENTRAINMENT EFFECTS

The withdrawal of cooling water removes trillions of aquatic organisms from waters of the United States each year, including plankton (small aquatic animals, including fish eggs and larvae), fish, crustaceans, shellfish, sea turtles, marine mammals, and many other forms of aquatic life. Most impacts are to early life stages of fish and shellfish.

Aquatic organisms drawn into cooling water intake structures are either impinged on components of the intake structure or entrained in the cooling water system itself. Impingement takes place when organisms are trapped on the outer part of an intake structure or against a screening device during periods of intake water withdrawal. Impingement is primarily caused by hydraulic forces in the intake stream. Impingement can result in (1) starvation and exhaustion; (2) asphyxiation when the fish are forced against a screen by velocity forces that prevent proper gill movement or when organisms are removed from the water for prolonged periods; and (3) descaling and abrasion by screen wash spray and other forms of physical injury.

Entrainment occurs when organisms are drawn into the intake water flow entering and passing through a cooling water intake structure and into a cooling water system. Organisms that become entrained are those organisms that are small enough to pass through the intake screens, primarily eggs and larval stages of fish and shellfish. As entrained organisms pass through a plant=s cooling water system, they are subject to mechanical, thermal, and/or toxic stress. Sources of such stress include physical impacts in the pumps and condenser tubing, pressure changes caused by diversion of the cooling water into the plant or by the hydraulic effects of the condensers, shear stress, thermal shock in the condenser and discharge tunnel, and chemical toxemia induced by antifouling agents such as chlorine.

For a more detailed discussion of impingement and entrainment and the effects on aquatic organisms, refer to the preamble to the final rule and The Regional Benefits Assessment for the Proposed Section 316(b) Rule for Phase III Facilities (EPA-821-R-04-017).

2.0 PERFORMANCE STANDARDS

The final Phase III rule makes new offshore oil and gas extraction facilities subject to requirements similar to those under the final Phase I new facility regulation. Phase III existing facilities will continue to be permitted on a case-by-case basis using a permit writer's best professional judgment (BPJ). The performance standards considered for the final Phase III rule were similar to those required in the final Phase II regulations. Overall, the performance standards that reflected best technology considered under the proposed rule were not based on a single technology but, rather, were based on consideration of a range of technologies that EPA had determined to be commercially available for the industries affected as a whole and have acceptable non-water quality environmental impacts. Because the requirements implementing section 316(b) were applied in a variety of settings and to potentially regulated Phase III facilities of different types and sizes, no single technology was found to be most effective at all existing facilities.

For the final rule, EPA considered the performance standards for impingement mortality reduction based on an analysis of the efficacy of the following technologies: (1) design and construction technologies such as fine and wide-mesh wedgewire screens, as well as aquatic filter barrier systems, that can reduce mortality from impingement by up to 99 percent or greater compared with conventional once-through systems; (2) barrier nets that may achieve reductions of 80 to 90 percent; and (3) modified screens and fish return systems, fish diversion systems, and fine mesh traveling screens and fish return systems that have achieved reductions in impingement mortality ranging from 60 to 90 percent as compared to conventional once-through systems.

Available performance data for entrainment reduction are not as comprehensive as impingement data. However, aquatic filter barrier systems, fine mesh wedgewire screens, and fine mesh traveling screens with fish return systems have been shown to achieve 80 to 90 percent or greater reduction in entrainment compared with conventional once-through systems. EPA notes that proper operation and design of fine mesh wedgewire screens and use of biofouling controls help ensure that the through screen velocity is minimized in order reduce impingement impacts.

3.0 REGULATORY OPTIONS CONSIDERED

EPA proposed requirements for the location, design, construction, and capacity of cooling water intakes based on the volume of water withdrawn by a Phase III facility. The final rule applies to new offshore oil and gas extraction facilities that have a design intake flow threshold of greater than 2 million gallons per day and that withdraw at least 25 percent of the water exclusively for cooling purposes.

The final rule establishes requirements for the reduction of impingement mortality at new offshore oil and gas extraction facilities. In this final rule, fixed facilities with sea chests and all non-fixed (or "mobile") facilities are not required to comply with standards for entrainment.

EPA considered requirements for Phase III existing facilities to meet performance standards similar to those required in the final Phase II rule, including an 80-95% reduction in impingement mortality and a 60-90% reduction in entrainment. In the final Phase III rule, however, EPA determined that uniform national standards are not the most effective way to address cooling water intake structures at existing Phase III facilities. Phase III existing facilities continue to be subject to permit conditions implementing section 316(b) of the Clean Water Act set by the permit director on a case-by-case basis, using BPJ.

The performance standards presented at proposal were intended to reflect the best technology available for minimizing adverse environmental impacts determined on a national categorical basis. The type of performance standard applicable to a particular facility (i.e., reductions in impingement only or impingement and entrainment) would have varied based on several factors, including the facility's location (i.e., source waterbody) and the proportion of the waterbody withdrawn. Impingement reductions were required at all facilities subject to the performance standards. Entrainment reductions are required at facilities 1) located on an estuary, tidal river, ocean, or one of the Great Lakes, or 2) located on a freshwater river and withdrawing greater than 5% of the mean annual flow of the waterbody. At proposal, facilities located on lakes or reservoirs may not disrupt the thermal stratification of the waterbody, except in cases where the disruption is beneficial to the management of fisheries.

EPA proposed three possible options for defining which existing manufacturing facilities would be subject to uniform national requirements, based on design intake flow threshold and source waterbody type: The facility has a total design intake flow of 50 million gallons per day (MGD) or more, and withdraws from any waterbody; the facility has a total design intake flow of 200 MGD or more, and withdraws from any waterbody; or the facility has a total design intake flow of 100 MGD or more and withdraws water specifically from an ocean, estuary, tidal river, or one of the Great Lakes. These are options 5, 9, and 8 respectively in the table below.

In addition, EPA considered a number of options (specifically options 2, 3, 4, and 7 below) that establish different performance standards for certain groups or subcategories of Phase III existing facilities. Under these options, EPA would have applied the proposed performance standards and compliance alternatives (i.e., the Phase II requirements) to the higher threshold facilities, apply the less-stringent requirements as specified below to the middle flow threshold category, and would apply BPJ below the lower threshold.

The regulatory options as well as other options considered are described in detail below:

Option 1: Facilities with a design intake flow of 20 MGD or greater would be subject to the performance standards discussed above. Under this option, section 316(b) permit conditions for Phase III facilities with a design intake flow of less than 20 MGD would be established on a case-by-case, BPJ, basis.

Option 2: Facilities with a design intake flow of 50 MGD or greater, as well as facilities with a design intake flow between 20 and 50 MGD (20 MGD inclusive), when located on estuaries, oceans, or the Great Lakes would be subject to the performance standards. Facilities with a design intake flow between 20 and 50 MGD (20 MGD inclusive) that withdraw from freshwater rivers and lakes would have to meet the performance standards for impingement mortality only and not for entrainment. Under this option, section 316(b) requirements for Phase III facilities with a design intake flow of less than 20 MGD would be established on a case-by-case, BPJ, basis.

Option 3: Facilities with a design intake flow of 50 MGD or greater would be subject to the performance standards. Facilities with a design intake flow between 20 and 50 MGD (20 MGD inclusive) would have to meet the performance standards for impingement mortality only and not for entrainment. Under this option, section 316(b) requirements for Phase III facilities with a design intake flow of less than 20 MGD would be established on a case-by-case, BPJ, basis.

Option 4: Facilities with a design intake flow of 50 MGD or greater, as well as facilities with a DIF between 20 and 50 MGD (20 MGD inclusive), when located on estuaries, oceans, or the Great Lakes would be subject to the performance standards. Facilities that withdraw from freshwater rivers and lakes and all facilities with a design intake flow of less than 20 MGD would have requirements established on a case-by-case, BPJ, basis.

Option 5: Facilities with a design intake flow of 50 MGD or greater would be subject to the performance standards. Under this option, section 316(b) requirements for Phase III facilities with a design intake flow of less than 50 MGD would be established on a case-by-case, BPJ, basis.

Option 6: Facilities with a design intake flow of greater than 2 MGD would be subject to the performance standards. Under this option, section 316(b) requirements for Phase III facilities with a design intake flow of 2 MGD or less would be established on a case-by-case, BPJ, basis.

Option 7: Facilities with a design intake flow of 50 MGD or greater would be subject to the performance standards. Facilities with a design intake flow between 30 and 50 MGD (30 MGD inclusive) would have to meet the performance standards for impingement mortality only and not for entrainment. Under this option, section 316(b) requirements for Phase III facilities with a design intake flow of less than 30 MGD would be established on a case-by-case, BPJ, basis.

Option 8: Facilities with a design intake flow of 200 MGD or greater would be subject to the performance standards. Under this option, section 316(b) requirements for Phase III facilities with a design intake flow of less than 200 MGD would be established on a case-by-case, BPJ, basis.

Option 9: Facilities with a design intake flow of 100 MGD or greater and located on oceans, estuaries, and the Great Lakes would be subject to the performance standards. Under this regulatory option, section 316(b) requirements for Phase III facilities with a design intake flow of less than 100 MGD would be established on a case-by-case, BPJ, basis.

Exhibit 4-1 summarizes which performance standards apply under each of the proposed options considered for Phase III existing facilities (options 5, 8, and 9) as well as the other options considered:

Exhibit 4-1. Performance Standards for the Regulatory Options Considered

Option	Minimum Design Intake Flow Defining Facilities as Existing Phase III Facilities					
	> 2 MGD	20 MGD	30 MGD	50 MGD	100 MGD	200 MGD
1	BPJ	I&E				
2	BPJ	Freshwater rivers and lakes: I only All other waterbodies: I&E		I&E		
3	BPJ	I only		I&E		
4	BPJ	Estuaries, oceans, Great Lakes: I&E All other waterbodies: BPJ		I&E		
5	BPJ			I&E		
6	I&E					
7	BPJ		I only	I&E		
8	BPJ					I&E
9	BPJ				Estuaries, oceans, Great Lakes: I&E All other waterbodies: BPJ	

Key:
- BPJ - Best Professional Judgment
- I&E - 80-95% reduction in impingement mortality and a 60-90% reduction in entrainment, where applicable
- I only - 80-95% reduction in impingement mortality
- Estuaries - includes tidal rivers and streams
- Lakes - includes lakes and reservoirs

4.0 OTHER CONSIDERATIONS

EPA considered other issues relating to performance standards for Phase III existing facilities and new offshore oil and gas extraction facilities, including closed-cycle cooling and the use of sea chests, respectively.

4.1 Closed-Cycle Cooling

EPA based the Phase I (new facility) final rule performance standards on closed-cycle, recirculating systems (see 66 FR 65274). Available data suggest that closed-cycle, recirculating cooling systems (e.g., cooling towers or ponds) can reduce mortality from impingement by up to 98 percent and entrainment by up to 98 percent when compared with conventional once-through systems (see 69 FR 41601). In the final Phase II rule, EPA did not select a regulatory scheme based on closed-cycle, recirculating cooling systems at existing facilities based on (1) its generally high costs (due to conversions); (2) the fact that other technologies approach the performance of this option in impingement and entrainment reduction, (3) concerns for potential energy impacts due to retrofitting existing facilities, and (4) other considerations (see 69 FR 41605). For individual high-flow facilities to convert to wet towers, the capital costs range from $130 to $200 million, with annual operating costs in the range of $4 to $20 million (see Phase II final TDD, DCN 6-0004).

Using the lower bound costs per facility, an option that would require closed-cycle cooling at Phase III existing facilities with more than 50 MGD would have cost more than $20 billion in capital costs and well over $600 million in annual operating costs. Therefore basing a rule on closed-cycle, recirculating cooling systems would result in estimated annualized costs of more than $2 billion, which would cost several orders of magnitude more than any of the options EPA considered at proposal. Since the proposed performance standards (performance standards similar to Phase II) would have achieved at least a 60 percent reduction in impingement mortality and an 80 percent reduction in entrainment, these costs would have been borne without at most a two-fold increase in benefits. Therefore, EPA did not further consider closed-cycle, recirculating cooling systems as a basis for the final performance standards for existing facilities.

4.2 Entrainment Reductions for Offshore Oil and Gas Extraction Facilities Using Sea Chests

Facilities using sea chests may have limited opportunities to control entrainment as required by the Phase I rule. EPA recognizes that MODUs using sea chests may require vessel specific designs to comply with the final 316(b) Phase III rule. EPA identified that some impingement controls for MODUs with sea chests may entail installation of equipment projecting beyond the hull of the vessel (e.g., horizontal flow diverters). Such controls may not be practical or feasible for some MODUs since the configuration may alter fluid dynamics and impede safe seaworthy travel, even for new facilities that could avoid the challenges of retrofitting control technologies.